CREATIVE LITTLE SCIENTISTS: Enabling Creativity through Science and Mathematics in Preschool and First Years of Primary Education

D4.3 Country Reports

Report 9 of 9:
Country Report on in-depth field work in the UK

Author(s):

Jane Johnston, Alison Riley, Ashley Compton, *Bishop Grosseteste University College, UK.*

Esmé Glauert, Natthapoj Vincent Trakulphadetkrai, Jane Maloney, Patti Barber, Andrew Manches, *Institute of Education University of London, UK.*

James Clack, Teresa Cremin, Anna Craft, *Open University, UK.*

www.creative-little-scientists.eu

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Contact Information
Coordinator
Ellinogermaniki Agogi, Greece:
Dr. Fani Stylianidou

Lead partner for this deliverable
Ellinogermaniki Agogi, Greece:
Dr. Fani Stylianidou, Dimitris Rossis

Website: http://www.creative-little-scientists.eu

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1. Aims of this Report

The *Country Report on in-depth field work in the UK* forms part of the *Country Reports* (Deliverable D4.3) of the EU-funded project *Creative Little Scientists* and aims at presenting the qualitative analysis of data gathered through field work in schools in the UK.

The fieldwork was carried out during the months January-April 2013 in each of the nine participating European countries (Belgium, Finland, France, Germany, Greece, Malta, Portugal, Romania and the UK) representing a wide spectrum of educational, economic, social and cultural contexts. The findings of this qualitative study aim to reveal the potential for creativity and the role of inquiry in the classroom realities of pre-primary and first years of primary science and mathematics education, and are grounded on concepts and synergies identified in the *Conceptual Framework* (D2.2) and operationalized in the *List of Mapping and Comparison Factors* (D3.1) developed previously in the project. Moreover, they aim to complement the findings of the *Report on Mapping and Comparing Recorded Practices* (D3.2) and the *Report on First Survey of School Practice* (D3.3), previous project deliverables which addressed the same goals through the analysis of relevant policy records and teacher survey data respectively.

The focus of the fieldwork was on sites where there were indications that we would find 'good practice', and covering all pupil age groups from age 3 up to 8 years and the different provisions of pre-primary and early primary education in the country. The characteristics of 'good practice' emerged from reflection on findings of previous project deliverables: the *Conceptual Framework* (D2.2), the *Report on Mapping and Comparing Recorded Practices* (D3.2) and the *Report on First Survey of School Practice* (D3.3). This has enabled the project to document and analyse practice at the cutting edge of creativity in early science and mathematics, revealing insights into whether/how:

- children's creativity is fostered, and
- the emergence of appropriate learning outcomes is achieved.

As far as the latter is concerned, focus was placed on (but not limited to) issues of central importance in current science and mathematics education discourse, including generating children's interest in science and mathematics, avoiding emergence of misconceptions and stereotypical images, and considering gender, socio-economic and cultural issues.

The in-depth field work followed the research design and methodology specified for the project and set out in detail in the *Methodology for in-depth fieldwork* (D4.1), and involved the use of interviews and observations with teachers and children, using field notes and audio recordings. The present report presents the analysis of data in relation to 25 cases (each case comprises one teacher and the children they work with), based in 15 sites of pre-primary and early primary education. Each case contains episodes, documenting examples of science and mathematics through the lens of creativity.

Finally, this report is one of the working documents that will provide input to the *Report on Practices and their Implications* (Deliverable D4.4), which is the final outcome of Work Package 4. The latter will give a detailed account of the analysis of the evidence gathered through the field work in all

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partner countries, as well as identify a set of exemplary Case Studies illustrating the variety of approaches observed and the possibilities identified.

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2. Methodology

The full range of methodological planning and framing for the fieldwork study presented in this report is set out in the *Methodology for in-depth fieldwork* (D4.1). The following sections serve as a reminder of some of its essential elements, and mainly provide the details of how this methodology was implemented in the fieldwork carried out in the UK and described in this report.

2.1 Research Questions

The research questions for this report originate from the project's overall research questions as they are identified in the *Conceptual Framework* (D2.2). The overall research questions are:

RQ1 How are the teaching, learning and assessment of science and mathematics in early years in the partner countries conceptualised by teachers and what role if any does creativity play in these?

RQ2 What approaches are used in the teaching, learning and assessment of science and mathematics in early years in the partner countries and what role if any does creativity play in these?

RQ3 In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics, and how do teachers perceive their role in doing so?

RQ4 How can findings emerging from analysis in relation to questions 1-3 inform the development of practice in the classroom and in teacher education (ITE and CPD)?

As articulated in the *Conceptual Framework*, the first question is focused on mapping conceptualisations in relation to classroom practices in preschools and early primary education, while the second and the third on probing practice in such settings in science and mathematics education using the lens of creativity. The final question draws on both the mapping and probing questions and seeks to apply what has been learned so as to develop practice (in relation to ITE and CPD).

As mentioned above, this report is dedicated to revealing current practice in the intersection between science, mathematics and creativity in both pre-school and first years of primary education in the partner countries. As such, this report has to focus on research questions RQ2, RQ3 and provide input towards RQ4.

Sub-questions running across all research questions probe:

- **Aims/purpose/priorities**, including teachers' explicit and implicit perspectives and identities as scientists and mathematicians, and in relation for example to: aims and purposes of creativity in science and mathematics education; how science and mathematics are taught and learned in relation to other domains of knowledge; how these shift from pre-school to primary across the consortium; how these relate to inquiry-based science education (IBSE); views of creativity in relation to perceived purpose.

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- **Teaching, learning and assessment**, including learning activities, pedagogy and resourcing, and in relation for example to: multimodal expression and experience; learning activity types; resources used; dynamics between adults and children; exploration; questioning and argument; also how teachers assess creativity in early science and mathematics education.
- **Contextual factors**, including ethos, teacher characteristics and teacher general education and knowledge, skills and confidence, curriculum, institutional factors, home-school links and the wider cultural background, location, grouping, time.

Moreover, drawing on the framework of curriculum components 'the vulnerable spider web' (van den Akker, 2007, p.39) these three broad strands have been broken down into ten more narrowly-defined dimensions, which focus on key questions about aspects of learning in schools. Along these dimensions and sub-questions, a number of factors reflecting the study's scope and parameters for mapping of and comparisons between existing approaches to and practices of early years science and mathematics education, i.e. which have a strong potential to foster the development of creative skills in children, have been identified in the *List of Mapping and Comparison Factors* (D3.1), and are explicitly addressed in this report.

Table 1 shows these dimensions, sub-questions and factors, and their codes. Factors highlighted in yellow concern important issues identified in the previous deliverables (Conceptual *Framework* (D2.2), *Report on Mapping and Comparing Recorded Practices* (D3.2) and *Report on First Survey of School Practice* (D3.3)) as needing further investigation. This report focuses on these factors as they enable the mining of key issues identified by previous reports and thus ensure continuity and consistency amongst the various parts of the research study.

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Table 1: Dimensions, Sub Questions and Factors

	Dimensions	Sub questions	Factors important to nurturing creativity in science and mathematics in the early years	Coding
PEDAGOGI-CAL INTERVENTIONS	Learning Activities ***Interaction***	How are children learning?	*Focus on cognitive dimension incl. nature of science* • Questioning • Designing or planning investigations • Gathering evidence (observing) • Gathering evidence (using equipment) • Making connections *Focus on social dimension;* • Explaining evidence • Communicating explanations	• LA: Ques • LA: Plan • LA: Obs • LA: Equip • LA: Connect • LA: Expl • LA: Comm
	Pedagogy ***Interaction***	How is teacher facilitating learning?	• role of play and exploration; role of play valued • role of motivation and affect ; Efforts made to enhance children's attitudes in science and mathematics • role of dialogue and collaboration; *collab. between children valued* • role of problem solving and agency ; use of IBE/PBL, Children's agency encouraged • fostering questioning and curiosity - Children's questions encouraged • Diverse forms of expression valued • fostering reflection and reasoning; children's metacognition encouraged • teacher scaffolding, involvement, Sensitivity to when to guide/stand back	• P: Play • P:Affect • P:Collab • P:Agency • P:Ques • P: Express • P: R and R • P: Scaff
	Assessment ***Framing and Interaction***	How is teacher assessing how far children's learning has progressed, and how does this information inform planning and develop practice?	*Assessment function/purpose* • formative • summative • recipient of assessment results NO CODE *Assessment way/process* • strategy • forms of evidence ; excellent assessment of process +product, Diverse forms of assessment valued • locus of assessment judgment – involvement of children in peer/self assessment	• A:Form. • A:Summ. • A:Strat. • A:Evid. • A:Peer/self

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	Materials and Resources ***Framing and Interaction***	With what are children learning?	• rich physical environment for exploration; Use of physical resources thoughtful; Valuing potential of physical materials; Environment fosters creativity in sci/ma • sufficient space • outdoor resources; recognition of out of school learning • informal learning resources • ICT and digital technologies; confident use of digital technology • variety of resources • sufficient human resources • policy documents; NO reliance on commercial schemes	• M:Explor. • M: Cr • M:Space • M:Outd. • M:Inf. • M:ICT • M:Variet. • M:Human • M: Pol.

	Dimensions	**Sub questions**	**Factors important to nurturing creativity in science and mathematics in the early years**	**Coding**
PEDAGOGICAL FRAMING	Aims and Objectives ***Framing and Interaction***	Toward which goals are the children learning?	• knowledge/understanding of science content • understanding about scientific inquiry • science process skills; IBSE specifically planned • capabilities to carry out scientific inquiry or problem-based activities; use of IBE/PBL • social factors of science learning; collaboration between children valued • affective factors of science learning;efforts to enhance children's attitudes in science and maths • creative dispositions; creativity specifically planned	• AO: Kn.Sc • AO: Und. SI • AO: Sc Proc Skills • AO: IBSE/PBL • AO: Social • AO: Affect • AO: Creative
	Location ***Framing and Interaction***	Where are they learning?	• outdoors/indoors Recognition of out of school learning • formal/informal learning settings/ • small group settings	• L. Out/ • Indoors. • L.Formal/ Informal • L.grp
	Grouping ***Framing and Interaction***	With whom are they learning?	• multigrade teaching • ability grouping • small group settings • number of children in class	• G:MG • G:Abil. • G:SmallG • G:No.

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2.2 Research Instruments

The methodology document for the fieldwork (D4.1) set out a series of core and repertoire research instruments. All partners have been expected to use the same core instruments so as to collect similar data to enable comparisons. Additionally, each partner was encouraged to use a repertoire of instruments, depending on preferred approaches and existing expertise. Data was to be collected across four areas spanning site and case (see D4.1, p33):

1. **WIDER SITE CONTEXT**: encompassing data from existing Deliverables D3.2, D3.3, and D3.4.
2. **CASE PEDAGOGICAL CONTEXT**: the setting's teaching and learning policies and planning documents as appropriate, assessment records if they exist, overview of resources and a map of the space.
3. **CASE OBSERVATION OF PEDAGOGICAL INTERACTION AND OUTCOMES** (episodes of learning involving children and teachers):

   Core Instruments: Sequential digital images capturing detailed interactions, with fieldnotes supplemented by audio recording (later transcribed) and an overall timeline, enabling narrative construction

   Possible additional repertoire instruments: teacher journals, Fibonacci style tools to support diagnostic observation, Involvement Scale, Reggio style documentation, conceptual drawing, video.

4. **CASE ORAL EVIDENCE (INTERVIEWS)- PERSPECTIVES ON PEDAGOGICAL INTERACTION AND OUTCOMES (children + teachers):**

   Core Instruments: individual interviews (teachers), group interviews (children) using digital images from observations, 'learning walk' led by child, looking at children's work.

   Possible additional repertoire instruments: supplements to interviews such as conceptual drawings or teacher journals. Some oral interviews might be spoken to audio recorder.

The core instruments used for fieldwork in the UK were a classroom map, fieldnotes of observations with a timeline, audio recordings, photo sequences, artefacts, individual interviews with teachers, group interviews with children and learning walks. In addition repertoire instruments were employed in the following cases: video recording in Ella, EN8; Lisa, EN8; Sarah, SC2 and Maria SC3 and conceptual drawing in Martha, SC2. Some of the teachers had completed the CLS questionnaire in 2012 during Work Package 3. Those who had not were asked to complete it in 2013. Although, many instruments were used the case studies do not always draw on every instrument, depending on relevance.

In addition to these, researchers used information from school websites, inspection reports and national curriculum documents to establish the context of the research.

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2.3 Data Collection

2.3.1 Sampling principles

The methodology document for the fieldwork (D4.1) specified that each partner should visit a minimum of four sites (i.e. schools/preschools), five where possible and gather data from a minimum of six cases (i.e. one teacher and the children they work with) reflecting both settings (pre-school and primary education). In order to reflect the science and mathematics focus of the project, partners were asked to aim to identify three episodes of activity per case (ensuring at least one each of science and mathematics) resulting in a total of 18 episodes being reported per partner. The episodes are meant to provide illustrations of actual practice - chosen because they exemplify one or more of the aspects identified in Table 1.

The sample of cases was thus deemed to be a purposive one, involving a range of contexts, learning opportunities and teacher populations and age ranges of children. Moreover, the following selection criteria were identified to be used as part of the selection of each national sample (see D4.1, p28):

- Includes appropriate diversity (e.g. in respect of culture, circumstance, language).
- Covers appropriate age span 3-8.
- Represents span of mainstream (i.e. not special) early years provision.
- Settings primarily focused on education not care.
- There are indications of good practice of early years mathematics, science and creativity.
- Allows us to mine one or more of the important research foci (identified in previous deliverables and shown in Table 1).
- Geographical accessibility for researchers.

As previously mentioned all of the CLS partners were instructed to collect a minimum of 18 episodes. Since there are three UK partners this meant a minimum of 54 episodes. The UK partners were required to conduct fieldwork in the four nations of the UK, therefore the cases and episodes were spread across the four nations. As England is by far the most populous of the UK nations it was decided that the majority of the cases would come from England. All three of the partners undertook research in England but in addition to this cases were collected by the Open University in Northern Ireland, by the Institute of Education in Scotland and by Bishop Grosseteste University in Wales.

The CLS teacher survey undertaken in 2012 included a question about whether the respondent wanted to take part in the fieldwork phase. Many of the English sites used in the fieldwork were drawn from these volunteers. These schools were then investigated using information such as school websites, inspection reports, and prospectuses, for their qualities regarding science, mathematics and creativity in the early years. Once some of these schools had been identified as having evidence good practice such as awards or positive inspection reports a sample was selected to represent a range of school types (nursery, infant, full primary), a range of settlements (large city, small city, rural) and range of school intake related for example to diversity (monocultural /multicultural;

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proportion of children with English as an additional language; socioeconomic background as represented by the proportion of children eligible for free school meals). These schools were supplemented with some that were personally known to the researchers as having good practice. The teachers and classes used within these schools were also volunteers and were selected to represent the full CLS age range of 3 to 8 years old.

The sites used in Wales, Scotland and Northern Ireland were selected using a similar process, although there had been far fewer questionnaire responses from these nations, resulting in fewer volunteers. This was further complicated by the fact that the UK institutions involved in CLS are all based in England and had limited contacts in the other UK nations. Therefore additional advice and recommendations about possible schools were sought from school inspectors and local higher education institutions involved in teacher education. Schools were then approached directly to ask if they might be interested in participating in the research. A final sample was selected from those that volunteered taking into account the sampling principles outlined above. The final selection of sites is shown in Table 1 below.

The recommendation in the methodology was for four visits to each site, with a suggested timetable of research instruments to use during each visit. Because of the distances involved and limited availability of some teachers and researchers, in some cases the visits were combined, with all of the research tasks undertaken in fewer days.

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Table 1: Final Selection of Sites

Fieldwork Sites		EN1	EN2	EN3	EN4	EN5	EN6	EN7	EN8	NI1	NI2	SC1	SC2	SC3	W1	W2
General Selection Criteria																
Phase	Preschool	X	X			X	X		X	X		X	X		X	X
	School	X		X	X			X	X		X	X		X	X	X
Governance	Non-fee paying	X	X	X		X	X	X	X	X	X	X	X	X	X	X
	Fee paying															
Age(s) of children	3		X			X	X			X		X	X			
	4	X	X			X	X		X	X	X	X	X		X	X
	5	X		X	X	X		X	X		X	X		X	X	X
	6	X		X	X			X	X		X	X		X		X
	7	X			X				X		X				X	
	8	X													X	
Mixed age groups		Y	N	N		Y	N	N	N	N	N	Y	N	N	N	N
Special school		N	N	N		N	N	N	N	N	N	N	N	N	N	N
High Diversity	SEN	Low	Low	Low		Y	Y	Y	Y	N	N	Low	Low	Low	Low	Y
	Non-native speakers	N	Y	N		Y	Y	Y	Y	N	N	Low	Low	Low	N	Y
	Socio-economic disadvantage	N	Y	Y		Y	Y	Y	Y	Y	N	Low	Low	Low	N	Y
Location	Urban		X			X	X	X	X				X			X
	Suburban									X	X	X		X	X	
	Rural	X		X												

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2.3.2 Ethical issues

Any fieldwork undertaken with young people can potentially carry ethical implications, both in terms of the conduct of the researcher whilst undertaking fieldwork, and in the collection and application of data following the fieldwork period.

Each partner was required to identify and meet the ethical approval policies for their institution, school system, region and country as appropriate. In addition, the consortium identified the following minimum standards that were applied by all partners in all cases:

- Participation to the research was on an informed voluntary basis. Letters for school staff and parents were developed for this purpose (see D4.1, Appendix 4, p72). Written consent was obtained before the fieldwork was undertaken. The right to withdrawal was clearly communicated.
- Explicit permission was requested to take and use photographs (and videos where appropriate) of the children and staff for the project in project reports and publications.
- Explicit permission was requested to interview children as part of focus groups.
- The sites used, the adults and children who were involved were given pseudonyms to protect their identities.
- Any electronic data collected was stored on password protected encrypted storage systems, where only authorised staff had access. An agreed protocol for storage and labelling of data was agreed (see D4.1, Appendix 7, p85).

All UK partners gained ethical approval to conduct fieldwork from their respective institutions. In Scotland ethical approval was also required and gained from the two local educational authorities concerned.

Informed consent

Informed, voluntary participation was a key ethical consideration. UK partners made initial contacts with schools that had expressed interest in the research to explain the project to relevant staff and answer any questions. Information leaflets and consent forms were prepared for staff, parents and children to invite them to participate. Participation was entirely voluntary. Consent was sought from the head teacher and staff for conducting the research in the school. Once staff had agreed to be involved in the research, information sheets and consent forms were sent out to parents to discuss with their children. If children or their parents did not wish to participate in the research, the children were disadvantaged in any way. They were still involved in classroom activities but not be included in records of observations or in interviews conducted in the class. Children were also asked at each stage in the research whether they wished to join in. The consent form outlined the different research instruments that might be employed. This included permission to take and use photographs of the children for the project. In some cases parents gave permission to participate but not to use photographs, sometimes for child protection issues. In these cases the researcher was made aware of which children could not be photographed and they were carefully omitted from photographs, although included in the fieldnotes. Through the information leaflets and

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conversations with staff, children and parents in the schools it was also made clear that they were free to withdraw from the research, or elements in the research, at any point by contacting the researcher visiting their school. Contact details were provided at the end of the information leaflets and consent forms.

Confidentiality and anonymity

At the outset of the work in schools ground rules for participation were established – in particular the importance of confidentiality and anonymity. Only the staff, parents and children in the school know who has participated. No names of schools, staff or parents are reported in the research. Pseudonyms have been used to protect the identity of participants.

Data protection

Personal data provided by participants will only be used for research purposes and will be protected according to the EC directive 95/46/EC. All data gathered during the project is stored in password-protected files in a secure location accessible only to the researchers. Stored data does not make reference to real names or contact details. As indicated above, in the final research reports no real names or information are included that can identify comments of particular participants.

Risks to participants

Arrangements for fieldwork were designed to fit in with classroom routines, to minimise disruption and demands on the time of both staff and children. Researchers emphasised that they were seeking to identify positive examples of practices and to draw upon a privileged opportunity to capture children's interactions and discussions. Most of the research involved the researcher observing and documenting classroom practice so it put minimal pressure upon the children, although the presence of an observer, especially one taking photographs and audio recordings does cause some disruption. However, some of the research instruments, such as the group interview and the learning walk, involved children taking part in activities outside of their normal practice. The teachers recommended children who they thought would be confident in participating in these activities but the children were also given the choice of whether to participate or not. Researchers took opportunities during each visit to check that all participants were comfortable with what they were doing.

All researchers had a CRB check (and a PVG Membership Statement if working in Scotland). Participants were informed that they would not report details of what individuals shared with researchers (through what they say or do) unless they judged there might be risks to participants or researchers. In such cases they would follow the child protection procedures in place in the school and local education authority.

Dissemination of findings

All schools who have participated in the research will receive:

- A certificate of participation in the EU funded research project Creative Little Scientists.

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- A report on practices and their implications, which will include a set of exemplary case studies illustrating the variety of approaches observed throughout the nine European countries participating in the project.
- A publication containing exemplary teacher training materials, which will be selected on the basis of good practices identified in the case studies, as well as being consistent with the guidelines and curricula for teacher training produced by the project.

Parents were able to request a copy of the report of the research on the consent form. All participants can also follow the work of the project and its publications on our website at www.creative-little-scientists.eu.

2.4 Data Analysis

2.4.1 Process

As already mentioned, the methodology agreed for the fieldwork specified that each partner would produce a minimum of six identified cases, with a minimum of three narrative episodes per case to fully explore the opportunities presented for the fostering of creativity in early years science and mathematics education. A narrative episode in this case was defined as a written narrative account that describes an observed event or series of connected events of science and mathematics teaching/learning with a creativity focus, which forms a coherent story by itself. These were to be drawn from observations selected for their relevance to the pre-identified project factors and supported by information gathered through a minimum of two types of core data. Where possible the views and thoughts of the children in addition to those of the teachers were sought; extracts from relevant transcripts, containing they key areas of interest specific to the focus of the episode are provided.

All data were coded using a set of deductive codes, based on the project factors (see Table 1), and were discussed in terms of Siraj-Blatchford et al.'s (2002) framework to explore pedagogy in terms of pedagogic framing and pedagogic interventions. Their opportunities for science or mathematics creativity were highlighted.

Finally, the episodes were combined in overall cases, which included information about the site, the setting and the teacher. These cases and related episodes are presented in this report.

2.4.2 Final sample cases and episodes

The characteristics of the final sample cases and episodes are given in the table below.

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Site code	Teacher	Year group(s)	Science episodes	Mathematics episodes
			England	
EN1	Jenny	Reception & Year 1	Ice Car	Fruit Café Bear
EN1	Louise	Years 3 & 4	Sound Space	Art Mother's day
EN2	Fleur	Nursery	Cornflour Pulleys Bubbles Ice Buttons *Ramps*	*Ramps*
EN2	Sally	Nursery	*Baking* *Soft play* Digiblue	*Baking* *Soft play*
EN3	Wendy	Year 1	Classifying Starting Points Animals needs	Counting on
EN4	Caroline	Year 2	None	Shapes Caterpillar boots
EN4	Linda	Year 1	Straw flutes Outdoor sounds	None
EN5	Anita	Children's centre / nursery	Gloop Emma's ball Ice and gloop	None

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			Syrup	
EN6	Jennie	Nursery	Volcano Cars and ramps	Bee Bots
EN7	Emily	Year 1	Waterproof materials	Balancing Doubling
EN8	Lisa	Reception	*Push and pull*	*Push and pull* Cubes in the hoop Counting minibeasts
EN8	Ella	Year 2	Egg carriers Habitats	Block graphs
Northern Ireland				
NI1	Alice	Nursery	Gloop Shaving foam Bubbles	None
NI1	Maeve	Nursery	Ice *Outdoor sandpit*	Shapes *Outdoor sandpit*
NI2	Siobhan	Primary 1	Gingerbread man investigation Gingerbread man raft	
NI2	Andrea	Primary 2	Flowers and food dye	Outdoor measuring

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Scotland				
SC1	Martha	Nursery	Melting and freezing Water play	Cake shop
SC1	Mary	Primary 1	Day and night	Counting money Sorting and counting
SC2	Sarah	Nursery	*Baking* Forest School Scout Camp	*Baking*
SC3	Maria	Primary 2	Touch activities	Alien challenge Price prediction
Wales				
W1	Joanne	Reception	Jelly Cooking flapjacks	Shop role play
W1	Denise	Year 3	Puppets *Cooking courgette muffins* Discovering properties of materials	*Cooking courgette muffins*
W2	Brenda	Reception	Making musical instruments Carpet musical instruments	3D shape
W2	Joan	Year 1	Light and Dark Life cycles	Big maths, beat that

There were 8 sites and 12 teachers in England, with 41 episodes; 2 sites and 4 teachers in Northern Ireland, with 10 episodes; 3 sites and 4 teachers in Scotland, with 12 episodes and 2 sites and 4 teachers in Wales, with 12 episodes.

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2.4.3 Limitations

The fieldwork was undertaken during a short period of time during winter 2013. This means that a limited view was obtained. Some topics, such as ice, were well represented due to the prevailing weather conditions at the time. Had the research been undertaken during the summer term the episodes seen might have been very different, especially with regard to using the outdoor environment. In some cases the timing had a definite impact on the type of science and mathematics observed. Linda (EN4) reported in her interview that earlier in the year she had spent more time focused on teaching scientific and mathematical facts, although during the observation period she mostly used a problem-based, investigative approach. One of the Welsh schools reported that they were holding a special science week just after the fieldwork period ended so unfortunately this was not observed.

In some sites the researchers observed everyday practice, with no special arrangements. However, in some sites the teachers rearranged their normal timetable so that the researcher could observe science and mathematics lessons at mutually convenient times. Also, some sites may have put on special activities which they felt met the aims of the CLS project. During the first visit, Louise, at St Denis school (EN1), told the researcher that she “doesn’t usually do activities like this but drops them in every so often”, implying that this was not usual practice. However, it was clear from the children’s reactions to the lesson that many aspects of it were very familiar to them.

An additional limitation is the fact that most of the observations were conducted by a single researcher. This severely limits what can be observed and recorded. This was noted in the Alice (NI1) case study, “Unfortunately, with so much rich activity happening in the classroom throughout the day, it was not possible to observe this in any detail. This certainly highlights one limitation of qualitative research in that the researcher chooses where to observe and ultimately selects both what and why data is collected, how it is analysed and subsequently how it is presented.” A further limitation related to this was noted in the case of Jenny (EN1). Jenny had a mixed Reception and Year 1 class and believed strongly in providing free play opportunities for the children. Several of these occurred during the observations, however the researcher tended to stay with the teacher rather than observe the free play closely. The reason for this was that the teacher was usually involved in activities that were part of the overall lesson and contributed to rich episodes. Also, the free play that was observed was frequently not related to science or mathematics. However, the overall result was that the case study presents a much more teacher-centred picture of this class than exists in reality.

Overall, 75 episodes were collected in the UK. However, these were derived from a small number of schools so the ability to generalize from these is limited.

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3. Case Studies

3.1 Case: 'Jenny'

3.1.1 Context

Where?	Country	England			
	Setting name	EN1 - St Denis Church of England Primary			
	Location within setting	Pre-School / Primary School			
Who? (children)	Year group/age of children	Reception and Year 1; 4-6 years old			
	Number of children in class	20 (science) 27 (mathematics)			
Who? (adults)	Number of adults	2 or 3			
	Role of adults	1 teacher and 1 or 2 teaching assistants			
	Case teacher role	Science Co-ordinator			
When?		1	2	3	4
	Dates of visits	24/1/13		6/2/13	27/2/13
	Times of visits	9:00-12:20		1:20 – 2:30	1:20 – 3:00

School / Setting

St Denis is a smaller than average English primary school, with fewer than 150 pupils. It was originally built in 1860 but was extended significantly in 2004 and 2011. It is in a small village in a rural area. Although the front of the school faces a road with houses, the Year 3 /4 classroom overlooks a field of sheep. It is a state school, run by the Local Authority, but has Church of England Voluntary Controlled status. This means that the school has a religious character and that a minority of the governing body are appointed by the church. However, religious adherence is not a requirement of admission. The vast majority of pupils are from white British backgrounds, with only a very low percentage of pupils from minority ethnic backgrounds and even fewer with English as an additional language. There is also a low percentage of pupils eligible for free school meals (3%), which indicates that the area is reasonably affluent. The school's results in national tests for English and mathematics at Year 6 have been consistently above the national and local averages, with nearly half achieving higher levels in mathematics. There are no longer national tests for science but the school's teacher assessments in science at Year 6 (2012) show 100% of children achieving Level 4 (the expected level for this age group) and 52% exceeding this by achieving Level 5.

The school has obtained a series of awards, including: Gold Primary Science Quality Mark, Green Flag Eco School; National Healthy Schools status; Food for Life bronze award and Artsmark silver award. In the lobby the school keeps a booklet of local newspaper clippings. These included an article

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praising the school's science and an article about receiving funding from a local business for mathematics resources. The school produces regular newsletters for parents, which always include English and mathematics updates. The newsletter for the period of the research included information about Creative Little Scientists, ideas for working on mathematics with your child, including some suggested websites, an announcement about World Maths Day and 'Green News' related to Eco-Schools, including information about the upcoming Waste Week. For World Maths Day the children would be competing on-line against other schools worldwide and raising money with a sponsored number facts event. The school is also raising money for the Marie Curie Cancer Care by growing daffodils.

The school places high value on both mathematics and science, which is reflected in the school aims, since English, mathematics and science are the only subjects to be specifically identified. They also value creative aspects of learning, which also feature in the aims.

The school aims include:

- To encourage each child to develop a lively enquiring mind with the ability to question and discuss whilst becoming an increasingly independent learner
- To promote high standards in literacy and numeracy
- To use children's natural scientific curiosity to give them a deeper understanding of the world in which they live.
- For everyone, children and adults, to be involved in lifelong learning.

The school's mathematics policy, which was written by Louise, emphasises the role of problem solving in mathematics. Its aims include:

- To promote enjoyment and enthusiasm for learning through practical activity, exploration and discussion
- To develop the ability to solve problems through decision-making and reasoning in a range of contexts
- To understand the importance of mathematics in everyday life

The policy talks about children working in pairs on open-ended problems and games, children being encouraged to ask questions, as well as answer them, and children using a range of resources, including ICT. The narrative episodes from both cases in this school demonstrate that all of these aspects of the policy are enacted in lessons.

St. Denis' science policy, which was written by Jenny, emphasises developing enquiry skills: observing, measuring, recording, predicting, evaluating, interpreting and explaining. The policy states that the school does not use a commercial scheme. The different science topics are loosely set out in a long term plan for each year group but the policy refers to the 'Creative Curriculum' and suggests that science should be linked to the class' overall topic where possible. Greater flexibility is

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recommended for the Early Years Foundation Stage, with planning "responding weekly, or even daily, to the children's interests and experiences." A range of assessment approaches are used and assessment is not limited to written products. The school holds regular science assemblies to "not only help children develop a sense of awe and wonder but to recognise that science may ask as many questions as it answers." There is a science committee, consisting of both staff and pupils, meets to decide how science is taught and to ensure that science has a high profile in the school. The high profile was represented in the staff room by posters on the cupboards about assessing science enquiry skills. In addition to the science policy, each class has a poster which informs science teaching and observations of science.

"Science Teaching in our school is good when…

…it is hands on, minds on, and well resourced.

…teachers and pupils feel motivated and enthused by the learning.

…when there is sufficient time to follow through children's ideas and to complete experiments.

…teachers and children work together to habitually ask questions, and find answers through enquiry and investigations.

…it is relevant, creative and cross-curricular.

…when the outside classroom is utilized.

…when children and teachers feel confident to challenge and make mistakes."

This definition of good science teaching fits in well with the Creative Little Scientists' ideas about creativity in science. As with the mathematics, these ideas about science were witnessed in practice in both cases in the school.

Teacher

Jenny is a female teacher in her 40s, who has been teaching for more than 11 years. She is the leader for both science and the early years. Her undergraduate degree was in social science and education, followed by a PGCE, and she has since completed some Masters modules. Jenny studied some science at undergraduate level but mathematics only to upper secondary. Her initial teacher training emphasised mathematics, science, pedagogy, creativity, ICT and developmental psychology.

In the last 18 months Jenny had taken part in some science CPD. The forms which had the most impact were science courses and participating in a science network. Jenny is moderately confident in her understanding of scientific inquiry and the competences to carry this out, pedagogy generally and science pedagogy specifically. However, she rates her knowledge of mathematics pedagogy as very low. She is slightly more confident about her mathematics teaching but this is less confident than her science teaching and assessing. This limited confidence has an impact on her teaching. She reported that, "*I am much less creative (and confident) in my approach to mathematics & feel more constrained by a curriculum which I do not understand well enough to make my own. Having said that I do sometimes plan open ended investigations etc but nowhere near as much as with science.*" She has some confidence in her knowledge of scientific ideas and processes. However, her limited knowledge in science does not inhibit her enthusiasm for the subject. In the interview she explained, "*I'm not an expert and do so many things wrong but isn't science great*!"

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Jenny teaches a mixed Reception and Year 1 class. However, she also does some science teaching with the Year 6 class. This includes taking a group of Year 6 children to six local nurseries each term where they lead science activities with the nursery children. These activities involve stories, play and exploration of scientific ideas. In the interview Jenny talked about these visits as important learning activities for both the Year 6 children and the nursery children, but also as a form of CPD for the nursery staff, who generally have little science training. With her own class she teaches science for 1 to 2 hours per week. For mathematics she teaches her own class along with additional Year 1 children from the mixed Year 1 and 2 class, for 1 to 2 hours per week. The main science topics this year are forces (making kites / water tray); changing materials (making playdough / cooking); plants (growing / planting); animals (studied a dead bird) and materials (testing materials to make a waterproof hat). Although she designed the overall science framework for the school she feels it is more important to follow the children's interests and environmental conditions. This was exemplified by her study of freezing and melting during a cold snap and the car investigation prompted by the children's questions.

Jenny rated all of the purposes for science in the questionnaire as very important. The science outcomes which she addressed very often were: collaborating with other children; planning and conducting simple investigations; to have positive attitudes towards science learning; and to be interested in science. She reported rarely focusing on the knowledge aspects. Jenny reported using nearly all of the learning / teaching contexts and approaches very often, with a few quite often. The only ones that she rarely used were digital technologies and history. The contexts she feels are most likely to promote creativity are open / unstructured play, teaching science from stories and physical exploration of resources. However, she qualified this by saying that, "I think that it is the questions that you ask children and the time you give them to think about and answer the questions that is most important alongside the other activities e.g. telling a story & then drawing out children's thinking, or observing free play with materials & then commenting/listening to children's comments." In terms of teaching approaches, Jenny feels that encouraging problem finding and problem solving and using questioning are most likely to develop creativity. However, she also qualified this response: "*I think most of these activities are potentially useful in encouraging creativity - it depends how you present them e.g. children solving practical tasks could be dry - or it could be linked to a story or real life problem, children could be motivated and given time to follow through their ideas. All of these suggestions are potentially very useful but it depends how you present them*." Jenny reported that she very often encouraged the children to observe natural phenomena and quite often got the children to ask questions, design and conduct investigations and use simple equipment, which she felt were the activities most likely to develop creativity. She said that she rarely asked the children to use data to construct reasonable explanations or communicate their results. However, during my observations she put considerable emphasis on encouraging the children to communicate their reasoning. She mostly uses guided approaches for inquiry skills but takes an open approach to children investigating questions. She strongly agrees with the teacher facilitating children's inquiry and providing enough time for them to solve problems and disagrees with the teacher demonstrating problem solving approaches first. This was borne out in classroom

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observations where she only modelled problem solving approaches after the children had attempted their own solutions.

In terms of assessment Jenny prioritises positive attitudes towards science as most important, followed by understanding of inquiry and the skills to carry out inquiry. Knowledge about science and scientific processes are given some importance. Jenny mostly assesses through classroom interactions, although she quite often uses evaluation of children's pictures, gestures and physical activity, portfolios of work and questioning. In the interview she discussed the Learning Journey books for the reception children that have photographs, recorded comments and annotated work. She never assesses science through homework or tests. Jenny reports rarely using praise or reward for most aspects of science and mathematics. St Denis is a registered High/Scope provider and the High/Scope approach encourages intrinsic motivation rather than extrinsic praise or rewards. She did report using praise for motivation and collaboration in science. Jenny discussed formative assessment of science and mathematics, saying that assessment expectations were more formal in mathematics. In the interview she discussed the 'rising star' tests she is obliged to use fortnightly with the Year 1 children. These are formal tests that she does not like, although she acknowledged that they can provide useful evidence of progress. She uses assessment for a variety of purposes in science, although not for grouping children or providing feedback for children and rarely for target setting and monitoring.

Jenny feels that the school is very well resourced for hands-on equipment for science outside the classroom, but less so for inside the classroom, although the budget for supplies is good. They are also well resourced for computers, digital technologies, library materials and teaching assistants. There is a similar picture in mathematics, with a very good budget for supplies, good ICT resources and hands-on equipment outside the classroom. Jenny very often prepares her teaching materials herself, drawing on the school and national curriculum and assessment guidelines. Jenny also draws on resources and ideas she has gained from the Science Learning Centre at York. She frequently uses library books, hands-on equipment, computers and natural resources, such as shells, feathers and leaves for counting and sorting. She never uses text books.

Classroom

This is a mixed Reception and Year 1 class with children ranging from 4 to 6 years old. This means that this setting spans both pre-school and school in the English context. Reception is part of the Early Years Foundation Stage, which is the pre-school curriculum in England. Children join Reception in the academic year in which they will turn 5. In many schools, including this one, the children will start in the September after their fourth birthday, but they are not legally required to be in school until they are 5 years old. Therefore, although they are following a pre-school curriculum, some of the Reception children are officially school-aged. The Year 1 children are part of Key Stage 1 that is considered the start of the national school curriculum.

There are 10 Reception children and 10 Year 1 children in the class, although seven Year 1 children from the mixed Year 1 and 2 class join this one for mathematics, bringing the class size to 27. There were several considerations used when deciding whether a Year 1 child should be in the Reception /

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Year 1 class or the Year 1 and 2 class. Those who stayed in the Reception / Year 1 class were partly those who were weaker academically but preferring a practical, hands-on learning style was a prime consideration. Friendship groups were also considered, as was position in the family, with younger siblings being given the chance to stay in Reception / Year 1 to have a chance to be the older child.

The classroom is quite large, encompassing much of the original school, with several different areas dedicated to different aspects of learning. (See the classroom map below.) There is a small outdoor area dedicated to this class but they also have easy access to the main playground and field.

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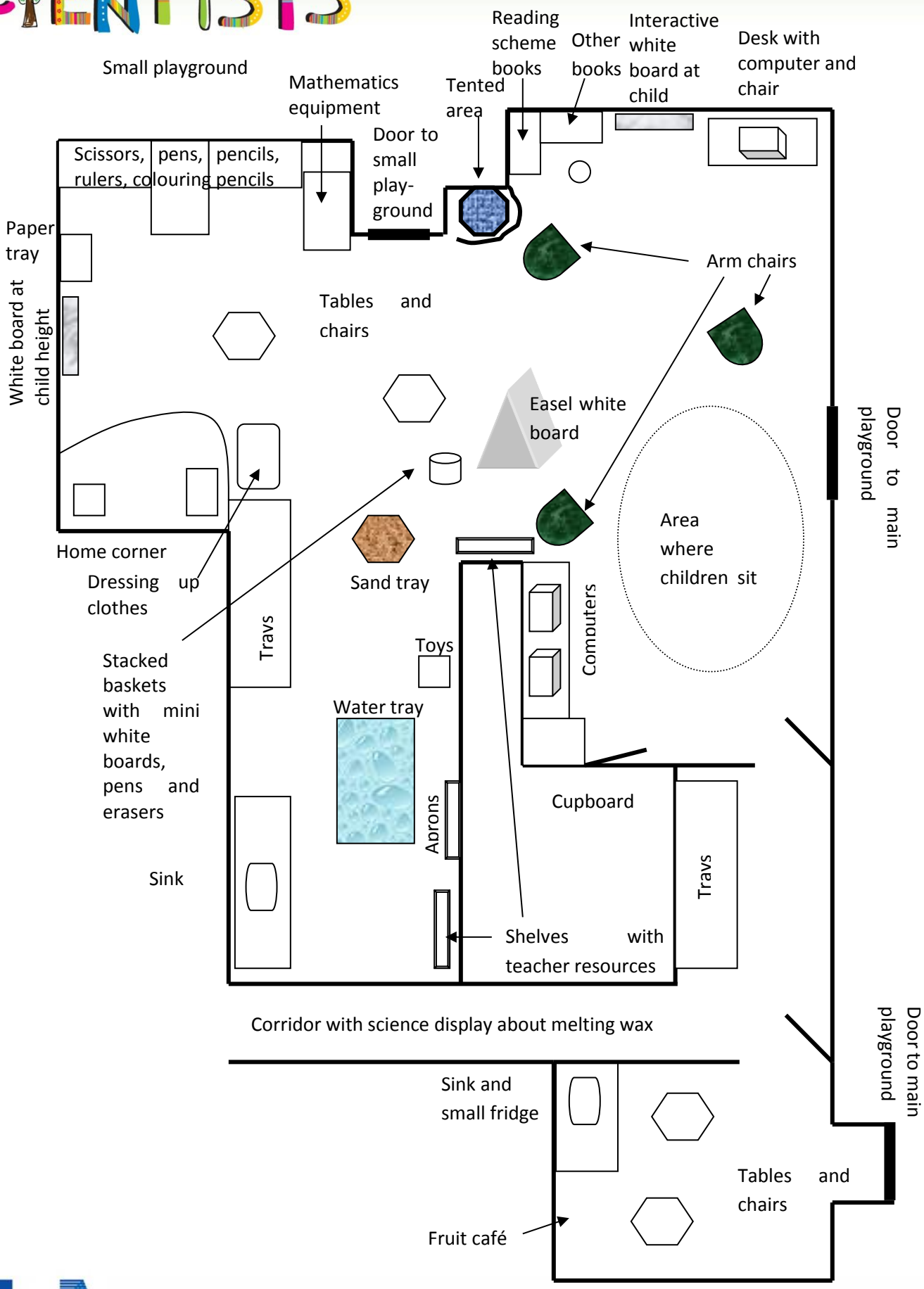

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3.1.2 Episodes

This case comprises of four episodes:

1. Ice episode – exploring freezing and melting (science)
2. Cafe episode – learning how to use money (mathematics)
3. Bear episode – using interesting resources to explore ways of making 6 (mathematics)
4. Car episode – exploring children's questions about a car on different surfaces (science)

Each of these will be presented separately drawing on the data in the episode data in the appendix and making a narrative episode that uses data and analyses the data to make an argument about the synergies between science and maths and creativity.

It should be noted that the episodes mostly focus on interactions between the teacher and the child(ren). There was a strong tradition of children 'choosing' in this classroom while the teacher worked with a small group of children. These child-initiated activities may have included science and mathematics but they were not observed, which is a limitation of these episodes due to having a single researcher in the classroom. The researcher tended to follow the teacher because these activities followed on from the whole class activities, which were forming rich episodes. This should not be taken to mean that there were no child-initiated activities relevant to the study and further research in this school should concentrate on this. A further limitation of the research is that it was very difficult to discern what individual children were saying on the audio recordings when the children were involved in child-initiated activities because of the background noise. Direct quotations from the teacher are more common because she was able to project her voice, making it clearly audible on the recordings.

Episode 1: Ice

The first observation at St Denis coincided with very cold weather and persistent snow. Jenny decided to investigate freezing and melting with the children rather than stick to the whole school topic, which was Africa because the children were very excited by the snow. She wanted the children to think about what melting and freezing were and what affects these. She prepared a variety of resources for the lesson: ice sculptures that she made with the children earlier in the week, ice balls and ice balloons. However, this episode extends beyond a single lesson to incorporate a further whole class investigation and some independent activities.

Pedagogical framing

The aims of this lesson in terms of scientific knowledge were to explore freezing and melting, but also to develop the science process skills of making predictions, observations and designing an investigation. The lesson took place both indoors and outdoors and included both formal, teacher-led aspects and informal, child-initiated aspects. The groupings ranged from whole class, to small group, to pairs to individual work. The observed lesson lasted nearly two hours but was part of a sequence of related experiences, both teacher-led and child-initiated, over several weeks.

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Image 1.1: BoxBoys observing ice

Pedagogical interactions

The episode began several days before the first observation with the children making ice sculptures by placing leaves and twigs and the end of a piece of string in a cake pan with some water and then leaving them outside to freeze. The idea came from the Woodland Trust website. The observed session started with children extracting their ice sculptures from the trays. The children then took their sculptures outside and found places on the trees and bushes to hang them. Back in the classroom they were asked to make predictions about what would happen to their ice sculptures. The teaching assistant then read a story about polar bears, focusing on the cold climate and making links throughout the story to the children's own lives. After playtime the children remained outside to observe their ice sculptures. Back in the classroom they discussed their observations and their earlier predictions.

Image 1.2: Unveiling the ice ball

Image 1.3: Feeling, looking and describing

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Jenny then explained how she had made some ice balls and presented herself as very excited about sharing these balls with the children. She then showed great disappointment when she took a tub from the windowsill and found it was full of water rather than an ice ball. The children called out suggestions about what had happened, saying it had melted because it was too warm in the classroom and too sunny near the window. The teacher explained she had 10 more ice balls in the freezer but that she was not allowed to keep them there so challenged the children to think of ways to keep them from melting out of the freezer. She asked the talking partners to share their ideas and pushed them to explain why they had chosen that. After the children had made their suggestions the teacher and teaching assistant both made their own suggestions. The teaching assistant suggested burying the ice ball in the snow and Jenny suggested wrapping it in a coat. The class then went outside to place their ice balls in the spots they had decided.

Back in the classroom Jenny explained that they would be making bird cakes later and asked the children if they thought the lard would melt if she left it on the window sill like the ice ball. Some agreed and some disagreed. The children then sat in a circle and they passed two ice balloons around. Jenny encouraged the children to feel the ice balloon and observe it closely, describing what they felt and saw. This was followed by a free choice of activities, which included exploring the ice balloons further. At the end of the lesson the teacher checked the lard to see if it had melted and got the children's suggestions of how to melt it. They then went outside to check the status of their ice balls.

In a subsequent lesson Jenny followed up the idea of putting an ice ball in a coat to prevent it melting. She asked the children to predict whether the ice ball in the coat or the uncovered ice ball would melt first. She used large toy bricks to make a 3D block graph of their responses, including children who had said they did not know. They then checked the progress of the ice balls over the next weeks.

In their Learning Journey books there were records of the children's participation in the ice activities, including photographs, quotations and descriptions. These records also included activities the children had devised themselves, including a boy building a snowman and the girls making decorated snow cakes which they set up in a shop for children to buy at playtime.

Opportunities for science learning

Many science process skills were involved in this episode. The Early Years Foundation Stage (EYFS) curriculum requires that the children 'know about similarities and differences in relation to… objects', 'talk about the features of their own immediate environment', 'make observations … and explain why some things occur, and talk about changes'. Throughout the episode the children were encouraged to make observations and discuss these with their talking partners, as well as the class as a whole. Jenny asked the children to touch and look closely at each item and then describe what they felt and saw. She drew attention to some aspects, such as the bubbles inside the ice balloon, when describing her own observations.

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Image 1.4: Block graph of predictions

The Key Stage 1 curriculum, which applies to the Year 1 children in the class, has additional process skills which applied in this episode including: asking questions, collecting evidence, exploring using the senses, thinking about what might happen, comparing outcomes with predictions and communicating what happened. The children were asked to make predictions and asked to explain why they believed that would be the outcome. These predictions were followed up with observations to check if the predictions came to pass. With the ice ball in the coat the predictions were recorded by constructing a 3-D block graph with signs on each stack explaining what the blocks represented. After the first observations of the ice ball in the coat and the unprotected ice ball the children were allowed to revisit their predictions and change them in the light of the evidence. This resulted in many of the children switching to the unprotected ice ball melting first. The children discussed this in the group interview:

Child: *"It's the ice balloon experiment!"*
Researcher: *"What happened in the end? Did it ever melt?"*
Child: *"That one melted first and that one melted last and them people were not sure."*
Researcher: *"So the one in the coat …"*
Child: *"Melted after the other one."*
Child: *"I thought that one [with nothing on] would melt first and I was right."*
Child: *"I was first not sure and then I decided it was that one."*
Researcher: *"So why do you think the coat one didn't melt so fast?"*
Child: *"Because it has got protected."*

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Child:	*"I wasn't sure which one would melt first so I got put on that one and I didn't know so I didn't win."*
Child:	*"It was only an experiment!"*

Jenny had raised the idea of putting the ice ball in the coat in the initial lesson but the children had called out "No!" When she asked why they responded that coats are warm. She used the further investigation to challenge this idea. Although the children now recognise that the coat can 'protect' the ice ball, it is unclear whether they understand that this is due to insulation and what insulation entails. There was some evidence that the children understood that covering an item would offer some protection from the sun but whether they understand that this protection is insulation is questionable.

Jenny:	*"Why under the bush?"*
Child:	*"to keep the sun from getting at it"*
Jenny:	*"To keep it in the shade! Will that stop it melting?"*

On the learning walk Jessica explained the ice ball in the coat investigation.

Jessica:	*"And it didn't melt. And it's still there but it's a bit smaller."*
Researcher:	*"So the one that had nothing on it, what happened to it?"*
Jessica:	*"We put it in a bowl and it made a great big puddle in the bowl."*
Researcher:	*"And what's happened to the one in the coat? You say it's still there?"*
Jessica:	*"Yeah"*
Researcher:	*"And how long ago was this that you put them out? Was it last week? Before the weekend?"*
Jessica:	*"Four weeks ago" [N.B. It was actually the previous week.]*
Researcher:	*"Wow that's a long time! So the one in the coat hasn't melted. Did that surprise you?"*
Jessica:	*"It's just like that little ball now."*
Researcher:	*"Does it surprise you that putting ice in a coat stops it from melting? Does that surprise you? What happens when you put a coat on?"*
Jessica:	*"It keeps the shade away."*
Researcher:	*"Do you think it keeps the shade away from the ice?"*
Jessica:	*"I think it will be melted for half term."*
Researcher:	*"So you think a few more weeks and it will melt."*

The EYFS curriculum does not outline specific knowledge that the children need to learn in science, however, Sc3 Materials and their Properties in Key Stage 1 of the National Curriculum states that children should "explore and describe the way some everyday materials [for example, water, chocolate, bread, clay] change when they are heated or cooled."

The children understood that water needed to be cold to freeze and that heat would make ice melt. In the group interview, they explained this:

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Child:	*"That was when we made our ice things. That's our ice things."*
Researcher:	*"Did you like doing that?"*
Child:	*"Yeah."*
Researcher:	*"What did you learn about with the ice things?"*
Child:	*"Well, how we made them was…Mrs W got some tins and we got some leaves and trees and string …"*
Child:	*"We had to pour in water and then we had to put it outside so it would freeze."*
Researcher:	*"And what happened? Oh, the water froze."*
Child:	*"Yeah."*
Researcher:	*"Why did it freeze?"*
Child:	*"Because it was outside and it was really cold."*
Child:	*"And it was snowing"*
Researcher:	*"So could we do it today?"*
Child:	*"No"*
Child:	*"Um, no"*
Child:	*"No, no, no!"*
Child:	*"Because it's too hot."*
Researcher:	*"It's too hot today."*
Child:	*"And they would melt quite fast."*
Child:	*"Melty, melty, melt, melt"*

They also understood that heat was needed to make the lard melt, making connections to their experiences with ice, with one child suggesting that, "It needs cold water first. No, no, hot water. Hot water melts things. When I had ice hot water melted it." However, some children were aware that the lard would need greater heat to melt than the ice when the teacher asked them to predict if it would melt when placed on the windowsill where the ice had melted.

The children were involved in designing their investigation and then conducting it. The teacher had set the overall challenge of preventing the ice ball from melting but it was up to the children to decide how they would do this. All of the children elected to put the ice balls outside so Jenny got them to think about where outside they would put them and why, resulting in a range of outcomes. One child suggested drawing around the ice ball:

Child:	*"We could put a piece of paper and draw around it."*
Jenny:	*"Why?"*
Child:	*"So we could see what size it is."*
Jenny:	*"That's an interesting idea because we might forget how big it was."*

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Image 1.5: Recording the size of the ice ball

The children were encouraged to explore the ice balloon through play. This included them asking and investigating their own questions, such as does the ice balloon move more easily over wet surfaces and does it become more slippery when wet all over. The teacher also asked questions while they were playing with the ice balloons, such as: "*They were the same size before. I wonder why that one is smaller now.*"

At one point the children put the ice balloons in the water tray, which has one end deeper than the other. The ice balloon in the deep end floated while the one in the shallow end sat on the bottom (while still protruding through the water on the top). Jenny drew their attention to this and asked: "*Why does it float in this end but not that end?*"

During the Ice Bear story the teaching assistant made connections to the children's lives to contextualise it and help the children understand. There was also evidence of children making connections independently.

A child who was exploring the ice balloon said her hands were sore from the ice. She noticed that they had turned red. The child pulled her sleeves over her hands to protect them. "*Like gloves. Safety gloves*" She slid the ice balloon around and polished it with her sleeve. "*It looks like an igloo.*"

Image 1.6: Ice sculpture on display

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Communication was encouraged throughout the lessons. The children were in talking partners and small groups for most of the lesson. These groups were given time to discuss their ideas and then these were shared with the whole class, with each child called on to contribute. Jenny often followed up children's responses by asking them why, encouraging them to explain their reasoning.

Opportunities for creativity

Jenny used many teaching approaches that promote creativity. The ice sculptures were aesthetically pleasing and the children were very **motivated about making, observing and displaying** them. Several children expressed pride in their ice sculptures and asked the researcher to photograph them. This also **linked the subjects of science and art & design**.

Jenny used a variety of resources. In addition to the ice sculptures, she provided ice balls and ice balloons so that the children could explore ice of different thicknesses. Jenny had chosen the ice balloons because of their **great potential for exploration**. In the interview she said, "There are so many avenues you can go down. There's the friction. There's floating. There's melting." She also used lard to emphasise that things other than ice could melt. The story of the Ice Bear gave the children another context in which to consider ice, cold temperatures and melting and also linked to children's previous experiences. All of these encouraged the children to **make connections.**

The children were given opportunities for **open / unstructured play**. They were also encouraged to **try out their own ideas**, both during their play and in the more structured parts of the lesson. Physical exploration of materials was promoted.

Jenny used questioning to encourage **reflection and reasoning**. She often uses "*I wonder…*" statements which encourages **possibility thinking** in the children without providing the answers for them.

Although the children were not using role play or drama in the lesson, Jenny went into **role** when she was introducing the ice balls. She feigned great disappointment when she 'discovered' that the ice ball had melted and this had a motivating effect on the children who were quick to reassure her and offer explanations of what had happened. She then displayed great excitement as she revealed the ice balls and this communicated to the children. There was some evidence of **pretend play** in later child-initiated activities, such as making the snow cakes and selling them.

There was ample time and space for the **exploration**. Extensive use was made of the outdoors, with children going out to the playground and field several times at different points in the lesson. Within the classroom there was plenty of the space for the children to sit together for discussions and other spaces with equipment, such as the water tray, for the children to explore. The episode was not confined to a single lesson but extended over several weeks, with both teacher led and child-initiated activities.

Teacher creativity was also evident in deciding to introduce the ice mini-topic, which was not part of the planned curriculum, in response to the unusually cold weather and the children's excitement about the snow.

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Episode 2: Café

This episode is based around a single observation but the Fruit Café is an on-going, daily activity. Each day the children are provided with a snack of fruit or vegetables and a drink. Jenny has turned this into a mathematics activity by getting pairs of children to run the fruit café, supported by a teaching assistant. There is a menu with prices that are set each day for the various items. There are pots of real coins which the children use to pay for their snack, determining the coins they need with the support of the teaching assistant. The children who are running the café take the coins and in some cases make change. They keep track of the children who have been to the café by ticking their names on a recording sheet and they serve the snack. In the group interview the children expressed their enjoyment of running the fruit café.

Interviewer: *"Is it good being in charge of the fruit café?"*
Child: *"Yeah, I get to put out the money and you get to tick the list off!"*

Image 2.1: Running the Fruit Café

Jenny hopes that by the summer term the children will be able to run the café without adult support but currently feels that the benefit from the teaching assistant helping with finding the right money and questioning the children.

Pedagogical framing

This episode combined whole class, teacher-led activities related to money and counting, with a small group activity, the fruit café, which was run by children but supported by a teaching assistant. The whole class activity lasted about 15 minutes. The small group activity lasted for 40 minutes with all of the class participating at some point and the two children in charge keeping track of them.

The objectives for the session were:

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- Count reliably objects that can be touched and seen and those that cannot be touched or seen
- Apply mathematics in practical situations including counting, adding and subtracting
- Derive and recall addition facts and work out the corresponding subtraction facts

The application of the children's mathematics was a key focus in the fruit café.

Pedagogical interactions

The teacher used whole class activities initially, which involved the pupils taking part with both physical and verbal responses. The teacher used formative assessment, repeating activities and rephrasing questions when she observed children getting wrong answers. The children were in talking partners and had to reach agreement about their response, explaining their reasoning. The teacher was not involved in the fruit café aspect but the teaching assistant supported the children who came to the café by asking them questions and helping them find the appropriate money for their order.

Image 2.2: Teaching assistant helps with identifying and counting the coins

Opportunities for mathematics learning

The fruit café involves several aspects of mathematics. The EYFS mathematics curriculum includes "children count reliably with numbers from 1 to 20", "using quantities and objects, they add and subtract two single-digit numbers and count on or back to find the answer" and "children use everyday language to talk about …money to compare quantities and objects and to solve problems". The Key Stage 1 curriculum contains similar statements but has a greater emphasis on problem solving and stating that children should "approach problems involving number… presented in a variety of forms, in order to identify what they need to do" and "develop flexible approaches to problem solving and look for ways to overcome difficulties." Counting is the starting point for the children in this episode, working initial with 1 p coins. They are also developing coin identification and the understanding that different coins are worth different amounts. Because the children often

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purchase a drink and a piece of fruit there is addition of two numbers. By changing the prices on the menu Jenny is able to influence the numbers being added. In some cases the children running the café have to make change so are practising subtraction, either as counting on or as taking away or difference. There is also some data handling involved. The children have to find the prices for the relevant items on the menu, while the children running the café keep track of which children have taken part.

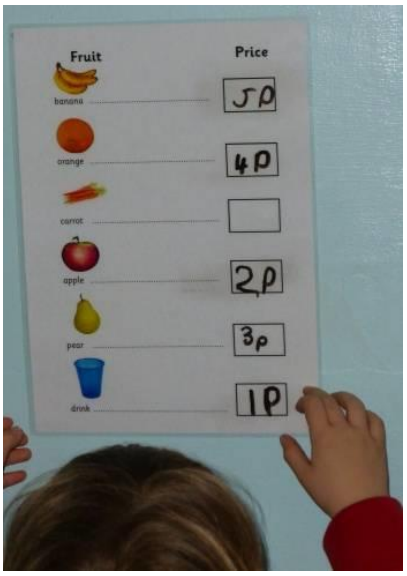

Image 2.3: Fruit café menu

In addition to the fruit café itself, this lesson contained several activities that developed counting and understanding what different coins are worth. The lesson started with the class singing *Hickory Dickory Dock, I am a digital clock*. In this activity the children take turns clapping out the 'hour' and the rest of the class have to count the claps to identify the time. Jenny commented that counting sounds was more challenging than counting objects that could be seen and touched. This was followed up with another sound counting activity. Jenny would take a number of coins and drop them one at a time into a metal tin, with the children counting the sounds in their heads, checking with their talking partner and showing the appropriate number of fingers. She was able to assess their responses quickly and repeated the activity if there were many children with the wrong answer.

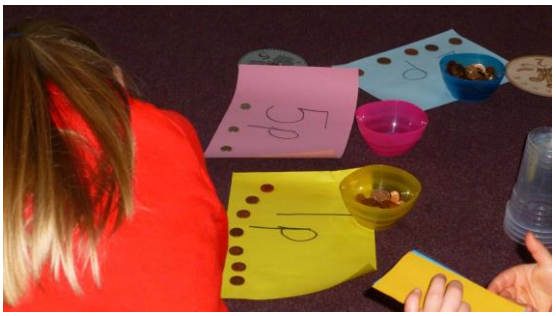

Image 2.4: Counting coins

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When the children had successfully counted the number of 1p, 2p and 5p coins she set these out on pieces of coloured paper. She set up a scenario where a kindly uncle was going to offer them some coins and they had to choose which ones they wanted by showing the appropriate coloured paper.

Image 2.5: Talking partners reach agreement

Jenny: "*Now do you remember I talked about that lovely uncle yesterday? Who might come around and give you some pocket money? And he might say I could either give you five 2p coins or three 5p coins or seven 1p coins. Which would be the most money to take and spend at the shops? I wonder, I wonder. What I want you to do now is talk to your partner about it and decide if you want the blue 2p, the pink 5p or the yellow 1p. Talk to your partner for a moment*."

Burble as children talk to partners.

Jenny: "*Okay what I want you to do now is agree with your partner which one you want. You've only got one set of paper between you so you've got to hold up the same colour. And you've got to decide whether you want 2p, 5p or 1p. Do you want the seven 1p, or the three 5p or the five 2p? Talk with your partner. Choose the right bit of paper to show me*."

In the interview Jenny explained her thinking behind this:

"*And I just wanted them to, force them to have an agreement. You never know. In some dyad somewhere there might be a really good discussion going on. Although most of the time there isn't. It's just those opportunities, isn't it?*"

The children made their choices and then Jenny called upon different pairs to explain their reasoning. A few of the children understood that the three 5 p offered the most money but many children felt that the seven 1 p coins were the most because it was the biggest number. Jenny challenged this by counting in groups for each amount:

Jenny: *"Ooh K, why did you go for the yellow one?"*
K: *"Because it's got the most pennies"*

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Jenny: *"Has it got the most pennies? Do you think it's got the most money? It's got 7 whole coins in that one."*

K: *"And the pink one has got 3 and 3 is lower than 7 and 5 is lower than 7 so 7 is the most."*

Jenny: *"Do you remember we counted in 1s and 2s and 5s to find out how much money there was? So shall we count how much money was on the one with the 2p coins. There were 5 coins weren't there. Shall we just count them? In 2s so 2p, 4p, 6p, 8p, 10p. So that's 10p there. Oh. So how much do you think there is in this one in pence? How many coins are there?"*

J: *"Seven, so it's going to be 7p."*

Jenny: *"Is it only 7p? Let's have a count. Ready? 1,p, 2p, 3p, 4p, 5p, 6p, 7p. You were right J. Oh, so that's less than that one then, isn't it?"*

K: *"No"*

Jenny: *"Well it is. How much was in this one?"*

Child: *"Five" [another child calls out 10p]*

Jenny: *"2, 4, 6, 8, 10" [counts coins into her hand]*

Children: *"10"*

Jenny: *"That was 10p but this one's only…"*

Children: *"7"*

Jenny: *"7p. And how much in this one? How much did you say it was K?"*

K: *"15"*

Jenny: *"Do you think it is? Shall we count it in 5s and see? 5p, 10p, 15p So how much in this one?"*

Children: *"15"*

Jenny: *"15p! And which one has got the most money in?"*

Many children: *"The pink one"*

Jenny: *"The pink one again. That's what we found yesterday wasn't it? It might be different next time."*

Counting coins was reinforced in the lesson plenary. Jenny put four 2p coins in a 'hiding' box. She got a child to shake the box and asked another child to look through the box window. The child saw 2 coins so Jenny asked how many coins were hidden, "*Talk to your partners. Show me with fingers*." Some said 2 and some said 3. The teacher then showed them that there were two; "*So there are 2 coins but how much money is that? Let's count…2p…4p.*"

In the group interview the children discussed another activity which developed coin counting. The children were given a collection of purses with different amounts of money and a recording sheet. They had to identify and count the coins in the purse and then work out how much money this was. Another activity observed was directing the BeeBots (floor robots) on a mat with different coins. The children had to identify the coins and then work out a route from one coin to another by counting the spaces.

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Opportunities for creativity

An important aspect of teacher creativity in this episode **is recognising the opportunity** for developing mathematics in an everyday activity. It is common in England for children to have a morning snack but it is unusual to see this turned into a mathematical activity. By using real resources (fruit, vegetables, drinks and real coins) the teacher was able to **make the links between mathematics and real life activities** very explicit.

Time is also a positive factor in this episode. Although a single lesson was observed, this is an on-going activity that will be constantly developed throughout the year. Sufficient space allowed the fruit café to be in a separate area to the rest of the classroom so the different activities did not disrupt each other. Sufficient human resources allowed a classroom assistant to support the activity while the teacher worked with the rest of the class.

Dialogue and collaboration were encouraged in the lesson, especially when the coloured papers were used to force an agreement between the talking partners. However, they are regularly encouraged during the fruit café interactions.

Jenny stated the importance of children learning to count and she had many different activities to practise this. **Using the song engaged** the children and made them count sounds. Dropping the coins in the tin gave them another chance to count sounds but this time they were able to check by counting visually. The BeeBot activity gave another context for counting but this time the check was done by inputting the instructions in the BeeBot and seeing if it ended up in the right place. The purses activity allowed the children to handle the coins, as well as see them. The children were encouraged to **make connections** between the different activities and the learning that was common to all.

Episode 3 – Bears

This was a short teacher-led activity that Jenny repeated throughout the weeks with a small group of children at a time. Jenny had prepared several boxes which had one window the children could see through and one window covered over. She put six Compare Bears in each box and gave the children a little torch to help them look through the box window. They would shake the box and count the bears they could see. They had to work out how many bears they could not see by using subtraction or counting on. They would then take off the lid and check they had the right number.

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Image 3.1: The Bear Box

Pedagogical framing

The objectives for the activity were:

- Count reliably objects that can be touched and seen and those that cannot be touched or seen
- Apply mathematics in practical situations including counting, adding and subtracting
- Derive and recall addition facts and work out the corresponding subtraction facts

This was carried out with a group of four children sitting on the carpet with the teacher and followed the whole class counting activities described in the fruit café episode, although on other days it would have followed other whole class counting activities.

Pedagogical interventions

Jenny said in the interview that she liked to use small group activities in teaching mathematics because she found that the children benefited from having close attention. She set the task and provided the resources and the recording sheet. She was then able to observe the children as the completed the task, prompting them with comments and discussion to investigate further.

Opportunities for mathematics learning

This activity practised number bonds to 6. However, Jenny pushed it beyond that by encouraging the children to look at the ways they had made 6 and determine whether they had found all the possible ways. She supported this by getting them to list the ways they had found already.

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Image 3.2: The Bear Boxes and Recording Sheets

Isabel: "1 is here and 6 are hiding."

Jenny: "Oh, so you can see 1 and there were 6 hiding. I wonder if that adds up. 1, 2, 3, 4, 5, 6, 7 So you could see 1 so how many couldn't you see?"

Isabel: "Five"

Jenny: "That's right because 5 and 1 make…"

Isabel: "Six!"

Jenny: "So let's see what numbers you've already got. That's a pair of numbers isn't it. 6 and 0; oh and you've got a 6 and 0 again; so that's the same; and what's this one here?"

Isabel: "5 and 1"

Jenny: "And 4 and 2. And…"

Isabel: "1 and 5"

Jenny: "1 and 5. So you've got four different pairs of numbers. Are there any other ways of doing it? If you shake it again I wonder if there's any other ways it could turn out."

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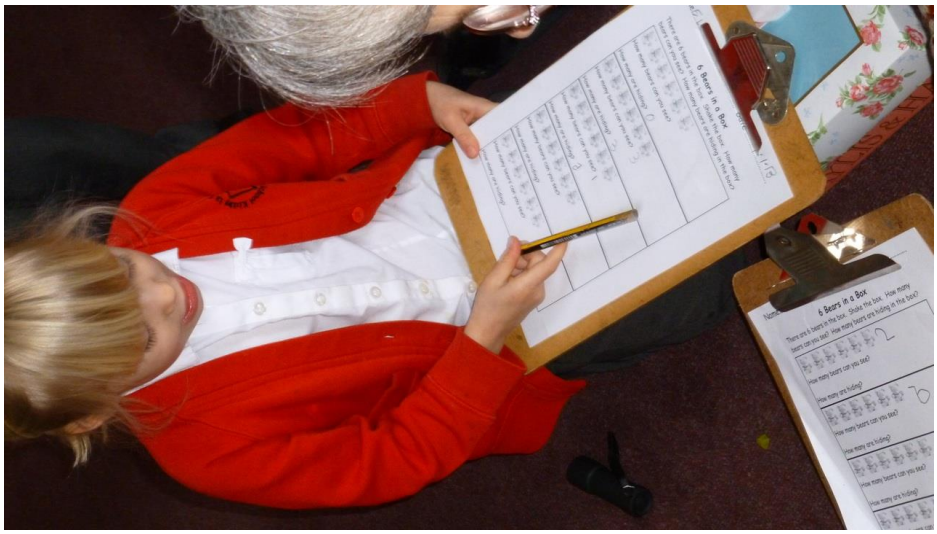

Image 3.3: Child explaining results

When Isabel could not work out the missing way Jenny sent her to get another set of bears so that she could use these to work out the possible combinations.

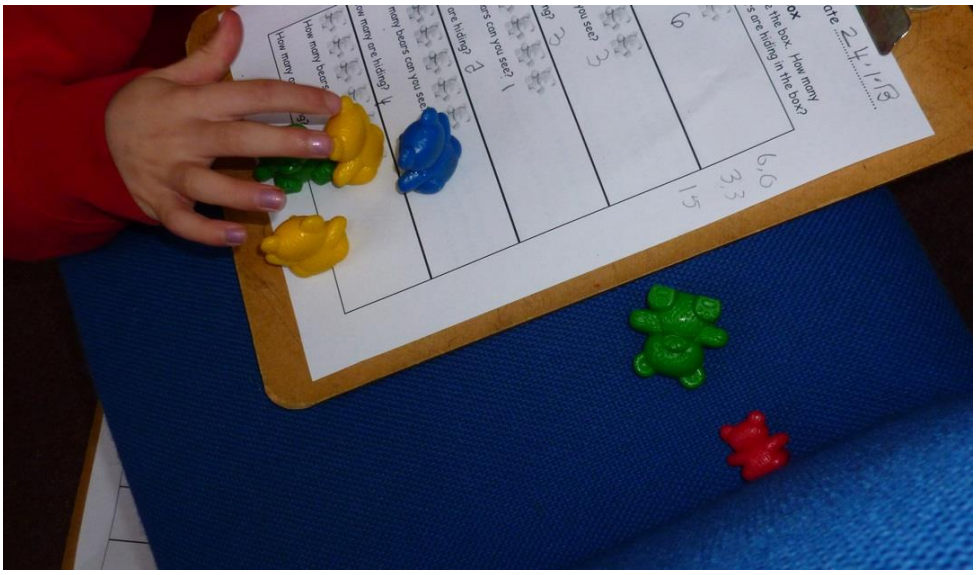

Image 3.4: Finding all the ways to make 6

Jenny: *"Let's just have a look. I just wonder if there were any other ways you could have done it. I'll tell you what go to the house corner and see if you can get 6 bears. And then see if you can split them in a way that isn't 6 and 0; 5 and 1; 4 and 2 and 1 and 5."*

With some help from Lydia, she found 3, 3.

Jenny: *"Did you find another one? Oh well done! I thought you could find another one. I wonder if you've got all of them. Do you think you've got all of the ways? I wonder, I wonder."*

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Image 3.5: Counting using resources and fingers

Opportunities for creativity

This was an **engaging** activity. The boxes and the bears were appealing and the children enjoyed shaking them and using the torches to help them count the bears. These acted as motivational factors for a basic counting and number bonds activity. The children perceived it as a play activity and enjoyed the fact that they were generating the combinations by shaking the box.

The teacher used **scaffolding and questioning** to help the children find all of the ways to make 6. She also modelled **possibility thinking. Collaboration** between children was also encouraged.

Episode 4: Cars

This episode took place after the half-term holiday week. In the afternoon children are given the opportunity to share news and talk about objects or events with the class. The day before this observation Chris had brought in a wooden car that he had made during half-term. The other children asked him questions about it, such as does it go on carpet and does it go on fluffy carpet. A few of the children had then tried this out using some materials in the classroom. Jenny thought this would be a good investigation for more of the children to pursue so she asked Chris to bring the car back the next day for them to study.

Pedagogical framing

Jenny reminded the whole class about Chris' car and the questions they had asked. She then set them the challenge of finding the best surface for using the car. Children were given the choice of participating in this or playing in the classroom or outside area. Several boys chose to work with Jenny investigating the car with different surfaces. Jenny's focus was on the children's questions, with the objective exploring how a car runs on different surfaces. She wanted the children to make observations and draw conclusions from these. During the investigation Jenny tried to draw the children's attention to the concept of fair testing.

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Pedagogical interventions

Jenny used the children's questions to set a task. She stayed with the group of children throughout the activity, leaving the rest of the class to play independently, although the outside area was supervised by the teaching assistant. Jenny scaffolded the children through questioning and "I wonder…" statements. She also refocused the children several times when they drifted from the set task. In discussion after the session Jenny said that she felt conflict between wanting the children to follow through so they could find the answers to their questions and allowing the children to follow their own ideas, even when these deviated from the task.

Opportunities for science learning

The children were undertaking inquiry. They were asking questions, designing ways to investigate these, gathering evidence through observation and were starting to think about measurement. These are all part of the Key Stage 1 science process skills. The children also made connections to their previous experiences of playing with toys on different surfaces at home and at school.

From their initial questions it is obvious that the children are aware that different surfaces have an impact on how a toy travels. This fits with the Key Stage 1 Sc4 requirement "to find out about, and describe the movement of, familiar things" but actually goes beyond this to the Key Stage 2 Sc4 statement about friction. There is no statement related to forces in the EYFS. The most relevant statement is "explain why some things occur, and talk about changes." They were able to find suitable materials to test (a smooth fleece blanket and a piece of thick faux fur). They later developed this by deciding to test paper as well, resulting in three levels of smoothness. When they test the paper the car travels far on it but sent many of the sheets flying and sometimes the car gets caught under a piece of paper rather than travelling over it. Jenny had suggested that having many pieces of small paper might cause a problem and supplied them with larger paper. However, when the larger paper arrives Chris has other ideas about how this could be used and the children never actually tested the car on it.

Image 4.1: Children's idea to test paper

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The children became aware that there were lumps in the fleece and realised that it was important to smooth these down so that the lumps would not interfere with the car. Although the children were not using the term 'fair test', this was evident in their reaction to the lumpy blanket. However, they did not recognise unfairness in how they pushed the car.

Image 4.2: Smoothing out the wrinkles to make it fair

The children differed in the force with which they pushed the car. Jenny tried to draw their attention to this: "*That's funny. It went farther when Henry pushed it.*"

When the children did not respond to this she persisted by saying, "*I still wonder why it went farther when Henry pushed it. What makes a difference?*" Eventually Jenny suggests using a ramp to make it more consistent.

Several of the children realised that they needed some way to mark where the car landed so that they could compare this. However, they struggled to find a suitable method. Chris started by putting his hand where the car stopped but he was unable to leave it there while conducting additional trials. It did not occur to him at this point that he could leave his hand there while other people launched the car. Later the children decide to mark the landing spot using BeeBots. They run several trials marking each with BeeBots and the children are able to compare the trials deciding that it has travelled about the same distance each time on the fleece and that this is farther than on the fur.

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Image 4.3: Using a ramp instead of pushing

Image 4.4: Measuring to compare trials

Opportunities for creativity

The episode is set up as a challenge for the children to investigate. **Play and exploration** are valued in this, with the children having opportunities to play with the cars and the different materials, although the teacher does refocus them on the question at times. Starting with Chris' toy and the **children's questions** helps ensure **motivation**. Children were also **given the choice** to work on this problem or to undertake other play in the classroom or outside so those who elected to take part in this activity are likely to have high levels of motivation.

Throughout the episode Jenny used **questioning** to encourage the boys' thinking and promote communication, "*What are you trying to do boys?*"; "*Which do you think is best?*"; "*How can we be sure this is the best?*" She also modelled **possibility thinking** with "I wonder" statements, such as "*I wonder why it went farther when Henry pushed it*." Jenny **scaffolded** the investigation through her questioning. She tried to draw the boys' attention to making it a fair test and using evidence to draw conclusions. She also refocuses the children's attention several times, although she allows them to

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pursue other things. Afterwards Jenny said that she was torn between letting the children follow their own ideas and trying to ensure that they follow through with these ideas rather than just flitting from one thing to another. At one of these points Jenny pushed the need to test the materials to answer the original question.

Jenny: *"How can we be sure this is the best?"*
Chris: *"We could get some paper and write down the answers."*
Jenny: *"But I don't know what the answers are."*
Kai: *"We could write down the instructions."*
Jenny: *"But I don't know what the instructions are."*

Kai then went away to write down the instructions, which he then explained to Jenny. He drew lots of arrows showing the different directions the car had gone in the earlier trials, **creating his own recording system**. Jenny responded positively to this explanation and demonstrated that she valued his recording.

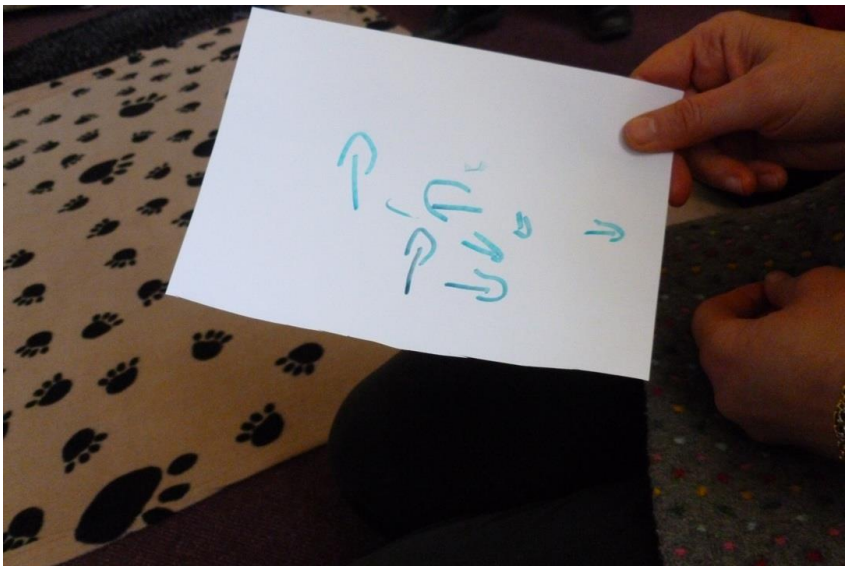

Image 4.5: Kai's Recording System

The children **collaborated** during the investigations, although the groupings altered over time with some children leaving and some later returning. They started by working together to spread out the different materials. Jenny encouraged collaboration by calling Chris back to the investigation when Kai and Tommy were having problems by asking if he could help them **solve the problem**.

This is a rich case with interesting practice in both science and mathematics, although Jenny described herself as less certain in mathematics. Four episodes were identified and there was potential for a fifth.

Synergies between science and mathematics and creativity

The synergies that were identified in the conceptual framework for CLS were well represented in this case. **Play and exploration** featured in all of the episodes, although some were teacher-led. The

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children were also given opportunities for totally child-initiated play. Some of these, such as building snowmen and making snow cakes for sale (Ice episode), were included in the episode, having been discussed in the children's Learning Journey books. Other child play went unobserved by the researcher and was not included, although the many opportunities provided by the teacher for child-initiated play demonstrates that she values this. **Motivation and affect** were key features in the activities and resources provided by Jenny, with both being appealing in all of the episodes. The bear boxes were particularly appealing and the children really enjoyed using the torches to peer into them (Bear) She made use of song (Fruit Café) and story (Ice) and made links to art (Ice). Teacher questioning was evident in all episodes but child **questioning and curiosity** were less evident. Child questioning was the main focus of the Car episode and curiosity was evident in the Ice episode. It may be a mark of her lower confidence in mathematics that children's questions featured less in the mathematics episodes. **Dialogue and collaboration** were prominent in all of the episodes. The children used talking partners and discussed in small groups, as well as explaining to the whole class. The children were actively encouraged to work together in deciding how to preserve their ice balls (Ice) and which pile of money they wanted (Fruit Café). **Problem solving and agency** were particularly evident in the science episodes, with children designing their own approaches when given a specific challenge. There was also some problem solving in the Bear episode with children asked to find all possibilities for making 6. The problem solving in the Fruit Café episode related to application of number in a real life context. Agency was a feature of the Fruit Café with the children enjoying being in charge of the café, setting out the equipment, serving the children, keeping track of the stock, recording which children had participated and making change when needed. Although the fruit café was not child initiated they enjoyed the responsibility involved in the task. **Reflection and reasoning** were encouraged in all of the tasks, although the children were not always capable of explaining their thinking and they did not always understand the concepts involved (e.g. the relative value of coins in Fruit Café and insulation in Ice). **Teacher scaffolding** was especially important in both modelling and encouraging reflection and reasoning. Jenny was particularly skilled at listening to the children and asking pertinent questions or making "I wonder…" statements rather than telling the children the answer.

3.1.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

Jenny uses a combination of whole class and small group activities in her lessons, with a particular emphasis on collaboration and dialogue. She encourages play and exploration, in both teacher-led and child-initiated activities. Jenny includes objectives that try to stretch all the children in this mixed age class, although she recognises that some of these are overly challenging for the younger children. Nevertheless she feels they benefit from early exposure to these ideas and is very pleased when some of them do demonstrate understanding beyond their age expectations. Teacher scaffolding through questioning and modelling possibility thinking is prominent.

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What role if any does creativity play in these?

Teacher creativity was evident in the imaginative activities, the interesting resources and the mode of delivery. Jenny also demonstrated creativity in deviating from the whole school planning framework so that she could respond to the children's interests and the environmental conditions. It is clear that this is important to her since she included in the science policy permission to deviate from the science framework, especially in the foundation stage. Nevertheless, this is an aspect where she felt tension. Commercial schemes are not used in science and their use is limited in mathematics, with Jenny coming up with her own ideas but also finding inspiration from the internet and the regional science learning centre. In terms of teaching for creativity, Jenny encouraged the children to make connections, to design their own investigations, to reflect and reason and inquiry or problem based learning. Time, space (both indoors and outdoors) and resources were provided for the children to explore and there was a positive atmosphere where ideas were valued. Jenny encouraged children to make predictions but also gave them the opportunity to revise their predictions later in the light of observations. Child creativity occurred through play and exploration, making things, asking questions and curiosity. There were fewer examples of children independently creating scientific or mathematical ideas, although there were some. Assessment in science was primarily formative and informal, with both the teacher and teaching assistant collecting a range of evidence, including photographs and recording children's dialogue, and then annotating it. In the interview Jenny said she assessed science through conversations with the children and used her judgements to move them on. In contrast, mathematics was assessed through fortnightly tests and children's progress was closely monitored in the school. Jenny was very aware of the accountability and felt she had to prove that her methods, which included allowing the Year 1 children to play, were successful by the measure of these knowledge based tests. This tension, combined with her lower confidence in mathematics, may have restricted her creativity in mathematics, especially with children raising questions and solving problems.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

The appealing activities and resources motivate learning and promote a positive attitude towards science and mathematics. Both subjects were linked to everyday life and children were given the opportunity to apply their learning, which will help make their learning relevant. The teacher's use of drama and setting up scenarios drew the children in and there was obvious enthusiasm from the children who were eager to participate. Although it did not form an episode the 'shape monster' activity, where a decorated box threatened to eat the children if they did not feed it the right shape, was a good example of this. The children squealed with delight as they carefully thought about what shape would fit the criteria and then tentatively fed it to the shape monster. In the group interview the children expressed enjoyment about all the activities that had been observed.

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How do teachers perceive their role in doing so?

Jenny sees science as really exciting and wants to share this enthusiasm with the children. She and the teaching assistant promote learning through:

- Planning stimulating lessons
- Focusing on inquiry skills
- Encouraging play and exploration while providing time, space and resources
- Scaffolding learning through questioning and modelling possibility thinking
- Addressing concepts in multiple ways with a variety of resources
- Making connections and making learning relevant
- Encouraging collaboration and dialogue
- Responding to children's interests

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3.2 Case: 'Louise'

3.2.1 Context

Where?	Country	England			
	Setting name	EN1 – St Denis Church of England Primary			
	Location within setting	Primary School			
Who? (children)	Year group/age of children	Years 3 and 4; 7 - 9 years old			
	Number of children in class	28			
Who? (adults)	Number of adults	4 or 5			
	Role of adults	1 teacher and 1 or 2 teaching assistants and 1 or 2 volunteers			
	Case teacher role	Mathematics Co-ordinator			
When?		1	2	3	4
	Dates of visits	6/2/13		27/2/13	
	Times of visits	9:00-12:40		9:00 – 12:40	

School / Setting

Louise is at St Denis School with Jenny. See case above for details.

Teacher

Louise is a female teacher in her 40s. She has a Bachelor's in Education and a certificate in art. She has been teaching for more than 20 years and for the last few years has had a mixed Year 3 and 4 class, as well as being the lead teacher for both mathematics and art. She studied both mathematics and science at upper secondary school. During her initial teacher training mathematics, science, creativity, ICT, pedagogy and developmental psychology were all emphasised.

Louise has taken part in a range of CPD activities in the last 18 months in both science and mathematics. During the period of the Creative Little Scientists research in her school, Louise was frequently out of school for CPD, including mathematics network meetings. This restricted the opportunities for observing in her classroom so the four observations were completed over the course of two mornings. The forms of CPD which have had the largest impact were courses and conferences in science and mathematics, informal discussions with colleagues in both subjects and participation in a network of mathematics teachers. She has also observed science and mathematics teaching in both her own and other schools. Louise is very confident about teaching mathematics and fairly confident about her knowledge of science and pedagogy. She is less confident about assessment, especially in science. In the interview Louise felt that confidence was important in teaching because, "*If you're not confident you don't always deliver as well because you're less enthusiastic.*" She felt that sharing successes and failures within the school was important but that this would only work in a school were you felt supported rather than scrutinised. She felt that at St Denis the ethos was that we are all in this together and that the focus was on the child. However, she had experience of other schools that did not have such a supportive atmosphere.

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She teaches mathematics daily, so more than 4 hours per week. Science is often taught in blocks rather than in a weekly time slot. The main science topics for the year are Earth and Beyond, Sound, Magnetism / Forces and Materials and their Properties.

Louise agreed strongly with all of the purposes for science put forward in the questionnaire and she taught the outcomes listed very often, with only a few at quite often. The learning / teaching contexts and approaches had similar responses, with nearly all used very often or quite often. The only two which were used rarely were open / unstructured play and role / pretend play. Louise felt that drama, physical exploration of materials and making cross-curricular links were likely to develop creativity; however, she also suggested communication, questioning and discussion as important. In the interview she talked about cross-curricular links she was making in the lessons but also her pleasure in the fact that the children had made unexpected links to the map work they had been doing in geography recently. The teaching approaches she felt were most likely to promote children's creativity were encouraging problem finding, fostering imagination and fostering autonomous learning. In the interview Louise described the 'scientists in the making' as the ones who were asking questions. Similarly in mathematics she felt it was important to get the children to think outside the box. Louise reported that the assessment pressures in mathematics could inhibit some of these approaches but that it was still possible to develop creative thinking in mathematics. The activities she felt were mostly likely to develop creativity in science were the ones which she undertook most frequently: observing natural phenomena, asking questions and communicating the results of their investigations. The other activities related to science inquiry were all undertaken quite often. She uses a mixture of open and guided activities, with the most open ones related to investigating questions, explaining and communicating. In the interview Louise said that teacher scaffolding was important, knowing when to stand back and when to step in. She strongly disagrees that teachers should demonstrate ways of solving problems first, but rather should allow children to find their own ways with the teacher facilitating this and providing enough time. In the interview she said it was important that the children got a chance to record their own ideas in their own ways, rather than completing a worksheet. In all of the observations Louise put a large emphasis on the children communicating their ideas in a variety of ways.

In terms of assessment, Louise feels that assessing positive attitudes towards science is the most important aspect, although knowledge and understanding are also important. She uses self-assessment approaches, questions in context, problem-based task and portfolios of children's work to assess them. In the interview she discussed using 'thumbs up' and 'wibble' for a quick self-assessment. The 'thumbs up' demonstrates the children feel they have accomplished the objective while the thumb 'wibble' indicates that they have not or are unsure. She avoids thumbs down because she feels it encourages them to be negative and silly. She finds paper and pencil assessments a "*turn off*". She also assesses classroom interactions and analyses children's pictures for scientific reasoning but other methods are only used rarely and she does not set science homework. During the interview she mentioned that she was assessing the children through observation, although she was not keeping notes of this. She also commented on several pictures the children had drawn to represent how sound travels. According to the questionnaire she praises

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children frequently for all of the aspects listed and uses her assessments for a wide range of purposes. This was evident during the observations. While looking at the series of photographs she commented that it was "*lovely to see them so engaged*". The only purpose which is rarely used in science is setting targets with children. This is used frequently in mathematics, where the assessment procedures are more formal. The mathematics target setting is used to inform parents and for tracking progress within the school. Louise stated that, "*The need to track achievement should not but does increase the pressure for more 'formal' teaching though we have noted that in fact more problem solving and investigation would actually produce better assessment data*."

Louise feels that the school is well resourced for both science and mathematics, particularly with audio-visual resources, digital technologies and classroom assistants. These were all used during the observations. The school does not use any text books in science and she feels they are not particularly well resourced with text books in mathematics. The resources she uses very often are teaching materials she has prepared herself or downloaded from the internet, audio-visual resources, digital technologies, computers and other ICT resources and equipment for hands-on exploration. In the interview Louise talked about the importance of making lessons hands-on and practical. She also makes frequent use of playing cards and games in mathematics. She prepares for teaching by consulting curriculum guidelines, online resources and the Department for Education website, but also by discussing good ideas with colleagues. She also refers to text books and assessment guidelines.

Classroom

This is a mixed Year 3 and Year 4 class with children ranging from 7 to 9 years old. This means that some of the children are beyond the Creative Little Scientists age range, but the majority were under 9 at the time of observation. For mathematics, the Year 4 children go to a separate teacher so the mathematics observations were purely of Year 3 pupils.

The Year 3 and 4 classroom is part of the 2004 extension. The room is rectangular with tables in groups around outside and a large carpet space in the middle. There is a small room at the side, which is shared with the next class. During the observations additional spaces were used, including the hall, the ICT suite and the playground.

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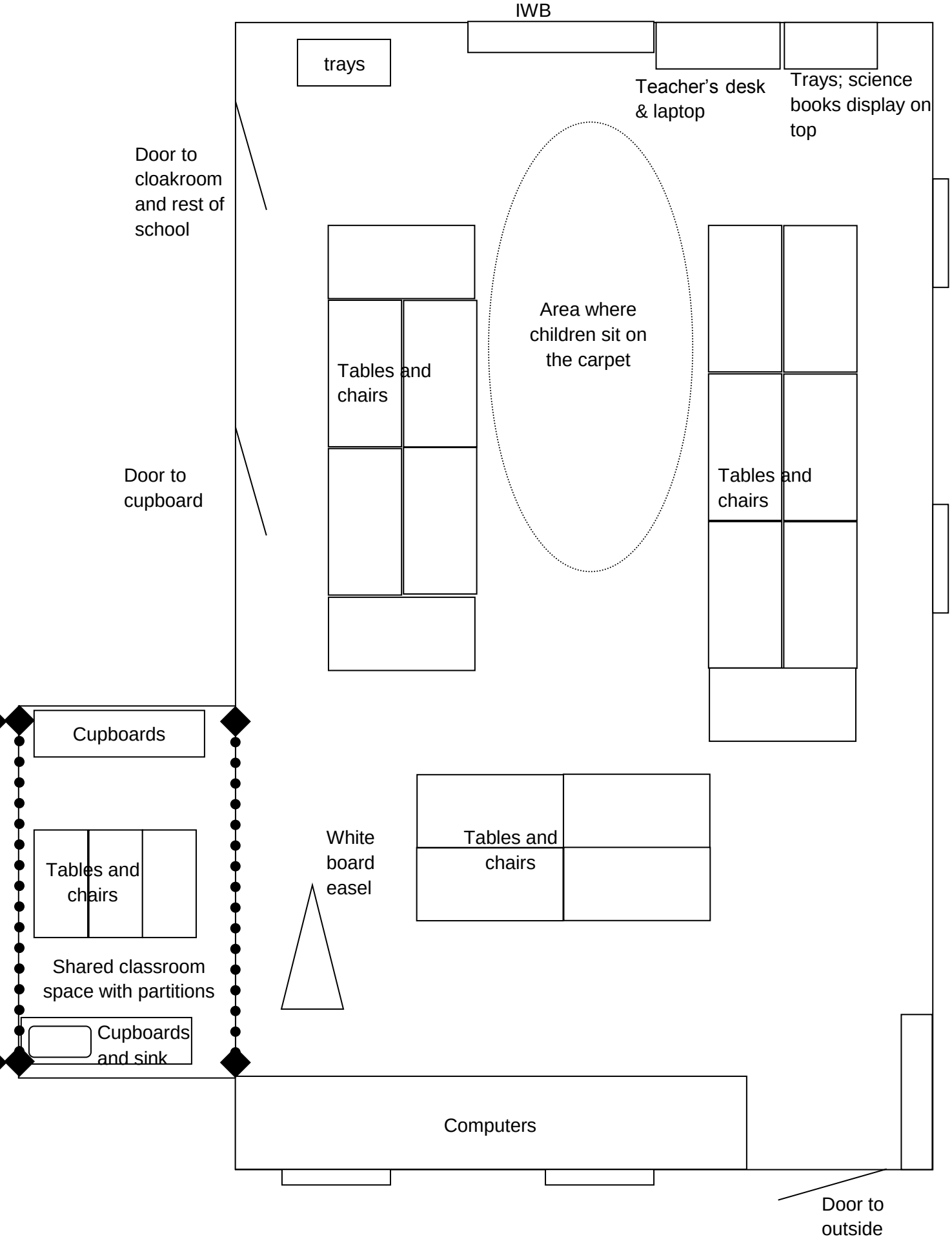
IWB
trays
Teacher's desk & laptop
Trays; science books display on top
Door to cloakroom and rest of school
Area where children sit on the carpet
Tables and chairs
Tables and chairs
Door to cupboard
Cupboards
Tables and chairs
Shared classroom space with partitions
Cupboards and sink
White board easel
Tables and chairs
Computers
Door to outside

3.2.2 Episodes

This case comprises of four episodes:

1. Art episode – combining Japanese pictures and mathematics
2. Sound episode – exploring resources to answer how sound travels (science)
3. Mother's day episode – solving a practical problem in mathematics
4. Space – working in groups to answer a collection of questions about the planets (science)

Each of these will be presented separately drawing on the data in the episode data in the appendix and making a narrative episode that uses data and analyses the data to make an argument about the synergies between science and maths and creativity.

Episode 1: Art

In this lesson the children were presented with three pictures by the Japanese artist Hokusai and then split into groups to solve mathematical problems based on these. The lesson started with the children practising their multiplication tables through chanting, clapping and questioning in differentiated groups with the teacher or teaching assistant. This was followed by children playing 'Shut the Box' in pairs, with each other or against an adult. This game involves making decisions about which number bonds to 12 to use and there was a great deal of discussion. The three paintings and their associated problems were then introduced to the whole class. The Great Wave off Kanagawa required the children to estimate length and use proportional reasoning; the Ferry Boat crossing the Sumida River involved estimating how many people there were; Hibiscus and Sparrow was used to explore shape and symmetry.

Pedagogical framing

Louise was particularly interested in the children choosing the equipment and mathematics they would need to solve the problems. In the interview she said that they were good at using equipment when it was provided but needed encouragement to select it for themselves. On the Learning Walk the children acknowledged that they had "maths kits" full of equipment which they could use when they needed them but the children did not use these during the observations.

In terms of the National Curriculum objectives, all of the groups were addressing several aspects of Using and Applying Number:

> 1b. "break down a more complex problem or calculation into simpler steps before attempting a solution; identify the information needed to carry out the tasks";
>
> 1c. "select and use appropriate mathematical equipment, including ICT"; and
>
> 1d. "find different ways of approaching a problem in order to overcome any difficulties."

The groups with the wave and ferry pictures were also applying Ma2 4b"choose and use an appropriate way to calculate and explain their methods and reasoning", while the wave group was also solving simple problems using ratio (Ma2 2h), which is more advanced than is usually expected

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of Year 3. The group with the hibiscus flowers was using a different area of mathematics, focusing on Shape Ma3 2b and 2c, visualising and describing 2D shapes, recognising reflective symmetry and creating patterns.

Pedagogical interactions

The children worked in small groups, each supported by an adult. Mathematics is taught in single year groups so this was just the Year 3 children and there was an unusually high number of children absent due to illness, resulting in a class size of 12 with four adults. After some initial planning time in their groups Louise stopped them all to remind them about the equipment possibilities. She asked each group in turn to think about what they might need and then asked a child from the group to get these. Because each group was supported by a teaching assistant or volunteer, Louise was able to oversee all of the groups, interacting closely with different groups at different times.

Opportunities for mathematics learning

There were many different aspects of mathematics within this lesson. In the initial section when the children were practising their multiplication tables Louise asked questions which encouraged the children to make connections between multiplication and division and between different tables. For example,

Louise:	*"What is an easy way to make 6?"*
Child:	*"3 add 3 is 6 so you just double it"*
Louise:	*"So we can take our three times table and just double it. Can we do that with anything else?"*
Child:	*"From 2s to 4s"*
Child:	*"And 8s"*
Louise:	*"How do you get to 8s?"*
Child:	*"You double 4s."*
Louise:	*"Double 4s. Well done. You are so good. Fantastic."*

These were not new connections to the children, but ones which Louise was reinforcing.

In the Shut the Box game the children had to think flexibly about what number bonds made the numbers from 2 to 12. There was considerable collaboration and discussion between the children.

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Image 1.1: Playing Shut the Image

One pair of girls rolled a 4 and a 5 and went through several possible combinations.

"4+5 but we've already turned over 9."
"8 and …?"
"No, we've used 1."
"7 and 2."

When the children were playing against an adult they used the same roll of the dice which highlighted that you could make different decisions with the same numbers and allowed the adults to model strategies and talk through their decision making processes.

Image 1.2: Own way of calculating

In the main activities all three groups had to decide what mathematics and what equipment they needed to solve the problem but the other mathematical objectives were different for each picture. In the Ferry Boat picture the children decided to start by counting the number of boats. This was not a simple proposition because the boats in the distance were not clear and answers ranged from 26 to 29. The children commented that it was hard because different people had different answers. They then counted the visible people in the boats in the foreground and used these as the basis for their estimation. However, they noted that some of the boats were bigger than others and might carry more people. The children use multiplication or addition to come up with an overall estimate

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for people on the river. They chose their own method for completing the calculation. The photograph 'One way of calculating' shows the child's use of partitioning the numbers to multiply 26 x 13 using the distributive property, in an informal written method.

Image 1.3: Playing with symmetry

With the Hibiscus picture the children explore symmetry using double sided mirrors. As well as finding mirror lines the boys are enjoying making distorted pictures through their mirror placement, which can be seen in the photograph. The children also identified what 2-D shapes had been used to make the picture and then used a box of plastic shapes to help them create their own symmetrical shape pictures. The children were good at identifying lines of symmetry on the original picture but found it harder to use lines of symmetry to make their own pictures, which Louise acknowledged in the interview.

With the Great Wave picture the children started by using their hands to estimate the ratio of the boat length to the height and width of the wave. They then checked this using a ruler. Once they had worked out the ratios they went into the hall to mark out the sizes of the boat and the wave. The teaching assistant recorded their process:

“The children decided that the boat was about 4 metres long and the wave was double that (8 metres) they said the wave was twice as high and twice as wide as the boat. The children used the trundle wheel to measure out the boat and wave to give them an idea how big the wave would be.”

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Image 1.4: Measuring the boat

They used metres sticks to mark out the length of the boat and sat inside it, which can be seen in the photograph. They used copies of the wave picture to mark the corners of the wave.

Because they had completed the problem before the end of the lesson the teacher gave them an additional task. She asked them to look closely at the waves and how the edges had been painted to look like claws or hands in a threatening manner. She asked them to estimate how many hands there were. The children in the photograph decided there were too many to count so counted a small section and then tried to multiply this by how many sections of that size they thought there were.

Image 1.5: How many hands?

The lesson finished with each group reporting back to the class what they had been doing and the reasoning involved. This was primarily an oral communication, although the children in the hibiscus group also displayed their own shape drawings.

Opportunities for creativity

Pupil agency was an important factor in this lesson, supported by **adult scaffolding**. The children were given **problem solving tasks** but then expected to determine what they needed to do to solve the problem and what equipment and mathematics they needed to achieve this. The children sometimes found this difficult and the teacher scaffolded this by allowing the children to discuss their ideas in groups and then asking each group to identify the equipment they needed. Each group also had an adult working with them, scaffolding the children through **questioning**. When the boys had worked out that there were 26 boats and 13 people per boat the teaching assistant asked, “How

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would we work it out?" When the boy replied with a calculator, the teaching assistant persisted with, "But what would you put on the calculator?" Sometimes the adults were more directive. One of the two boys suggested multiplying 26 x 13 but the other suggested adding 26 + 13. The teaching assistant asked the second boy what he would be finding if he added 26 boats and 13 people and what the first boy would be finding by multiplying 26 boats by 13 people per boat. **Collaboration** among the children provided further scaffolding in the game and the picture activities, with **dialogue** encouraged.

Play and exploration were encouraged in the group who were exploring symmetry and shape. The teacher responded positively to the boys making distorted pictures with the mirrors rather than seeing this as off-task behaviour. She encouraged them to look closely at both sides of the mirror and describe what they saw and how they would know if they had found a line of symmetry. Using the plastic shapes allowed the children to try out several different ideas for their own pictures before drawing an arrangement they liked.

Louise believes it is important for the children to **make connections** in their learning. This was shown in the basic connections they were making in the multiplication tables but also cross-curricularly between art and mathematics in this lesson. She also responded very positively to the children making an unexpected connection between the Hibiscus picture and the maps they had looked at in their previous topic.

Motivation and affect were also creative factors in this lesson. This included the game at the beginning of the lesson which they children clearly enjoyed and allowed them to practise basic number skills in a fun way. The pictures were aesthetically pleasing and the children were very eager to use them, showing excitement when they were first displayed. The group tasks were all interesting and the children displayed positive attitudes towards them, remaining engaged throughout the lesson, even when they were finding the tasks difficult.

Episode 2: Sound

In the sound episode Louise set up a series of tables around the classroom with various equipment for the children to investigate how sound travels. The children then had to make a poster to visually represent how sound travels. Before the lesson Louise had explained to the researcher that she was being experimental in this lesson and did not know what was going to happen "but that's what's exciting, isn't it!" In an interview after the lesson she commented on how engaged the children had been and how pleased she was that the children had used the resources in unexpected ways.

Pedagogical framing

Louise planned this lesson to follow the singing assembly and made links to this and past music lessons. She started the lesson by asking the children about lungs and their role in talking and singing, making links to past lessons about human biology. The stated aim of the lesson was to be able to explain how sound is made. This relates to the National Curriculum Sc3 3e that sounds are made when objects vibrate. During the lesson the children were also exploring Sc3 3f which relates to changing pitch. However, they were also addressing numerous aspects of Sc1 by designing their

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own tests, using evidence from observations, using simple equipment and communicating their findings.

Pedagogical interactions

Louise used a PowerPoint presentation at the beginning of the lesson to play various sounds and raise questions about sound. Louise then assigned the children to different tables and set the task of using the materials to determine how sound travels. The tables contained: rice in pots with drums; trays, jugs of water and tuning forks; glass bottles, a tray and a jug of water; tuned musical instruments, such as recorders, flutes, clarinets and alto saxophone; untuned musical instruments such as a frog guiro; hollow pipes cut to different lengths. Louise emphasised that it was up to the children to decide how to investigate the question.

The adults mostly observed the children and asked questions to prompt thinking. The children were given about half an hour to explore the resources on two tables. Those who were confident then explained what was happening to another group, so peer teaching. All of the children were then gathered together and individuals were called forward to demonstrate to the whole class how sound worked with different resources. The lesson finished with more of the PowerPoint presentation, focusing on the deaf percussionist Evelyn Glennie. Louise showed a picture of her performing barefoot in her show 'Feel the Sound', while playing a recording of her performing 'Flight of the Bumblebee' on the marimba, which led to a discussion about sound and vibrations.

Image 2.1: Self-assessing

In addition to assessing the drawing product, Louise also assessed process, through interactions and observations while the children were exploring. Louise used self-assessment at several points in lesson. After the children been exploring sound for about 15 minutes she stopped them and asked them to show her with thumbs up if they had found a way to show sound or a 'wibble' if they were not sure. She used it again after the second set of explorations and this time there were more thumbs up. She then used those children who were confident to explain to the rest of the class. At the end of the lesson Louise asked for a show of hands of those who had enjoyed the lesson.

Opportunities for science learning

The children worked in small groups, collaborating and discussing their findings. Most used the resources in expected ways, such as putting the rice on the drums and putting water in the bottles.

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However, some did unexpected things, such as using the rice containers as maracas and clinking the bottles together rather than blowing in them or tapping on them. The children observed closely and discussed their observations with each other, sometimes using scientific language.

One group who were putting rice on a steel pan drum observed:

"It's jumping!"
"The noise is so loud it makes it jump."
"It's vibrations."

The Rice bouncing on drum photograph (above) shows how the children tried to represent this visually.

In the group interview George talked about the photograph (tuning fork makes waves) where he was exploring vibrations with tuning forks and then the picture he had drawn to represent this (recording tuning fork waves).

George: "That's where I was using tuning forks...We used the tuning forks and put them in the water and it made a big splash."
Researcher: "It made really good circles. So, what was the point of the drawings? Why were you doing these drawings?"
George: "Um, to show how they make sound and how they vibrate and things."
Rebecca: "How sound travels"

Image 2.2: Tuning fork makes waves

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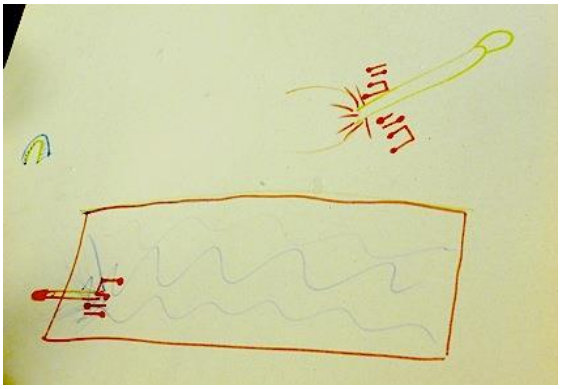

Image 2.3: Recording tuning fork waves

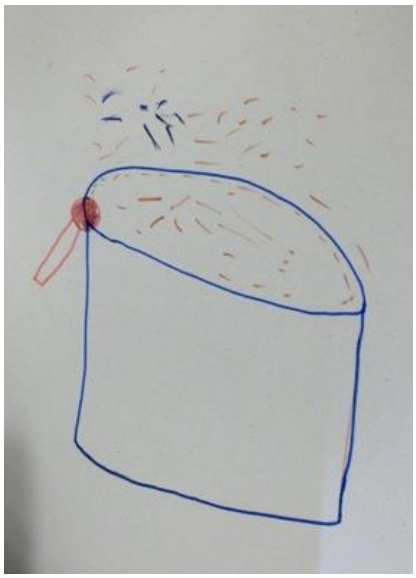

Image 2.4: Rice bouncing on drum

The children understood that adding different amounts of water to the bottles would have an impact on the sound but were not sure what this would be and had difficulty articulating it. George was most able to communicate these ideas.

Rebecca: *"George said it would... that Marek would get... it would be hard for Marek because he's got a full bottle and it would be easy for Lucy because she's got..."*

George: *"Because there was more air for the sound to go in and get back out and less for Marek because the water was taking up the space."*

Joseph and Maisie added different amounts of water to the bottles and discussed the impact when they clinked them together.

Joseph: *"It makes it darker. Thought it would be lighter."*
Maisie: *"That one's gone really high pitched."*

Some children, like Maisie, used the term pitch, but many, like Joseph, referred to darker and lighter rather than pitch or higher and lower.

When the groups were explaining to each other, Louise worked with a group on the steel pan drum. When George held the side of the drum she drew attention to this and got the child to describe what was happening and explain why. She then asked them to compare what was different when the drum was held and not held. George said that holding the drum stopped the vibrations.

In the plenary Louise drew attention to the relationship between length and pitch. After comparing the sound of two bottles with different amounts of water, she asked Holly to play the flute and asked the children what happened when she moved her fingers. George explained that if you cover the

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holes the air has to travel farther to get out. Louise then got a child to demonstrate making music with pipes of different lengths (like pan pipes):

Louise: *"So which is the higher one?"*
Child: *"The shorter one"*
Louise: *"So the shorter column of air, the higher the sound. And the longer one?"*

Opportunities for creativity

The lesson was **well resourced** which aided creativity. The children had a variety of materials which they could use in different ways. They were given the **opportunity to explore** these in the ways they wanted, promoting child agency, although the overall goal was set by the teacher. The children were working **collaboratively** in pairs or small groups and were supported by a large number of adults (approximate ratio of 1:4).

Louise said it was important that the children get a chance to **record their own ideas in their own ways** rather than just completing a worksheet. She was very pleased with many of the drawings and the variety in them, *"Lovely explanation. You can really see it."*

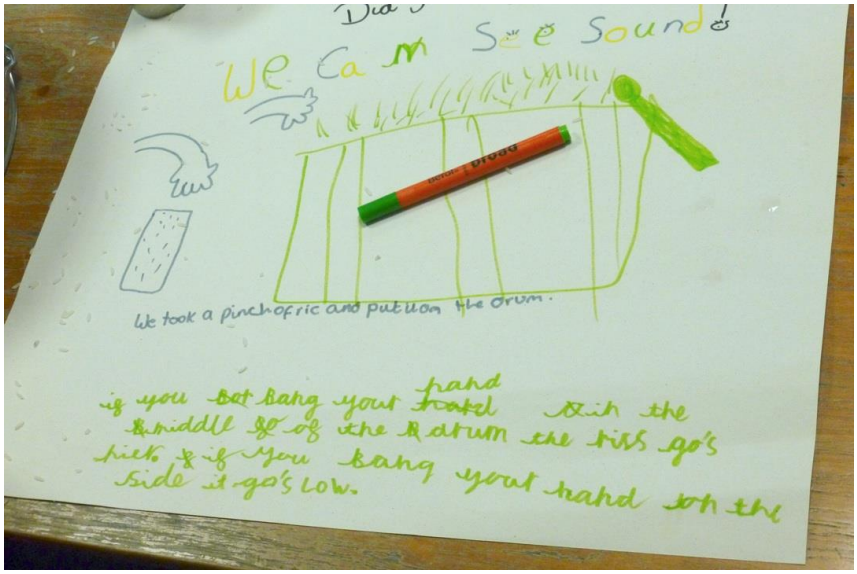

Image 2.5: Recording with words and pictures

Louise scaffolded the children by **asking questions** and helping them **make connections**.

Louise: *"Do they all make the same noise?" [refers to bottles with different amounts of water]*

Louise got a flute and asked a child to play it. Then she demonstrated that it is possible to blow across the bottles in the same way.

Louise: *"What's in there?"*
Melissa: *"Glass"*

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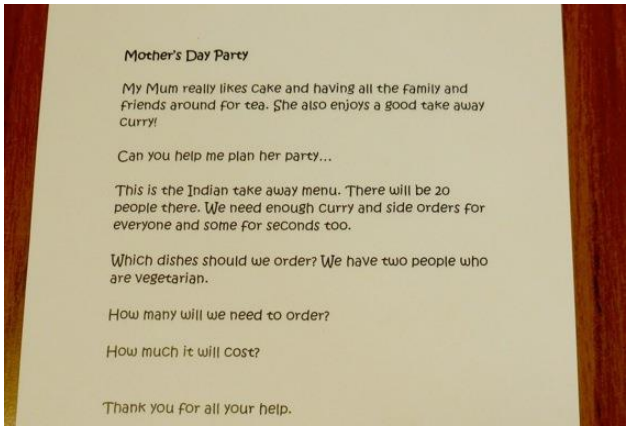
Louise: *"... and in there?"*
Melissa: *"Water"*
Louise: *"There's glass and water and what's there...?"*
Melissa: *"Nothing"*
Louise: *"Air, there's air. Do they all make the same sound?"*
Melissa: *"One is lighter"*
Louise: *"So some are higher and some are lower. But which is which? Can you find out? Can you put them in order?"*

These challenges encouraged the children to explore the materials and determine their own ways of investigating.

Episode 3: Mothers' Day

This lesson had several parts. It started with the children going to the computer suite to use a website which allowed them to practise basic calculations while competing against children from around the world. They then returned to the classroom to play a card game which practised addition. Louise then set the children different group tasks, all around the premise of helping her prepare a Mother's Day party for her mother.


Mother's Day Party

My Mum really likes cake and having all the family and friends around for tea. She also enjoys a good take away curry!

Can you help me plan her party...

This is the Indian take away menu. There will be 20 people there. We need enough curry and side orders for everyone and some for seconds too.

Which dishes should we order? We have two people who are vegetarian.

How many will we need to order?

How much it will cost?

Thank you for all your help.

Image 3.1: Menu Instructions

Pedagogical framing

The main objective for the lesson was determine how to solve a practical problem. This addressed most of Using and Applying mathematics section 1(a - i), Problem Solving. In addition, different groups had differing subject knowledge objectives depending on their task. One group had to use Indian take-away menus to devise a dinner for 20 people, including two vegetarians, because her mother liked curries. Another group were given a cake recipe which made 12 slices and asked to make enough cake for 20 people. These two groups had to work on calculations (Ma2 3a, 4a and b) and extract data to solve their problem (Ma4 1c and d), while the cake group also had to use proportion (Ma2 2h). A third group was asked to design placemats for the tables so they would be pretty. This involved drawing shapes and patterns using reflective symmetry (Ma3 2c).The final group had to devise a punch recipe for the party. They had to use appropriate measuring

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instruments (Ma3 4b). At the end of the lesson the groups reported back to each other and all tasted the two punch recipes.

Pedagogical interactions

Louise encouraged collaboration among the children who worked in pairs or small groups. Each pair or group had to produce a single product, ensuring that the children worked together. Although the boys in the menu photograph had their own menus to use, they worked together to determine what should be ordered. Each task was supervised by a teaching assistant or volunteer, leaving Louise free to supervise all groups, spending some time with each. The punch group were in the small shared room at the side (see classroom map) but the rest of the groups were at large tables in the main classroom.

Opportunities for mathematics learning

All of the children were working on the Using and Applying Mathematics aspect of the curriculum. This includes investigational skills such as reasoning and deciding what equipment and mathematics to use. The other aspects of mathematics depended on the group. The menu group worked on data handling and addition. The main challenge in this was the amount of data from which to select. The cake group had to think about proportion and multiplication. The placemat group had to think about reflective symmetry. Louise had identified in previous lessons that the children were good at recognising reflective symmetry but found it difficult to apply to pictures they were drawing. This proved to be true in this lesson as well, although the children demonstrated progress by being able to self-correct. The punch group involved fractions and measuring capacity. In the photograph the girls are trying to read the scale on the measuring jug before pouring the juice. This was something they had done before but still found challenging.

Image 3.2: Measuring the ingredients

Image 3.3: Planning image

After reading the recipe the cake group needed to determine how much cake should be baked. The cake group decided to make three cakes, which the girls explained in the group interview:

Researcher: "Why did you decide on three cakes?"
Rebecca: "Because if there's going to be 20 people we might want two but if they're going to want seconds we might want three."
Researcher: "So if you're having cake do you sometimes like to have seconds?"

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Rebecca: *"Yes!"*
Laura: *"Yes, I love to have seconds. I always have a bit of both."*

This meant they had to triple the amounts in the recipe, which was written in both metric and imperial measurements.

Researcher: *"Did you do the tripling on the grams or the ounces or on both?"*
Rebecca: *"We did it on the ounces. Mostly."*
Laura: *"Yeah"*
Researcher: *"They're easier numbers aren't they?"*
Rebecca: *"Yeah"*
Researcher: *"Because three 8s is much easier than three 225s."*

Rebecca: *"Yeah! Three 8s is 24. 225 would be 600...7 maybe...Somewhere around 700 or 800 maybe?"*
Researcher: *"Pretty close. 675. Very near 700."*

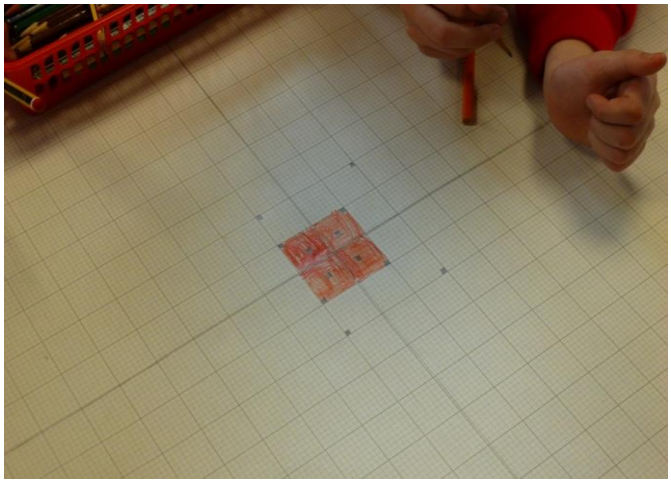

Image 3.4: Self-correcting mistakes

The pair of boys who were making a placemat made several mistakes but self-corrected these. They realised that they had drawn something that was not symmetrical (which can be seen in the picture Self-correcting) because they had miscounted. They adjusted their design to incorporate the mistakes and decided that it actually looked better that way.

The cake group had finished their task before the end of the lesson so Louise asked them determine the latest time they could start making the cakes. They said they knew the preparation time for one cake but not for three. She got them to discuss the possible scenarios. They debated whether it was three people making one cake each or one person making all three cakes, and whether this one person was making the three cakes consecutively or in one big batch. They also considered whether three cakes would fit into the oven at once. Louise was interested in a realistic solution rather than having the children solve it as a disconnected calculation.

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Opportunities for creativity

Although she does not use much open / unstructured play Louise likes to incorporate **games** in her lessons. The games serve to **motivate** the children to practise basic number facts. The computer game encouraged quick mental methods because they were racing against another player. In the group interview the children reported enjoying using this website. The children also reported enjoying the pontoon card game, which did not depend on speed but involved reasoning. They were able to explain how they decided to 'stick' or 'twist' (draw another card).

Researcher: "How do you decide if you're going to stick or twist?"
Rebecca: "Because if we've got like 19 then we know it's too risky to chance it."
Researcher: "Why is it too risky?"
Rebecca: "Because if you go over you're going to lose and you really want to win."
Laura: "Yeah, if you get above..."
Rebecca: "So you might want to stick and wait to find out how much the other people get. If they get over then the... another person has to change over and if they get over then you're probably going to win."
Researcher: "So when would you definitely, definitely twist?"
Rebecca: "When you're like on under 10 or you're like on 11 or something like that. Very low numbers."
Laura: "If we're on 15 we would twist."
Rebecca: "Yeah. That's what we did and actually didn't get bust so I would say up to 15 and under twist, you can twist."
Researcher: "So you feel the risk is worth it up to 15?"
Rebecca: "Yeah"
Researcher: "But beyond that ... Why is it more dangerous after 15?"
Laura: "Because if it's higher than ... Because if the numbers are higher you're not going to want to twist just in case you get a big number."
Researcher: "And there's lots of 10s aren't there. Because you told me that the 10s and the jacks and the queens and the kings are all 10s."
Laura and Rebecca: "Yeah"

Image 3.5: Debating whether to stick or twist

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Although they were not explicitly taught about the probability elements of the game, the girls have reached their own conclusions based on having played several times, with the desire to win a motivating factor. They have some trouble explaining this clearly but they have developed a good understanding of the factors which affect the game.

Louise invented **a purpose** for the children's work. Whether she actually used the results for her mother's party or not, the children took the tasks seriously and were quite **motivated** by the context for the work.

Louise scaffolded the children when they were struggling. She did this primarily through **questioning**. She also encouraged **collaboration** and **dialogue** in the pairs and small gropus for mutual support. A pair of girls were struggling to find where the middle of the paper was to draw the line of symmetry.

Louise: *"How would you know where the middle is?"*
Anna: *"We could measure it?"*

The children struggled to find the middle of the paper but recognised that where they were was not the middle.

Louise: "What else could you do? What do you have on the paper?"

The girls tried counting squares from the outside (see photograph) until they met in the middle. They had to work together and discuss what they were doing for this to be successful. They found the centre line and then used the same method to find a 2nd line of symmetry.

Louise used **interesting resources**. The group that got to design the punch had a variety of juices, fizzy water and fruits. They **enjoyed the making process** and all of the children enjoyed tasting the punch. The punch group included a 'twist' in each recipe and challenged the children to determine what it was. The wealth of human resources was another factor, with each group supported by an adult.

Episode 4: Space

Louise started the lesson by opening a series of envelopes (apparently) from the year 1 and 2 teacher who wanted Louise's class to teach the younger children something about the solar system. The children were excited about this and immediately came up with ideas of things they might teach the younger children. Each adult was given an envelope with a specific question for their group.

Pedagogical framing

As was common for Louise's class, there was an investigational objective, which was the same for all groups and then separate content objectives for each group. The common objective was for the children to determine how to answer their question. This relates to Sc1 1a (decide how to find answers), 1b (find relevant sources of information) and 1h (use a range of methods to communicate findings). The questions for the different groups were:

- How many planets are in our solar system? [and their order from the sun]

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- What is an eclipse?
- How big are the planets?
- How wide is our solar system?
- What does the solar system look like?

These relate to 'Sc4 The Earth and beyond':

4. Pupils should be taught:
The Sun, Earth and Moon
   a. that the Sun, Earth and Moon are approximately spherical
   Periodic changes
   b. how the position of the Sun appears to change during the day, and how shadows change as this happens
   c. how day and night are related to the spin of the Earth on its own axis
   d. that the Earth orbits the Sun once each year, and that the Moon takes approximately 28 days to orbit the Earth.

Image 4.1

However, they go well beyond this to incorporate knowledge of the other planets in our solar system. The eclipse group also used aspects of Sc4 Light relating to reflections and shadows.

Pedagogical interactions

Each group was supported by an adult who scaffolded them through questioning and, in some cases, through supplying information. In this lesson Louise supported a group herself, although she left them at times to check on the progress of the other groups. The year 4 children were in one group and were located in the computer suite, using the computers in their research. One group was in the hall using a dark cupboard to explore eclipses. Another group was on the playground trying to represent the distances between planets. This left only two groups in the classroom. Collaboration and dialogue within the groups were encouraged and then each group had to report back to the others in the plenary. The children also had to think carefully about how they were going to present their findings to the younger class who had limited reading abilities.

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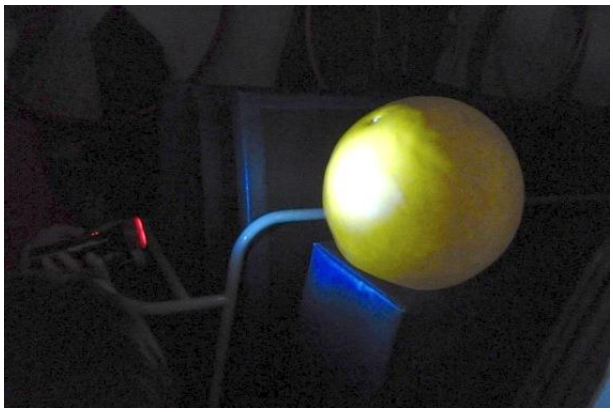

Image 4.2: Making eclipses in the cupboard

Opportunities for science learning

The children had learned a mnemonic to remember the order of the planets. They used this several times in the lesson and Louise took several opportunities to get the children to name the planets in order. At several points in the lesson Louise and the children discussed the issue of Pluto and the fact that it is no longer classed as a planet. Louise emphasised that scientists have changed their mind about Pluto's status and that some have determined this because of its size and some because its orbit crosses other orbits, She also discussed the role that technology has had in making these observations.

The group that had to represent the size of the planets focused on relative size. They used the idea that if the sun were a beach ball then the Earth would be a pea and worked out the rest of the sizes on that basis. This proved to be a memorable image and was stated by a couple of the children in the group interview as something they had learned during the lesson. This group made the planets using clay. However, when they came to make the sun they realised that there was not enough clay to do this. Instead they joined hands in a circle to represent how much larger the sun is than the planets (see photograph below).

Image 4.3: Representing the sun with clay planets

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The children who were exploring eclipses used torches and a large ball in a dark cupboard. They set up a large ball on a mat frame and shone torches at it (see photograph), one at a time, to see the shadows cast and related this to eclipses. The teaching assistant asked each child to explain what was happening when they shone the torch.

Child: *"The sun would be somewhere over here. The moon would move and when the moon is between the Earth and the sun it makes a shadow."*

In the plenary the children used two circles of the same size to explain to the class how eclipses worked. Louise questioned this.

Louise: *"Are the moon and the sun the same size?"*
George: *"Sort of for an eclipse"*
Louise: *"I like that answer. Hold your thumb up and block out someone's face. So if it's far away you can cover with something small."*

The group who tried to work out the width of the solar system on the playground struggled initially, unsure of where to start once the teaching assistant had found out the distances between the planets and the sun. He had divided the numbers by 1000 to make them more manageable. The boys used a trundle wheel to measure the painted court area of the playgrounds finding the length was 24 metres. They decided that the centre circle was the sun and put a cone representing Pluto on the edge of the court (12 metres away from the sun). They worked out that Uranus should be about half way between the sun and Pluto so put this six metres away from the sun. They knew that Neptune should be between Pluto and Uranus but were unable to work out where it should go. Both the concept of ratios and the large numbers proved too challenging for them, although they had noticed a doubling pattern (approximately) from Jupiter to Saturn to Uranus to Neptune to Pluto. At this point Louise suggested an alternative approach, starting at the fence and then working outwards, determining if all the planets would fit on the playground. Eventually they determined that most would but not all.

Image 4.4: Measuring the distance between planets

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Opportunities for creativity

Louise had set up a topic display area which contained several books, including **story books** about space, and some pieces of rock with the questions, "Is this moon rock? How do we know?" She had visited Jodrell Bank observatory over half-term and had purchased resources to use with this topic, including the book 'Silly Solar System', which she read to the children at the start of the lesson. Previously they had watched some Doctor Who (a popular science fiction programme) to get the children thinking about travelling through time and space.

The **purpose** Louise created for this lesson really motivated the children. By setting the task in the context of teaching younger children, she established that she did not want the children to do alot of writing because the younger children would struggle to read this. Instead she encouraged pictures, artefacts, oral presentations and short written pieces.

Louise encouraged the children to **make their own decisions** about what equipment they would need rather than just supplying them. She also wanted them to make their own decisions about how they would address the task.

Louise: *"Do you think we're going not need some things to help us?"*
James: *"A metre stick?"*
Louise: *"What might be even better than a metre stick?"*
James: *"One of them"*
Louise: *"One of them is called a trundle wheel."*
Matt: *"Computers"*
Louise: *"Mr D, do you know how big the solar system is?"*
Mr D: *"Bigger than the playground!"*
Louise: *"How far is our nearest planet?"*
Mr D: *"I don't know."*
Child: *"4 metres?"*
Louise: *"I would be very worried if it was four metres away. We need some facts. Where can we get them?"*
Matt: *"Computer"*
James: *"Books"*

Image 4.5: Exploring video clips on the computers

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There was a **good collection of resources,** including books, computers, video clips, torches, clay, measuring equipment, drawing materials and large paper. There was also **generous staffing**, with each group supported by an adult and an overall ratio of approximately 1:6. The children also had **considerable space**, with the groups spreading out into the hall, playground and computer suite, in addition to the classroom. This allowed them much more scope for **exploration** than if they had all been within the classroom.

Image 4.6: Books on display for science topic

3.2.3 Summary and conclusions

This was a rich case, with all four of the lessons observed resulting in an episode. However, Louise's class is from the upper age range of the CLS project and this is reflected in the structured, teacher-led lessons, without time given to free play and child-initiated exploration that features more in the Early Years Foundation Stage.

Synergies between science and mathematics and creativity

Many of the synergies that were identified in the conceptual framework for CLS were well represented in this case. **Play and exploration** featured, although the play was in the structured form of games in mathematics lessons, rather than child-initiated and unstructured play. There was no evidence of time given for unstructured child-initiated play in the observations or interviews. Exploration occurred in all the episodes, although to different extents with different groups. **Motivation and affect** are highly important to Louise. She made considerable efforts to make lessons engaging, through the resources she provided, the context or purpose for the lessons and the connections she made to other subjects. During the lessons it was obvious that the children were highly motivated and in the group interview they expressed their enthusiasm for the lessons. Louise uses **questioning** to prompt the children's thinking but there was less evidence of the children asking their own questions. The science lessons did spark some child **curiosity**. In the sound lesson the children were allowed to explore the resources and many were intrigued by what they were finding. The space topic resulted in child curiosity with some of the children talking about what they had found out through their own research. Both science topics had been supported by a display of relevant books and resources, which the children were allowed to use to find out more. There was

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less evidence of curiosity in the mathematics lessons. **Dialogue and collaboration** were key features in all of the lessons observed. The children worked together in small groups or pairs, having to collaborate to create a product or answer a question and then each group had to present their work to the class. **Problem solving and agency** were also prominent in all of the lessons. In each lesson observed the groups had different tasks but all had a common objective related to problem solving or inquiry skills. The level of agency varied but in all of the lessons the groups had to determine how to undertake their tasks. However, agency was limited by the fact that all of the tasks were teacher initiated, rather than children answering their own questions. **Reflection and reasoning** are important to Louise, which was shown by her emphasis on the children explaining their thinking in various ways. **Teacher scaffolding** occurred through questioning and helping children to make connections. The very favourable adult-child ratios in all of the lessons observed made scaffolding easier because each small group had an adult to support them and often Louise was able to move from group to group. The children were also able to support each other because of the emphasis on collaboration.

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

Louise uses a combination of whole class, small group and paired work. She values collaboration and dialogue so sets tasks that involve the children talking and working together. Because she sets different tasks for each group, communication is important in the plenary when she gets the groups to report back to each other. Her objectives focus on inquiry skills and problem solving (Sc1 and Ma1 in the National Curriculum). Teacher questioning is used to scaffold the children's thinking and help them make connections. Her use of many adults to support groups helped with this considerably. Louise was fortunate to have two adult volunteers who were preparing to enter initial teacher education, but she also benefitted from flexible staffing in the school, where teaching assistants could be borrowed from other classes when needed for particular activities. Louise used a range of strategies for formative assessment, including observations of the children working, discussions with the children, discussions with the teaching assistants, analysis of the products and child self-assessment. In several lessons she asked the children to show whether they felt they understood the concept, using thumbs up or a hand 'wibble'. In the sound episode she responded to a large number of wibbles by allowing more time for exploration and then asking again. The second time there were more thumbs up and these children were asked to explain to their peers. In discussion with the researcher, Louise explained that she felt that problem solving was the best approach to learning mathematics but that opportunities for this seemed to diminish as the children got older because of fears about the summative assessments in Year 6. The same pressures did not apply to science.

What role if any does creativity play in these?

Louise demonstrated teacher creativity in the imaginative lessons and contexts (Mothers day; Space). She uses a range of approaches, including stories and games. Louise is the subject leader for both mathematics and art, which, she explained, leads her to make connections between these

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subjects (Art episode). However, she also made connections between science and music in the sound episode and encouraged the unexpected connection the children made between the hibiscus picture and what they had learned about maps in geography. In terms of teaching for creativity, Louise provided space, resources and adult support. The structured timetable of the Year 3 and 4 class, with the year groups taught separately for mathematics, limited flexibility with time. In each lesson there were some groups who did not finish their tasks and might have benefitted from more time. The structured lesson format used in Key Stage 2 resulted in teacher-led lessons, with very limited opportunities for child-initiated play and exploration. The pressure of high stakes summative assessment in Year 6 and the content of the National Curriculum contributed to this. Child creativity was most evident in children determining how they were going to solve a problem. However, there was also evidence of them making connections (Art). Developing mathematical and scientific ideas that were new to them was demonstrated in the children's explanations (Sound; Mother's Day). Louise encouraged this by getting the children to articulate their thinking orally and by representing their work in different ways (Sound; Space).

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

The children were very motivated in all of the lessons observed and spoke of their enthusiasm for mathematics and science in the group interview. Providing a purpose for the activities was a motivating factor (Mother's day; Space). Using games was also highly motivating (Art; Mother's Day). Louise said she liked using PowerPoint presentations to provide a visual focus in some lessons (Sound). The children responded positively to the use of story (Space). The science displays were noted by the children in the learning walk and the group interview and these encouraged the children's interest in the subject, through a combination of factual books, fiction books and other resources. The emphasis on collaboration and dialogue, with many small group tasks, seemed to motivate the children as well.

How do teachers perceive their role in doing so?

Louise stated that she wants to encourage the scientists and mathematicians of the future and that these are the ones who are able to 'think outside the box'. She said that part of her role was to encourage them to ask questions, although in the lessons observed most questioning was from the teacher. Louise explained that focusing on problem solving and inquiry skills was central to this. She does this through:

- planning stimulating activities
- providing adult support, space and resources
- scaffolding through questioning
- making connections
- encouraging collaboration and dialogue

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3.3 Case: 'Fleur'

3.3.1 Context

Where?	Country	England			
	Setting name	EN2 - South Green Nursery			
	Location within setting	Pre-School			
Who? (children)	Year group/age of children	Nursery 3/4 years			
	Number of children in class	21 (AM) /14 (PM)			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher and 1 teaching assistant			
	Case teacher role	Teacher			
When?		1	2	3	4
	Dates of visits	12/2/13	26/2/13	01/03/13	11/3/13
	Times of visits	12.30 – 3.00	12.30 – 3.00	12.30 – 3.00	9.00 – 3.00

School / Setting

South Green is a local authority nursery located on a council estate in the East Midlands of England. The nursery has a children's centre attached and is next door to the primary school where most pupils will attend once they enter mainstream school. The majority of pupils in the school live on the estate which is an area of considerable social deprivation, although some parents from outlying villages choose the nursery because of its excellent reputation (the last three OFSTED inspections have judged the nursery as outstanding – the most recent was in July 2012).

Despite the area in which the nursery is located it is well situated, and has good outside space which is well resourced – the children have their own garden area in which they grow vegetables, and at the rear of the school is a small 'orchard' which has recently borne fruit (apples and pears) – children are encouraged to eat their own produce when it is ready.

The school is currently undertaking changes to the organisation and structure which is a direct result of changes to the funding formula for nurseries, as such the school has fallen from 4 classes to three, and staffing numbers have been reduced, this has resulted in changes to provision for pupils whereby the number of full time places have been cut considerably which has impacted on the school day, sessions are now repeated in the afternoon to ensure that all children have the same input. In addition most parents opt to send their children to school in the morning rather than the afternoon, which provides an imbalance in support.

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Across all visits to the South Green Nursery it has been identified that the children's free play outside lends itself to opportunities for scientific creativity but without the support that the indoor play has offered, however it is worth mentioning this since it reflects the whole school philosophy of maximising learning at all opportunities, but also allowing the children the opportunity to explore freely at their own pace without being encumbered by adults.

The setting has a well-positioned outdoor area which they utilise fully, some of the more 'favoured' activities are always available to the children (bikes, trikes and tractors), but it was also observed that other activities were planned in giving some variety to what was available for the children – the pulley system as described in a previous narrative episode was one such activity, however I also noted the following two child led activities which whilst not suitable as a narrative episode are worthy of mention.

In a previous topic children had been looking at construction sites and building, a box of such materials were still available as free play materials and one child was keen to dress up as a construction worker, and do some building.

Alongside this children had access to a sandpit in which there were two devices designed to move sand from one area to another. Children were required to manipulate the handles and their body positioning to move the sand. Height of the children was a big factor, and some of the smaller children required a little help with the manipulation of their machine!!

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Teaching assistants were at hand to support with the challenges of being vertically challenged.

Where children were finding this easy another level of challenge was generated with the addition of a wheel-barrow in which to put the sand.

This required the children to lean back further in order to get the necessary height to place the sand in the barrow.

This illustrates the role of the adults in the setting who are facilitating activities which promote enquiry and problem solving, and are ever ready to add further support or challenge to those who need it

In another area of the playground children had access to a small play area which contained a mixture of flour and baby oil.

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The mixture allowed children to build solid structures such as sand castles, but this then returned to a powder when squeezed, thus reinforcing the work done inside on properties of materials.

Teacher

Fleur has worked at the school for the past 5 years as a teaching assistant and is currently in her final year of a BA (Hons) Applied Studies Degree course which is a work based degree; she has recently been accepted onto a teacher training course through school direct. For the duration of the research period Fleur had responsibility for the class as part of her professional contexts module which required her to teach for a set period of time. Fleur was working under the direction of a more experienced staff member but was responsible for planning and delivery of short taught sessions appropriate to the age of the children as well as facilitating follow up child directed activities. Fleur explained that taking responsibility for the whole class was already part of her role in the school even prior to undertaking the placement as there was very much a team teaching element to the whole school, and all teaching assistants took responsibility for whole class teaching as part of the Planning, preparation and assessment (PPA)organisation of the school.

In her interview, Fleur identified that children were natural scientists who '*see things we don't,* [as] *we are not at their level of thinking*'. However, science at this stage should be informal as *'they need to be able to experience, touch feel things'.* She feels that the EYFS curriculum does not particularly lend itself to teaching science, as there are *'only really three elements that link to science'* and

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'understanding of cause and effect' that was evident in the previous EYFS curriculum was *'gone, now it's just why things happen and changes over time'.*

In Fleur's class assessment is incidental by making notes from comments, videos and photographs and some focussed observations that help planning. She identified in her interview that her planning needs to be very detailed mainly to ensure colleagues can pick up her teaching, but not necessarily to plan details for individual children because some children *'need more help to be able to discover whereas others become aggravated if you keep butting in, or keep saying try this...you have to get the balance right'.*

Classroom

The class consists of twenty-one pre-school, nursery children (aged 3 and 4 years of age) who attend in the morning session and fourteen children who attend in the afternoon session. Parents are able to select which session they would like their children to attend in accordance with the government guidelines of 15 hours free nursery education per week, a small number of children attend full time i.e. 15 hours over 2.5 days. There are two full time professionals working with the children; Fleur who is the teaching assistant currently undertaking a teaching placement and a classroom teacher.

The classroom is set out as a typical nursery, with a variety of indoor and outdoor play and work areas (see plan below).

The classroom has a carpeted area, set apart from the main classroom which enables practitioners to work with small groups or the whole class without disturbance from the busy classroom activities. This area had its own Interactive Whiteboard along with soft chairs and cushions for children to engage in quiet reading activities should they wish. The rest of the classroom is zoned into particular areas e.g. painting, number area, music, role play etc., children are able to move freely between activities, and at each visit it was noted that activities within each zone varied according to the main topic focus or class input for that day. Children also had access to a small bank of computers. The classroom was bright and cheerful, with children's work displayed, as well as displays related to learning. Equipment was accessible and labelled with words and pictures so children could select their own equipment, thereby directing their own learning.

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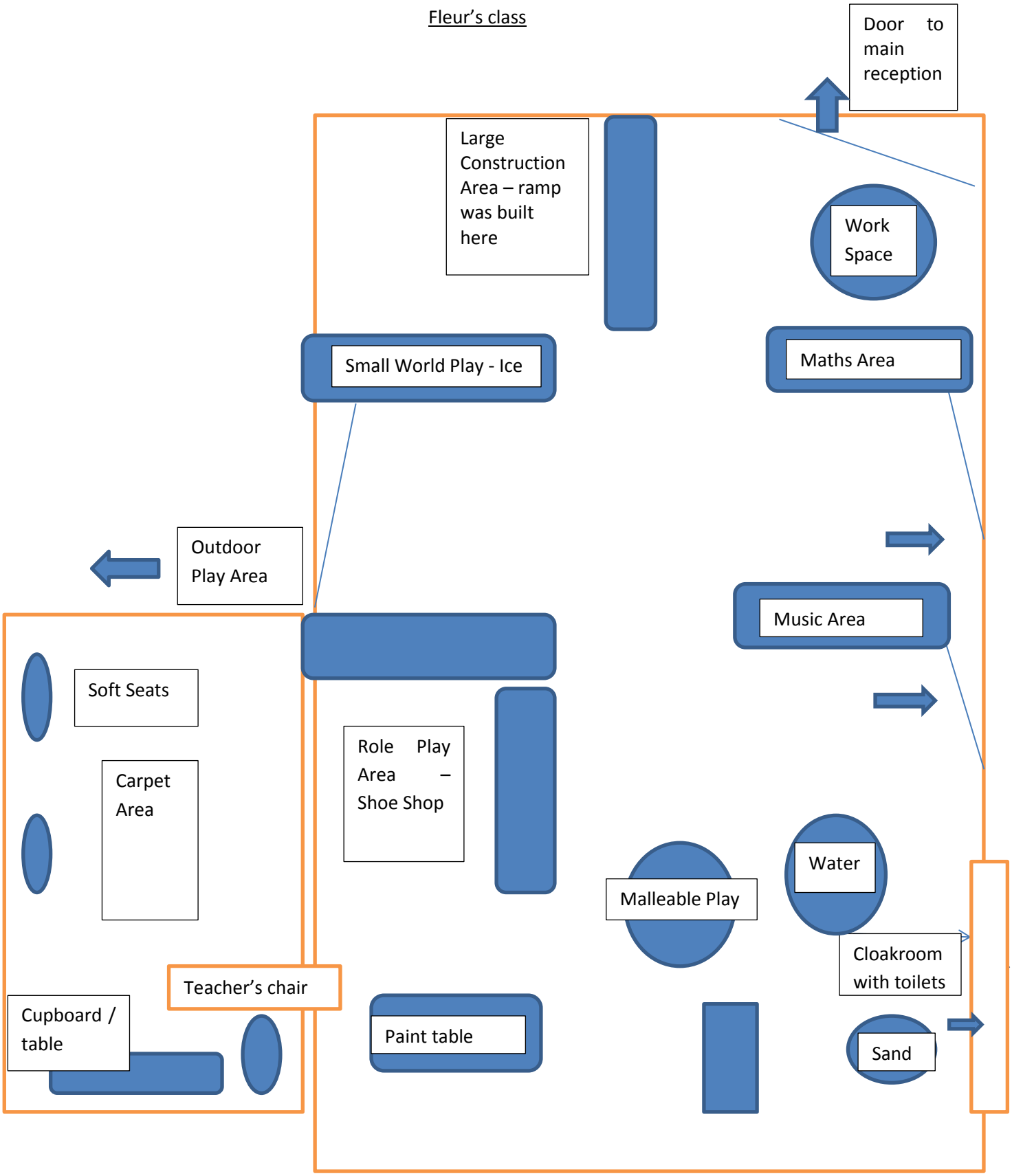
Fleur's class



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3.3.2 Episodes

Episodes were gathered during afternoon visits to the South Green, in view of the organisation of the school activities are set out in the morning and repeated in the afternoon in order that both morning and afternoon children have the same experiences. The episodes identified were all as a result of free flow play activities set up for the children which were supported by an adult.

Episode 1: Cornflour

In this episode a Teaching Assistant (TA) was positioned at a table with a group of six mixed ability 3 and 4 year old children. The activity was free flow so during the session period some children left and others joined the activity. Materials to hand included shallow trays, water jugs, cornflour and crepe paper. The activity was one of a series of lessons which looked at the changing state of materials.

Pedagogical framing

The emphasis of the session was to observe the changing state of the water as and when different materials were added. The materials had been specifically chosen for their properties i.e. cornflour to thicken the water and crepe paper to change the colour of the water. In addition the crepe paper also changed state once wet.

Pedagogical interactions

During this session the children's understanding of basis scientific concepts was supported by a more knowledgeable adult. Learning was directed by way of specific instruction, but this was supported by embracing the children's own exploration and the use of questioning and dialogue as the children began to control the direction of their own learning.

Opportunities for science learning

The activity began with each child having a shallow tray to which water was added, the children were encouraged to put their hands in the water and feel the change to the state of the water as cornflour was added. The Teaching Assistant supported the children's learning by asking children what it felt like as the cornflour was added. The children were using appropriate vocabulary around the temperature of the water 'it's warm' rather than the state i.e. water getting thicker and so were not fully focused on the learning objectives at this stage.

Image 1.1: Pouring in water

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The children were more interested in playing with the water – fetching water from the sink and pouring it into the tray, rather than seeing the effect of the cornflour on the water. In this way they were more involved in following their own line of inquiry. The Teaching Assistant did not labour the issue; rather she acknowledged the children's interests, whilst at the same time moving the activity on through the addition of the crepe paper to the mixture of cornflour and water. The children were presented with red and yellow crepe paper to add to their trays, they were encouraged to feel the crepe paper supported with the use of words such stretchy, colour etc. Again, the children were more interested in mixing the paper into the water at this stage, and the crepe paper was an ideal material for this activity for two reasons, since it changed state once in the water mix, but also changed the state of the mix through colour leakage. As expected the children noticed two things, firstly the crepe paper went soggy resulting in a range of vocabulary emerging e.g. slippy, slimy, stretchy (vocabulary supported by the Teaching Assistant), and secondly the water started to change colour. There was lots of dialogue between the children regarding the different shades of colour of the water. The children were able to recognise colours and were able to recognise that mixing red and yellow resulted in orange. The Teaching Assistant fetched a colour mix chart with the two colours of crepe paper (red and yellow = orange) and asked children what colour is your water now, why is it this colour, what did we add.

Image 1.2: Colour mixing chart

Image 1.3: Blood

Children were encouraged to cut their own strips of paper and add more observing the different colour changes. One child noticed that the paper has also dyed her fingers, she held her finger up and said it 'looks like blood'.

As it was a free-flow activity some children left and others arrived to engage in the activity and it was interesting to note that children who stayed began to act in a supporting role i.e. fetching water, telling the new children what they were adding and advising them of colour changing.

Opportunities for creativity

The activity itself was creative, giving the children opportunities for hands-on experience with learning through **play and exploration.** The children were encouraged to explore for themselves with the Teaching Assistant offering her support as required, she took her lead from the children using

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dialogue and questioning to further their understanding, whilst at the same time gauging when the activity needed moving on.

The children enjoyed exploring the materials, and particularly liked the feel of the crepe paper as it changed state and became more slimy and stretchy, here they began to use their own vocabulary and started to draw on some imaginative parallels i.e. likening the mix to soup. The activity was very much **play based** with the direction dictated by the children, at this age trying to direct learning might inhibit the **natural exploration** which was occurring in this instance, and therefore whilst the children may not have been learning what was originally intended their use of **observation** and associated **dialogue** would suggest the development of basic scientific concepts.

In terms of the synergies which the Consortium identified between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10), the children are demonstrating the following.

- **Play and exploration** – throughout the activity the children were playing and exploring the materials
- **Dialogue and collaboration** – dialogue between children and children and TA and children was rich. The children were heard to compare their mixtures in terms of state and colour, and when new children joined the group existing children showed them what to do
- **Questioning and curiosity** – throughout the task

Scaffolding was evident throughout with the TA using questioning and supporting children's learning through taking her lead from the children and using this to direct learning.

Episode 2: Pulleys

This was a free play activity which took place in the outdoor play area of South Green Nursery during an afternoon session. The activity was supervised by an adult as the task required the children to stand on a raised platform which had been set up with a pulley system with a bucket suspended from a rope. On the opposite side of the platform was a piping system running from the top to the bottom of the platform (Pulley System). Children had to send balls from the top of the platform to the bottom and then transport them back to the top of the platform using the pulleys.

Image 2.1

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Pedagogical framing

Whilst the activity was a free play one the activity had been set up to help children to understand how a ropes and pulley system worked and to develop skills of problem-solving. This episode involved four children aged between 3 and 4 years of age.

Pedagogical interactions

Again because this was a free flow activity there was no directed adult input, however for health and safety purposes a TA was positioned at the activity and as such the adult did support the activity through dialogue and interaction.

Opportunities for science learning

The children were required to work as a team in solving the problem of moving the balls between spaces, requiring them to assign themselves different duties e.g. dropping the balls, collecting the balls, raising the balls. They made amicable decisions between themselves as to what roles they would undertake and quickly established a routine of dropping, collecting and hoisting the balls. This was largely child led with minimal adult intervention which was largely by way of encouragement, such as 'hoist it up', ' quickly collect those balls', 'whoops, try again'. There was also little interaction between the children as they concentrated on the jobs they had assigned themselves, which resulted in little interaction and dialogue between children. The activity did, however, generate some good problem solving skills as well as team work skills since if the child at the bottom of the platform didn't collect the ball there would be nothing for the children at the top of the platform to hoist up and so on.

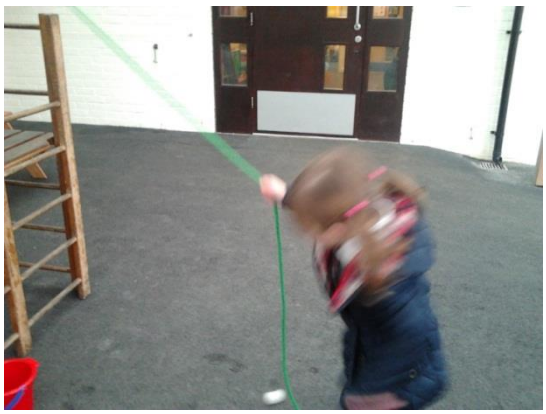

Image 2.2: Choosing where to stand

After a while, the child at the base of the platform who was responsible for hoisting the bucket to the top began experimenting with standing position, standing to the side of the platform, closer and further away. At this point the Teaching Assistant interacted with the children by making comments and asking questions such as, 'it's much harder when you stand closer isn't it', 'goodness you are a long way away – what's going to happen now?' and 'you can hoist the bucket up faster when you stand at the side can't you?'.

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She also continuously used scientific vocabulary and concepts such as pull, winch, pulley, faster, slower, etc.

Opportunities for creativity

In itself the activity was creative in as much as it allowed children to explore scientific concepts through their self-directed **play and exploration.** The children were drawn to something new and different in their playground which provided **motivation and affect**, and in the first instance had to work out for themselves through **problem solving** how the equipment worked and what they needed to do, interestingly the children needed little direction here suggesting that children are natural problem solvers, who provided they have the right materials will be able to work out for themselves how things work.

Good collaborative skills were noted here, and through silent assertion the children established their own roles and maintained these roles through the duration of the play period. Further **child agency** was observed when the child operating the pulley began to experiment with her standing position, teacher **scaffolding** was observed here also as the TA commented on and encouraged the child's actions, pointing out to the child the impact which her actions were having on the pulley. Throughout **questioning and dialogue** was used to motivate and engage the children.

In terms of the synergies the Consortium identified between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10), the children are demonstrating the following.

- **Play and exploration** – this was the main aim of the lesson, encouraging children to direct their learning through their play activities
- **High value of motivation and affect** – through presenting new and different experiences to the children through their free play opportunities
- **Dialogue and collaboration** – the TA maintained a steady stream of dialogue throughout the activity
- **Problem solving and agency** – children had to work out how to move the balls from the top to the bottom of the platform, then back to the top.
- **Teacher's scaffolding** was evident throughout.

Episode 3: Bubbles

This episode took place in the indoor classroom with six 3 and 4 year old children in the afternoon session of the nursery. The activity involved the water tray with bubbles and a variety of objects to blow bubbles and was planned by Fleur following her previous observations of the children's attempts to blow bubbles during a free- play session. Fleur decided to capitalise on the children's natural curiosity by providing them with bubble mixture in the water as well as a variety of tools from which to blow bubbles. Fleur introduced another dimension to the activity by encouraging the children to record their observations on a simple chart.

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Pedagogical framing

The learning objectives were to understand the properties of materials, and to record results in a simple format. This was part of a sequence of lessons in which the children were looking at the changing state of materials.

Pedagogical interaction

Fleur had positioned herself at the water tray so she was there to support the children in their investigations. The task was explained as children joined the activity and once the children had found a tool which allowed them to blow bubbles they were encouraged to record their findings on the chart provided. In addition Fleur supported children with questions throughout.

Opportunities for science learning

The children were presented with appropriate equipment to support them in their learning, with some materials which would allow them to blow bubbles easily e.g. sieve, metallic fish slice and others that wouldn't e.g. wooden spoon.

Image 3.1: Materials for bubble blowing

Image 3.2: Recording results

The children naturally wanted to blow bubbles, and quickly learned which tools were good for bubble blowing and which weren't, and motivation was further encouraged with the opportunity to record their findings on a laminated chart using a sticky dot.

Fleur was available to encourage and direct the children, and also supported their learning by asking them questions as to why they could blow bubbles with some tools and not others, she also asked leading questions such as ' can we blow bubbles with the wooden spoon… why not?' Here the children demonstrated an understanding of the properties of materials, showing that objects needed a 'hole' so bubbles could be formed. Children were also able to compare and contrast the size and shape of bubbles – the sieve made lots of very tiny bubbles whilst the fish slice made long thin bubbles which did not free easily, and here further exploration was made as to how to blow the bubbles to maximise the number and quality of bubbles formed. Collaboration was evident between the children as they began to demonstrate to one another the best bubble blowing techniques.

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At one point one child fetched a funnel from a collection of water play resources nearby and tried to blow bubbles using this. It was noted that they could blow a bubble using the funnel but the bubble could not escape from the mouth of the funnel without bursting and this led to discussion as to whether this could be recorded or not. This was then compared to the sieve which produced lots of tiny bubbles which could easily be freed. This showed good child agency with the children choosing their own tools for experimentation, and also having to make informed choices as to whether this was a bubble in the true sense of the word.

Image 3.3: Using the funnel

Opportunities for creativity

The activity itself was **motivating** for the children, particularly given that the inspiration for the activity came partly from the children's previous explorations. The children were given the resources required to carry out the activity but also felt confident enough to select their own resources from other areas of the classroom, showing good **child agency**. There was clear evidence of **collaboration** between the teacher and children and the children themselves, where those who had mastered the art of bubble blowing shared their expertise with those who couldn't blow bubbles. **Dialogue** was ongoing throughout, with Fleur using questioning to ascertain how far the children had understood the properties of materials in relation to their bubble blowing potential. The recording chart added further motivation in that it gave the children a sense of purpose to the activity.

In terms of the synergies which the Consortium identified between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10), the children are demonstrating the following.

- **Play and exploration** – was a fundamental part of the activity
- **High value of motivation and affect** – activity was planned following the children's own interest, children were motivated to find more tools to blow bubbles through, the children were keen to record their findings
- **Dialogue and collaboration** – when discussing the tools which enabled bubbles to be blown and in supporting one another in how to blow bubbles

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- **Problem solving and agency** – main theme of the lesson was to find tools to blow bubbles
- **Questioning and curiosity** – throughout the task
- **reflection** – when looking at the chart at the end of the lesson

Furthermore, the **teacher's scaffolding** is apparent in the planning of the activity, and throughout as the children engaged in the activity

3.3.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

In Fleur's class, child-initiated play and exploration are used as the predominant pedagogical approaches and she sees her role as facilitating the children's natural curiosity about the world around them and the scientific phenomena that they experience. In these episodes activities were planned from the children's attempts to blow bubbles in the water trough or the direction of inquiry is decided by the children.

What role if any does creativity play in these?

These three episodes showed creativity is through the encouragement of problem-solving and children's agency. As Fleur identifies in her interview the resulting solutions to problems and scientific ideas that children express are unexpected and show creativity. The approaches also encourage children to make connections, challenge intuitive ideas and develop skills of reasoning.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

Motivation and affective development is an important aspect of Fleur's practice, so that play and learning are synonymous and children do not distinguish between the two. This approach to play and exploration capitalises on children's interests and allows the children to follow their own lines of inquiry and create scientific understandings, alongside language development (including increasing vocabulary).

How do teachers perceive their role in doing so?

Fleur and other adults facilitate learning and development through:

- Planning activities that stimulate interest and curiosity in the children.
- Providing support and scaffolding learning where appropriate and standing back and allowing the children space to make their own learning decisions and solve problems in their own way.

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- Allowing the children to make decisions about the focus of their inquiry, even if that takes them away from the planned learning objectives.
- Making connections between scientific concepts and phenomena, but not introducing scientific concepts artificially. Children are seen as natural scientists exploring their world and the teacher introduces new ideas or encourages further exploration as appropriate.
- Reinforcing scientific concepts and vocabulary and thus supporting the development of the learning objectives.

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3.4 Case: 'Fleur'

3.4.1 Context

Where?	Country	England			
	Setting name	EN2 - South Green Nursery			
	Location within setting	Pre-School			
Who? (children)	Year group/age of children	Nursery; 3/4 years old			
	Number of children in class	21 (AM) /14 (PM)			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher and 1 teaching assistant			
	Case teacher role	Teacher			
When?		1	2	3	4
	Dates of visits	12/2/13	26/2/13	01/03/13	11/3/13
	Times of visits	12.30 – 3.00	12.30 – 3.00	12.30 – 3.00	9.00 – 3.00

School/setting

See case above

Teacher

See case above

Classroom

The class consists of twenty-one pre-school, nursery children (aged 3 and 4 years of age) who attend in the morning session and fourteen children who attend in the afternoon session. Parents are able to select which session they would like their children to attend in accordance with the government guidelines of 15 hours free nursery education per week, a small number of children attend full time i.e. 15 hours over 2.5 days. There are two full time professionals working with the children; Fleur who is the teaching assistant currently undertaking a teaching placement and a classroom teacher.

The classroom is set out as a typical nursery, with a variety of indoor and outdoor play and work areas (see plan below).

The classroom has a carpeted area, set apart from the main classroom which enables practitioners to work with small groups or the whole class without disturbance from the busy classroom activities. This area had its own Interactive Whiteboard along with soft chairs and cushions for children to engage in quiet reading activities should they wish. The rest of the classroom is zoned into particular areas e.g. painting, number area, music, role play etc., children are able to move freely between activities, and at each visit it was noted that activities within each zone varied according to the main

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topic focus or class input for that day. Children also had access to a small bank of computers. The classroom was bright and cheerful, with children's work displayed, as well as displays related to learning. Equipment was accessible and labelled with words and pictures so children could select their own equipment, thereby directing their own learning.

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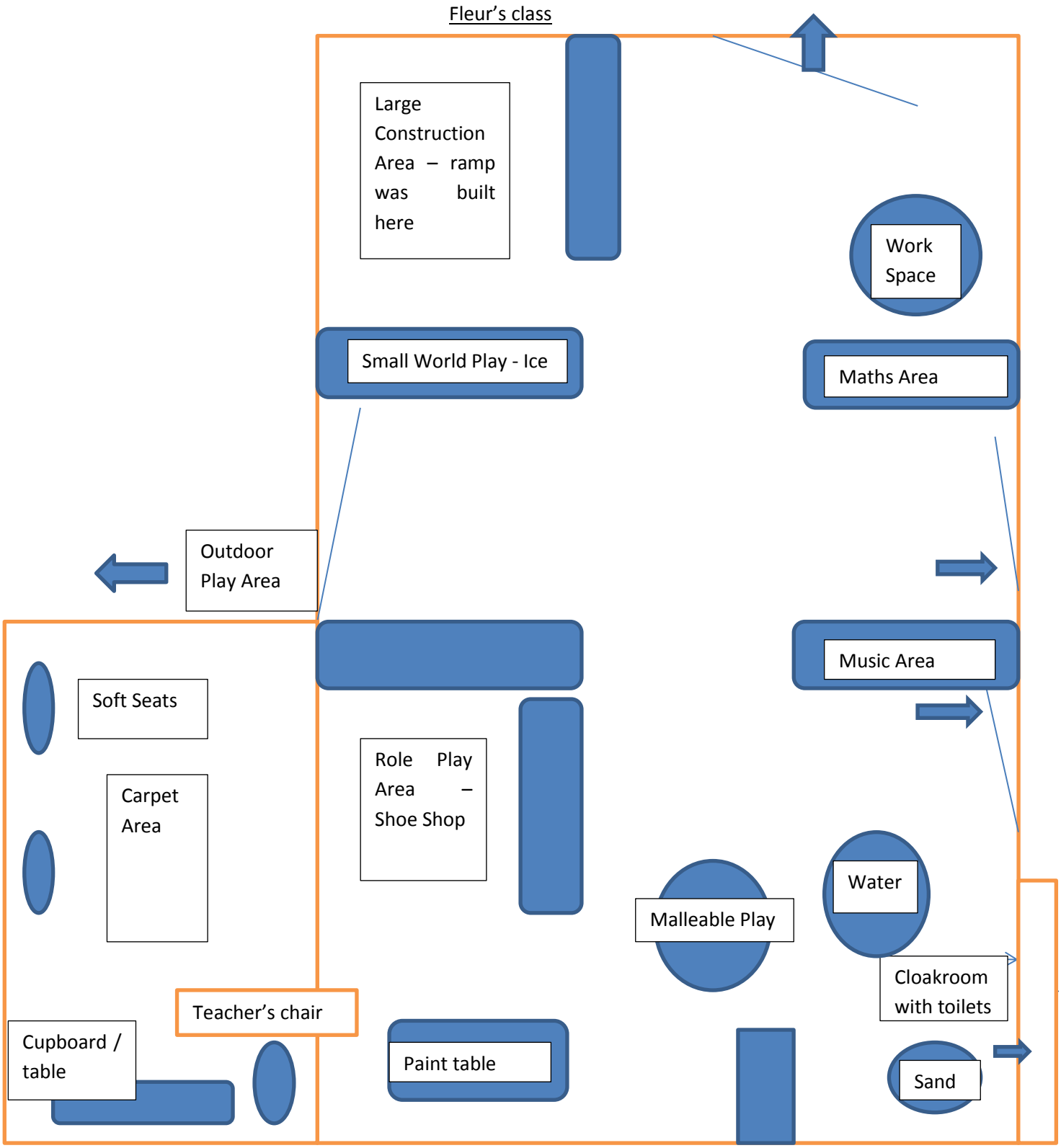
Fleur's class



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3.4.2 Episodes

The observations were predominantly done over half days to accommodate the structure of the nursery, with morning and afternoon sessions. There were few structured sessions to observe as much of the school day is spent in child initiated play, and there was limited specific maths or science as the children were not able to cope with periods of instruction. However, the activities which were set out lent themselves to science and maths, and children had plenty of opportunity to engage in creative ventures through the resources available. Professionals were always on hand to encourage the pupils in their ventures and used rich vocabulary to support their learning and move their learning on.

The first two episodes used here are ones generated by adults in a formal way, whilst the final episode is solely child initiated.

Episode 1: Ice

This episode took place in an afternoon session in Fleur's nursery class with mixed ability 3 and 4 year old children, who moved to the activity when they wished. The activity was related to the class topic which was looking at changes in materials, and was one of a sequence of lessons which looked at the changing state of materials. Fleur remained at the activity table throughout the course of the session supporting and facilitating children's learning as and when required.

Pedagogical framing

The learning objectives were to consider properties of materials and the pedagogical approach was child initiated play; as such children were encouraged to investigate in their own way whilst Fleur took her lead from the children and the direction in which they chose to take their learning.

Pedagogical interactions

In this episode the children's scientific understanding was encouraged by the range of materials on offer to them. Fleur ensured that the children had access to materials which would encourage scientific exploration and was rich in potential learning opportunities.

Image 1.1: Small World Play table

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The children's explorations were very much dependent upon the state of the ice at various stages during the afternoon. For example, in the first instance the ice was very hard so the children simply held it, with some attempting to chip pieces off using the stones and small world toys or hitting it on the table. At this level their exploration was supported with questions such as, 'what does the ice feel like', which promoted curiosity, collaborative problem solving and agency was also evident as children began planning their own explorations trying to extract ice that was firmly embedded in the pots. In her interview, Fleur identified how she encouraged curiosity and creativity in one particular instance by allowing a child to lick the ice as "*he was desperate and he might not have that sort of experience, he was excited after and was going to get his mummy to make some… but they don't always have these experiences".* Fleur was mindful that these children may not get these types of experiences at home, which is why she felt it important that she allowed the child to lick the ice, however she was quick to reiterate that this particular piece of ice was removed from the table after the child had licked it.

Image 1.2: Breaking the ice

As the ice melted exploration changed to reflect the changing state, and Fleur began to make links between the ice and water encouraging observations related to the dripping of the water by holding up pieces of ice and watching the water drip; one child observed and commented on the squelching noises made when she squeezed the water in her hand, whilst another child noticed that the ice became translucent as it melted. Fleur encouraged the children to rub the ice to increase the speed of this happening – the children began putting the ice to their eyes to see through it.

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Image 1.3: Dripping water

Image 1.4: Looking through ice

Image 1.5: Squelching

Throughout the period of activity there was much emphasis on vocabulary related to the properties of ice, and children were heard to make comments relating to the ice being hard, cold, shiny etc. Fleur encouraged, but didn't force, the vocabulary. Children were also able to draw on previous knowledge to help them explain some of their observations, discussing how they could put the ice in the oven to speed up the melting process or put it outside to stop it from melting.

Opportunities for creativity

Fleur presented many opportunities for creativity in the task, first and foremost in the presentation of appropriate materials which would draw the children to the activity and keep them engaged. For example, embedded in the ice were crystals and glitter, which gave the children incentive to break the ice to' free the treasures'. The small play area is one which is familiar to the children and by including objects associated with the cold she was **encouraging connections** to be made from the outset. Children were enabled to be creative by the lack of restrictions on the activity and whilst Fleur had clear objectives in mind when setting up the activity these by no means dictated the direction of the children's learning. Rather more the focus was on **play and exploration** as a means of encouraging the development and understanding of scientific concepts.

In terms of the synergies which the Consortium identified between science and creativity (*D2.2 Conceptual Framework*, pp. 9-10), the children are demonstrating the following.

- **Play and exploration** – in terms of the variety or materials available to the children

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- **High value of motivation and affect** – taking the lead from the children and enabling them to direct their own learning
- **Dialogue and collaboration** – when using vocabulary and encouraging dialogue between the children
- **Questioning and curiosity** – throughout the task

Furthermore, Fleur was **scaffolding** learning throughout through the structure of the play area and through her questioning and dialogue.

Episode 2: Buttons

This activity was a follow up to a previous lesson, intended as reinforcement to establish whether the children had understood the concepts previously taught and a repeat of one from the morning session, however Fleur had altered the input based on what she had observed from the previous sessions. The activity was planned to fit with the current topic for the classroom which was looking at changes to materials, and was closely linked to the children's exploration of ice.

Pedagogical framing

The learning objective for the session was to be aware of change over time, and was very much a teacher led activity.

Pedagogical interactions

The activity was led by Fleur, and whilst questions were used to establish the level of understanding there was little opportunity for children's own exploration or capacity for them to direct their own learning. However, this was a relatively short activity, and following children were given the opportunity to explore concepts further through planned activities.

Opportunities for science learning

The activity began with Fleur reminding the children of the previous time they had done this activity, she showed them the chocolate buttons and the children were asked to make connections with previous work, the children were keen to answer questions as they were confident in their answers and they were happy to express their own ideas as to what will happen to a chocolate button held in their hand. Fleur then gave each child a chocolate button to hold in their hands, and the children were encouraged to hold the chocolate button tightly in their hand for the duration of a chocolate related poem.

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Image 2.1: Holding the chocolate button

At the end of the poem children opened their hands to see what had happened to their button. The children noted the difference between their melted buttons, and this was supported by Fleur's use of questioning, "*what's happened to the chocolate?" "What shape is the chocolate now?"* This appeared to be a little challenging for the children so was followed up with "soft or hard?"

Image 2.2: Melted chocolate

Interestingly, Fleur's button had not melted and this was used as a further learning opportunity as Fleur asked them why this was, explanations were provided for this for this; "*your hands are cold", "our hands are hot".* The activity lent itself to appropriate vocabulary for this age of children e.g. hot, cold, melt, sticky and also making the connections between the warmth and melting.

In her interview Fleur was pleased to note that the children had moved on from the previous activity, *'the first time most said it wasn't chocolate anymore but straight away this time they remembered it was still chocolate, they understood just because it looks different it's still the same and that's hard for them to understand. This reinforces the importance of repetition and reinforcement for this age of children, and* Fleur was able to use this in her assessment of the children. The activity also led to new lesson plans on changes.

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Opportunities for creativity

Fleur had demonstrated a creative approach to **planning the activity**, recognising that the children would be **motivated** and **engaged** in an activity, which involved chocolate. This was a material that they were familiar with and presented a good contrast to the previous activity on ice – which had the same learning objectives, and demonstrated that the effect of heat on different materials presented the same results. Chocolate also reacted much quicker to the effects of heat than ice, appropriate for this age of children where levels of concentration are somewhat limited. Throughout the children were being encouraged to **make connections** between the previous activity and their own explorations.

Fleur used the activity to reinforce key vocabulary, and also as a starting point to the children's own investigations when the ice activity was once again repeated, this shows the importance of reinforcement and repetition as a means of encouraging **child agency** since when the children went on to undertake their own explorations they had a good starting point and were already using appropriate vocabulary.

In terms of the synergies which the Consortium identified between mathematics, science and creativity (D2.2 Conceptual Framework, pp. 9-10), the children are demonstrating the following.

- **High value of motivation and affect** – in relation to the materials chosen
- **Questioning and curiosity** – largely through Fleur's own questioning
- **reflection** – in their responses to questions

Furthermore, the **teacher's scaffolding** was an integral part of the session.

Episode 3: Ramps

This activity was unplanned child initiated play where 3 and 4 year old children explored cars rolling down ramps made by wooden blocks. Two children planned the activity by creating a ramp from large bricks on the carpeted area. The construction was built to height and at the top of the construction they placed a wedge shaped brick which they were using as a ramp to roll cars down.

Pedagogical framing

This was an unplanned activity as such no pedagogical framing was evident.

Pedagogical interactions

The children prompted the learning, and were completely absorbed in the activity. There was little need for adult intervention, and when support and encouragement was offered by the researcher this was met with polite resistance, the children preferring to direct and control their own learning.

Opportunities for mathematics and science learning

The episode was unprompted by an adult with the children taking advantage of the large play area and the range of materials available to them. One child had built the ramp and was happily rolling small cars down it.

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As a second child joined the activity the children began collaborating so that one child was collecting cars at the bottom whilst the other continued rolling the cars down the ramp. They were unwilling to engage in adult dialogue about why the cars went faster, but their actions indicated that they were using scientific and mathematical ideas to solve problems. For example, as the 'car park' became full the child organising the cars attempted to stop progress by putting her hand at the base of the ramp to stop any further cars adding to the pile, and as the number of cars increased further the children engaged in problem-solving by arranging the cars so that more would fit on the 'car park area'.

Image 3.1: Built ramp

Image 3.2: Stopping cars

Image 3.3: Arranging the cars

Opportunities for creativity

This was solely a child initiated activity in which they were demonstrating good **child agency.** The children showed **innovative thinking** which was supported by the fact that materials were freely available to them and they had **ample space** in which to work. The children were confident in their ability to both access and use the resources to direct their own learning and they sustained concentration for a good period of time, showing absorption in the activity. Some collaboration was evident in as much as the children undertook their own roles and concentrated on these, the only time when direct collaboration was viewed was when the child sorting the cars stopped the cars rolling down the ramp so she could organise the cars to fit thereby applying some **basic problem solving skills.**

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In terms of the synergies which the Consortium identified between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10), the children are demonstrating the following.

- **Play and exploration** – this was child initiated showing learning through play
- **High value of motivation and affect** – the children were completely absorbed in the activity and were motivated by their own desire to roll the cars down the ramp and sort the cars accordingly
- **Problem solving and agency** – in designing the ramp and sorting the cars

3.4.3 Case summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

In Fleur's class, play and exploration are used as the predominant pedagogical approach and she sees her role as facilitating the children's natural curiosity about the world around them and the scientific phenomena that they experience. Sometimes, play and exploration are child-initiated, with limited adult support and scaffolding of learning and on other occasions, they are teacher-initiated and directed.

What role if any does creativity play in these?

Creativity is evident in the teacher's planning that provides experiences that motivates and encourages problem-solving and children's agency. As Fleur identifies in her interview the resulting solutions to problems and scientific ideas that children express are unexpected and show creativity. The approaches also encourage children to make connections, challenge intuitive ideas and develop skills of reasoning.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

Motivation and affective development is an important aspect of Fleur's practice, so that play and learning are synonymous and children do not distinguish between the two. This approach to play and exploration capitalises on children's interests and allows the children to follow their own lines of inquiry and create scientific understandings, alongside language development (including increasing vocabulary).

How do teachers perceive their role in doing so?

Fleur and the class teacher facilitate learning and development through:

- Planning activities that stimulate interest and curiosity in the children.

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- Providing support and scaffolding learning where appropriate and standing back and allowing space where adult interaction and intervention would adversely affect creative thinking and scientific development. Understanding when to interact or intervene and when to stand back is a pedagogical skill that is hard to define and develop, but essential to creative scientific development.
- Making connections between scientific concepts and phenomena, but not introducing scientific concepts artificially. Children are seen as natural scientists exploring their world and the teacher introduces new ideas or encourages further exploration as appropriate.
- Reinforcing and revisiting scientific concepts and experiences and drawing attention to connections between concepts.

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3.5 Case: 'Sally'

3.5.1 Context

Where?	Country	England			
	Setting name	EN2 - South Green Nursery			
	Location within setting	Pre-School			
Who? (children)	Year group/age of children	Nursery; 3/4 years old			
	Number of children in class	21 (morning) /14 (afternoon)			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher and 1 teaching assistant			
	Case teacher role	Teacher			
When?		1	2	3	4
	Dates of visits	12/2/13	26/2/13	01/03/13	11/3/13
	Times of visits	12.30 – 3.00	12.30 – 3.00	12.30 – 3.00	9.00 – 3.00

School / Setting

See Fleur case

Teacher

Sally is an experienced senior teacher who has worked at the school for the past 8 years. She is a trained early year's practitioner and has overall responsibility for creative development in the school in addition to being the curriculum coordinator. Sally currently works part time on a 0.8 contract. Typical of staff in the nursery Sally has a secure knowledge of the range of EYFS subject areas, so is confident in supporting all aspects of 'Understanding the World'.

Sally has a full time teaching assistant and in their planning they ensure that adult supported activities are available for the children, alongside a range of free-play activities. During the period of observation the class topic was on 'Growth' which Sally explained lent itself well to scientific enquiry. The children had been involved in seed planting in the classroom, and as a whole school they had entered a regional competition for growing potatoes. Sally explained that they tried to make links between their topics, and that being involved in the competition added an extra incentive for the children to understand about growth.

Classroom

The class consists of twenty-one pre-school, nursery children (aged 3 and 4 years of age) who attend in the morning session and fourteen children who attend in the afternoon session. There are two professionals working with the children; Sally who is the class teacher and a teaching assistant.

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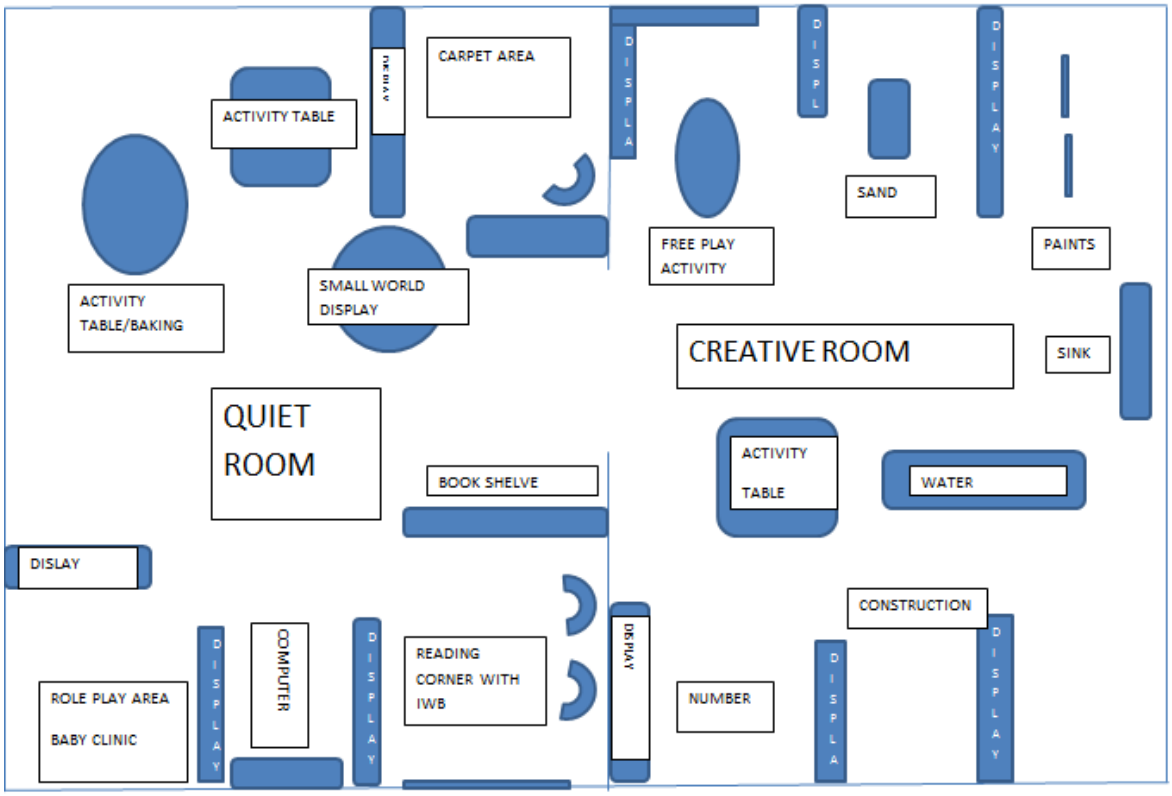
The classroom is spacious, consisting of two large rooms with a partition door separating the two. (See plan below).

The first room is referred to as the 'quiet room' – this has two large carpeted areas, one intended as a reading area with book shelves and an interactive whiteboard set at child height, whilst the other has a teacher's chair and an area for the children to sit or play quietly. The room also has a role play area and activity tables which are set out for free-play activities. The classroom has a computer for the children to play on. The classroom is well resourced, and resources are placed at child height so the children have ownership of the activities they choose to do – the classroom walls display both children's work and posters and labels designed to support their learning.

The adjoining room is referred to as the creative area, and this room is designed for more 'messy' play and large play resources such as blocks and large cars. The room has two sinks, and sand, water and paining is available for the children, the room also opens out onto a large outside play area, which too is well resourced. Again, resources are at child height and suitable labelled to give the children a degree of choice over activities.

In both rooms activity tables had been set out with specific resources of teacher led activities to direct the learning.



A plan of Sally's classroom

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3.5.2 Episodes

Episode 1: Baking

The episode took place during a baking activity in Sally's nursery classroom, during the afternoon session and involved five mixed ability 3 and 4 year old children. The activity was led by Sally (the class teacher), and Sally explained to me that it is a tradition in the school to bake a cake when a child has a birthday, as such the children are all used to the process of cake baking, but Sally also uses it as a learning experience for the children.

Pedagogical framing

Whilst this was not specifically planned as part of the topic work for the class Sally explained that they used cake baking as an opportunity to observe what happened to materials during the cake making process as a result of mixing, heating and cooling. Opportunities also arose for mathematics understanding by way of counting, weighing and measuring.

Pedagogical interactions

By its very nature the activity was largely teacher led with Sally directing the children at each stage of the process. Sally's focus was on the use of vocabulary associated with what was happening to the materials, and she used questioning continually to establish the children's understanding and keep them engaged in the activity.

Opportunities for mathematics and science Learning

The activity started with the children gathered around the baking table, having washed their hands and putting on aprons; this was a familiar start to this activity. They then used antibacterial gel to ensure their hands were germ free.

Sally initiated the activity by asking the children what they were doing and what ingredients they needed to bake a cake, thus undertaking some revision of previous baking activities. The children listed the ingredients that were on the table.

Image 1.1: Preparing the ingredients

Image 1.2: Measuring the ingredients

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During the activity, there was lots of scientific dialogue around changing state (what happens to the ingredients as they are mixed) and mathematical dialogue around weighing and measuring; "*yes we have to weigh it – we need 6oz, let's look for the marker*". As one child started spooning the margarine onto the scales, Sally monitored how much using dialogue and questions to support the child and keep the attention of the other children, "*we have 3 now…how many do we need?", "nearly there" "not too much now J" "whoops we've got a bit too much, let me take some off, what happens if we have too much?*"

When the ingredients had been added together, Sally put the mix into two bowls so the children could mix it, saying "*I'm splitting it in half so we can share the mixing, what's going to happen to the sugar when we mix it*".

Some children referred to a chocolate cake that had been made on a previous occasion, although this was not a chocolate cake the children were able to make links with previously learned concepts Sally brought their attention back to the cake they were currently making them reminding them they were not making a chocolate cake today and drawing them back to the sugar and butter mixture and what was happening when they mixed them together. She then drew their attention to the next ingredient which were the eggs. As they added the eggs, the children were urged to count how many were being added to the mixture;

Sally: *"What goes in next…can you remember?"*
Child: *"Eggs"*
Sally: *"How many?"*
Child: *"3"*
Sally: *"What do we do with the eggs?"*
Child: *"Crack"*

Image 1.3: Mixing the ingredients

Image 1.4 Cracking eggs

The children cracked and mixed the eggs remembering they needed a fork to crack the egg and putting their thumbs into the egg to break it open. They also remembered that they shouldn't let shell go into the mix. They then weighed and added the flour, again observing how the mixture was changing. Children were involved in the activity from start to finish and encouraged to watch what

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was happening to the mixture and describe this. As she was taking it to the oven Sally continued to ask them questions about what was going to happen to the cake now so that they would be able to share it.

Image 1.5: Finishing off

Opportunities for creativity

Sally took an activity which the children were **familiar** with and used this as an **opportunity** to help children develop scientific concepts – changing state of materials, and mathematical concepts – weighing and measuring. The children were **motivated** because they were making something for one of their peers, and also because they get to eat the results of their work which gave the activity a real **sense of purpose**. **Repetition and reinforcement** is a common strategy used in the school to help children to develop concepts, and here the children were keen to answer questions and show what they knew. Children were **drawing from their previous experiences**, and whilst these were not always factually accurate Sally was able to use this – **correcting their misconceptions** and taking their learning forward.

In terms of the synergies the Consortium identified between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10), the children are demonstrating the following.

- **High value of motivation and affect** – the activity had a rea**l** sense of purpose which was a motivating factor
- **Dialogue and collaboration** – was a consistent feature throughout the activity
- **Questioning and curiosity** – Sally used questioning throughout

Furthermore, the **teacher's scaffolding** was evident throughout

Episode 2: Digiblue

This episode took place during the morning session in Sally's nursery classroom with two children aged 3 and 4 years of age, at any one time. The activity was linked to the class topic on growth and used concepts that the children were already familiar with i.e. the digiblue microscope which is attached to the computer, and seeds which the children had previously set.

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Pedagogical framing

The learning objectives were to use the digiblue microscope to identify parts of seeds and sprouting seeds. The activity used seeds the children were already familiar with – some in their original form and some which had previously been set and were beginning to grow. Sally's intention was to encourage children to look closely at parts of the seed, and develop a firmer understanding of the process of growth in seeds.

Pedagogical interactions

The activity was teacher led, and by working with small groups of children Sally ensured that the children had the opportunity to look closely at the seeds. She used questioning throughout to generate interest and gauge the level of understanding. By using seeds which the children had set themselves previously they were able to make links between what the seeds looked like before growth began and how they appeared now.

Opportunities for science learning

Sally sat at the computer and started the activity by calling two children to work with her. She asked the children if they could remember what the digiblue microscope was, one child remembered it was for looking at things as they had recently used it when it snowed to look at snowflakes, thus making connections to when the microscope had been used before. Sally then introduced the seeds and questioned the children about them:

Sally: "What are these?'

Child: "Planting things"

Sally: "Yes we plant them – can you remember what they are called?"

Child: "Seeds"

Image 2.1: Looking at seeds

Image 2.2: Image on the screen

Sally reminded the children that they could see the seeds under the microscope on the computer, and showed them how to capture the image using the camera facility, reminding them where they could see their photo. She also told them they would print them later to put in their learning journey books.

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Sally brought out a seed which had begun to sprout; the children didn't really seem to understand what was happening to the seed although they knew it was growing, and that they had to water it to help it grow.

The teacher used questions to generate interest and encourage children to look closely at the seed. Sally had to explain that she had taken the seed out of the soil and it had begun to sprout, the children closely observed the seed. Sally also referred back to the previous activity asking the children what the name of the seeds were and asked them to remember what they had done to them to start them growing.

Images 2.3 and 2.4: Examining seeds

Sally: "What did we do with them?"
Child: "Gave them sun and water"
Sally: "Yes, what happened to them?"
Child: "Grew"
Sally: "Yes, what are these bits at the top"
Child: "Leaves"

Opportunities for creativity

Sally wanted the children to see for themselves how seeds grew, and whilst they had discussed this during the planting of the seeds she wanted them to have the opportunity to see the stages of the process more closely. The digiblue microscope added a **creative dimension** to this, linking ICT in a **cross curricular** way, Sally had also thought about **increasing the motivational factor** by using the seeds which the pupils had already set. The pupils knew then what the seeds had looked like prior to planting and could see how they had begun to change as a result of this, thereby making links between **cause and effect.** By using seeds which had different growth rates the children were also able to see different stages of the process – the cress was fast growing and therefore already had stems, roots and leaves, whilst the beans had only just begun to sprout, the seed having cracked and the roots only just beginning to show. Sally used questioning throughout to encourage the children to think carefully about the process.

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In terms of the synergies which the Consortium identified between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10), the children are demonstrating the following.

- **High value of motivation and affect** – through using seeds the children were already familiar with
- **Dialogue and collaboration** – was used throughout to encourage the children to think carefully about the process
- **Questioning and curiosity** – throughout the task
- **reflection** – when asking the children what they had found out and what might happen next
- **Teacher's scaffolding** was an integral part of the lesson.

Episode 3: Soft Play

The school is lucky enough to have a 'soft play' area which is a room consisting of large vinyl covered cushions which cover the whole floor space, supplemented by large vinyl covered three dimensional shapes and a ball pool. The area is timetabled and used as part of the curriculum for physical development. In this episode Sally used the area in a cross curricular way, combining physical activity with science through making reference to the effect of exercise on the body, and encouraging the children to move as animals.

Pedagogical framing

The learning objectives were to understand the effect of exercise on the body and to move like animals. There were tentative links with the class topic on 'Growth and Ourselves', but more importantly the activity showed how the nursery applies a cross curricular approach to learning.

Pedagogical interactions

The activity was teacher led and Sally used dialogue throughout to direct the children and to encourage and motivate them.

Opportunities for mathematics and science learning

Sally started the activity by sitting each child on a rubber spot in the soft play area, thus ensuring they had sufficient space in which to work. She then engaged the children in a warming up exercise explaining to them that they were going to 'warm up' their bodies, with 10 star jumps followed by 10 big jumps. The children were encouraged to count to 10 along with the Sally. They then ran on the spot as fast as they could and then slowly. At the end of the warm up Sally asked the children to feel their chests and the children observed that their hearts were beating fast. She then made the link between exercise and their fast heart beat 'yes, exercise makes your heart beat fast'. In this warm up activity, Sally made cross curricular links to reinforce counting and to show understanding of effects of physical exercise on heart.

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Image 3.1: Warming up

In the next part of the activity, Sally asked the children to move like animals, thus reinforcing understanding of characteristics of animals. She also used associated vocabulary to reinforce the idea of animal movements, such as elephants stomping and snakes slithering. They also counted how many legs different animals had and moved like zebras on four legs and that they had to use their hands and feet to replicate this.

Images 3.2 and 3.3: Moving like animals

When the children had returned to their spots, Sally said, 'now children you need to have your listening ears because I am going to tell you a story about some animals, and when you hear the animal I want you to move around like the animal' Reinforcement of key vocabulary was used to describe animals. She then told a story using the animals that the children had been moving like, she made use of vocabulary to remind children of how the animals moved:

'the snake slithered across the grass'

'the elephant stomped'

'the kangaroo hopped'

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At one point the snake stopped for something to eat, one child asked "*what did he have to eat?*" indicating the children's interest in the story and confidence in asking questions.

Opportunities for creativity

Sally was able to combine the use of a physical development session with an opportunity to reinforce some key concepts in science – effect of exercise on body / moving like animals, and mathematics – counting and directional vocabulary. The children were **motivated to learn** because they were doing a physical activity, and were out of their normal classroom environment. **Maximising opportunities** to teach concepts to this age of children are an important part of the South Green ethos, and children are given every opportunity to **learn in a variety of ways** showing a **creative approach to learning** at the school.

The children themselves showed an eagerness to participate, and used their bodies creatively to demonstrate how the different animals moved – Sally selected the animals well to enable the children to show creativity in their movements, and this was supported by associated vocabulary e.g. stomped, slithered which further supported the children in the choices they made. The story at the end of the activity gave Sally the opportunity to assess what the children had learned from the activity.

In terms of the synergies which the Consortium identified between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10), the children are demonstrating the following.

- **Play and exploration** – the activity was play based and gave the children the opportunity to explore with their bodies
- **High value of motivation and affect** – the activity was made 'fun' for the children thereby increasing their motivation
- **Dialogue and collaboration** – Sally used a steady stream of dialogue to encourage the children and they were encouraged to watch and support one another

Teacher's scaffolding was a key feature of the lesson.

3.5.3 Summary and conclusions

RQ2: Probing practice:

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

In Sally's class, the pedagogical approach for the three observed episodes was teacher-led play and exploration. Cross-curricular opportunities for mathematics and science were capitalised on, so that mathematics and science were part of play activities, rather than discrete subject-based activities.

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What role if any does creativity play in these?

These activities showed creativity by encouraging the children to make connections between previous ideas and activities and cross-curricular concepts and ideas. The Soft Play activity also enabled the children to explore mathematical and scientific ideas in a creative way.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

Sally motivates and encourages children by her interaction and questioning, accepting each child's answer and using it to build on their understandings. In this way the children are directed to 'correct' answers rather than being 'corrected'. In addition, developing their scientific and mathematical vocabulary motivates and encourages the children to think and talk in a mathematical or scientific way (as seen in the baking episode above.)

How do teachers perceive their role in doing so?

Sally facilitates learning and development through:

- Planning activities that stimulate interest and curiosity in the children.
- Providing support and scaffolding learning through developing vocabulary and questioning.
- Making connections between scientific concepts and phenomena.
- Reinforcing scientific concepts and thus supporting the development of the learning objectives.

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3.6 Case: 'Wendy'

3.6.1 Context

Where?	Country	England			
	Setting name	EN3 - Clover Infant School and Nursery			
	Location within setting	Primary School			
Who? (children)	Year group/age of children	Year 1; 5/6 years old			
	Number of children in class	28			
Who? (adults)	Number of adults	1 + variable			
	Role of adults	1 teacher + assortment of TA's for different subjects			
	Case teacher role	Co-ordinator			
When?		1	2	3	4
	Dates of visits	24/2/13	25/2/13	5/3/13 (2 researchers)	
	Times of visits	12.30 – 3.00	11.00 – 2.30	9.15 – 1.30	

School / Setting

Clover School is situated in an ex-colliery village in the East Midlands. The school also serves other villages around the locality. The area is one of social deprivation, and children come into school with significantly poor skills in language and communication. The school's last OFSTED was in 2008 where they were judged as outstanding. There are currently approximately 200 pupils in FS and KS 1, with two classes in each group as well as some split year groups. The school also has a nursery attached.

Children at key stage 1 are split into ability groups for English and mathematics, the school day starts with English 9.00 – 10.00, Mathematics 10.00 – 10.45 and then children return to their own classes for topic work each day which is a cross curricular approach to teaching through whole school themes.

The school provides a lot of enrichment activities (zumba, activate, singing) which created some problems whilst observing episodes as observations were frequently interrupted by the class partaking in these activities.

Teacher

Wendy is a very experienced class teacher and has worked at the school for a considerable amount of time, as such she knows the children and their families extremely well, and will frequently draw on this experience when entering in discussions with the children. Wendy is responsible for a year 1 class, a year group which she has significant experience in; she is also the school science coordinator. Wendy identified in her interview that planning for science was thematic in a two yearly cycle, 'that's so children don't end up doing things twice, then we plan everything around the topic'. Wendy feels

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that most of the thematic planning lends itself to science because 'it's important … a core subject', but that mathematics does not always fit in the theme. A theme/ topic always starts with a brainstorm with all the teachers in parallel classes brainstorming with their individual classes. The brainstorm is then used as a basis by which future sessions are planned, using the children's own interest in the topic as a starting point. Wendy acknowledged that it was important that children were not being taught what they already knew, and equally their own interests were catered for as this increased motivation. The role play areas in the classrooms were important in this as 'it just pulls everything together so the children make connections'. Children are encouraged to raise their own questions during the brainstorm session and Wendy explained that they are then encouraged to research the answers to their questions in their own time. At the end of each topic the class returns to the starting point brainstorm and reflect on what they have learned through the duration of the topic.

Classroom

The class is one of three parallel Year 1 class, with twenty-eight children aged 5 and 6 years of age. The classroom is set out as a working early years class, with five tables, an interactive white board, with a carpet area in front of it and a role play areas, which was set up as a pet shop area.

Wendy's role play area

The children on their learning journey, showed the researcher their topic books in which they had started the work of Carnival of the Animals, but they were unable to say much about the topic at this stage.

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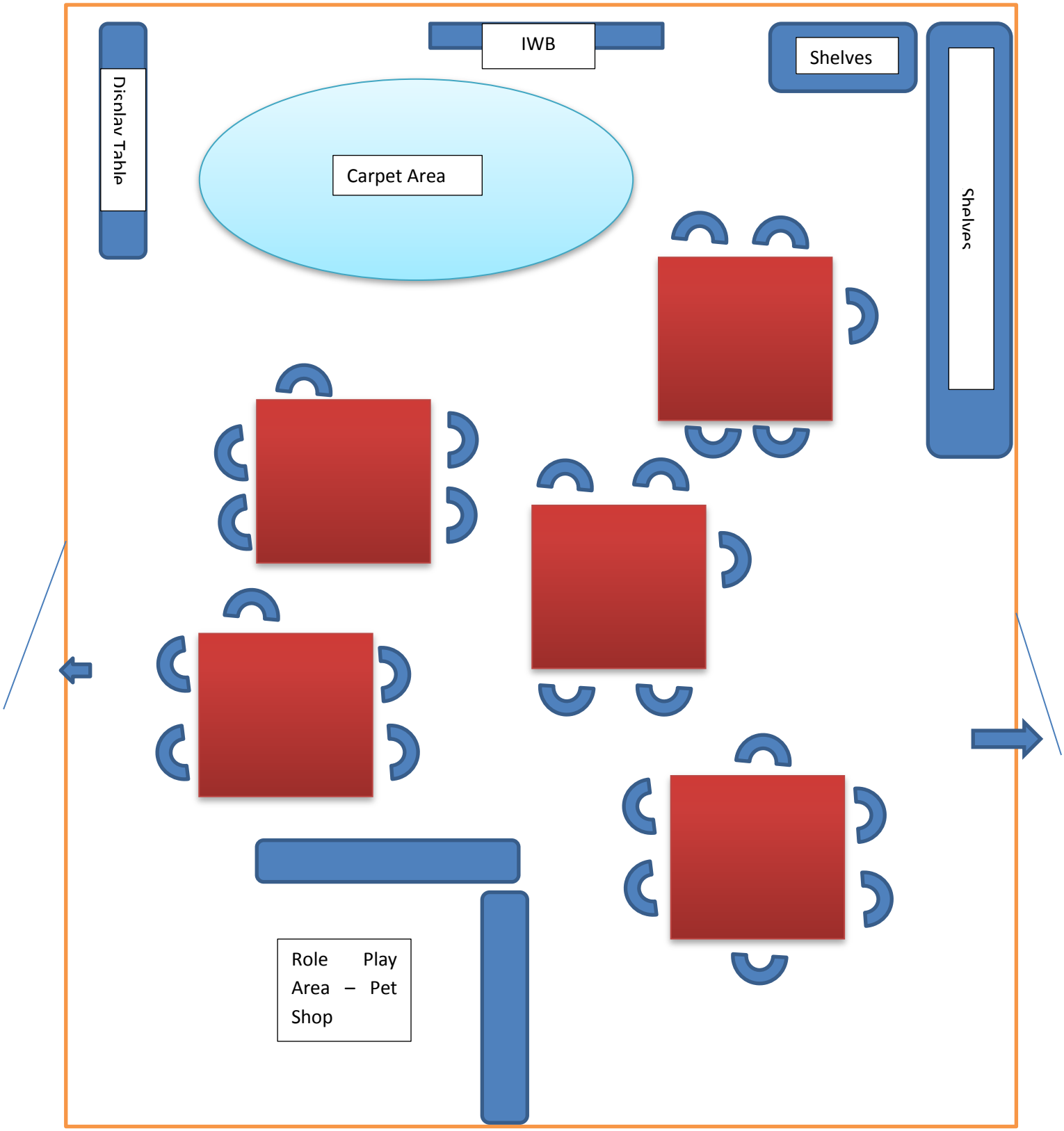

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3.6.2 Episodes

Episode 1: Classifying

The episode took place with ten out of the twenty-seven children (aged 5 and 6 years of age). There were two adults in the class; Wendy who was the class teacher and a Teaching Assistant. The session was planned as part of the class topic on 'Carnival of Animals' and the children had been tasked with sorting animals according to observable characteristics.

Pedagogical framing

The learning objectives were to:

- able to classify animals by known or observable properties
- able to find information about animals from books and internet
- know what an animal needs for food, shelter and care

Pedagogical interactions

In this activity Wendy wanted the children to take ownership for their work, developing skills of independence and making choices. The activity began with Wendy framing the learning intentions through some open discussion and reflection of earlier work which had formed a starting point for this activity. Wendy reminded the children about a grid they had made in the morning about what animals need, what they eat, where they live, what kind of care they need. She then asked the children to identify what a dog needs apart from a home and food and the children identified that a dog needed exercise. Wendy expanded on this by discussing how much exercise dogs of different sizes needed.

Opportunities for science learning

Wendy described the task for the session putting the children into three groups; 'Some people are going to be classifying. I do not mind what groups you put them in. I do not mind if you work by yourself, in pairs, in groups or the whole table. Scientists always discuss things but you don't have to argue. You can talk about things to help you'. She really emphasised that she wanted the children to make their own decisions and gave some examples of sorting reasons from the morning group: hot places / cold places; mammals / other animals; farm animals / zoo animals / pets, again emphasising that she wanted the children to decide the categories but that they needed to have really good reasons for their classification decisions.

Wendy went on to work with this group of ten children, reminding them again to think about their reason before choosing the animals. Most children were working in pairs and some pairs were just copying the pairs beside them so Wendy encourages them to make at least one of the circles different.

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Image 1.1: Selecting animals

Some of the choices the children made are opposites, for example hot places / cold places, others identified farm and water animals, whilst others had real potential for intersection, for example pets / fly. However, this was not discussed and the pre-drawn circles do not overlap. The children were well motivated and enjoyed choosing different animals from the pile.

Images 1.2, 1.3 and 1.4: Making choices

Wendy said they needed to check if they put their answers in the right place, but that sometimes it was difficult to know. This and the following discussion about whether the sea was a hot or cold place seemed to confuse the children a little. The children then started to identify things they don't know, although they don't word them as questions there was a lot of good discussion throughout the activity.

Wendy interacts with the children and checks their decisions and sometimes the children added additional remarks about the animals or the places to justify their decision. One child is very knowledgeable about animals and contributes frequently and at length. For example, Wendy pulls out a tortoise from the water group and the child identifies the differing characteristics of tortoises and turtles, saying that a tortoise 'lives on land' and has a 'hard shell' a turtle 'lives in the water' and 'has flippers'. Wendy identifies that they need to find out more information about turtles and tortoises for the other activity of researching animals and making a fact book about them. Wendy continues to reinforce facts about animals and the different groups' decisions about their

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classification categories and connections are made to the children's previous knowledge about animals and their experiences (e.g. on holiday).

Image 1.5: Classifying turtle and tortoise

Opportunities for creativity

The children were encouraged to devise their own criteria for classifying the animals, with a firm emphasis on their being no right or wrong answer, providing they could justify their reasons for selection then this would be acceptable, this encouraged **good child agency** and the children were keen to identify the similarities and differences between animals, and devise different categories. There was also plenty of opportunity for children to discuss their choices between themselves which encouraged **good collaboration and problem solving**, and this was well supported by Wendy who was able to **scaffold** their learning as and when it was appropriate. As the task developed the children could become more creative in their responses, trying to find more diverse categories for selection.

The activity was practical, hands on, with the children having the toy animals from which to make their choices which presented a **play and exploration** element to the activity, the children were able to move the animals around so if a wrong decision had been made then this was quickly rectified thereby increasing the **motivational** factor.

The activity gave the children the opportunity to demonstrate their knowledge and understanding, and because most children had some basic knowledge of animals and their characteristics this increased the confidence factor, and also encouraged dialogue and collaboration amongst the children.

In terms of the synergies which the Consortium identified between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10), the children are demonstrating the following.

- **Play and exploration** – the activity was designed to be hands on and practical, and the children were encouraged to make their own choices

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- **High value of motivation and affect** – particularly in relation to the encouragement of diverse choices
- **Dialogue and collaboration** – this was rich throughout – the children worked in pairs and were keen to share their knowledge with one another and with Wendy.
- **Problem solving and agency** – the children were set the task of choosing their own criteria for selection so needed to take ownership of the task
- **reflection** – encouraged by Wendy asking children to talk about their selections
- **teacher's scaffolding** is apparent as Wendy was there to support the children and ask questions to generate further thinking.

Episode 2: Counting on

In this episode 22 lower ability 5 and 6 years olds were working, during the morning session, with Wendy (the class teacher), the Teaching Assistant (working with one child on a one-to-one basis) and a student teacher. The student teacher was responsible for planning the session, and she led the oral and mental starter before the children went into their ability groups for group tasks – each of the groups had an adult working with them.

Pedagogical framing

The learning objectives were to form number pairs to 7 and to find the missing number in a number problem up to 7 using resources (Whiteboard, Bird cage laminate, Birds, Counting bears, Counting blocks). The activity was informed by the class mathematics planning cycle.

Pedagogical interactions

The activity was led by the student teacher who modelled the activity with the whole class prior to them working in their own ability groups – each of the groups had a knowledgeable practitioner working with them who scaffolded the activity using a variety of resources applicable to the needs of the group.

Opportunities for mathematics learning

The student teacher introduced the activity to the whole class, who were sitting on the carpet and said that the learning was to make number pairs to 6 and 7 as a follow up to a previous lesson. A lot of reinforcement was needed as this was a lower ability group but the student teacher generated further interest by varying the use of questions. As a resource the student teacher had a laminated sheet with two bird cages which could be used with sticky birds. The birds and cages gave good visual impact and the student teacher was able to use it to her advantage when generating questions, for example, 'we have to put him in the cage or he will fly off'. She began with a number of birds in one cage then asked the children how many birds she put in the other before adding the total. Each step was recorded in the form of an algorithm on the white board. Since this was the lower ability group, there needed to be lots of repetition using rich mathematical vocabulary to generate responses, such as, ' 2 in one 2 in the other, how many altogether', 'you've just done me an adding sum', 'give me a number smaller than', 'I've got 1,2,3,4,5 how many more to make 7'. This

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helped the children gain confidence so more birds were added to make it up to 10, children were encouraged to use their fingers to make number bonds to 10.

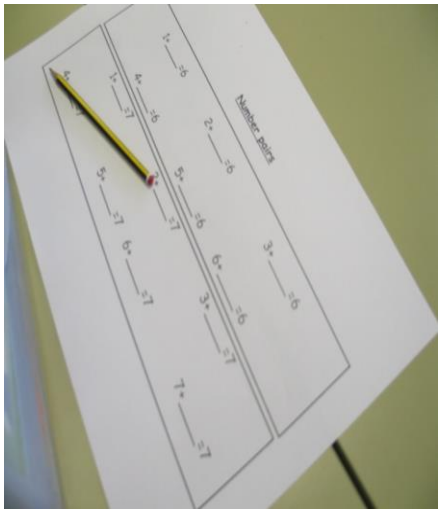

Image 2.1

After this introduction, the children moved to independent activities on their tables which involved finding a missing number in an algorithm e.g. 5 + _ = 7.

This had not been modelled on the carpet but each group worked with an adult, who had been well informed of intentions prior to start of lesson and had resources appropriate to their ability level. The result was that there was good use of adult support and well-chosen resources to support learning; one group had their own birds and cages, one had counting bears and one had counting cubes. Each table had a set of sums to complete using the selected resources to support them.

Image 2.3

In the counting bear group, the student teacher modelled the use of the counting bears as a means of solving the problem, putting bears into two separate dishes to demonstrate how the algorithm worked. The session was built up with children taking it turns to put the bears in to the dishes until they were confident to do the sums on their own. There was a need to reinforce and build up skills

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needed to do the activity so the student teacher did a lot of scaffolding before she was confident that the children understood fully what they were doing.

Image 2.4

In the counting blocks group, the children were adding blocks to a tower, choosing different number bonds to make the total (6) – the blocks stacked on top of another so if they chose the wrong bonds they would topple. Wendy was working with this group and kept reinforcing what the children needed to do through good use of questioning and positive support and a lot of adult intervention and whilst the children understood the formula of what they had to do; they seemed less sure of why and how it worked.

Image 2.5

Opportunities for creativity

Whilst opportunities for creativity amongst the children was minimal in this activity the creative element was in the **planning of the activity**, where by the student teacher had considered carefully how best to teach the concept of number bonds in a practical, visual way which would help to **embed the concept** for the children. The class teacher had already explained that this group of children were of a lower ability level, and as such a **practical kinaesthetic activity** was fitting to maintain levels of **motivation** and help the children to understand the concept.

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The **resources** were well chosen, both for their **visual appeal** and in terms of allowing children to **physically manipulate the resources** as a means **of practically working** through each number problem. There was much **repetition and reinforcement** which meant that once the children were ready to move onto their individual questions they were able to successfully work through the process independently.

Staff resources were maximised, so each member of staff working with a group was fully aware of the expectations for their group, and this also minimised potential disruption which might occur if children are unoccupied.

In terms of the synergies which the Consortium identified between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10), the children are demonstrating the following.

- **High value of motivation and affect** – through the careful selection of resources
- **Questioning and curiosity** – staff working with the children used questioning throughout to motivate and engage the children

Teacher's scaffolding was an essential part of the activity

Episode 3: Starting Points

This was a starting point activity with all twenty-eight mixed ability 5 and 6 year old children and took place in the afternoon session, on the carpet, at the start of a new topic on Carnival of Animals. Wendy and a student teacher were present. This is an activity which was familiar to the children as each time they start a new topic they begin with a brainstorm of what they already know about a topic and what they would like to find out. Wendy uses post-it notes to record questions raised by the children and once the information has been found this is added to the sheet. The children were particularly excited by this topic as this is an area in which they had some prior knowledge.

Pedagogical framing

The purpose of this session was to elicit the children's current conceptual knowledge for formative assessment purposes. The intention was to raise questions and potential gaps in understanding which would form the basis for planning future topic work sessions.

Pedagogical interactions

The session was very much adult led with Wendy directing the discussion through asking questions and recording the children's responses on a flip chart. As children made comments and suggestions Wendy was able to use this as a means by which to elicit what the children knew already about the topic.

Opportunities for science learning

After an initial introduction to the topic which the children were clearly familiar with, Wendy used a flip chart to brainstorm the children's understanding, beginning by asking, "*So what do we mean carnival of animals?*" The children came up with terms such as 'carnivore' and 'herbivore', which the Wendy praised them for remembering from a previous activity; in her interview Wendy identified

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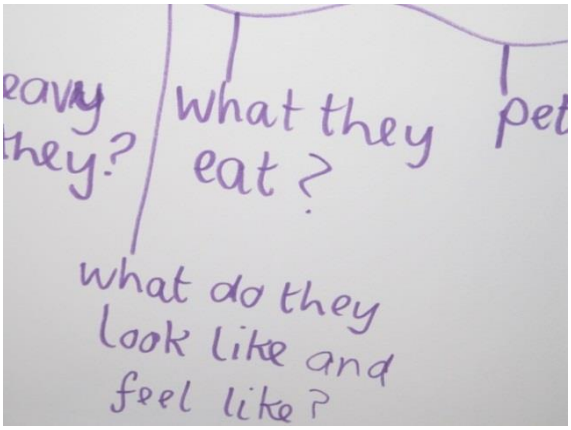
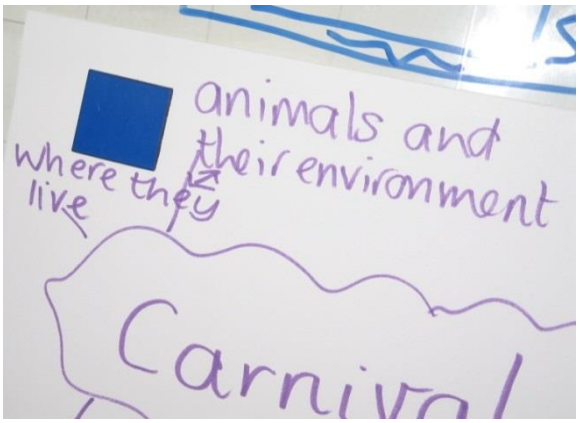
that this built on knowledge from their topic on dinosaurs. The children were eager to participate and Wendy used a good range of open questions to engage the children in discussion, alongside this she helped them with their vocabulary – introducing correct vocabulary alongside their own word choices. Each idea, such as what animals eat or look like and where they live was written on the flipchart.





Images 3.1 and 3.2: Starting Points

Wendy's questioning directed the children towards different categories/ classification of animals, which were recorded on the flip chart and then she began to focus on how the children could research information on different animals; 'I didn't know that, perhaps this is something we could find out children, remember I don't know everything, sometimes we have to write questions to find out later – lets write the questions down'. These questions were written down on post-it notes and added to the brainstorm. The children identified different ways to research from asking parents to the internet. Finally, Wendy reviewed what had been put on the flip chart and reminded the children of what questions they were going to find out as a result of this.

Episode 4: Animals needs

Following on from episode 3 the children were tasked with reflecting on what they already knew about animal's needs, focussing specifically on pets since this is an area which the children already have prior knowledge of. The episode focusses on six mixed ability 5 and 6 year old children, working with the Teaching Assistant.

Pedagogical framing

The activity had the learning objective to identify specific needs of animals and involved children completing a handout using a word bank. The handout was a grid of five pets and the children had to put information regarding feeding, care etc. using a picture and word bank to help with ideas.

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Image 4.1

Pedagogical interactions

They were supported by the Teaching Assistant who supported them by keeping on track, asking questions and reminding them where to put information.

Images 4.2 and 4.3: Animal Needs

Whilst the activity itself was uninspiring the discussion generated showed good understanding of scientific concepts related to this age of children and the Teaching Assistant used her knowledge of the children well to bring out discussion elements. One discussion about the needs of fish in fish tanks, led to a discussion of dolphins:

Child:	*"I have a dolphin at home'*
Teaching Assistant:	*"Really M, a dolphin? – that must need a lot of room"*
Child:	*"It's just a baby dolphin – I have to feed it with a bottle, but I have to be careful that the sharks don't eat it"*
Researcher:	*"Yes I can see that would be a problem'*

Whilst the dolphin was a fabrication the child displayed knowledge about caring for baby animals as well as the dangers in water from the sharks suggesting simple scientific connections are being made.

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Opportunities for creativity

Episodes 3 and 4 demonstrate the commitment Wendy shows to working from where the children are currently at in terms of their knowledge and understanding, and in both activities there was evidence of rich **dialogue and communication**. **Questioning** was used throughout as a means of generating discussion and gauging the children's current levels of knowledge and understanding, and the children were actively encouraged to formulate their own questions which would be answered as part of planned activities later in the topic, this reflects Wendy's comments in her interview about motivating the children to learn. Some child **agency** was evident in this approach to the start of topics. The brainstorming activity also illustrated the approach to **assessment**, eliciting conceptual knowledge at the start of the topic and "*at the end of each term… well half term now it's changed… we look at what the children have done… we go back to the brainstorm and children tell us what they have learned … and any answers to questions we have found out… I like the children to find things for themselves, not that I know everything sometimes I don't know so I set them a challenge*".

In terms of the synergies which the Consortium identified between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10), the children are demonstrating the following.

- **High value of motivation and affect** – through using the children's own interests as starting points
- **Dialogue and collaboration** – when discussing what the children already knew about a topic
- **Questioning and curiosity** – children's questions encouraged
- **Reflection** – in reflecting what they had put on their brainstorm

Furthermore, the **teacher's scaffolding** is apparent as Wendy leads the lesson.

3.6.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

In Wendy's class, the approach to learning in science appears to be mainly dialogic, although in mathematics the episode involved more exploration to solve mathematical problems. All activities are teacher-led, although there are opportunities for children to choose direction of learning and whilst these are encouraged by Wendy, they are not always capitalised on.

What role if any does creativity play in these?

Creativity is evident in the approach to formative assessment, eliciting children's ideas at the start of a topic, but there appears to be a tendency to follow previously planned activities, rather than follow children's lines of inquiry.

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RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

The children's involvement in planning activities, the rich discussion that encourages questioning and the practical, exploratory approach to mathematics and science fosters interest and motivates the children. In addition, good connections are made with previous learning and experiences and this motivates and encourages children in further learning.

How do teachers perceive their role in doing so?

Wendy recognises that effective scientific and mathematical development occurs through:

- Planning activities that use children's current knowledge as starting points.
- Providing support and scaffolding in children discussions and practical activities, to reinforce learning.
- Making connections between children's ideas and concepts.
- Reinforcing and revisiting scientific concepts and experiences.

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3.7 Case: 'Caroline'

3.7.1 Context

Where?	Country	England			
	Setting name	EN4 – Ridgeway Primary School			
	Location within setting	Primary School			
Who? (children)	Year group/age of children	Year 2 – age 6-7			
	Number of children in class	29			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher, 1 Learning Support Assistant. LSA largely spending time with individual children with SEN, such as specific numeracy and literacy needs			
	Case teacher role	Lead teacher, sole responsibility for class			
When?		1	2	3	4
	Dates of visits	210113	010213	130213	010313
	Times of visits	Morning	Afternoon	Morning	Morning

School / Setting

Ridgeway Primary School is a large, popular and over-subscribed primary school for children aged 3-11, organised into two parts: the pre-school Foundation Stage Unit for children aged 3-5 (90 children) and the main primary school for children aged 5-11 (262 children). The school, which occupies a large, well-resourced site with good indoor and outdoor facilities (including a full-sized playing field shared with the neighbouring secondary school) is situated in an affluent town around thirty miles north of London. Recognised as outstanding by Ofsted (2006), 98% of 11 year olds having attained level 4 in both English and mathematics for the previous three years, children in the school with statemented special educational needs (2%) and those eligible for free school meals (10%), are below the national average.

The school has long been committed to creativity, particularly arts-based, is recognised as offering outstanding music education (Ofsted, 2006) and has been researched for its creative teaching and learning. In mathematics, staff lead other local primary schools in extension activity for the most able pupils in the top years, using investigative approaches to exploring mathematical ideas. In

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relation to science, the school foregrounds the practical investigation of living things and life processes, properties of materials and physical processes; these are undertaken outdoors as appropriate. An annual science and environment week involves workshops, speakers and competitions. The school has links with a nearby experimental agricultural site.

Children's learning is enhanced by over 90 networked computers with internet access, interactive whiteboards and other digital media. Children actively contribute to the school's website. The school actively holds awards including Eco School, Active Mark award, Healthy Schools and Green Tree.

Teacher

Caroline has been a teacher for ten years and teaching at Ridgeway Primary School for six years. She is the Key Stage 1 coordinator at the school and ran the pilot 'Creative Curriculum' in her class four years ago, which was subsequently rolled out to the other classes in the primary school. She feels that she is confident in her mathematics teaching, however is less confident in science, stating in the interview, "*I wouldn't say science is my strength, but I would say I'm trying to give them the experiences to find the answer, rather than me just telling them.*" This 'giving children experiences to find the answer' appeared to typify Caroline's (observed) science and mathematics teaching.

Classroom

Caroline's classroom, in common with all classrooms in this one-story primary school, has access to both the indoor and the outdoor spaces of the school either side of it. The indoor side leads directly out into a wide corridor containing hangers and shoe lockers for children's coats and shoes; the outdoor side directly out into a garden, and a grassy playing area shared with the rest of the school in which large and small fixed and portable play equipment can be found. Within the classroom itself, which is semi-carpeted, are a series of small low round tables which facilitate group work, and a small bank of computers together with a range of resources at children's height both in the main learning area and in the art and craft area where a sink and drying rack as well as work tables and art equipment can be found. The classroom is equipped with a book corner and an interactive whiteboard. On the walls are many colourful displays of children's work as well as learning resources such as vocabulary.

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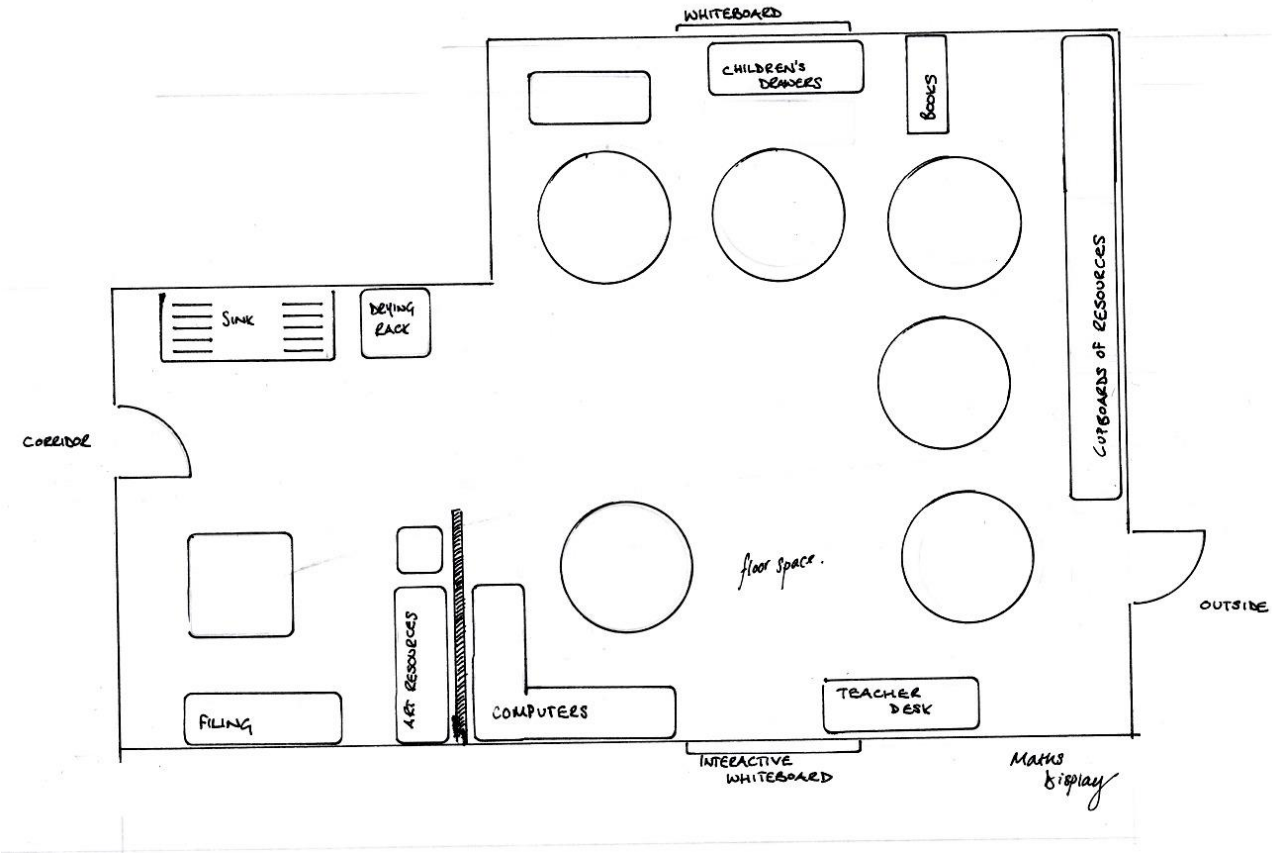

There are 29 children in Caroline's class. During much of the day, they work in pairs or small groups of up to six, working at tables (see classroom map). In mathematics, children are often grouped by ability (as determined by in-school, quantitative testing such as arithmetic or multiplication tests), while this less often the case in science. As noted above, the school is situated in an affluent area and consistently scores highly on national tests. The children in this class reflect this, with many of them attaining above average scores in the national tests. Caroline identified that "*Certainly just looking at knowledge, they're all achieving*" however she felt that their investigative skills were less well developed and this was something she was keen to focus on in her teaching. This theme, of high knowledge but comparatively low skills was repeated during the interview, where Caroline noted how it was difficult to teach some of the children due to their experiences. Caroline's opinion was that, "*I think we're lucky [at RPS] in that a lot of our children's basic general knowledge, I think, is quite solid… a lot of the knowledge objectives aren't that challenging for them because it was things they could easily identify so part of the challenge comes in them opening up into something more investigative*". The children's experiences often meant that they were very independent and Caroline aimed to provide opportunities for open ended problem solving and for them to work in collaboration with others in order to develop these skills.

3.7.2 Episodes

The two episodes from Caroline's class each integrate mathematics and / or science learning with creativity. Each is drawn from within a separate learning activity and two of the three foregrounds

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particular, bounded, learning moments documented in close-up documentation of small numbers of children.

Episode 1: Shapes

Introductory comments

This session followed previous lessons during the week, in which the class had discussed these various properties. The activity was initiated by the teacher, and the children worked in five groups at tables with plastic interlocking shapes ('Polydrons') with which to construct three-dimensional shapes, prompted by a number of cue cards. These cards encouraged the children to make shapes under particular constraints; 'make a shape with less than eight corners', 'make a shape with more than six faces' and so on. The main focus of the episode here became two children, Tobias and Caitlin who begin to work together to construct a shape that has more than six faces and who once it has been constructed, start to create a playful narrative around it. This then draws in other children at the table, who then participate in this narrative.

Pedagogical framing

The emphasis of the lesson was to explore the concepts of sides, vertices and faces in three dimensional shapes. There were no restrictions on the size of the figures that the children could make using the cue cards as prompts and the polydrons as resources, and no other limits (for example, shapes needing to be regular or convex, or needing to contain a given number of shapes) other than those on the cue cards.

Pedagogical interactions

During this activity, the children's mathematical exploration was framed by the teacher having posed the task for the whole class. At the start of the lesson, Caroline devoted short period to discussion of the task in hand. Then, working at tables in groups of five, the children worked with the cue cards and the plastic polydrons, whilst the teacher moved between the groups engaging with children as they worked and occasionally interrupting the class. As discussed in the section below, Caroline's focus is on encouraging the children to have a strategy. However, during this particular episode it is the children who prompt one another's learning.

Opportunities for mathematics learning

The task encouraged children to recognise the properties of three-dimensional shapes by constructing a range of possible shapes using the interlocking shapes (Polydrons). The open ended nature of the task meant that the children were able to combine the tiles to make regular or irregular shapes under the direction of different cue cards, described above. There was minimal practitioner input into the actual construction of the shapes, other than reminding the children about the cue cards, and asking further questions about the sides, vertices and/or faces.

When referring to the National Curriculum, we can see a number of areas that the activity covers in the 'Shape and space' section of the curriculum – more specifically sections 1a and 2a, b and c (see

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below). Polydrons were chosen by the teacher as the task, so it would not be appropriate to suggest that children were selecting the 'appropriate mathematical equipment' (1c).

Using and applying shape, space and measures

1. Pupils should be taught to:

Problem solving

a. try different approaches and find ways of overcoming difficulties when solving shape and space problems
b. select and use appropriate mathematical equipment when solving problems involving measures or measurement
c. select and use appropriate equipment and materials when solving shape and space problems

Communicating

d. use the correct language and vocabulary for shape, space and measures

Reasoning

e. recognise simple spatial patterns and relationships and make predictions about them
f. use mathematical communication and explanation skills.

Understanding patterns and properties of shape

2. Pupils should be taught to

a. describe properties of shapes that they can see or visualise using the related vocabulary
b. observe, handle and describe common 2D and 3D shapes; name and describe the mathematical features of common 2D and 3D shapes, including triangles of various kinds, rectangles including squares, circles, cubes, cuboids, then hexagons, pentagons, cylinders, pyramids, cones and spheres
c. create 2D shapes and 3D shapes
d. recognise reflective symmetry in familiar 2D shapes and patterns."

(from http://www.education.gov.uk/schools/teachingandlearning/curriculum/primary/b00199044/mathematics/ks1/ma3, accessed 11th March, 2013)

Throughout the lesson, children could be heard counting the edges of the two-dimensional Polydron tiles and counting the corners, edges and faces of the three-dimensional shapes they were making. All the children appeared adept at naming the two-dimensional shapes (triangles, squares, rectangles, and hexagons) and knew vocabulary such as 'regular' and 'irregular' shapes. However, there was occasionally confusion on describing 3D shapes as 2D shapes (for example, naming a square-based pyramid a 'pentagon'). This would agree in part with Caroline's assertion that the children were confident in their knowledge – certainly in their knowledge of 2D shapes the children

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across the class all appeared to be confident. Some children, despite knowing the vocabulary such as 'irregular' and 'regular', were not able to determine which 3D shapes were 'regular'.

There were a number of times when Caroline appeared to be emphasising the importance of starting with a strategy. After a short period of time (approximately seven minutes) allowing all of the children to have a first try at making some of the shapes, she interrupted the class and said,

> "*I know as well, that some people on this table have picked up a sentence and thought about a shape that they already know might actually match that sentence so Rory (pseudonym) had a, and Rick (pseudonym) had a sentence which was "Make a shape that has less than six faces", I think that was your first one wasn't it? And they knew straight away a shape on the board that would match that, so they went for that… Nick (pseudonym) picked a sentence that says "Make a shape that has more than six faces", and Nick had to do a bit of thinking because you said, "Well, I know that a cube or a cuboid has six faces, but it needs to have more than six faces." So he started to build a cuboid, and then he stopped and had a think and we could see that he's come up with quite a good plan of he can now make a shape that is not just going to have six faces, it's going to have more than six faces. So Laura (pseudonym) asked the question, does it have to be one of the shapes that we already know, it doesn't have to be, but actually, thinking about those shapes has helped some of us get started. So think about what you already know*."

The emphasis is very much on planning and strategising. Subsequently, a number of children can be heard on the audio recording to be talking about the various facts that they know and developing a way forward before starting the activity.

Opportunities for creativity

The initial mathematics task was set up for children to generate **imaginative, purposive outcomes** that might be **original** and which would be **valued** within the curriculum task – these are terms which frame the CLS approach to creativity. In relation to the observed emphasis in scientific and mathematical creativity on **generating and reasoning between alternative strategies and ideas**, whilst the task is set up to enable the generating of alternatives as we will see the children do not really reason between these but become distracted by an imaginative narrative not anchored in mathematics.

In addition, drawing on the Possibility Thinking literature, the task was framed as 'possibility moderate': children were expected to explore what they could make with the shapes given certain parameters. Scaffolding was offered in the whole-class discussion that began the activity and through written activity prompts set up at each table in advance of the children starting work (see Image 1.1).

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Image 1.1: Table at the start of the lesson

Using the more general definition above however we do see evidence of the children's creativity. Interestingly, the curriculum suggests that children should use 'the correct language and vocabulary for shape' however Tobias and Caitlin used a number of different ways to describe the shape that they had made (Image 1.2). Caitlin points out, with justifications, to Tobias that the shape they have made was not a cylinder, having six sides, and so they named it a "*cylinca*". They inform Caroline of this when she asks what they have made, and their justification for it, demonstrating by touching all of the sides. Here we can identify **creative dispositions**, such as **sense of initiative**, **innovative thinking**, **imagination** and **reasoning skills**, all to be found in the List of Factors

Image 1.2: Tobias and Caitlin making their shape

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Within this episode, however, the most creative dimension was, perhaps, these two children's development of a narrative beyond the task. Their transformation of the activity towards developing an imaginative story around the transformation of the 'cylinca' into a 'house' (Image 1.3) takes them into other forms of creativity and not creativity within mathematics. So whilst we see them becoming **immersed** in the **'as if'** space of their narrative (drawing in others including the researcher), this is not, it could be argued, mathematical creativity. They do however mathematically explore together and manifest the following:

- Asking questions – '**What if…'** and **'what can I do with this**' – seen in both diversions
- **Play** – both are operating in an exploratory, playful fashion with respect to their own investigations
- **Problem-solving** – the problem is 'found' for them by the teacher's instructions however the children together chose one of these – make a shape with more than six sides - and then worked to solve it
- These children develop a **collaborative and communal outcome**

Image 1.3: The 'house' made from Polydrons

In terms of the synergies which the Consortium identified between mathematics, science and creativity (D2.2 Conceptual Framework, pp. 9-10), the children are demonstrating the following.

- **Play and exploration** – both in terms of using the Polydron shapes and within the narrative
- **High value of motivation and affect** – particularly in relation to the interpretation of their shape as a 'house'

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- **Dialogue and collaboration** – when discussing the nature of the shape, Caitlin's explanation to Tobias of his cylinder misconception, and when discussing the 'house' narrative
- **Problem solving and agency** – as a result of the way in which the task is constructed
- **Questioning and curiosity** – throughout the task
- (to an extent) **reflection** – in their feedback to Caroline towards the end of the lesson

Furthermore, the **teacher's scaffolding** is apparent in the task structure, and was visible throughout the lesson.

Episode 2: Caterpillar boots

Introductory comments

This lesson was described by the teacher as a 'problem solving' lesson and at the end of the week was a chance to practice or implement some of the mathematics that they had learnt early during the week. The children were presented with an relatively open-ended problem in which children were asked to find a way of dividing 100 into groups of 8, 4 and/or 6, using the context of a caterpillar's unwanted shoes being divided between spiders, lizards and butterflies. No restrictions were given on the task (such as having to give 'shoes' to all types of animal or, say having to give to a minimum number of particular animals.) This of course means that there are a large number of solutions to the problem.

Pedagogical framing

In her interview Caroline talks about the school as a whole having "*definitely made the effort to change how we teach and to take on board the fact that we need to be giving the children those opportunities to investigate rather than … just presenting information*"; she frames this problem-solving activity as a typical response to this challenge. Having a large number of possible solutions to the problem was an explicit aim of Caroline's; as she puts it, "*I was trying to make the point that actually we don't have to find all the possibilities, the challenge is in how we do it rather than getting the answer and I think a lot of our children think getting the answer is what we are looking for rather than any kind of exploration on the way*". Due to the nature of national testing, she felt that there could often be a preoccupation in the children with find 'the answer', with little acknowledgement that there may be more than one solution to a given problem. This is as much to do with parental pressure as anything else – as noted above, the school consistently achieves high scores in the national testing and there is a high expectation from parents on both the school and the children to continue this. As such, Caroline stated that she often tried to present the children with open-ended problems in order to make them more alert to the notion that mathematical questions do not always have a 'correct' answer. Again, this ties in with the teaching aims above of focusing on the strategy and planning more than the actual final outcome.

Pedagogical interactions

This was a whole-class lesson in which children were all working on the same task, but encouraged to talk with one another as they tried to work out their solutions. Caroline was meanwhile moving

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from table to table, scrutinising what children were doing and making regular interruptions to the class as a whole reminding the children that her emphasis here was on developing an appropriate approach, saying, for example: "Remember, I don't want to know what you're answer is, I want you to tell me what your strategy is", and then broadcasting from time to time what she is noticing about how children are tackling the problem, whilst engaging them in dialogue, for example, "*Laurie's spotted that if the butterfly's got six legs and the lizard's got four legs, together that makes ten, so Laurie's thinking that might be so that might be a way to start solving the problem because ten is a nice number… Would it just be one butterfly and one lizard Laurie*?" Encouraging children's talk was a particular emphasis throughout the school. Caroline noted in her interview that "*we [the teachers at Ridgeway Primary School] are trying to aim to talk for only nine minutes in an hour's lesson, so much less talk from us and more from them [the children]*". This might be the children responding to questions from the teacher, or in discussion with each other.

Opportunities for mathematics learning

During this narrative episode, we can explicitly identify particular aims from the 'Number' section of the curriculum, particularly from the 'Using and applying number' area. These would include those under section 1, 'Problem solving' and section 4, 'Solving numerical problems'.

Using and applying number

1. Pupils should be taught to:

Problem solving

a. approach problems involving number, and data presented in a variety of forms, in order to identify what they need to do
b. develop flexible approaches to problem solving and look for ways to overcome difficulties
c. make decisions about which operations and problem-solving strategies to use
d. organise and check their work

Solving numerical problems

4. Pupils should be taught to

a. choose sensible calculation methods to solve whole-number problems (including problems involving money or measures), drawing on their understanding of the operations
b. check that their answers are reasonable and explain their methods or reasoning.

(from http://www.education.gov.uk/schools/teachingandlearning/curriculum/primary/b00199044/mathematics/ks1/ma2 , accessed 8th March 2013).

The open nature of the task allowed children to make decisions about the best way to approach the problem solving activity, and the problem sheet that they had for the lesson (see Image 2.1) allowed them to use whichever calculation method they felt most appropriate – there were a wide variety of

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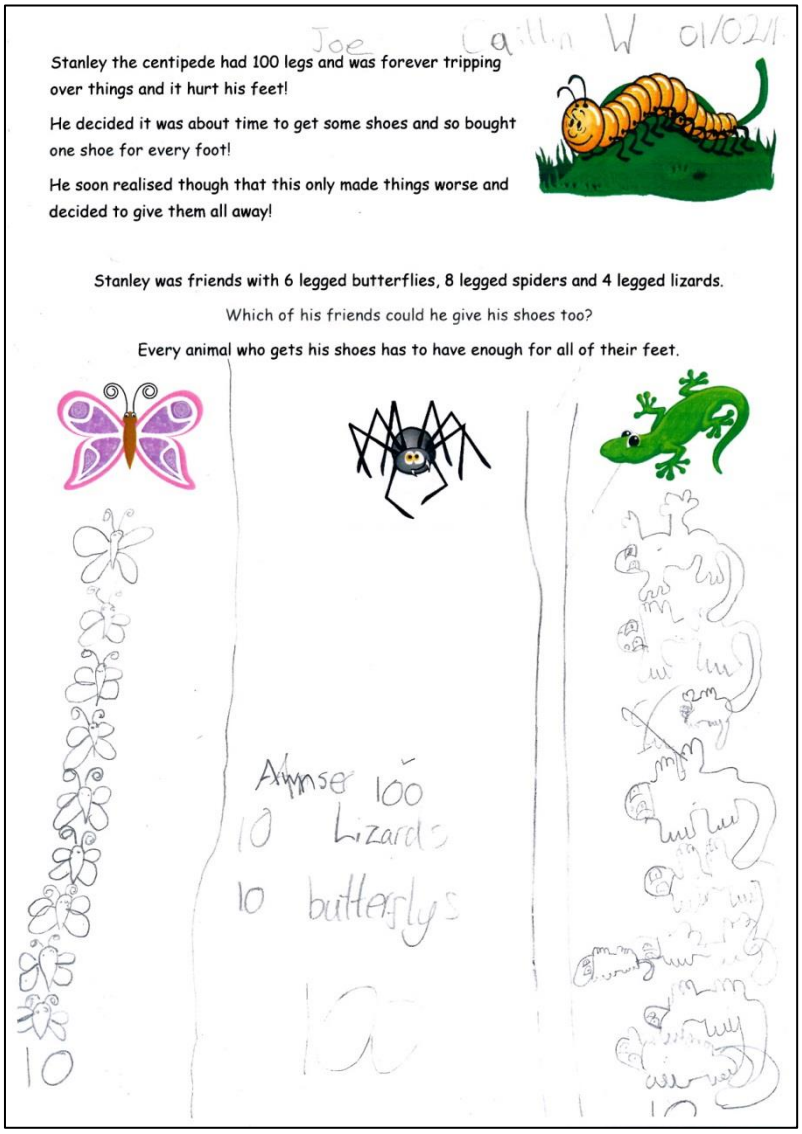
different responses and answers from the children (e.g. Image 2.1) with some children using multiplication, some children using repeated addition, some counting back from 100 and finally one pair noticing that the $8^2 + 6^2$ totalled 100 (though not expressing it in quite this way). The children were also allowed to represent this how they felt was most appropriate and, as the pictures show, a number of different approaches were used, including drawing pictures of the animals as well as writing out the various forms of calculation.



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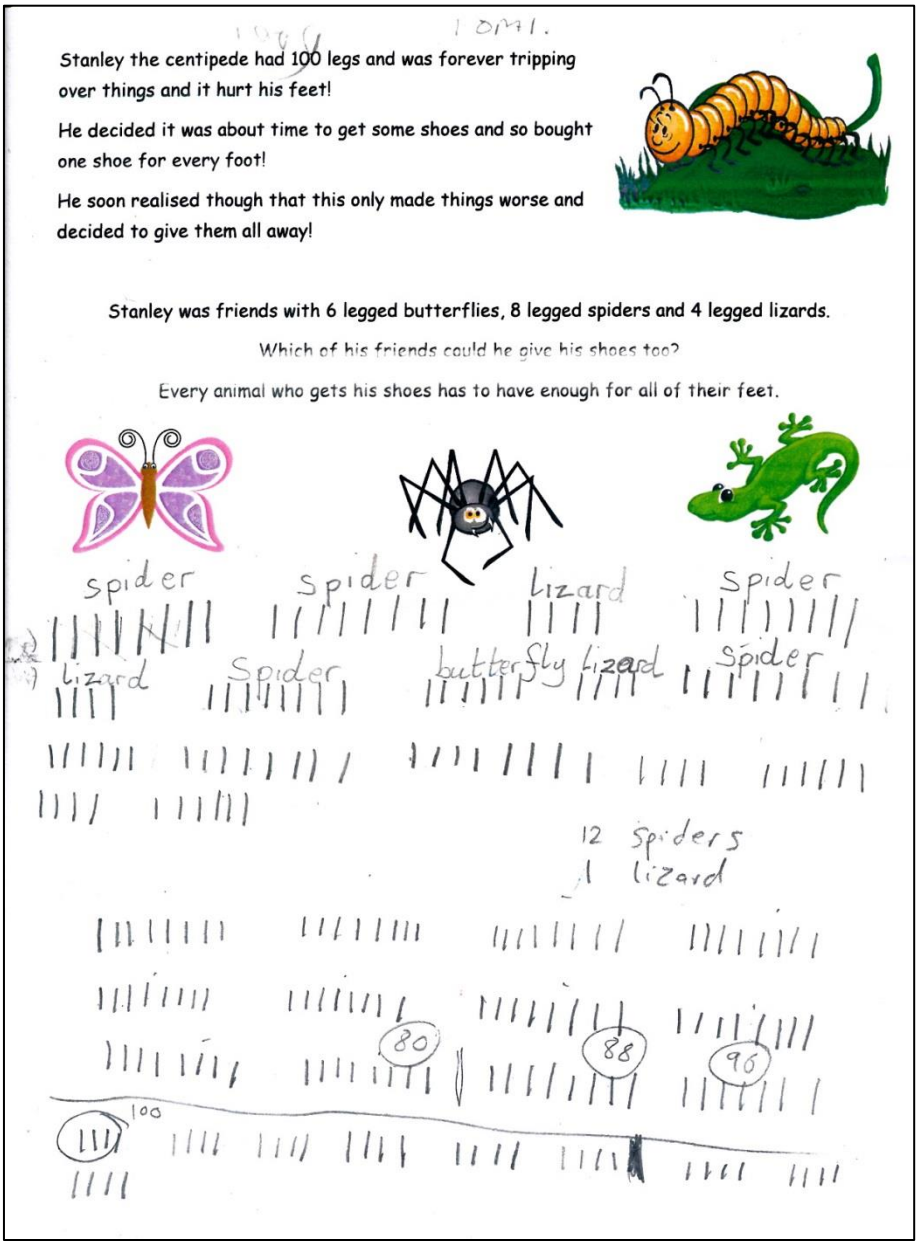

Stanley the centipede had 100 legs and was forever tripping over things and it hurt his feet!

He decided it was about time to get some shoes and so bought one shoe for every foot!

He soon realised though that this only made things worse and decided to give them all away!

Stanley was friends with 6 legged butterflies, 8 legged spiders and 4 legged lizards.

Which of his friends could he give his shoes too?

Every animal who gets his shoes has to have enough for all of their feet.

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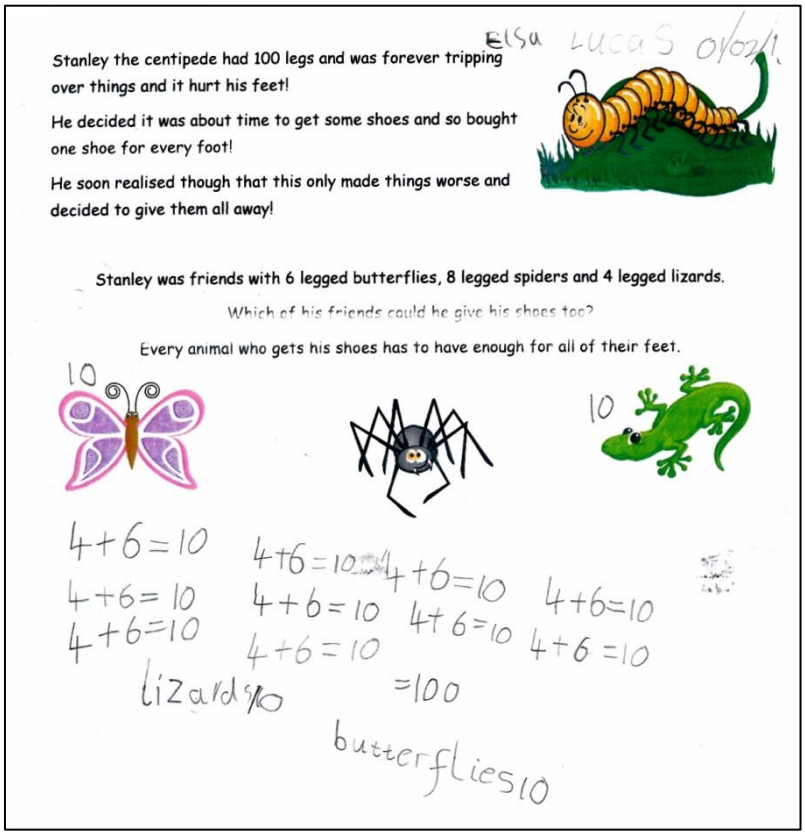

Image 2.1: Three examples of worksheets

As noted above, there was ample opportunity for discussion/collaboration. The children could therefore be seen to be fulfilling a number of different areas of mathematical activity in line with the national mathematics curriculum appropriate to the age level.

Opportunities for creativity

In contrast to the other activities identified, where one main episode of creativity could be identified and explored for analysis, within this activity can be identified a number of shorter instances of children's creativity, facilitated through the teacher's pedagogy. As noted above, there were a number of different ways that children approached solving the problem, and how they represented their workings and findings. What is identified here is how the pedagogical interventions identified in the lesson provided the opportunity for different children to manifest creativity in their mathematical activity in these different ways. Thus rather than describing one instance in detail, it is more appropriate to discuss the overall pedagogy.

In this example, Caroline provided the children with a problem solving exercise that had a wide range of possible outcomes. Caroline welcomed the wide **range of responses** that had been generated by the children and indeed encouraged children to come up with their own strategies in order to solve the problem and the different ways of representing the outcomes. The emphasis of the lesson itself was not so much on the children's answer per se, but on developing these problem solving strategies. As such, teaching led to a wide range of **outcomes** from the children, each

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original, meaningful and personally **valuable** to its author(s) – all features discussed as pertinent to creativity in the early years in the earlier *Creative Little Scientists* work.

Caroline had suggested in the interview that the children in her class were "*possibly the sort of children who maybe don't have to solve problems regularly themselves, [and] also… the type of children that don't like to get things wrong*". As such, the use of problems that have multiple answers and the valuing of multiple forms of expression was an explicit attempt on Caroline's part to attempt to **enhance children's attitudes towards mathematics**, particularly towards **inquiry-based** or **problem-based learning** by providing them with an environment in which they are allowed to make mistakes and recognise that there is not always a 'right answer'. Indeed, this emphasis on strategies was a feature of her teaching. As has been discussed previously, Caroline plans activities to specifically include **collaboration** between children as this is one of the skills that she feels the children need to develop. This could be seen in this activity, where children were working in ability-determined pairs. All these features; enhancing attitudes, focus on inquiry-based learning and fostering collaboration, are factors listed within the *Creative Little Scientists* literature as important to creativity and science and mathematics education. Collaboration together with the nature of this task, facilitated mathematical creativity as defined in the Conceptual Framework for Creative Little Scientists, in other words, the **generating of alternative ideas and strategies as both an individual and a community, and reasoning critically between these.**

There was less emphasis on developing the specific mathematical knowledge in this task. Caroline discussed in the interview how the knowledge levels of the children were, in the main, above average, therefore her role in this was more scaffolding the development of strategies rather than direct teaching of mathematical facts. She aimed to provide a **safe environment** for the children to operate in.

3.7.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years? What role if any does creativity play in these?

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics? How do teachers perceive their role in doing so?

In the lessons observed, a number of themes emerged that might characterise teaching and learning approaches. Caroline noted in the interview that she felt that the children in the class were, on the whole, reaching expected standards in their scientific and mathematical knowledge, however they were less adept in their investigative skills. She felt that her class were all confident in their knowledge levels, particularly in science, meaning that "*a lot of the knowledge objectives aren't that challenging for them because it was things they could easily identify*". In order to engage the children and develop the learning then, Caroline suggested that she would try to focus on more investigative aspects of science and mathematics. Throughout the observed lessons, there appeared

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to be an emphasis on developing investigative skills such as **planning** investigations, **using equipment** and **observing and recording** the outcomes through **inquiry or problem based learning**. However, these activities were highly **scaffolded** by Caroline as she sought to support them in their development of their investigative skills.

Helping children to **develop strategies** appears to be an important part of her teaching

While these activities were strongly scaffolded, there did appear to be opportunities for the children to be creative, as Caroline provided children with the **time and space** and a **safe environment** to make predictions, experiment and to potentially 'be wrong', rather than setting up activities that focused on obtaining a 'correct' answer. Caroline's teaching, and indeed the school's curriculum, therefore was very much focused around the children's needs, and encouraging them to develop those skills in which they perhaps lacked confidence.

There was little evidence of assessment in the lessons observed. In the interview, Caroline did discuss how much of the assessment in **science was formative**, since standardised national testing in science had been abolished. Nevertheless, as implied in the interview in which she stated that "*looking at knowledge, all of the children are achieving*", there is an (albeit tacit) admission that teachers do refer to and record standards that children have attained.

In contrast, **mathematics** is still very much formally assessed in national tests, and therefore there was a definite emphasis on **summative assessment**. Pencil and paper mental arithmetic and multiplication tests were observed as part of the mathematics lesson 'warm ups' and these were used to track children's progress and abilities. This then informed **grouping**, as children were grouped according to ability in mathematics lessons (though this was not the case for science.)

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3.8 Case: 'Linda'

3.8.1 Context

Where?	Country	England			
	Setting name	En4 - Ridgeway Primary School			
	Location within setting	Primary School			
Who? (children)	Year group/age of children	Year 1 – aged 5 – 6			
	Number of children in class	29 children in whole class group; two particular children focused on for Episode 1.			
Who? (adults)	Number of adults	2			
	Role of adults	One class teacher, one Learning Support Assistant (often working with specific children, or taking small groups aside to work on literacy skills)			
	Case teacher role	Lead teacher, sole responsibility for the class			
When?		1	2	3	4
	Dates of visits	210113	010213	130213	010313
	Times of visits	Morning	Morning	Afternoon	Afternoon

School / Setting

Ridgeway Primary School is a large, popular and over-subscribed primary school for children aged 3-11, organised into two parts: the pre-school Foundation Stage Unit for children aged 3-5 (90 children) and the main primary school for children aged 5-11 (262 children). The school, which occupies a large, well-resourced site with good indoor and outdoor facilities (including a full-sized playing field shared with the neighbouring secondary school) is situated in an affluent town around thirty miles north of London. Recognised as outstanding by Ofsted (2006), 98% of 11 year olds having attained level 4 in both English and mathematics for the previous three years, children in the school with statemented special educational needs (2%) and those eligible for free school meals (10%), are below the national average.

The school has long been committed to creativity, particularly arts-based, is recognised as offering outstanding music education (Ofsted, 2006) and has been researched for its creative teaching and learning (eg Craft et al, in press). In mathematics, staff lead other local primary schools in extension activity for the most able pupils in the top years, using investigative approaches to exploring mathematical ideas. In relation to science, the school foregrounds the practical investigation of living things and life processes, properties of materials and physical processes; these are undertaken

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outdoors as appropriate. An annual science and environment week involves workshops, speakers and competitions. The school has links with a nearby experimental agricultural site.

Children's learning is enhanced by over 90 networked computers with internet access, interactive whiteboards and other digital media. Children actively contribute to the school's website. The school actively holds awards including Eco School, Active Mark award, Healthy Schools and Green Tree.

Teacher

Linda has taught this age group for many years in this school, and in the last two years or so has begun to offer learning opportunities that have greater potential for children to follow their fascinations. This builds on what the Foundation Stage (3-5 year olds) unit within the school has been seeking to do, as the children Linda teaches move into her class straight after their experience in Foundation Stage so a more open approach in Year 1 offers greater continuity in approach and expectations. Having said this, Linda indicated that the prospect of becoming involved in the project had made her more aware of her teaching practice and as a result, had perhaps angled her teaching more towards science investigation than previously, stating that she had tried during the data collection period to "*focus a lot on their investigative skills which we haven't done so much of that in the year, it's been a lot of… learning facts about things, but less about them finding out about things themselves*". In common with other teachers who we worked with, Linda was very positive about the experience of her classroom and her practice acting as a research focus, suggesting this experience had encouraged her to use investigations more often in her teaching, and particularly in science. Being aware of what *Creative Little Scientists* was aiming to document, had prompted her to "*Try to make science a little bit more open… although that's is a general target really for all of us [the teachers at this school] in our lessons throughout the curriculum*" and to *"think a little bit more now about more open ended questions and getting [children] to think through something a little bit more carefully"* in other words to focus a little more on the scientific creativity that *Creative Little Scientists* sought to document ("'generate alternative ideas and strategies as an individual or community, and reason critically between these", as given in the *Creative Little Scientists* Conceptual Framework).

Classroom

There are 29 children in Linda's class which includes an art, craft and design area as well as a more formal area containing a number of tables at which several children can sit at once and a carpeted area. Children all sit at designated tables during the day and work in pairs or small groups that are determined according to ability in mathematics (as determined by in-school, quantitative testing such as arithmetic or multiplication tests). Grouping in science is usually done by friendship groups, (though this often this resulted in groups being of similar ability.) The classroom is well resourced, with a reading corner, a role-play area, and four PCs (plus one for the teacher). In common with all classrooms at Ridgeway Primary School, there is an interactive whiteboard, as well as a regular whiteboard on the opposite wall. There are displays of the children's work throughout the classroom, particularly reflecting literacy work (such as poems) and art, as well as numeracy and literacy prompts, such as multiplication tables and the names of regular shapes. There is one full-

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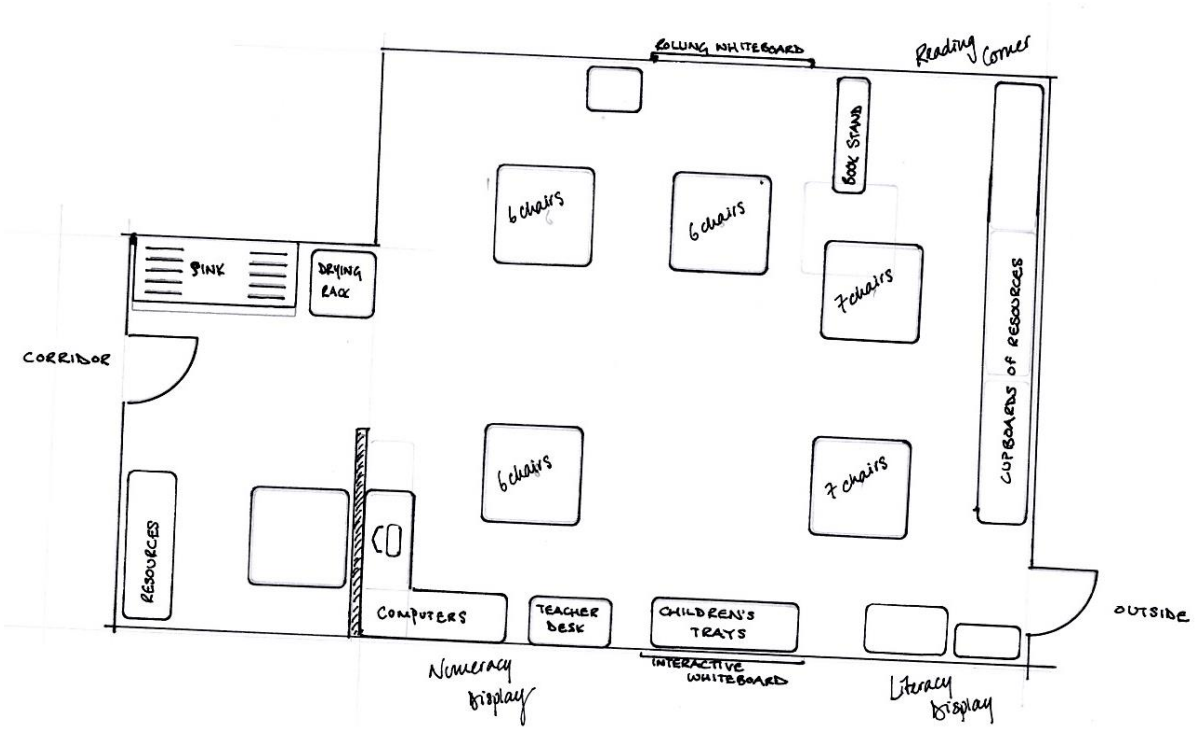
time Learning Support Assistant (LSA) who works variously on a one-to-one basis with specific children with identified learning needs during class time and also with small groups (three or four children) on literacy and numeracy skills who are deemed by the teacher to need extra help. During such small-group support sessions, these children usually work on a separate activity from the rest of the class and work on a small table just outside the main classroom space (see classroom map below.) One wall of the classroom contains a door which gives direct access to a grassy outdoor area where there is play equipment as well as garden in which children can grow plants. The other wall gives direct access to a wide school corridor containing a cloakroom in which children can store coats, shoes and gym equipment.

Map of Linda's classroom



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3.8.2 Episodes

There are two episodes offered for this case.

Episode 1: Straw flutes

Introductory comments

This activity from which this episode is drawn formed part of a class topic on Sound lasting several weeks. This topic incorporated a number of curriculum areas aside from science indicated above: information and communications technology, mathematics, music, literacy. The activity initiated by the teacher, and involved children working in groups at tables to investigate what would happen to the sound made by blowing through a straw 'flute' when the straw length was altered by being cut.

The children worked in parallel pairs on their own personal investigation (which they each plan in writing before starting the practical work and then discuss with their partner as they work) for an hour, interrupted by two whole-class discussions on the carpeted area of the room about the focus of this work and the way the children were each approaching it and various shorter instructional interludes. The children were to make 'straw flutes' by flattening one end of a straw and cutting the end into a point. Making another short cut down the length of the straw would create a reed-like effect when was blown down the cut end, vibrating to produce a high-pitched noise. The aim of this activity was for the children to investigate the different sounds that different length straws would make. They had to make a **prediction**, **describe the method** that they were going to use (either in word form or in pictures) and then **carry out their investigation**.

The main focus of the episode offered here became two children, Sarah and Julian, who moved off the main task onto their own other, personal, investigations.

Pedagogical framing

In common with other teachers in the school, Linda sought to make curriculum links in learning; as she put it during her interview, *"we think about where we could make links".* At the time of the visit, the over-arching topic for the class was 'Sound', into which a number of curriculum areas were integrated: ICT, mathematics, science, literacy, music. She values inquiry-based science education and tries to encourage children to investigate their hypotheses, seeking always to balance children's ideas with some whole-class guidance; once children are working on their investigations, she sees the role of the teacher as one who prompts children to *"think about [their] ideas".*

This activity was framed as a whole-class lesson with a whole-class discussion with the children sitting together on the carpeted area of the room in which the goal of the activity is introduced. Linda emphasised to the class the importance of writing out an investigative plan containing a hypothesis and instructions. She recognised that drawing is helpful for this as well as writing and emphasised that in scientific drawings, labels are important. The children then moved to their tables to begin the investigation and as the children worked on their investigations Linda moved from table to table, occasionally stopping the class to ask a question or to point out to the class as a whole what one particular child or pair has been doing. She talked in her interview about

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importance of regularly focusing the class as a whole whilst such investigations are going on: *"I find that works quite well, bringing them back and then sending them off again".*

Pedagogical interactions

During the episode involving Sarah and Julian below, it can be seen there was in fact very little interaction with the class teacher; where there is adult-child interaction this is mainly with the researcher who was sitting at the same table as the children.

Sarah and Julian worked alongside each other helping each other with the practicalities of the task:

S: "Shall I do the cutting bit? I'll do the cutting bit OK?"
J: "No we're both goin' to do the cutting bit."
S: "So you can cut one point off and I'll cut another point."
[… they help one another on the technical side]
S: "Oh I forgot how to do it."
J: "Oh let me help"

Fairly soon after this both children began, without discussion with one another, to explore their own pathways. It was only through conversation with the researcher that it became clear what they were doing. For her part, Sarah began to look at how she could fasten two flutes together (Image 1.1).

Image 1.1: Sarah joining two straws together

Julian meanwhile began to fill one straw with lots of tiny pieces that he had cut off (Images 1.2 and 1.3), his reasoning being that he wanted to silence the flute as there was so much noise in the room. He predicted that his flute would make no noise if blocked up and in discussion with the researcher then said it would be too loud if he did blow it so he did not wish to: "*it makes quite a loud sound…. You can't hear mine because I don't want to hear it because the noise is so loud".* Linda was surprised about this afterwards as Julian is not known to be sound-sensitive; listening to the

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recording however there was a lot of sound in the room with thirty children blowing three lengths of flute each to investigate the sound made.

Julian, despite having moved 'off task' during the investigation, noticed before the end of the lesson what others at his table had written as their predictions and altered his own to say something very similar ('the sond [sic][will] get softer' as the straw gets shorter).

Image 1.2: Julian cutting off small pieces of the straw

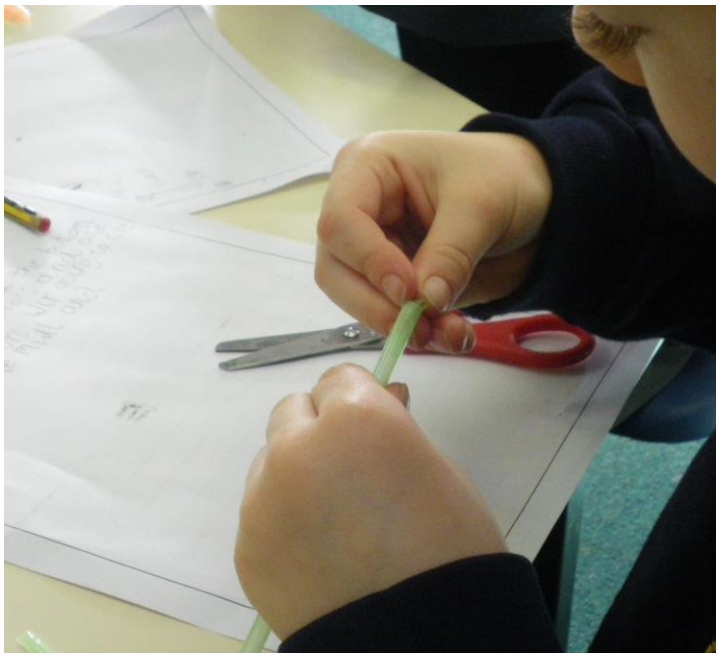

Image 1.3: Julian filling the straw

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As Sarah and Julian worked, they were in discussion; Sarah seemed particularly focused on the way they have responded to the task, and seemed concerned about what Julian has done since by filling his flute with small pieces of straw, it could make no sound at all. The interchange between the children included the following:

S: *"Pushing out small pieces from J's straw flute, now trying to make his work."*
J: *"You can't hear mine cos I stuck things into it cos I don't want to hear the noise – it's so loud"*
S: *"You have to Julian – you can't… please…"*
J: *"It's only all the bits…. Oh that's all…"*
S: *[laughs – emptying his flute of all of its pieces]*
J: *"No I like it like that … may I have back Sarah now please… I actually did make this."*

Julian several times reiterates the need for quiet and in this interchange the children seemed to be vying for the role of learning leader, in defining the scope and point of the task.

As the groups worked at their tables, Linda was moving around the classroom space discussing children's hypotheses and experiments with them. At the end of the lesson she invited a whole-group discussion in which Julian was one of the first children to raise his hand to share his experience, giving coherent and convincing explanations of his actions, their outcomes and why his straw made no noise, responding positively to his teacher's reminder about the focus of the lesson, with an explanation about why his straw would make no sound at all in response to his teacher's question:

T: *"So why didn't the sound come out then … why didn't you hear anything?"*
J: *"cos these were stopping it"*

Opportunities for science learning

There were a number of areas of learning that could be observed in the 'straw flutes' lesson, summarised as

- **Developing a hypothesis** to be investigated
- **Practical investigation** of hypothesis
- Use of senses (sight, hearing) to **observe** these changes
- Using an (experimental, scientific) method – predict, test and review

Comparing this to the National Curriculum, a number of objectives can be identified, both from the skills and content areas of the curriculum. Here, 'Sc1' refers to skills-based objectives, while 'Sc4' relates more to content-based objectives.

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"Knowledge, skills and understanding

Ideas and evidence in science

1. Pupils should be taught that it is important to collect evidence by making observations and measurements when trying to answer a question.

Investigative skills

2. Pupils should be taught to:

Planning

a. ask questions [for example, 'How?', 'Why?', 'What will happen if ... ?'] and decide how they might find answers to them
b. use first-hand experience and simple information sources to answer questions
c. think about what might happen before deciding what to do
d. recognise when a test or comparison is unfair

Obtaining and presenting evidence

e. follow simple instructions to control the risks to themselves and to others
f. explore, using the senses of sight, hearing, smell, touch and taste as appropriate, and make and record observations and measurements
g. communicate what happened in a variety of ways, including using ICT [for example, in speech and writing, by drawings, tables, block graphs and pictograms]

Considering evidence and evaluating

h. make simple comparisons [for example, hand span, shoe size] and identify simple patterns or associations
i. compare what happened with what they expected would happen, and try to explain it, drawing on their knowledge and understanding
j. review their work and explain what they did to others."

In the straw flutes lesson then, it is possible to identify features of the lesson that address a wide variety of curriculum areas, including 1 and 2f, (use of senses), 2a and 2c (Developing a hypothesis) and 2i (comparing what happened with the prediction, and trying to explain this). The planning sheets were intended to help children focus this scientific thinking.

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Image 1.4: Sarah and Julian planning their investigations

Within Sc1, the curriculum states that "Teaching should ensure that 'scientific enquiry' is taught through contexts taken from the [content-based, Sc4] sections on 'life processes and living things', 'materials and their properties' and 'physical processes'." (see link below) In this lesson, we saw activities from the 'Materials and their properties' area of Sc4 – more specifically, the objectives within the 'Light and sound' area can be identified. These are outlined below:

"Light and sound

3. Pupils should be taught:

Making and detecting sounds

c. that there are many kinds of sound and sources of sound
d. that sounds travel away from sources, getting fainter as they do so, and that they are heard when they enter the ear."

(Sc1 from http://www.education.gov.uk/schools/teachingandlearning/curriculum/primary/b00199179/science/ks1/sc1, Sc4 from http://www.education.gov.uk/schools/teachingandlearning/curriculum/primary/b00199179/science/ks1/sc4, both accessed 12 March 2013)

The content of the straw flutes lesson (in addition to other lessons throughout the term not observed but discussed informally with Linda) appears to be addressing sections 3c and 3d in Sc4. The emphasis on developing knowledge of **science knowledge** through **practical scientific inquiry** was a feature of this lesson. For this lesson, each child **planned their investigation** in writing before starting the practical work and was required to discuss with a partner as they worked for the hour-long lesson. However, the investigation was determined by Linda before the start of the lesson, with prescribed equipment (see Image 1.4). While children were to plan out their investigation before starting, there was an expected method that the children were expected to use, and thus the

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children's answers were expected to be variations on the same version. This example then should be described more as **guided investigation**, rather than a truly open investigation.

Interestingly, despite this apparently guided approach to the investigation, children's hypotheses were all valued by Linda. In this class, science is very much seen as a **subject** that is **independent**, that is, it is not integrated with other areas of the curriculum such as mathematics or literacy. There appears to be a strong **fit to school policy**, rather than any use of commercial textbooks.

Opportunities for creativity

The guided nature of the task was pre-defined, and may be classed as 'possibility narrow'; children were expected to do particular things in this activity and to work on their own in a structured way with a very limited range of things to change (i.e. length of pre-assigned straws). **Scaffolding** was given both in two whole-class discussions and also through the individually focused worksheets (Image 1.4).

Within the episode described, what was creative was, arguably, Sarah and Julian's shift away from the task and each in their own way seems to evidence the *Creative Little Scientists* definition of creativity as **imaginative purposive activity** with **original** and **valuable outcomes**; each also seems to evidence the definition of scientific creativity which the project discusses in the Conceptual Framework, i.e. the **generating of alternative ideas and strategies and reasoning critically between these**. During both diversions the children seemed to be making creative connections, Sarah in lengthening her shortened straws and Julian in exploring the impact of small particles on sound.

- **Immersion** in the task –Sarah and Julian each become immersed in their own investigations
- Asking questions – '**What if…'** and **'what can I do with this**' – seen in both diversions
- **Play** – both are operating in an exploratory, playful fashion with respect to their own investigations
- **Problem-finding and problem-solving** – both children identified their own problems and tried to solve them
- In identifying their own investigations each of these two children seemed define their own sense of **relevance** in the experience they engaged in**, control** over its articulation, a feeling of **ownership** over their learning, and opportunities to **innovate**
- These two children seemed largely **intrinsically motivated** toward their own investigations
- The children work in parallel with one another so individually but as they remember the task in hand, move back into a collaboration, which includes others as appropriate (Another child, Lara (pseudonym), joins them at the end of the session as her partner has gone to read to a teaching assistant and Sarah initiates the discussion by saying "*so let's hear Lara*")

Episode 2: Outdoor sounds

The aim of this activity was to further develop children's understanding of the principles of sound. The learning objective for the lesson or "WALT" ('We Are Learning To') was to "Understand that

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sounds travel away from sources", directly reflecting one of the content aims of the national curriculum. As was discussed in teacher interview, Linda was throughout the data collection period trying to approach science and mathematics teaching from a more investigative-type approach and this was apparent here. Children were to conduct an investigation outside into how sounds became fainter as they moved away from the source. The children spent the first 16 minutes of the lesson sat on the mat in the classroom in a whole-class discussion with Linda. Here they discussed the activity and made some predictions about what might happen moving away from the source of a sound. The children suggested a number of different answers, including "longer", "lower" and "quieter". Children were then paired up and encouraged to discuss how they might approach the investigation. Children were given approximately three minutes for this. The children then moved to the outside covered area. Working in pairs, one child would make a noise – clicking fingers, rustling tissue paper, humming – and the other in the pair would write down what happened as they moved away. The noises that the children were to make had been pre-planned by Linda, and chosen as ones that would become noticeably quieter as the distance increased. The children were to then record their observations in a table that they had been given before they went outside. Following these three observations, the children were then allowed to choose an instrument from a box and repeat the investigation. Instruments here included maracas, triangles, drums and tambourines. Linda described the investigation and its outcomes in the interview.

> *"Today with the investigation, again [I was] trying to make it a little bit more open… I was thinking yesterday about sounds and… I obviously didn't want them to go miles and miles away from each other so I need some quiet sounds, reasonably quiet sounds… I wanted to kind of structure it a little bit but then maybe get them to choose some of the sounds they wanted to use or, the way they wanted to do it, yeah so and recording as well… I have had a quick look at the their sheets just now, some of them it is quite, they know what they mean, they were trying to explain to me what they mean but that will need, yeah a little bit of kind of talk maybe, feedback from me to them in the next session about what they found out and what they meant."*

The children then returned inside and sat on the mat to discuss their findings as a whole group, with children asked to tell those around them what they found and then selected children reporting back their findings. This provided Linda an opportunity to review their findings and formatively assess the children. For example, she was able to address some misconceptions or confusions regarding language, correcting children on their use of 'lower' instead of quieter – "*Got lower? Are you sure that's the word you want to use?*" – one the Linda suggested in informal conversation was a common misconception that she felt might have had something to do with volume controls.

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Image 2.1: Linda working with children outdoors

Pedagogical framing

It was clear from the 'WALT' at the start of the lesson that there was an emphasis on developing or reinforcing children's **knowledge and understanding** about sound. While there was a certainly an observable emphasis on investigations, this emphasis on what might be termed '**science facts**' was certainly present. Additionally, it appeared that an additional aim, particularly over the course of the observation period, was to develop the **problem solving skills** involved in children's **investigations** through the use of inquiry-based education and problem-based learning. It was apparent through the structure of the lessons that Linda was attempting to develop children's ability to conduct scientific investigations through providing carefully considered **scaffolded** activities. Linda also repeatedly noted the importance of **fostering children's interest in science** and develop **positive attitudes**. She suggested that children at this age "*love finding out things*" and as such science teaching was about "*just getting them interested, get[ting] them involved and engaged.*" As with much of the teaching and learning seen in the school, there was an emphasis placed on **collaboration** and developing children's ability to work together, as seen by children worked in pairs (Image 2.2) or small groups in many of the activities observed over the course of the observation period.

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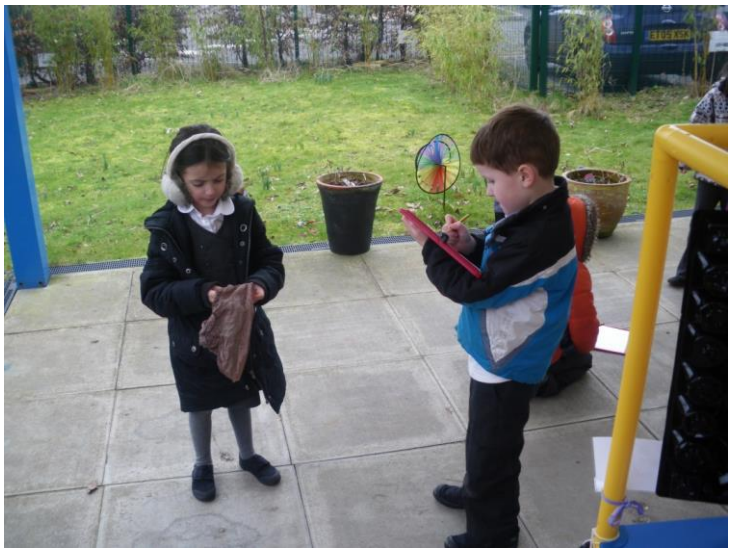

Image 2.2: Children working in pairs

Pedagogical interactions

The activity that had been set up for the children allowed for a number of learning activities to undertake a number of learning activities. As part of the school's effort toward a more investigative approach to science teaching and learning, children were encouraged to (verbally) **plan** their investigations in the classroom before undertaking them under the outdoor covered area. **Gathering evidence** through using the senses was a central part of the investigation, as was **recording** these observations in a formal way. Children were to describe the events that they observed in words (Image 2.2 and 2.3) and, once inside were encouraged to **communicate** their findings either with the class as a whole, or with one another. As noted above however, the learning intentions for the lesson indicated that learning **scientific concepts** and facts was a key part of the lesson. As such, it is possible to suggest that children drawing **connections** with previous knowledge learnt during the term. This is particularly the case given that this episode links in with the straw flutes episode observed earlier in the observation period.

Linda explicitly stated in the interview that the children were "*so keen [in] this little class, they love finding out things, they go home and they do things off the back of what we have done in school*". As such, there was less an effort to increase or enhance children's attitudes towards science, rather to continue and foster this enjoyment and interest. To this end, Laura appeared to be moving towards providing activities that were "*this kind of practical activity outside and more open ended, something where they can talk to their friends and think a little bit more, 'what do I want to do here?' you know gets them, gets them involved and engaged.*" Such **engagement** and **self-agency** within the task was a feature of the pedagogy observed in Linda's classroom. The way in which lessons were structured, with a period of time devoted to **planning** the investigations, and a period of time for **reflection** on the results appears to be developing their independence of thought and metacognitive capabilities.

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Opportunities for science learning

The observation highlighted a number of avenues in which science learning could be observed. Firstly, there was the factual **knowledge** about the nature of sounds, as highlighted by the learning objective for the lesson (repeated above). This explicitly relates to the science curriculum, with the learning objective using the language used in the National Curriculum documentation. Section Sc4 from the National Curriculum is set out below:

> **"Light and sound**
>
> 3. Pupils should be taught:
>
> Making and detecting sounds
>
> e. that there are many kinds of sound and sources of sound
> f. that sounds travel away from sources, getting fainter as they do so, and that they are heard when they enter the ear."

(from http://www.education.gov.uk/schools/teachingandlearning/curriculum/primary/b00199179/science/ks1/sc4, accessed 12 March 2013)

As it is possible to see then, the learning objective ('understand that sounds travel away from sources') is directly taken from **policy documentation**. This emphasis is typical at Ridgeway Primary School where there is, as noted, a strong emphasis on national testing and sustaining the high standards attained in these.

In addition, and in line with Linda's attempt to develop children's problem solving skills, it was possible to observe a number of investigative approaches in the science teaching and learning. These would include;

- **Practical investigation** of an phenomenon (in this case the emitting of sounds from a source and how they change)
- Use of senses (sight, hearing) to **observe** potential changes
- Using an (experimental, scientific) method – predict, test and review.

Each of these, particularly the first and third, was scaffolded by Linda, who aimed to support the children's development in these areas (see Image 2.1). When considering more general, investigative skills in the curriculum, it is possible to identify the above in the documentation. Below is section Sc1 from the National Curriculum for science, which focuses on the more skills-based side of science.

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"Knowledge, skills and understanding

Ideas and evidence in science

1. Pupils should be taught that it is important to collect evidence by making observations and measurements when trying to answer a question.

Investigative skills

2. Pupils should be taught to:

Planning

a. ask questions [for example, 'How?', 'Why?', 'What will happen if ... ?'] and decide how they might find answers to them
b. use first-hand experience and simple information sources to answer questions
c. think about what might happen before deciding what to do
d. recognise when a test or comparison is unfair

Obtaining and presenting evidence

e. follow simple instructions to control the risks to themselves and to others
f. explore, using the senses of sight, hearing, smell, touch and taste as appropriate, and make and record observations and measurements
g. communicate what happened in a variety of ways, including using ICT [for example, in speech and writing, by drawings, tables, block graphs and pictograms]

Considering evidence and evaluating

h. make simple comparisons [for example, hand span, shoe size] and identify simple patterns or associations
i. compare what happened with what they expected would happen, and try to explain it, drawing on their knowledge and understanding
j. review their work and explain what they did to others."

As with the previous episode described, many of the investigative skills outlined in section Sc1 of the National Curriculum can be seen to be developed in this episode, such as 'Using first-hand experience and simple sources to answer questions', 'think about what might happen before deciding what to do' (as seen by the discussion on the mat before leaving the classroom) and 'explore using the senses… and make and record observations and measurements' (as seen on the investigation sheets, Image 2.3).

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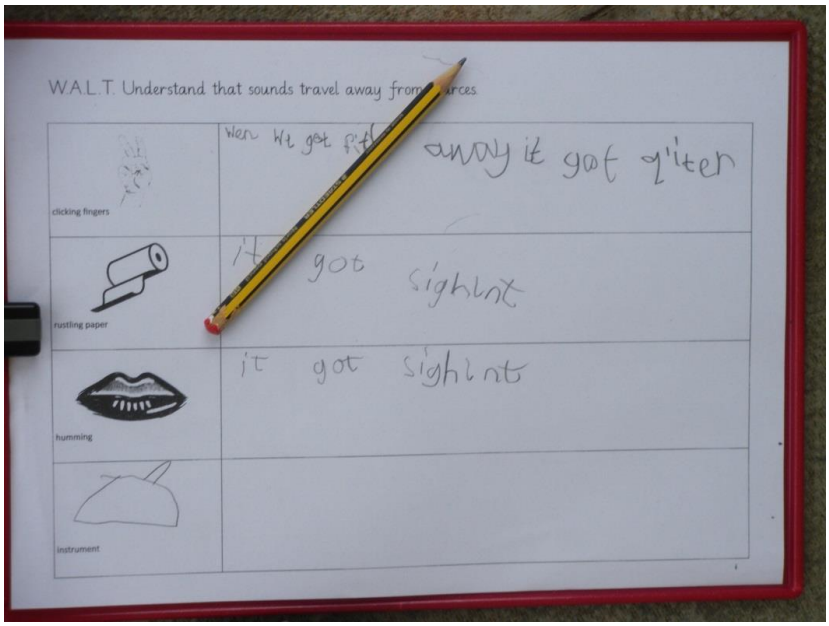

Image 2.3: Investigation sheet

Opportunities for creativity

As with the Straw Flutes described above, there appear to be a number of opportunities for creativity. The remit for this investigation was slightly broader than the Straw Flutes one, with children allowed to choose some of their own sound-making devices to test towards the end of the activity, rather than being prescribed in advance. Thus while creativity occurred in the Straw Flutes episode, this occurred through what might be described as a push back against the remit of the investigation, here there is more scope within the initial borders and boundaries of the learning activity.

Children were then able to, and indeed encouraged to extend the problem beyond the initial WALT and incorporate mathematical activity – measuring the distance before the sounds that were made because inaudible. This prompted a discussion about the most appropriate way to measure the distance. While Linda had brought from the classroom a number of metre-rules, there were other ideas suggested by the children. These included (the less scientific approach) "*just look*" to more innovative and imaginative approaches to measuring, such as one child suggesting that they may a measuring tape by "*Get some string and write some numbers on it and see how far it is*".

When looking to features of creativity present within this episode, we can identify a number of the characteristics that have been associated with mathematical/scientific creativity by the *Creative Little Scientists* project, as they engaged in generating alternative ideas and strategies together and reasoned critically between these ideas and strategies. The activity also fostered the children's engagement in generating imaginative valuable ideas. In addition:

- Children were **immersed** in their own investigations and focused on finding solutions to both the set task (that is, the sounds suggested to them) and to the self-chosen instrument

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- The children could all be seen to be involved in explorative **play**, playing with ideas, concepts and approaches to the task. Indeed, the children each appeared to be taking different approaches to the task. Some pairs were seen to be edging away from one another in order to see what happened gradually, while others started close then immediately went far away. Children were therefore allowed to find their own way of problem solving.
- The children all seemed to be interested in and **motivated** towards the task – indeed this was a particular aim of Linda's (and one apparently achieved), who suggested that developing interest and enjoyment, "*getting them engaged… just making science interesting*" was a major part of teaching at this age group
- **Imaginative** and **innovative** approaches to measuring distance

3.8.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years? What role if any does creativity play in these?

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics? How do teachers perceive their role in doing so?

Although this was not observed, as noted at the start of this case study Linda did indicate in the interview that she had spent an amount of time earlier in the term focusing on teaching science and mathematical facts, while the observations saw more **problem-based, investigation-learning**, with Linda adapting her teaching approach in order to "*try and think a little bit more now about open-ended questions*". It may therefore be slightly disingenuous to fully characterise the teacher as necessarily using problem-based learning as the main means of teaching, despite this being the approach most often seen during the research visits. Furthermore, it was not possible to ascertain the extent to which these investigations were reinforcing established knowledge or, alternatively, how far this was genuine problem-based learning. That is to say, the themes of the science experiments tied in with the overall theme for that half term (sound), but it was not initially clear from the practitioner how much had been of this science content had been taught in other contexts – that is to say, while Linda suggested that "*it has been a lot of learning facts about things but less about them finding out things for themselves*", it appeared that the investigations observed were as much about enabling the children to consolidating existing knowledge as it was about building new knowledge through inquiry.

As with the other Case teacher in this same site, children's **collaboration** in Linda's science and mathematics lessons was a frequent occurrence. Children worked in small groups or pairs, from the start of activities and were happy to change/join groups as appropriate. This collaboration did not appear to be ability-matched in science, though children were grouped according to ability in mathematics.

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Linda stated that particularly important for her teaching was "*getting them engaged… just making science interesting for them because they can see that science covers all areas really.*" To that end, Linda looked to provide teaching and learning opportunities that would reach these goals. Nevertheless, since the children were less familiar with the notion of investigative learning, Linda did feel that at this stage, "*they [the children] do need a little bit of guidance… without having done anything like this previously to this half term… I want to give them a little bit more guidance… Maybe towards the summer, you know… I will let them be a little more free with it [investigations].*" As such, her teaching could be characterised as '**guided inquiry**', with an emphasis on **scaffolding** the development of **investigative skills**. This could be seen in, for example, the way that **hypothesising** and **predicting** were valued, as was **observation**, **describing** and **recording**, but the format of the experiments was teacher-structured (e.g. children told what resources they were to use), children were looking for "an answer" (e.g. pitch gets higher as straw gets shorter) and the ways in which they were to record their observations were fairly closely scaffolded by the teacher.

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3.9 Case: 'Anita'

3.9.1 Context

Where?	Country	England			
	Setting name	EN5 - Central Children's Centre			
	Location within setting	Pre-School			
Who? (children)	Year group/age of children	Age 3 – 4			
	Number of children in class	60 in this wing of the Centre, 8 in the keyworker group and 6 in the group observed for the first three episodes; 7 in the group observed for the fourth episode - due to absence of two children at key points.			
Who? (adults)	Number of adults	2			
	Role of adults	Both practitioners qualified practitioners			
	Case teacher role	Scaffolding/supporting			
When?		1	2	3	4
	Dates of visits	220113	300113	050213	130213
	Times of visits	Morning	All day	All day	Morning

School / Setting

Central Children's Centre (pseudonym) is a large children's centre (over 100 children) situated in a very large city in England. It caters for children aged six months to five years old, and attracts families from a wide range of socioeconomic and ethnic backgrounds and a proportion of its children belong to a mobile community of students involved in study at nearby Universities. There is a strong sense of community in the Centre, with active parental involvement.

The Centre is split in to two activity areas or wings, and joined by a large outdoor space. Children spend their mornings in one assigned wing as indicated below. During break time and the afternoon session, children are allowed to move between the two wings via the outdoor space. Lead practitioners work as 'key group leaders' and are responsible for children's learning and wider welfare, working with them over a long period, as they grow up through the age groups, often working with children for their whole time at the Children's Centre. This builds a strong bond between not only the practitioner and the child but also between the practitioner and the parents. Children spend the morning working in their 'key groups' with their key group leaders, qualified practitioners who are in charge of a small group of children, on directed, practitioner-supported

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activities and then spend the afternoon on less directed 'provocations' – activities set up around the Centre (both inside and outside) to engage the children's curiosity and play, and to foster their learning. These provocations are less structured than the morning activities and provide children more freedom in the task. They are supervised from a distance by the adults in the room – the key group leaders or nursery nurses (support staff to the key group leaders) – rather than the more direct contact seen in the morning activities. Due to the nature and structure of the afternoon activities, children do not interact solely with children in their key group but also with other children of different ages and from the other wing of the building.

Teacher

The practitioner for the episodes detailed below was Anita (pseudonym). Anita holds a bachelor's degree in early years education as well as a National Nursery Examination Board (NNEB) Certificate in early years education. She has worked at Central Children's Centre for over ten years and as such has known many of the children and their parents since the children were infants. This has meant that she has built strong relationships with the families at the Children's Centre and has been aware of their development over time. She draws on this deep and extensive knowledge of the children, along with her day-to-day observations, to inform her everyday practice.

Classroom

There are a total of eight children across the groups observed for the two episodes described below, all of whom are in the same 'key group'. Anita is their key group leader and has been with these children since they began at the Centre – some from the age of six months. All of the children at the time of the fieldwork were aged three or four years. None of the children had been formally assessed and identified as having special educational needs.

The classroom, and indeed the Centre, is well-resourced with a number of different activities available for the children to choose from during the . Inside the classroom, this includes a water tray, an art easel, construction equipment, a role play corner, a library corner with a wide range of books, a sofa and armchairs (which is used for the introductory session of key group activities), and a mark-making table (see classroom map). Outside, there is also a wide range of different climbing equipment, a large sandpit, tricycles and scooters. When children arrive in the morning they are free to choose which activity they want – it is only for the keyworker group session (approximately 45mins per day) that they are directed to a particular activity. This directed activity is developed from the keyworker practitioner's observations, through which they identify which areas of curriculum development the children have been developing less frequently than others – for example, if it has been noted that none of the children have been using the mathematical activities set out that week, then the practitioners may set up an activity to develop numeracy skills.

Note: there was also one other qualified practitioner present in both activities with Anita; Nina (pseudonym) in the cornflour mix activity and Barry (pseudonym) in the ice activity. Nina was also present during Anita's interview. However, as the lead teacher in each episode, Anita is the focus of this case study.

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3.9.2 Episodes

There are **four** episodes described below, drawn from two classroom-based activities observed during the data collection period. The first activity involved the children working with a cornflour and water mix alongside a provocation designed to stimulate exploration of the melting of ice. Three episodes are drawn from this double activity. The fourth and final episode is drawn from an activity where the practitioner was working on a different day with the same group of children on combining oil, syrup and water.

Episode 1: Gloop

Introductory Comments

Image 1.1: Emma

The first activity that Anita had set up was for children to engage with at the start of this particular morning was to mix together cornflour and water, described as 'gloop' by Anita. Two episodes could be identified in this activity. The first episode identified involved four year Emma, and her manipulation into a ball of semi-dried cornflour and water mix.

The second episode focused on four year old Marco, and his use of ice in a large plastic tray on a table.

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Image 1.2: Marco

Pedagogical framing

Anita and Nina were the two practitioners in the classroom for this activity. Their aim for this activity, in which six children were involved overall within this episode and the next, was to develop and reinforce children's **understanding and knowledge** of liquids and solids and how these might change. **Resources** for this activity were set out for the children before the activity started – mixing bowls, boxes of cornflour, jugs of water each and mixing tools. In addition, there were also bottles of food dye and various blocks of ice. The blocks of ice were included in order to further **explore** the notion of solid and liquids, while the food dye would add a visual element to the activity. Providing a number of different stimuli within the same activity was designed to maintain **interest and motivation** for all the children.

This was one of the first activities of the day and was set up at a table as one of a number of possibilities that children could choose from. Children entered the classroom and chose which activity they wished to work with. Children were encouraged to engage alongside one another and alongside adults; initial interactions were encouraged and scaffolded by practitioners. The children were then called into their keyworker groups and sitting in groups of eight on the carpeted area of the classroom, the activity was explained by Anita (keyworker group leader) and Nina (involved during the activities observed), before the children moved to the table to explore the materials.

The pedagogical aim was evidenced in two ways. Firstly, it could be seen in the discussion session on the mat in which children discussed and classified objects into two groups – solids and liquids, discussed within 'pedagogical interactions'. It could then be seen once the children moved to the table where the activity was set up and the focus of talk became the classification of the material into 'solid' or 'liquid'.

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Pedagogical interactions

There were two kinds of pedagogical interaction involved in this episode: the activity warm-up, which took place at the carpet, and then the activity exploration which took place at a table. During the activity warm-up, Anita announced, "Today we'll be learning about liquids and solids", and produced a basket of artefacts including a bottle of juice, a bottle of water, a frozen bottle of water, and a number of toys from the classroom. The practitioner held up different items for the children to see, and discussed with them its various properties, 'hard', 'soft', where it might be found/used and so on, before deciding whether it was a solid or liquid. As a group the children were invited to classify each as either a liquid or a solid. Anita modelled language and action for example asking, "Do you think we can pour it?"…"Or is it a solid?". She helped the children to agree on 'Pouring into a glass' as the characteristic for a liquid, meanwhile one of the children suggested another characteristic: "Put fingers through it".

Once at the table, **Children worked individually** in mixing their water and cornflour, each given a mixing bowl and a box of cornflour. Before adding water, they were encouraged by the practitioners to play with the cornflour in their hands and explore its properties in powder-form. The activity was largely **scaffolded**, with the practitioners, Anita and Nina, **guiding and instructing** the children when to add water and prompting discussion about the children's observations, modelling the language they wished the children to use and develop, and encouraging the children to try, for example, as the children start to explore the cornflour and water mix, the practitioners can be heard to say:

> *Anita: "Do you want to try?"*
> *Anita: "Is it too watery? How can we make it harder?"*
> *Anita: "Put more flour? Are you sure, it's already very floury"*
> *Anita: "Do you want to add a little more flour, it's very runny"*

The children added water at differing rates and in differing volumes. Where too much water was added at once, stirring became difficult as the cornflour solidified at the bottom. Here, additional support was needed from Anita; "*it's really hard, isn't it? Let me help you*". Where the mixture was too runny, excess liquid was poured into the large tray placed on the table.

The children could therefore see, explore and talk about the cornflour in a number of different diluted states and explore its properties in each of these, with the key words being 'liquid', 'solid'. Most of the talk documented was in fact from adults, although the occasional exclamation from a child was documented, for example, Ch: "*It's getting into solid!*".

Opportunities for science learning

There are seven areas of the curriculum in England in the Early Years Foundation Stage curriculum, three areas that might be described as 'skills-based' (communication and language; physical development; personal, social and emotional development) and four that are more 'content-based', through which the skills areas are developed (literacy, mathematics; understanding the world; and expressive arts and design.) This activity can be seen to be developing the 'understanding the world' area. It is described as follows:

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> **"Understanding the world** involves guiding children to make sense of their physical world and their community through opportunities to explore, observe and find out about people, places, technology and the environment."

Through this episode, Anita provided a number of opportunities to develop children's 'communication and language', largely through modelling the language she wanted them to use. This aim reflects the 'communication and language development' area of the early years curriculum, described as:

> **"Communication and language development** involves giving children opportunities to experience a rich language environment; to develop their confidence and skills in expressing themselves; and to speak and listen in a range of situations. "

(from http://media.education.gov.uk/assets/files/pdf/e/eyfs%20statutory%20framework%20march%202012.pdf, accessed 11th March 2013)

In this episode, it was possible to directly observe a number of different areas of learning that the practitioners were aiming to foster during the activity – both scientific and non-scientific, which all relate both to the curriculum objectives highlighted above and indeed many of the features discussed in the *Creative Little Scientists* documentation.

- **Observation/exploration** of changing states (solid to liquid, both cornflour and ice blocks)
- (Experimental) use of equipment and resources – a feature highlighted in the *List of Factors*
- Practitioners' attempts to link language and concepts (liquids/solids)
- Use of senses (e.g. cold with the ice, change of texture felt with the hands in working with the cornflower)
- Use **scientific facts** in the form of scientific **language**
- Active and sustained **engagement** with a task

As with many of the activities in Central Children's Centre, there was a strong emphasis on development of language. This is, in part, due to the wide range of children with English as Additional Language (known in English educational parlance as EAL) in the Children's Centre, as was discussed in the interview with Anita. In their interview, the practitioners conveyed their belief that the modelling of scientific language would "*facilitate that [language] development*" in the children. This emphasis on language development could be seen with the practitioners' introduction and then repeated use of key words; 'solid', 'liquid' and 'melting' throughout the session, and prompting the children to do the same. Also noted in the interview, Anita felt that, "*If they [the children] were left to their own device they probably wouldn't [use/develop the scientific language]*" and therefore it was key to have an adult around who could model the scientific language.

Nevertheless, while the practitioners used and modelled the language of 'liquid' and 'solid' throughout the activity, as indicated above this was less frequently imitated by the children. This was perhaps due to the children being actively engaged in the activity and thus only using the

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language when prompted by the practitioners. By working **independently**, rather than perhaps in collaboration with one or more others, the children were very much focused on their own activity reducing the opportunities for dialogue.

Image 1.3: Nina working with Emma

Opportunities for creativity

The episode was focused on laying some foundations for scientific creativity as defined in the Conceptual Framework for *Creative Little Scientists*, in encouraging children to explore individually and with one another, generating alternative strategies as they played with the cornflower and water mix. The activity did not involve much explicit critical reasoning between the strategies but could lay foundations for this. On the other hand there were few opportunities here for more general creativity, i.e. imaginative, purposive activity leading to original and valuable outcomes.

Episode 2: Ball-making

Introductory comments

Emma, aged 4, added enough water to her bowl for all the cornflour to no longer be in powder form, but not enough to make it runny. This meant that it was possible for her to form the cornflour mix into a ball by rolling it in the palm of her hands. This was in contrast to many of her classmates, whose mix was too diluted to do this. Emma forms the focus for this episode due to her original and novel outcomes from the activity, described below.

Pedagogical framing

The rolling of the cornflower into balls emerged from Emma's particular interaction with the resources. In the practitioner interview, Anita noted that at the start of the activity, Emma had been hesitant about touching the cornflour and water mix. Anita felt this hesitancy was to do with the sensory impact of the cornflour mix – something that as a practitioner Anita felt was "*great to explore as well*" within the activity. Anita and Nina were however prepared to 'stand back' to enable Emma to find her own ways to explore the cornflower mix. From initially appearing uncomfortable with the feel of the mix, after prodding and pushing the mix with her fingers and equipment she

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began to pick up small amounts of the mixture and to roll this into a ball between her hands. This became the lead activity for Emma within the observation and the pedagogical interactions centred around this, as Nina came to join her at the table.

Image 2.1: Emma working with the cornflour

Pedagogical interactions

Emma was largely silent for the duration of the activity, working alone; however Nina, noticing what she was doing, joined her at the table observing closely what she was doing, Anita keeping an overview of the children's engagement. Even then, Emma's spoken language use was minimal as she focused on the task rather than actively discussing with the practitioner or describing what was she was doing. Her making of a cornflour ball in her hands came, as indicated above, after a period of looking at the cornflour mix closely, where she appeared to be considering her next move. She then tentatively held the semi-dry cornflour mix in her hands, seemingly discovering and reflecting on its properties, and then moving towards making something new.

Noticing what Emma was doing, Anita was pleased at Emma's outcome, providing positive and dramatically surprised feedback, ("*Wow, well done! That's amazing!*"), as it was different from the other children's and further challenged Emma, encouraging her to make a larger ball. She then prompted a number of the children to try this activity with their cornflour mix, providing them with both prompts, "*See if we can make a ball*" and more direct instructions, such as "*If you squeeze it, you can make a… ball*". Nina then followed through, moving around the table encouraging other children to do something similar, and reinforcing the double property of the cornflower mix as both liquid and solid: "It *can* be runny and you *can* make things, do you know that?

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Image 2.2: Marco making a cornflour ball

Emma's explorations, then, led on to others in the group also attempting to make their own cornflower balls (e.g. Image 2.2); she had modelled both scientific and creative learning.

Pedagogically, the open-ended nature of the task provided Emma with the opportunity to explore the properties of the cornflour mix, and as indicated above the fieldnotes reveal that the practitioners were **standing back**, and giving Emma **time and space** to explore, allowing her to eventually get to the stage where she was comfortable with the materials. This was supported in the practitioner-interview, when looking at the pictures from the session. Anita described how, "*So she's [Emma] holding it, not too sure what to do with it, and after a while she [makes a ball] so she needed a bit more time to make her discovery*". Anita was aware of the need to provide Emma with space and 'a bit more time' in order to fully explore the cornflour mix. The pictures and fieldnotes then evidence both practitioners providing extra support and guidance, **scaffolding** the activity to allow and indeed encourage Emma to continue with and extend the activity, by mimicking what Emma has done, and challenging her to make larger balls (Image 2.3).

Image 2.3: Nina and Emma

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Opportunities for science learning

As discussed above, it was only after careful **observation** and tentative **exploration**, prodding and pushing the cornflour mix with her fingers and equipment, that Emma seemed confident enough to hold the mix entirely in her hands; at this point she began to mix and roll the cornflower mix into a ball between her hands (Image 2.1, above.) Emma seemed to be most engaged in the first and fourth of the science activities listed above ('observation/exploration' and 'use of senses').

Opportunities for creativity

Emma's **exploration** of the properties of the cornflour allowed her to come up with an **outcome** that was **original and meaningful** and one which led as indicated above, to other children in the group making their own cornflour balls (Image 2.2, above). Thus the activity enabled the fostering of everyday creativity, i.e. 'purposive, imaginative activity generating outcomes that are original and valuable' as defined in the *Creative Little Scientists* Conceptual Framework.

In addition, Emma's actions were a manifestation of scientific creativity as defined in the *Creative Little Scientists* Conceptual Framework, in other words, 'Science and Mathematics: "'generate alternative ideas and strategies as an individual or community, and reason critically between these". As Emma explored she generated an alternative strategy although the episode does not reveal what her critical reasoning might have been or might have gone on to be.

This episode also illustrates the interactions between the degree of constraint in a learning opportunity and the development of children's creativity. For whilst by giving children their own personal bowls in which to make their cornflower mix, the task enabled children to follow their own purposeful enquiries, and to generate their own ideas and strategies, there were firm constraints. Each child had the same amount of cornflour and the same amount of water, and the children were instructed to add water to the cornflour, rather than the other way round. As such, it could be suggested that there was, initially, only a very narrow degree of inherent possibility (room for exploration) within the task. Once this had been completed however, the children were presented with a far wider degree of possibility, with fewer constraints, such as being allowed to pour their mixture into the tray on the table, and more generally play and explore with the cornflour mix in new ways (including the addition of food colouring). Indeed, the various activities being undertaking around the table at any one time provided an illustration of the broad nature of inherent possibility.

Emma's actions following the initial instructional period were illustrative of this possibility-broad nature of the task and resulted in an **outcome** that was **original** and **personally meaningful**. This was evidenced by her focus on her personal activity (see Image 2.1 above), apparently happy to explore the properties of the cornflour and water mix and construct the gloop balls, without interaction from the practitioners or her peers.

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Episode 3: Ice and cornflour and water

Introductory comments

This episode comes from the same activity described above however focuses on a different child, four-year-old Marco, who turned his attention to the ice and melting activity introduced earlier in the case study, integrating the cornflower and water with a new enquiry focused on releasing frozen toys from blocks of ice.

Pedagogical framing

As noted in Episodes 1 and 2, once the initial instructional activity had been completed at the carpet, children were encouraged at the table to play and explore the cornflour and water mix. In addition to the cornflour and water mix discussed in Episodes 1 and 2, and the food dye and spoons, funnels and other such equipment that were set inside the large tray in the centre of the table aside from the children's own bowls, the practitioners later added one very large block of ice (made from freezing water in an economy-sized empty bean tin), and also a number of large blocks of ice (each popped out from plastic cups). Each of the smaller blocks of ice had toys frozen inside, as well as glitter and sequins.

Pedagogical interactions

Working alongside the other children and the practitioner, Marco began to move away from his first attempt at making cornflour mix, to focus on two ice blocks in the tray (ice that had been frozen in plastic cups and then removed, Image 3.1).

He seemed particularly interested in extracting the toys frozen inside them (toy ambulances) and appeared keen to find ways to make the ice melt quicker perhaps in order to get at what was inside the blocks. He rolled the ice blocks across the tray, crashed them together, rubbing them with his hands and tried rolling them in the corflour mix and rubbing the cornflour mix into them (Image 3.2). After each of these attempts, Marco peered closely at the blocks of ice to see the progress of melting. It is possible to infer then that these actions appeared to be ways Marco was trying in order to get the ambulances out of the ice.

Image 3.1: Marco rubbing the ice on the cornflour mix

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Marco worked alone; his practitioners give him space and time to do so, observing closely his investigation. Little spoken language was articulated by either Marco or the practitioners. From a pedagogical perspective, a range of strategies perhaps contributed to his engagement in the investigation. Firstly, Anita provided different resources in order to maintain interest and **motivation**. This providing of 'extra' or alternative opportunities within the overall activity appears to facilitate this one particular child's imaginative exploration of the melting ice. Providing Marco with the **space and time** to explore this avenue is also highlighted in the *Creative Little Scientists* documentation as important for creativity in science and mathematics in the early years.

Opportunities for science learning

The inclusion of toys frozen within the ice blocks was intended to pique children's curiosity and to prompt the further exploration of the notion of solid and liquid states through experiencing and exploring ice melting. Children's curiosity did indeed appear enhanced by the existence within the blocks of frozen toys as evidenced in Marco's behaviour where his play was testing out what could help the ice to melt so as to release the toy inside. The inclusion of the ice blocks also provided a further opportunity to reinforce the use of **scientific language** in the classroom, such as 'solid', 'liquid' and 'melting', and again, provided an open ended environment for **observation** and **exploration**.

Including the ice within the cornflower activity enabled practitioners at Central Children's Centre to expand the exploration and to stimulate **interests** of children in the group in another way. Indeed, this was an explicit aim of Anita's to provide a stimulating environment with a number of different activities that would appeal to all of the children and sustain their interest.

Opportunities for creativity

Marco seemed to take a more experimental approach, combining the two activities available to him (the cornflower and ice). In her interview, Anita noted that Marco was keen to move quickly on from the cornflour and water mix, her impression was that "*All [Marco's] mind was on the ice block, because he wanted to get the ambulance out*". Initially, Marco could be observed sliding the ice blocks across the tray, smashing them together, holding them in his hands and rolling them in the, by now, very thin cornflour mix in front of him. After these efforts, and with the ambulances still firmly stuck in the ice, Marco was then observed pouring and rubbing the cornflower mix on the ice in (Image 3.2), it appeared, an attempt to help melt the ice quicker.

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Image 3.2: Marco rubbing the ice on the cornflour mix

Here, Marco seemed to be generating alternative strategies to achieve change and thus seems to be evidencing the scientific creativity defined by the project, **generating alternative ideas and strategies**, and in accepting and rejecting the outcomes of these his **critical reasoning between these** is evidenced through behaviour. He appears to be **making connections** between his existing knowledge and the new stimuli presented to him, and using **innovative thinking** in order to **solve** his **self-posed problem** of freeing the toys from the ice. Marco's exploration is certainly focused on solving a problem. In his focus on this he is evidently engaged **in purposeful activity involving the imaginative question, 'what if?'** and is generating **valuable and original outcomes.** Thus in this sense is evidencing the general creativity approach defined in the Conceptual Framework for *Creative Little Scientists*.

Episode 4: Syrup

Introductory comments

This activity involved seven children aged three to four, exploring the densities of three different liquids – vegetable oil, water and golden syrup. When poured into a jar, the three liquids separate (Image 4.1). This was then followed by dropping a cork, a piece of Lego and a grape into the jar – the objects each float at the different boundaries of liquids.

Pedagogical framing

This is a 'typical' early years science experiment and can be found in a number of science activity books for children, and indeed online – see here for an example: http://www.doscience.org/files/Stacking-Liquids.pdf The experiment was carried out in the order described in this website (not including the stone dropped to the bottom of the jar) with the practitioner demonstrating each phase first and then the children undertaking it themselves.

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Image 4.1: Children pouring

Pedagogical interactions

This activity identifies **science as a separate** part of the curriculum, looking as it does to develop particular scientific language. This reinforcement on language could again be seen with Anita's repetition of the key words, floating and sinking, in between each stage of the experiment as the children engaged with the exploration under her step-by-step guidance.

At each step, Anita would hold up her example and describe to the children what had happened, stating for example, "*Look, it [the oil] is floating on the water*", (Image 4.2) and asked the children to look at their jar and compare, and subsequently to describe to her what they saw.

Image 4.2: Anita showing separated liquids

In the interview after the lesson, Anita stated that she did this in order that all the children might all observe her jar; "*I lifted it up because I thought, so that they could see it a bit more clearly, you*

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know, being at low level they couldn't quite see that oil and the water separate and the syrup and water sitting on top, etc., so I lifted it higher." In this way, Anita would be demonstrating the experiment and modelling the language for the children to then use to describe their experiments.

Unlike the previous activity observed, there appeared to be less opportunity for child-initiated exploration, as the practitioner demonstrated the method and showed the children the results, and the children were to replicate this. Rather than an explorative activity then, the emphasis was more on **observation** and **discussion of the outcomes** of the activity. Indeed, Anita did state in the post-activity interview that the reason she chose this activity was because "*it was a nice visual one, I think. I mean, they may not have grasped it [the concepts] fully yet obviously…when you go into it, you know, the weight and all that is too much for them to see, but it was a nice visual one and just see*". Thus it is possible to suggest that there is little emphasis on 'problem solving skills' in any meaningful way, as children are repeating the actions of the teacher. Anita then appears to be teaching the scientific concepts of floating and sinking through demonstration, and subsequently, planned opportunities for, for example, IBSE in this activity, were limited.

However, as discussed further below, one child did begin to ask her own questions which then spread throughout the group. This new enquiry depended for its development on Anita listening to Juliet's question about the layers of liquid, and responding to her request for a stirrer. As a result, the enquiry took on a new and unplanned dimension initiated by a child.

As the children stirred, Anita asked "*Is it mixing, is it all mixing together?*", Juliet. The children all answered, "*Yeah!*" This was true as Juliet had just finished stirring the liquids, and the golden syrup had yet to settle, meaning that there were still water and syrup – as seen in Image 4.3 below.

Image 4.3: Juliet stirring

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The pedagogic challenge of how to balance enquiry with scientific knowledge can then be seen in action, as Anita corrected Juliet saying, *"No, is it? It's amazing isn't it? It's spinning isn't it, but it's not mixing though. That shows you that water and oil don't mix. It will mix for a little while, but what happens eventually is the water and oil still separate don't they? Because it's a different type of liquid."* At this point, Juliet interjected, saying, "*It's hard to stir*", again potentially opening up a line of enquiry and yet with a focus on the science which is the focus of the activity, Anita continued, lifting the jar and saying, *"Now have a look, have a look Juliet, see what's happening. Did it mix, Juliet? Do you think it mixed? Hmmm, no, I don't think it's mixed. Does anybody else think it's mixed? The oil's still at the top."* Yet this was, perhaps, at the expense of Juliet's creative exploration.

Image 4.4: Anita demonstrating Juliet's stirring

Anita discussed her approach during the interview, saying that she corrected Juliet because, "*I said that's obviously going to happen for a little while but when we go back to it maybe later on this afternoon we'll see it separates again.*" Clearly Juliet's question or creative idea offered Anita the opportunity to reinforce the language of 'floating' and 'sinking', highlighting how "*the oil has gone back to floating again*". Yet there is clearly a fine balance between facilitating children's exploratory questions and how to help children to grasp scientific ideas.

Opportunities for science learning

This experiment looks at the various densities of both liquids and solids and uses these to explore the notions of floating and sinking. (Note that 'density' was not used – 'heavier' was the word used to describe why the golden syrup sank to the bottom.) It follows up the previous activity observed on solids and liquids (cornflour and water mix). From a science perspective, there were a number of aims, the most significant was the reinforcement of scientific language – particularly vocabulary relating to solids, liquids, floating and sinking.

- **Observation** re: layering of liquids

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- Manipulation and use of equipment and resources
- Linking of language and concepts (liquids/solids/floating/sinking)
- Use of (scientific) language – developing **scientific knowledge** about the properties of substances
- Active and sustained engagement with a task

As the children explored the ways in which the three liquids found their level within the jars, and the ways in which the different objects came to rest at different levels, one of the children (four year old Juliet), began to ask herself how she might mix up the layers. As she articulated this question, and asked what she might use for stirring them up, Anita listened and provided her with a up-ended paintbrush for this purpose (Image 4.3) Juliet's question then spread throughout the group, with each of the children engaging in this new and unplanned enquiry.

Opportunities for creativity

It did not appear however that the children were given much freedom in the activity to actively explore – indeed the children largely followed the practitioner in this task and as noted above planned opportunities for inquiry appeared to be minimal. However, while this was a fairly prescribed activity, since the children were given a particular order in which to pour in the liquids and then add the objects, it was still possible to observe how Juliet (pseudonym) sought to **generate purposive activity** in her exploration in pursuit of an outcome of value to her; she seemed to be meaning-making and to this extent she demonstrates creativity. Juliet was curious as to why the liquids were separated and wanted to attempt to mix them (Image 4.5). She wanted to see if stirring the liquids would mix them together to form one new liquid. Here we can see scientific creativity being enacted: she is **generating her own alternative exploration** and seems to be **bringing a criticality to her investigations**. It is possible to observe a number of skills being enacted – **predicting** or **hypothesising**, **making connections** (to the previous cornflour and water experiment), **imagination**, **curiosity**, **problem solving skills** and **reasoning skills**.

At the end of the planned activity, once all the liquids and solids had been added, Anita was happy to let Juliet try and again, lifted the jar in order to show Juliet's results to the rest of the class (Image 4.4). Anita then asked Juliet whether the liquids had mixed. Juliet answered that yes, they had and indeed it did appear that they had – the viscosity of syrup meaning that the liquids remained mixed for a short period of time. Anita commented in the interview that "*she [Juliet] could see that, in her mind, no, it's all mixed… she looked at it and she was saying the water's mixed because it changes colour.*" Juliet then has used her **problem solving** and **reasoning skills**, combined with **observation**. Despite the original remit then, Juliet had managed to undertake some enquiry of her own.

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Image 4.5: Juliet discussing her results

The role of the practitioner here in relation to the creativity in the episode is particularly interesting. By highlighting Juliet's ideas and demonstrating them to the class (Image 4.4), Anita allows Juliet some **freedom** to enact her creative ideas as well as develop motor skills within the activity (Image 4.3).

Nevertheless, Anita did channel the exploratory activity somewhat, providing the answers to Juliet's questions with a focus on imparting scientific understanding. Juliet nevertheless continued to be intrigued by the phenomenon and she could be seen to be examining the jars closely, **observing** the changes, looking around the table at others, as if to try and understand why the liquids should separate. Her **motivation** finds an answer to her self-posed problem, her **curiosity** and **creative thinking skills** is evident.

While she was provided with a description by the practitioner, she was not provided with an explanation, other than one that she already knew (that they are different types of liquid), nor is she scaffolded yet in how to explore this. She seems to be looking to find a way to explore this, however greater 'standing back' from the teaching may have further enabled Juliet's inquiry and understanding. At one level, it is possible to infer some inquiry-based learning from this. The children are learning further from the extension of the activity and the inquiry of Juliet. Nevertheless, the outcomes to this inquiry are being provided by the practitioner, rather than being established by the children themselves.

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3.9.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years? What role if any does creativity play in these?

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics? How do teachers perceive their role in doing so?

Providing opportunities for children's **observation** and an emphasis on the importance of 'correct' language were the two most frequently identified teaching and learning approaches during the data collection period. Indeed, it is the creation of situations for the observation of science phenomena that then provided Anita with the prompts for the development of language. Having said this, much of the activity and **exploration** observed in the children in the activities was **independent** – each of the children were free to explore in their own way, rather than in collaboration or partnership with others. This meant that, while **independent inquiry** could be fostered, dialogue and collaboration in the way that might be recognised in the *Creative Little Scientists* documentation was limited. Language that was developed was largely focused on terminology – what might be described as **scientific knowledge**.

The aim of teaching approaches at Central Children's Centre appear to provide children with a 'starting point' from which they can ask questions, experiment, observe phenomenon and so on. The phrase often used in CCC to describe these activities is "*provocations*" – they are semi-structured activities designed to 'provoke' the children into thinking, questioning and so on. During informal discussions as well as the more formal interviews, the practitioners suggested that these afternoon 'provocations' provide children with what might be described as inquiry driven/based learning opportunities.

The afternoon provocations are set up by adults for the children, therefore during such directed provocations the children do not necessarily have the opportunity to plan experiments or choose equipment for themselves. This was most clearly seen in the Episode 4 (syrup) above where this, combined with a structured nature and lack of 'standing back' meant that it was difficult for child-initiated inquiry to occur.

It may be especially important to note then that the practitioner has the ability to foster or shut down creativity/creative ideas and so needs to be aware and attuned to children's responses. The four episodes foregrounded in this Case illustrate how pedagogical tools such as standing back and providing children with the time and space to explore and develop their own ideas can facilitate creativity in science activities; and how not standing back enough can shut this down.

Anita did however appear to be keen to foster and sustain children's interest and **motivation**, and this could be seen in two respects. Firstly, this could be seen by Anita providing children with opportunities to explore their own interests or follow their own paths. This might be through

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allowing children the time and space to follow up their own problem solving ideas or by providing children with different materials or resources. Secondly, this might be by conducting experiments or activities that have highly affective results, as was seen in the golden syrup/oil experiment, which might produce unexpected results.

Although not explicitly seen in the observation period, **formative** assessment is a central part of practice at Central Children's Centre. Each child has a formal long-term record of their work in the form of a large A3 wallet-folder. In this folder are examples of the child's work and photographic images of them working, starting from when they arrived at the Centre and is constantly added to. Copies of children's work, such as paintings, collages or drawings, accompanied by verbatim quotes from child are displayed on the walls and eventually these too are added to the child's folder. Practitioners and Nursery Nurses would take digital photographs of children while involved in various activities in order to document their engagement in learning. These images too would be displayed on the walls as a shared reference point and record for children, parents and practitioners, and later added to the child's folder. Thus, it was possible for children, their parents and the staff working with them, to see at a glance the progression of each child's learning and development over a period of time in various aspects, such as mark-making, physical development (through photos) and communication (through the verbatim quotes accompanying the drawings) and of course their interest and engagement in particular issues, topics or kinds of learning. The folders therefore also provide additional information for parent-practitioner discussions.

Conclusion

The access that the children had in each of the tasks to either following their own interests or extending the tasks was a key feature of the creative pedagogy seen at Central Children's Centre. The six children present for the cornflour and water mix activity were each given the time and space to explore the materials available to them in ways that they saw fit. Practitioners then used their professional judgement as to when to step in and provide further prompts to the activity. The modelling of language was central and took up a significant proportion of Anita's teaching time. This was reflected in the interview, where Anita stated that she felt that this learning would not be possible without the intervention of a practitioner.

Where activities perhaps provided children with fewer opportunities to follow their own interests, time and space towards the end of the activity meant that children could express their ideas and questions, and have an opportunity to undertake activities to (potentially) answer them. However, true inquiry was limited by the practitioner's intervention and apparent willingness to intervene or correct the children when they suggested apparently incorrect answers.

The phrase 'child-centred learning' was used on a number of occasions, both in the interview and in informal conversation with the practitioner – indeed with all the practitioners at Central Children's Centre. While this can have a number of interpretations and be evidenced in a variety of different ways, teaching and learning at CCC was largely based around both the interests and needs of the children in that class. Despite the two activities highlighted here being very different, it is possible to

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identify in both examples of how the children informed pedagogy and how the practitioner reacted to the actions in the classroom.

Central to science learning was the development of language through the physical manipulation and/or observation of materials in the classroom. The sensory aspect of these activities, (particularly the cornflour and water mix activity), though important, was seen by the practitioners as secondary to language development.

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3.10 Case: 'Jennie'

3.10.1 Context

Where?	Country	England			
	Setting name	EN6 - Wayland Nursery School			
	Location within setting	Pre-School			
Who? (children)	Year group/age of children	Nursery (3-4 years old)			
	Number of children in class	94 on roll. A third attend all day, a third morning or afternoon only			
Who? (adults)	Number of adults	Varied according to time.			
	Role of adults	5 teachers, 4 Nursery Education Assistants and 6 Learning Support Assistants			
	Case teacher role	Deputy Head			
When?		1	2	3	4
	Dates of visits	14/02/13	15/02/13	24/02/13	26/02/13
	Times of visits	All day	All day	All day	All day

School / Setting

Wayland Nursery School is situated in large city in England in an area of high socioeconomic deprivation. Children who attend the nursery come from a wide range of linguistic, religious, ethnic backgrounds. The largest groups are children from Black African, Caribbean and Turkish or Kurdish heritages and over two thirds of the children speak languages other than English. The proportion of children with Special Educational Needs is higher than in most schools and more than a third of the children have speech and language difficulties. The school is part of a Children's Centre that offers a wide range of services to children and their families. There are 94 children on roll. A third of the children attend all day. These are children with Special Educational Needs or where attendance has been recommended by Social Services. Of the remaining children, a third of the children attend in the morning and a third in the afternoon.

The School has been rated Outstanding in its last five inspections. The most recent report in 2013 highlighted the excellent progress made by all children regardless of their background. The report commended the '*highly imaginative curriculum'* and '*teachers' use of highly innovative and creative methods'* that *'quickly engages and sustains children's curiosity and enthusiasm'* (Ofsted 2013).

The experienced staff at the School work together closely as a team. They demonstrate a strong whole school approach to learning and teaching reflected in the inspection evidence, School documentation, conversations with staff and observations in the setting. The experiences they

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provide for children offer rich opportunities for learning both indoors and out. Teaching and learning approaches draw explicitly on the concept of 'Sustained Shared thinking' (Siraj-Blatchford and Sylva 2002) with planning and teaching identifying and using questioning to foster dialogue and extend learning. The staff demonstrate considerable expertise in fostering inclusion through varied modes of communication including use of signing, pictures and real objects.

A wide range of strategies is employed to foster links between learning at home and at school. For example children regularly take books home to read with family members. There is a library of play activities accompanied by instructions in a range of languages. Each week children and parents can borrow activities to share. The staff set homework related to everyday materials or events at home. They organise 'Walk and Talk' outings for parents and children round the local area to highlight for parents opportunities and strategies for encouraging talk and learning

Teacher

Jennie, the Deputy Head at the School, has been teaching for over 20 years. She has a Bachelor Level Degree and is a qualified teacher. Mathematics and Science were both areas of emphasis in her initial teacher training.

The Nursery is divided into three indoor areas and one outdoor area. Children are free to move between areas. In her interview Jennie explained how the staff work as a team to plan the curriculum across the year, ensure breadth of experience and support and monitor children's progress. Long-term plans identify cross-curricular topics across the year, events linked to the seasons, cultural and religious festivals and visitors from outside organisations or individuals. Each week pairs of staff, a teacher and a nursery nurse are allocated responsibility for a particular area (indoors or outdoors). They undertake detailed planning for provision including a mixture of adult led and free flow child directed activities. One focus group activity is planned in each area each day. Examples of these activities are included in the Episodes that follow. There are also regular outside visits each week in the local environment for example to the shops or the library. Circle time and story time are planned to focus to ensure range and balance in focus across the curriculum.

Activities are reviewed in a team meeting each week. Pairs of staff report on the success of their planned activities in each area and on the responses and progress of individual children. This information is used to discuss the development of plans for the coming week and ways to meet the needs of particular individuals. Children's experiences are recorded using photographs stored in children's profiles. Children are invited on a regular basis to update their profiles and to reflect on what they have learnt.

In discussing opportunities for creativity, Jennie emphasised the importance of resources in the outdoor area. This is given as high priority as the indoor provision. Jennie commented "*You see children gathering up resources, finding themselves things and using them in a variety of way you would never have imagined*". She referred to rich potential for science learning offered by the ways in which children make swings out of hoops, pick up and study creatures or chalk on wet ground. She indicated the importance of adults' roles in fostering communication and language development

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to support learning through varied modes including signing, use of physical objects and photographs as well as speech.

Classroom

The Nursery environment consists of three indoor rooms and an outdoor area. The areas are well resourced to provide a wide range of experiences for example related to sand, water and malleable materials, designing and making activities, painting and mark making, construction, role play and small world play, computer games, mathematical games and puzzles and science-focused exploration. There are comfortable carpet areas in each indoor room with a wide range of children's books. Outdoors there are in addition climbing structures and an area for wheeled vehicles.

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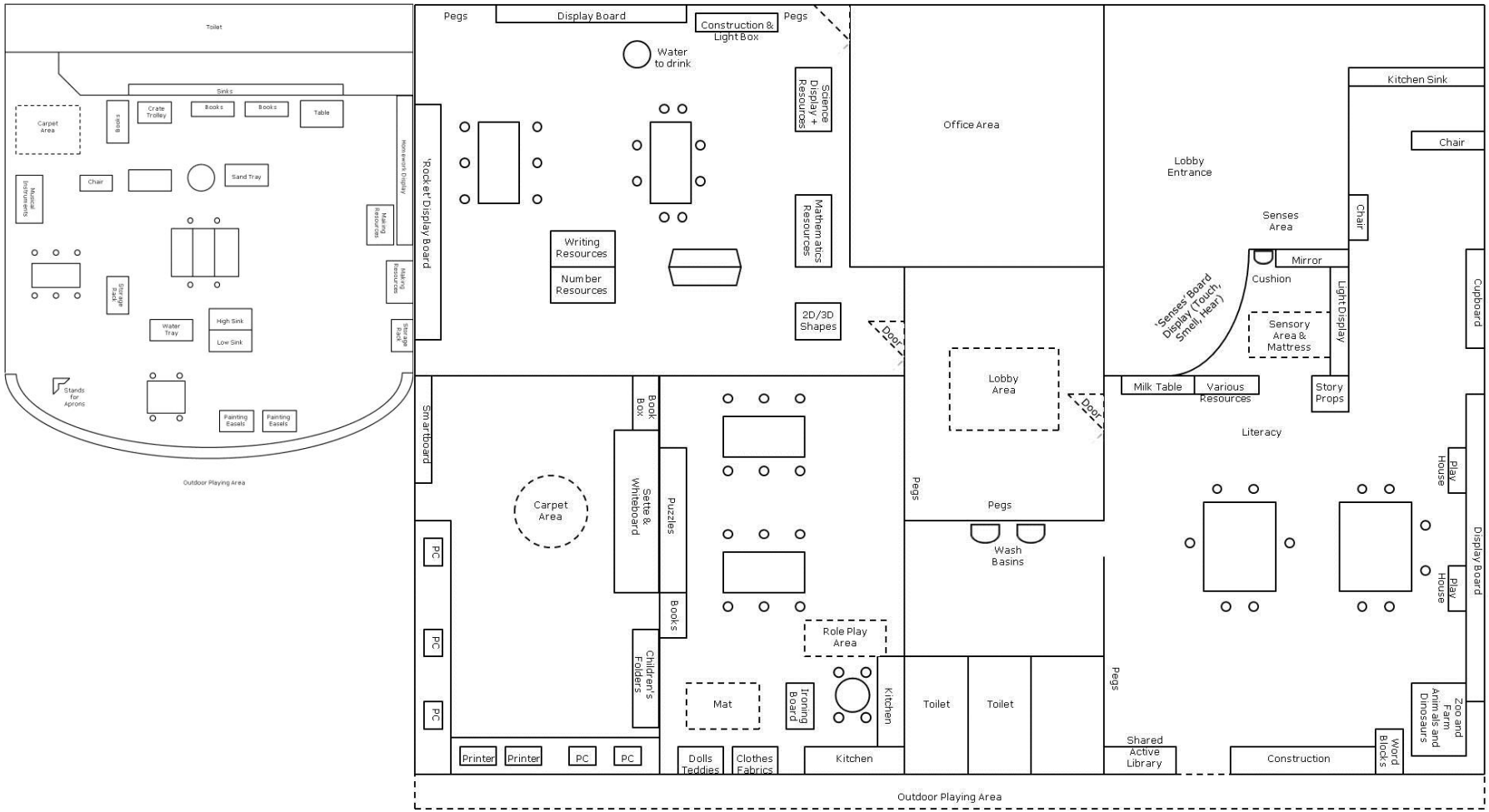
Jennie's Nursery Class at Wayland School



3.10.2 Episodes

Episode 1: Volcano

Karin had researched a series of exciting experiments using combinations of everyday kitchen materials to prompt children's interest and enthusiasm in science. In each case there were beautiful and often surprising phenomena to observe and describe. In a previous session the teacher had carried out the 'magic milk experiment'.

Pedagogical framing

This session focused on an experiment called *Volcano* in which warm water, red food dye, baking soda and vinegar were mixed together in a large plastic water bottle. **Materials** for the session were prepared in advance with the additional equipment of measuring spoons and a funnel to aid to aid the mixing processes and a large washing bowl in which to stand the water bottle and catch the eruptions from the 'volcano'. For safety reasons the activity was a teacher demonstration carried out with a group of children sitting round a table. The **aims** for the session shown in Karin's planning were for children to be able to: '*name all the ingredients, offer predictions, describe what happened and make a representation of what happened on paper*' (See Appendix).

Pedagogical interactions

Karin talked through with the children each stage in the instructions for the experiment, reading out the instructions at each stage and sharing her own excitement and lack of certainty about what might happen. She modelled the processes involved in following instructions and being prepared to learn and try out something new.

First she introduced the materials involved, **making connections** to children's **previous experiences** of materials for example:

Karin:	*"I need red food dye and this bottle that needs to be filled with warm water … back. Now what have we got – what is this called?"*
Mabel:	*"Vinegar"*
Karin:	*"Shall I drink it?"*
Mabel:	*[Loudly] "No no no it's not water."*
Karin:	*"You know crisps – salt and vinegar crisps – they have vinegar. Have you ever had that one? Got detergent and what is this one called?"*
Nash:	*"Baking powder [they are used to this from cooking]."*
Karin:	*"Actually baking soda – had to look it up on Google. Baking powder and baking soda are different. Got washing up liquid and now I need to read the instructions "put it in a bowl so it does not go all over the table".*

The bottle with red food colouring was then brought to the table by another member of staff.

Charity:	*"It looks like Ribena."*
Mabel:	*"I've got Ribena in my home."*
Karin:	*"I've got Ribena in my home too – I quite like Ribena."*

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Children were invited to **predict** what would happen to prompt their **curiosity** and a sense of anticipation. Children offered various ideas for example:

Nash: *"It might go everywhere."*
Zena: *"Will explode – go all round."*
Karin: *"Do you think it will go in our face?"*
Zena: *"In the bowl."*
Calvin: *"Think it will go in sky – there is going to be a hole in the roof."*
Mabel: *"Might melt."*

Then as the ingredients were added in turn Karin **asked questions** to encourage children's **observations** of the changes taking place. Children offered a range of observations at each stage.

Image 1.1: Adding baking soda to the mixture

For example as the baking soda was added to the mixture of water, food colouring and detergent Nash said "*there's steam coming out*" and Charity commented *"more bubbles on top".*

As the vinegar was added children were very excited. There was much laughing, screaming and commentary, for example:

Zena: *"It's going up and falling down."*
Nash: *"Everything is making it erupt from the bottle into the container."*
Karin: *"Cloe can you explain it?"*
Cloe : *"Makes the fresh air come out."*

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Image 1.2: Adding vinegar

Image 1.3: Watching the bubbles

At the end of the activity both Karin and the children together made drawings to record what they had seen. This allowed further opportunity for dialogue and reflection.

Image 1.4: Drawing the volcano

Image 1.5: Nash's drawing

Karin: *"Zena what do you like about this?"*
Zena: *"Red at the bottom and pink at the top – bubbles at the top get pink."*
Karin: *"Charity, what do you notice?"*
Charity: *"I liked the bubbles coming up."*
Karin: *"Pearl, what did you like?"*
Pearl: *"Bubbles."*
Karin: *"What about the bubbles?"*
Pearl: *"White now – look a bit soapy."*
Nash: *"Like it when the bubbles explodes."*

These extracts from the fieldnotes indicate the rich opportunities for sharing **observations** and **alternative ideas** about what might happen. Discussions with children a couple of days after the session underlined their excitement and the observations they had made. For example Nash said:

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> *"All came out of the top and flowed right down - because put baking powder and the vinegar and all poured out the top – and the teacher put food colouring and it came into the container in the bottom – so it went into the container to make it come out very lots of bubbles. And it erupted - that's what happened".*

Charity said *"There was bubbles coming out – I was laughing ….because I liked it! That's why".*

Opportunities for science learning

The volcano episode offered opportunities for fostering children's learning in relation to *The areas of learning and development* associated with the *Statutory Framework for the Early Years Foundation Stage (EYFS) (DfE 2012)*. It enabled children to address aspects of the *Early Learning Goals* associated with *Understanding the world (*within the section called *The World)*. For example the children were able to **make observations** and **talk about changes** in relation to **materials**. Characteristics of *effective teaching and learning* highlighted in the EYFS in particular '*children have and develop their own ideas and make links between ideas'* were also demonstrated in Karin's encouragement of children's **predictions** and **reflections**.

Opportunities for creativity

The activity generated great **interest** and **enthusiasm** throughout the day in both staff and children and attracted growing attention. Children watched with rapt attention and were keen to share their experiences. Children used their **imagination** in predicting what might happen, in some cases **making connections** to prior knowledge of volcanoes.

Image 1.6: Children and staff observing the volcano

Particular features of creative teaching evident in this episode included the provision of exciting experiences to foster children's **curiosity** and **interest**. Karin shared her own excitement in trying out a new activity, modelling and sharing a willingness to tolerate uncertainty and take risks. She used **questioning** to encourage **dialogue** about experiences. Children were invited to record observations and **reflect** on their experiences through drawing.

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Episode 2: Cars and Ramps

This episode took place in the outdoor area outside the classroom. Two ramps were set up alongside each other. The ramps consisted of two lengths of white guttering with blue ladder-like supports at each end with rungs, so that the height of each end of the guttering and therefore the slope of the ramp could be varied. Alongside there was a box containing a range of vehicles of various sizes.

Pedagogical framing

The **materials** provided afforded opportunities for children to **explore** what happened as cars went down the ramps. The learning objective for the session was that children should be able '*to predict the speed of a car and to be able to make it go faster or slower'(See Appendix)*. The activity was left out all afternoon for children to come and go and there was plenty of **space** and **time** for children to follow their own ideas and interests. Chioma's planning for the session (See Appendix) identified **key questions** that staff could ask to '*promote sustained shared thinking*' including: '*What is happening to the car? How can it go faster/slower? Which car do you think will go fastest/slowest? What do you think will happen if..?*' Key vocabulary was also identified for example '*fast, faster, fastest, slow, slower, slowest, ramp, high and low*' to support children in articulating their observations , predictions and explanations. Having two ramps alongside each other had a number of benefits. It allowed children to make direct comparisons of different cars or ramp heights. It also fostered **collaboration** and **dialogue** between children as they explored alongside each other.

Pedagogical interactions

Children's responses to the activity showed many features of inquiry-based learning. **Questions** and direction to their inquiries were suggested in their use of resources and sequence of actions, **planning** for the next step based on their **observations**. In dialogue with peers and adults in some instances children indicated **connections** they were making for example between the height of the ramp and the speed of the car. Predictions prompted by adults gave insights into children's developing **explanations** and reasoning. Examples to illustrate these elements of inquiry in children's responses are provided below.

Initially Zared and Rosalie were working alongside each other. Zared **observed** that one car went faster than the other. He made a **connection** between the positioning of the car on the ramp and how fast it went.

Zared:	*"Look [he puts a new car on the ramp] – fast really fast."*
Chioma:	*"Why do you think that one went fast and Romilly's slow?"*
Zared:	*"[Gesturing with his hands] – Sideways does not go."*
Chioma:	*"What happens if you change it?"*
Zared:	*"It goes fast."*

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Image 2.1: The car sideways on the ramp goes slowly

Rosalie **observed** that her truck went faster on one ramp than the other. In response to teacher questioning she suggested that this was because the ramp was really high.

Rosalie: *"That one really fast."*
Chioma: *"Look how fast it went – what about other cars?"*
Rosalie: *[She tried a truck on the steeper slope.] "Went faster on this one."*
Chioma: *"Went faster on the first ramp than on the second ramp?"*
Rosalie: *"Faster on second."*
Chioma: *"Why do you think?"*
Rosalie: *"Because really high?"*

Later on another group of children, Diana, Aiden and Daniel tried out larger vehicles including a fire engine and a bus. The children **observed** that these did not travel so smoothly down the ramps - as they wobbled or got stuck. They tried to **solve these problems** by varying the height of the ramp and shaking it to make the vehicles move.

Aiden tried a bus on the ramp commenting "*it turns over – turned again – it makes a rattling noise*". Aiden tried it on the lower ramp and it wobbled slowly down. He then repeated again the wobbly bus, several times, down the steeper ramp.

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Image 2.2: Aiden trying the bus on the ramp

Image 2.3: Diana trying the fire engine

Diana tried the fire engine. It went really slowly. She then moved the ramp to horizontal. Aiden tried his bus on the horizontal guttering and said "*Bus needs pushing"*. He lifted up the guttering to bump the bus along. He then lifted up the guttering to a higher slot and the bus went down by itself.

In another period of exploration that drew in a large group of children, Hilton and Inanna started a race. This part of the episode focused again on the height of the ramps. Hilton had a fire engine with his ramp set to the highest possible slope and Inanna a little green car. Her ramp was on a lower rung. Deanna (a Learning Support Assistant) asked "*Who do you think is going to come first*?" Hilton **predicts** *"my one'*. They noticed the fire engine came down first.

Image 2.4: Inanna trying varied slopes on the ramp

This was repeated several times. Inanna then adjusted one end of her ramp to the top rung and the other end too so her guttering was horizontal.

She **explained** what she was doing:

Inanna: *"I want mine to go first"*

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Deanna: *"What do you need to do?"*
Inanna: *"Push it – need to push it."*

She then tipped the ramp and the car went faster. Then she put the ramp back horizontal. Then she tilted again. Next she put the guttering on lower rungs but again horizontal.

Inanna: *"This is very, very slow."*
Deanna: *"How do you make it go fast?"*
Inanna: *"I tipped it up [demonstrating]."*
Deanna: *"That was fast."*
Inanna: *"And when I push it [with a gesture to illustrate]."*

Inanna continued to explore the effects of different slopes. She adjusted the guttering to make the slope steeper, again saying "*faster*" and smiling. She then adjusted the guttering to middle level rungs – with slight slope. She put a car at the lower end of the slope and pushed it up the slope. Here Inanna continued her explorations of **connections** between the slope of the ramp and the behaviour of her car.

Different adults engaged with this activity over time. Their approach reflected the importance given in the nursery to **children's own explorations** and decision making. As illustrated in the extracts above, they used **questioning** to encourage children to articulate observations, to explain the **reasons** for their actions and r**eflect** on their effects on the behaviour of the vehicles. Their presence supported **dialogue** and **collaboration** between children. On a subsequent visit to the nursery the ramps were set up indoors. Many of the children observed in this episode took advantage of opportunities to explore the ramps again. This time they explored the ways that different plastic animals slid down the ramps.

Opportunities for science learning

Children' explorations of cars down the ramp reflected the dimensions of *effective teaching and learning* in the *Statutory Requirements for the EYFS* (DfE 2012). Children had rich opportunities for **playing and exploring**. They participated **actively** and **persisted in the face of difficulties**. They demonstrated abilities to **express ideas** and to **make connections** between experiences. The children also showed characteristics associated with the *Early Learning Goals* associated with *Understanding of the World (Section on The World)*. For example they were developing knowledge of factors that might contribute to the **similarities and differences** in behaviour of the cars. They talked about how features of the cars and ramps **might vary** and **offer explanations** for their observations.

Opportunities for creativity

The activity offered rich opportunities for the development of creative dispositions. Motivation**, curiosity and sense of initiative** were shown in children's sustained engagement and the sense of direction in the focus of their activities over time. There were opportunities for **problem solving** as children tried to make vehicles run more smoothly or faster. They made **connections** for example

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between the height of the ramp and the movement of the vehicles and offered **explanations** for actions and ideas.

Features of creative teaching were shown in particular in the provision of **rich resources**, the **space and time** given for children's own **play, exploration and problem solving** and the use of **questioning** to support children's **reflection and reasoning**.

Episode 3: Bee Bots

This session involved children working with programmable floor robots called Bee-Bots. They are used widely in nursery and primary schools for introducing control, directional language and programming to young children. They are attractive and simple to use with buttons to press to make the Bee-Bot go forwards and backwards and to turn left and right through 90 degrees. The Bee-Bot has a memory that can store up to 40 steps.

This episode relates to the activities of two different groups of children over a half hour period. It illustrates ways in which the teacher, Dawn sought first to support children in becoming familiar with the buttons, developing skill and confidence through moving their Bee-Bot forwards to its destination (a planet) and then to encourage them to solve the problems they encountered when trying to get their Bee-Bot back home.

Pedagogical framing

Dawn's planning (see Appendix) indicated a number of key **aims** for this session including that children should

- know and use the directional language of forwards, backwards, left and right and the terms clear and go. Translations of this key vocabulary in Turkish and Spanish were included in the planning document.
- begin to programme a series of instructions.
- work alongside each other and take turns.

The activity took place inside in corner of one of the rooms in the nursery. Dawn worked with a **small group** of four children in turn. Each child had a Bee-Bot. Dawn had prepared cardboard pathways for each Bee-Bot marked out with four steps, each to a different planet – for example Moon, Mars Venus, or Neptune. The session was planned to **allow time** for children to familiarise themselves with the functions of the different Bee-Bot buttons and then apply their knowledge to making their Bee-Bots go to their planet and back. Children were free to participate as they wished, provided space was available.

Key **questions** were identified in the teacher's plan to encourage children to

- plan what they would do next for example: *'What do we need to do first? Which way do you want to go?'*

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- reflect on experiences for example '*What happened when you pressed that button, How did you make it go?*'
- think about how to make the robot perform particular actions for example '*Could you tell it to move over there? How could you make it do that?*'

Pedagogical interactions

The observations of the researcher started when the first group of children Diana, Zena, Lamont and Nash had managed to get their Bee-Bots to their planets and were now trying to get them to turn round and come back home, but were having difficulties. In response to Lamont's request for help, and noticing Zena was having similar difficulties, Dawn asked the children to look at Zena's Bee-Bot, to **offer alternative ideas** about what they might do and **observe** what happened, as can be seen in the extract below.

Lamont: "My Bee-Bot's gone the wrong way Dawn" [He had continued to press *forward* when he needed to press *backwards* or to turn the robot round to get it back home. Zena next to him was having the same problem.]

Dawn: "Watch – just leave him there for a minute." [She indicated to watch Zena's Bee-Bot]. "He wants to go back to Zena – what have we got to do?"

Image 3.1: Lamont and Diana trying to find way to get their Beebots home.

Nash stretched out his hand to show his idea.

Dawn: *"Just look and say* [encouraging him to articulate his idea]"
Nash: *"Push here* [to turn the robot round a quarter turn]"
Dawn: *"Ok Nash – do you want to have a look what happens?"*

Nash pressed turn and go.

Nash: *"It went that way* (pointing to indicate looking sideways]"
Dawn: *"Is that what we want?"*
Nash: *"You got to push that one again."*

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Dawn: *"Ok* [she pressed the turn button] *– and then what do I do?"*
Nash: *"Go zzzz [*copying the sound of the Bee-Bot*]"*
Dawn: *"Is he facing the right way now to get back to Zena? "*
Children: *"Yes."*

Having turned her robot round, Zena then set about trying to get her Bee-Bot to travel home.

Zena: [out loud] "*You need to press clear and then that one.* [She presses backwards]. *He has not moved? What do I do?"*
Dawn: *"Diana can you help us*?"

Diana pressed go and the robot goes backwards away from Zena. This provoked much laughter.

Lamont: *"I know I know – back."*
Dawn: *"Nash – what's your idea – can you do it?"*
Nash: [Pointing to the forwards button] "*Forwards*."
Dawn: *"How many times?"*
Nash: *"1234 and press the green button"*
[Robot goes back almost to home.]
Dawn: *"What have we got to do now Daphne?"*

Dawn pressed clear and with one more move forwards the robot arrived at home base. The children clapped their hands.

In the remainder of their time with the robots the children showed intense engagement with **solving problems** in getting their robots to travel to their planets and back. They laughed when things did not turn out how they wanted and **collaborate** with Dawn's support in trying to get the robots to turn or move the right way and to organise the sequence of actions. Diana and Nash both started to programme the robot to move several steps at a time

With the second group of Hakim, Jemma, Josef and Devon, Dawn again started the session by saying that their Bee-Bots are "*going to the planets*". She asked the children if they could remember what the buttons do, reminding them in particular about CLEAR and GO. The children then started to make their robots move forwards a step at a time. Debbie used **questioning** to encourage children to **explain** what they are doing.

Dawn: *"What do we need to make him go again Josef?"*
[Josef pressed clear, then forward, then green.]
Dawn: *"Ok keep going- they need to go to the planet."*

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Image 3.2: Josef starting his Bee Bot

The children all got their robots to the planets quite quickly. Dawn now **encouraged the children to offer ideas** about how many steps it took to get their robots to the planets and then about how they might get their robots to travel all the way to the planets in one go.

Hakim: *"We've got to the planets*." [He cheers]
Dawn: *"Because how many times did you push?"*
Josef: *"Six times."*
Dawn: *"Jemma – how about yours – are you going to land on the planet?"*
Jemma: *"I'm on the planet next to you."*
Dawn: *"Devon has yours come – how many times did you need to push it."*
Hakim: *"Lots of times."*
Dawn: *"How can we make it go all in one go – how many times would we need to push?"*
Josef: *"123456."*
Dawn: *"Lets try out and see."*
[Josef presses 123456. The robot sets off towards Mars – but also goes beyond.]
Dawn: *"Wow you did it - but now he's going to another planet – he's not stopping!"*
Josef: *"Gone in there* [in the kitchen]!"
Dawn: *"I think he's going for lunch – is he still going or is he stopped?"*
Josef: *"Stopped."*
[All the children are laughing.]
Dawn: *"Thank goodness for that. How are we going to get him back?"*

This prompted others to try out how many moves to get their robot past their planet into the kitchen. This was followed by similar explorations to those undertaken by the earlier group, concerning how to get their robots to come back to planet Earth using quarter turns to change direction.

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Opportunities for learning in mathematics

Children' explorations of the Bee Bots reflected dimensions of *effective teaching and learning* in the *Statutory Requirements for the EYFS* (DfE 2012). Children had rich opportunities for **exploring** how to control the Bee Bots to **investigate and experience things and have a go.** They participated **actively** and **persisted in the face of difficulties**. They demonstrated abilities to **express ideas** and to **develop strategies for doing things**. The children also showed characteristics associated with the *Early Learning Goals* associated with *Mathematics (Section on Space, shape and measures)*. For example they **used everyday language to talk about position** and direction to **solve problems**. They also indicated capabilities in relation to Understanding the world (Section on Technology) in **using technology for particular purposes**.

Opportunities for creativity

Features of creative teaching were shown in the use of **questioning** to foster **dialogue and collaboration** as children became familiar with the buttons on the Bee Bot and **tackled problems** in getting then to move forwards and backwards to their planets. Children were encouraged to articulate and explain ideas about what to do. Throughout the session the teacher modelled interest and amusement at the movements of the robots.

There were opportunities for development and demonstration of creative dispositions including **motivation and curiosity**. Children showed **problem solving** and reasoning skills – making increasing **connections** between the buttons they pressed and the resultant actions of the robot.

3.10.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

What role if any does creativity play in these?

Approaches to teaching at the nursery emphasise the **importance of play and exploration** and the provision of a rich environment for learning both **indoors and out**.

Staff planning indicates the potential in activities for the development of learning processes associated with science and mathematics and with creative dispositions. Opportunities for processes such as **predicting, selecting materials, representing ideas or reasoning** are identified explicitly. There is an emphasis on **collaboration** and **communication**. Clear indications are given of the kind of comparisons or **connections** children might make to support their developing understanding in science and mathematics. There is strong focus on fostering **children's interests, motivation** and **curiosity** and on providing meaningful activities linked to making connections to **everyday lives and experiences**.

Approaches to teaching are skilful in supporting access for the wide range of children in the setting. Adults adopt and encourage a **variety of modes of expression**. Adults undertake a variety of roles, at some times standing back, at others joining in activities alongside children, scaffolding through

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modelling and shared enjoyment or in the case of focus group activities using **questioning** to promote sustained shared thinking such as " *What do you think will happen if …? What do you notice? How could we do that? What do you think we should do next? Why do you think that happened?"*

Assessment information is used systematically by staff to inform planning and provision for individual needs. Children are encouraged to **reflect on their own learning** through discussions of photographs in their profiles that record key experiences across their time in the nursery.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

Fieldnotes (not just those associated with the episodes reported) provided evidence of children employing a wide range of inquiry processes across the rich range of activities planned each day including **observing, predicting, making connections or communicating ideas**, as anticipated in staff planning. Children showed **independence** in pursuing their own enquiries, demonstrating high levels of **engagement and interest**. Children's profiles and interviews with individual children reflected their **enthusiasm** and enjoyment and willingness to share and **reflect** on their experiences.

How do teachers perceive their role in doing so?

Key features of Jennie's perspectives on the roles of adults have been highlighted in the introduction of the case. Important dimensions include the high priority given to the provision of a **rich range of experiences** both **indoors and out** and the need to plan **meaningful activities** that make connections to children's **everyday lives**. For example Jennie highlighted the potential of daily activities associated with paint mixing, cooking or making playdoh. She indicated the importance of different experiences and approaches to introducing ideas in science and mathematics and the importance of giving children **time** and the chance to revisit experiences.

> *"Building on things and coming at it from several angles that can get missed out in later school number work or whatever – throwing bean bags, jumping along the logs - I think that is what is so wonderful about nursery and now reception provision - that children can explore through different methods and senses….variety of ways and never ending ..You cannot give them enough opportunities – say you have done shape or melting. You still need to come back again and again...It can take time."*

Jennie and the staff team demonstrate a strong focus on enabling every child to reach their full potential through detailed attention to their needs and progress and fostering confidence in **communication through varied modes.** Jennie indicated the importance of standing back and observing children's activities but also the value in engaging in joint activity and using **questioning** to extend learning based on careful tracking of children's progress:

> *"Getting that balance between adult directed and the child initiated and free flow and constant going back to things and repetition enables lots of children to work like that. That's*

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why we plot their progress quite methodically and at length to see what they are doing and where their gaps are".

She underlined the need for close collaboration and communication with parents to gain a full picture. "*There are also children who do lots of something at home and they really really don't want to do it anymore because they are used it."*

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3.11 Case: 'Emily'

3.11.1 Context

Where?	Country	England			
	Setting name	EN7 - Yardley			
	Location within setting	Primary School			
Who? (children)	Year group/age of children	Year 1 (5-6years)			
	Number of children in class	30			
Who? (adults)	Number of adults	3			
	Role of adults	1 teacher and 2 teaching assistants			
	Case teacher role	Class teacher			
When?		1	2	3	4
	Dates of visits	6/02/13	11/02/13	25/02/13	4/3/13
	Times of visits	9:00-11:30	9.00-11.30	9:00-11:30	9:00-11:30

School/Setting

Yardley primary school is an established school in an urban setting. It is a two-form entry school taking children from 3-11. The Early Years Foundation Stage includes two full-time Nursery classes. Children come from a wide range of ethnic backgrounds. About 15% speak English as an additional language and 27 different languages are spoken at home. Very few are beginners in English. The proportion of children eligible for free school meals is broadly in line with the national average. The number of children with learning difficulties and/or disabilities is below average, although is higher in some year groups. The most common learning difficulty is dyslexia. A small but significant number of children have complex needs. The school has a number of national awards including Healthy School and Artsmark Gold.

The head teacher has been at the school for many years and so have many of the staff. The school works in partnership with a local Higher Education institution where many of the staff were trained. Staff at the school are experienced in mentoring teachers in initial training. It regularly takes students on placement for school experience.

Yardley is a relaxed school with consistently good results and the teachers are given freedom to do things in their own ways. In the most recent Ofsted inspection report in 2009 the school was judged as outstanding. In particular the report stated:

> *'Standards in the current Year 2 are above average and pupils' progress since the end of their Reception Year has been very good. They have made exceptional progress in relation to skills*

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such as formulating and asking relevant questions, problem-solving and critical thinking. Pupils learn to work independently and develop the confidence to explore ideas and explain their thinking by themselves' (Ofsted 2009).

There is a Senior Management Team (SMT) that includes an inclusion manager and a co-ordinator for the early years. Any member of staff can attend the SMT meetings and put forward ideas to be considered. There has recently been INSET in the school to bring some of the good practice in the early years into the later years of primary schooling. For example construction activities and the provision of role-play areas are to be promoted in all classes across the school.

Teacher

The class teacher has a degree in English Literature and is a trained teacher with a Postgraduate Certificate in Education. She has been teaching for less than 5 years.

In her interview it was clear that provision for play is very important to Emily. Emily considers "*there is too much sitting at desks and we are trying to bring the play back into Key Stage 1*". For example, when magnets were first introduced she felt it was very important for the children to play with them and find out what would happen before more focused activity. She indicated she thought she was very lucky that this way of working was encouraged by the Senior Management Team at the school. The Local Education Authority where she works has set up a group for like minded schools to become more play based. This has been very popular so far. However Emily expressed concern about whether Ofsted inspectors would approve and that many schools are under pressure to work in more formal ways.

Emily has recently attended mathematics workshops and a conference that both had a large impact on her practice. She has been involved in a network of teachers focused on mathematics. Teachers involved are sharing practice about play- based approaches to mathematics including an examination of teaching strategies involving the use of a carousel of activities associated with a particular topic. She is fairly confident about her science subject knowledge and mathematics but is less confident about assessing children in both subjects. Positive attitudes to science are very important to her. She is more interested in fostering positive attitudes and scientific processes than knowledge and understanding of the subject.

Emily and her parallel class teacher work closely together.For the future they are considering having one classroom play-based and one with tables for writing and they are thinking carefully about the range of resources they use. Planning is done with the teacher in the adjoining parallel Y1 class. Planning is the same for both classes. This means they can swap rooms and share the resources. Emily spends considerable time planning the mathematics experiences for Y1 and the parallel teacher, who is the science co-ordinator, plans the science.

Special provision is made for Sam who is autistic. There are two other children who she is aware of when planning who find more difficulty in understanding than the others. A particular feature of Emily's approach to learning and teaching is that children are organised into mixed ability groups for

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classroom activities. "*I don't like ability grouping but another teacher does take out groups when I feel they need to be stretched or catch up*". Children are allocated talk partners (the children are paired with another child who they are asked to discuss things with and also work with in the classroom) and these are changed each week. When the children come in on Monday they have a new talk partner. Groups are then made up of three pairs of talk partners.

In terms of assessment Emily writes down who was able to complete a task successfully on her plans and this is put into the planning file. Then there are notes for the next time when she comes to planning the same topic. "*I write down notes in a box in my planning file but not every day. I do it especially if it's crucial like when I am teaching* Time *which I find hard*". Assessment in science is often through portfolios of their work. She rarely uses checklists or classroom interaction to assess the children. She never uses homework for assessment. Assessment in science is used to identify areas for improvement and to improve child science learning. Parents are informed of the children's progress in science but individual children do not get formal feedback on their progress.

Classroom

The classroom consists of tables arranged around a carpet. The places at the tables are not allocated specifically for any child. The introductions and plenaries for sessions take place on the carpet. The children are encouraged to move freely around the classroom. In the classroom there is a role play area in one corner. An Interactive White Board is used extensively for consolidation. There is a book area and a creative area around the sink. Resources for mathematics and science are shared with the parallel class. Each child has their own drawer to store their own work.

There are two Teaching Assistants who work with the class. Their main roles are to work with the children. They both take turns to support the child with autism.

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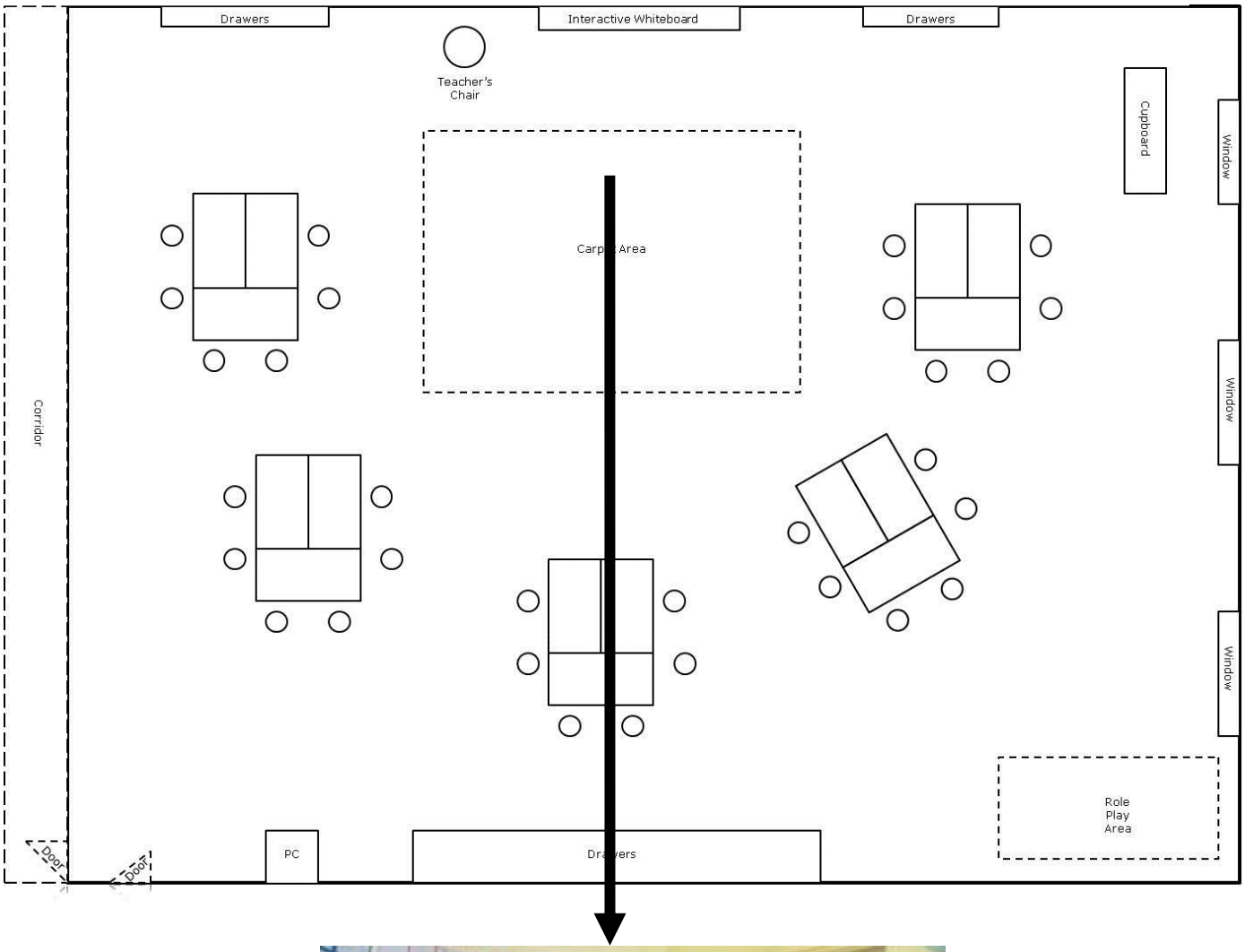
Emily's Year 1 Class at Yardley Primary School



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3.11.2 Episodes

Episode 1: Balancing Pens

Pedagogical framing

This episode is just a very small part of a lesson on measurement. The aims of the session were:

> *"To estimate, measure, weigh and compare objects, choosing and using suitable uniform non standard and standard units or measuring instruments"*

The following activities were made available to all the children over two consecutive days to be carried out in mixed ability groups in a rotation.

1. *Filling boxes*

   Large cardboard boxes of varying size labelled with letters. Estimate how many balloons/balls will fit in each box. Then check and write down the number on a label on the box. Order them from the one that holds the least to the most. Were you surprised? Why did you think that box would hold more/less than that one?

2. *Capacity of a jug*

   Show children a jug of water. Will one jug be enough to fill six cups? Ask them to find out how many cups the different containers will fill. Children take it in turns to pour water carefully into a cup OR count how many cupfuls fill a container. Each group records the amount onto a table. Then ask questions: which container filled the most jugs? How many more did x fill than y?

3. *Building towers*

   Build towers of 20 using different types of construction toys for example wooden blocks, lego, stickle bricks etc. Compare heights. Why are they different? Can you find out which is the heaviest/lightest tower?

4. *Measuring length with a metre stick*

   Use metre sticks. Find 3 things longer/taller than a metre stick and 3 things smaller in the classroom. Take children into the hall. Where would you start to measure the width of the hall? How many metres wide is it – estimate and record. Stop half way and ask if they want to change their estimate.

5. *Weighing*

   Weighing: find different objects that will weigh 1kg (might need to be 500g) Draw pictures on a diagram. How many cubes/marbles/100g weights does a tennis ball weigh – estimate and check.

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Image 1.1: Some of the measuring activities

The episode described here focuses on the Weighing activity (outlined above) that took place at the weighing table as just a small part of the wider lesson with a carousel of measuring activities and on Emily's plenary at the end of the session. They illustrate the **play-based approaches** emphasised by Emily, and her concern to foster **alternative ideas and reasoning.**

In planning, the tasks were set up to allow **problem solving** in mathematics. Children were provided with a **wide range of materials** to support their inquiries. The children worked in pairs and were encouraged to **collaborate**, to talk and discuss together. The task were designed to promote **questioning** and **reflection** on what happened and why.

Pedagogical interactions

The Weighing Activity

Image 1.2: The weighing table with balances and a range of items to weigh

The weighing table was set up with a range of materials, including small pens, Berol pens (larger), small animals, paint brushes and a balance scale to be shared between two children. The children were asked to use the balance to find out how many of each object was needed to weigh 100gms.

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They had a worksheet to fill in as they went along. On the worksheet they had to record the object and how many of that object weighed the same as 100gms.

Two children, Neil and Henry were using Berol pens to weigh how many pens would balance 100gms. They were working **collaboratively**. They were having difficulties in getting the scales to balance.

Neil: *"It's not balancing."*
Henry: *"Put on another one."*
Neil: *"But now it's too heavy."*
Henry: *"Take one off."*
Neil: *"It's still not balancing. It doesn't make sense."*

Henry offered an **alternative idea -** that they use smaller pens to balance the 100g weight. Prompted by Neal he **explained** his suggestion and his estimation of how many would be needed.

Henry: *"Let's try the mini pens they will work better."*
Neil: *"Why?"*
Henry: *"Because they are smaller."*
Neil: *"It isn't 100."*
Henry: *"Think we will need 30 to balance the 100g weight."*
Neil: *"This is too little because they weigh nothing. 100gms is not heavy."*
Henry: *"It's 39 that's right. 39 is 9 more than my guess."*

The children then moved on to finding out how many animals weigh 100gms.

Henry: *"I think it's 40- animals don't weigh much."*
Neil: *"Real animals do."*

Image 1.3: Neil and Henry working together

The situation created for these two boys was one where they were challenged to think and **solve**

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problems for themselves. What is happening? This wasn't what we expected so what do we do now and why is it not working? So what is the problem? They did not quite solve it but by coming up with the **alternative strategy** of using smaller and lighter objects their task became more straightforward.

Plenary discussion with the whole class

Emily asked many **questions** at the beginning and end of the session to **encourage thinking and reflection**. Discussion across the plenary was **scaffolded** by building up learning in very small steps. Emily began by discussing the appropriate equipment for measuring capacity. She then reiterated the same idea in relation to length, but expanding the nature of the problem. She was aiming for the children to understand the need for selecting and using the right equipment for measurement and was making connections across two types of measurement. For example Emily first asked some **questions** about measuring length. She began by asking about the length of a pencil and what item would be suitable for measuring this. They were given the choice of unifix cubes, feet or children. Michael suggested, "*measuring using people is no good because people are much bigger than a pencil*". Sophie suggested, "*using unifix cubes*". Emily moved on to asking about the width of their bedrooms at home and what tool they would use to measure it. She encouraged **alternative ideas** and **explanations** for children's suggestions.

Emily:	*"Which would you use – there is a choice of unifix, a ruler or a metre ruler?"*
Grace:	*"Metre stick"*
Sarah:	*[disagreeing] "The bedroom is bigger than a metre stick. Cubes would be better because there were lots and you could use lots of them. It would be better if you had 2 rulers. It won't stay like that if not enough sticks."*
Emily:	*"What would choose if there were enough sticks?"*
Audrey:	*"Using a metre stick isn't good because when you get to 10 then you have to go back to zero."*

The discussion in the plenary provided Emily with valuable **assessment** information to inform future planning. In sharing her evaluation of the session Emily indicated she was concerned that the children at the end had not understood about longer lengths and she felt that measuring up to a metre had reinforced that. It was not clear that they understood how to use a metre stick to measure longer lengths. The children seemed to think that it was impossible to measure without having many metre rulers. The problem here could be to do with transitivity and the children not being aware that one metre ruler is exactly the same length as another metre ruler. She decided therefore that in the next session she would provide activities going beyond a metre to give them the opportunity to think through the problem of measuring longer lengths.

Opportunities for mathematics learning

Emily provided a range of activities in the classroom that matched the remit of the National Curriculum for Mathematics that asks for children to have a wide range of experiences of measurement at Key Stage 1. It fits in particularly with the requirement for Ma3 Shape, space and measures: Understanding measures 4a '*compare and measure objects using uniform non-standard*

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units'. The language of measures is important, too and all of the activities encouraged the children to use the appropriate language for example, *'Is it heavier'?*

Opportunities for creativity

Creativity in teaching was shown through the rich opportunities Emily provided for **exploration.** Emily planned **meaningful contexts** and activities making links to **everyday events**. She modelled **enthusiasm** portraying the subject as being interesting. Emily **scaffolded** learning through small steps, slowly **building on children's ideas** in whole class discussion. She used **questioning** to motivate and to encourage children to express their ideas and to **foster reflection and reasoning** – making **connections** across experiences for example at the beginning of the plenary she talked about the appropriateness of the container for measuring the capacity and then moved onto the appropriate tool for measuring length.

The planned activities fostered children's **creative dispositions.** The children's attitudes to the mathematical activities were positive. They showed high levels of **engagement** and they were not daunted by challenges or by failing to get an answer. They showed a **sense of initiative** in coming up with ideas to **solve the problems** they faced and **reasoning skills** in justifying their suggestions.

Episode 2: Doubling

Pedagogical framing

This episode is based mainly an interview with the children following on from a mathematics session focusing on doubling. It illustrates in particular the children reflecting on their experiences after the lesson had taken place and the learning that came from it retrospectively. The aims for the session shown in Emily's planning were: '*to solve problems involving counting, adding, subtracting, doubling and halving'.* The following activities were made available to all the children over two consecutive days, to be carried out in mixed ability groups in rotation.

1. Snakes and Ladders game

This was a Snakes and Ladders game using doubles. The children had to roll the dice, ten depending on the number the dice landed on they doubled the number and moved that up the board.

2. Doubling larger numbers

There were number cards in a box and the children had to take out number cards at random and double them, using unifix if needed.

3. Finger painting

Children picked a card and printed a few dots on one side of a piece of paper that was then folded to make a butterfly with symmetrical dots on the wings. They were asked to write the number sentence representing the total number of dots for example 4 + 4=8.

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4. Number towers

Children picked a number card (for example 10). They then must build two towers of unfix made of the number on the card (for example 10 + 10) and write the double number sentence on paper.

Image 2.1: The unifix cubes to support the activity with larger numbers

In Emily's planning, the tasks were set up to foster **problem solving** in mathematics. The children worked in pairs. There was a **variety of equipment** available for them to use. There were boards for the snakes and ladders game, plus dice to use to travel along the board. The butterflies were made by using paint and paper. There were boxes of unifix to help with calculations. White boards were set out on the tables to use for recording the doubles operations.

Pedagogical interactions

The tasks offered opportunities for **play and exploration**. The children were encouraged to **collaborate** with their talk partners in the all activities and to talk and **discuss** their tasks. The roles of the adults were to **encourage children's questioning** and to **foster reasoning** by asking children to communicate to an adult about what they were doing.

The session started with a discussion with the whole class. Emily began the session with two hoops on the carpet. She began with **questioning** the children about doubling. The sequence of questions established the meaning of doubling and then discussed examples of doubling, slowly increasing the numbers and level of demand.

Emily: *"What is doubling?"*
Charlie: *"Longer, bigger. It's like 3 and adding on 3."*
Emily: *"What is double 3?"*
Charlie: *"6."*

She then increased the numbers slowly

Emily: *"Well done. Double of 6?"*

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Ishmael: [He put 6 in each hoop.] *"It's 12."* [He counted out – 12].
Emily: *"You are good at doubling so let's have a bigger number -11."*

Emily encouraged **prediction** and thinking about the numbers.

Emily: "Can you estimate or predict what the answer might be?"
Leo: "22."

Claire said 21 and counted 11 and then counted 11 again by starting at the beginning but then Leo said, *"10 and 10 is 20. 11 is one more and there are two 11's so it will be two more".* Emily praised Leo for his working out and then went on to explain the various activities. The children went with their talk partners to the various tables. At the end of the session Emily gave lots of positive praise for all the work the children had done successfully by adding double numbers. Then she used an IWB programme to check doubles of numbers to consolidate their understanding.

Children's reflections on their learning

Following the taught session the researcher had a discussion with a small group of children about their learning. These were children who had been observed during the session. Although it was not clear at the time they were observed what learning was taking place, afterwards they were able to use their learning effectively to reflect on strategies with double numbers.

Researcher: *"Did you learn anything when you were playing the snakes and ladders game?"*
Chloe: *"I learnt Doubles. Doubles in the snakes and ladders."*
Researcher: *"Doubles you didn't know?"*
Chloe: *"Yes"*
Researcher: *"What was the biggest double that you could have when playing?"*
Charlie: *"Biggest was 3+3."*
Researcher: *"Was it? Was there no larger number than 3?"*
Freddie: *"It did have 6."*
Ben: *"No it didn't no 6?"*
Children: *"It had 2 3's, 2 2's and 2 1's. 1 2 3."*
Researcher: *"What if there had been a 6? How far could you have moved then?"*
Alec: *"12 steps."*
Audrey: *"I think I know why it's up to 3, so it's not too easy."*
Ben: *"That is easy it should challenge you."*
Audrey: *"If it was 6 or 10 it would get finished straight away."*
Ben: *"If it was little numbers it would be so easy."*
Audrey: *"You just got there but if you had 20.you move 20 steps. You had 20 steps without moving you'd be at the finish."*

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Opportunities for mathematics learning

Knowing doubles of numbers in mathematics is regarded as a useful tool for doing more complicated operations. For example if 4+4 =8 then 4+5 = 4+4+1. The use of doubling is a good strategy for mental mathematics. In the National Curriculum for Mathematics knowing doubles of numbers to 10 is part of Ma2 Numbers and the number system: Calculation Mental methods (c). The reasoning that took place relates to the development of applying mathematics. Ma2 Number: Using and applying number 1(i) 'explain their methods and reason when solving problems'. Reasoning is an important part of the development of logical thinking in mathematics.

Opportunities for creativity

Features of creative teaching were shown in the Emily's planning of tasks to encourage **problem solving** and her explicit encouragement of collaboration and dialogue through pair work in talk partners. Emily **scaffolded** children's learning at the beginning of the session by building up the size of numbers. This provided evidence of children's **reasoning** skills prompted by Emily's **questioning**.

In observing the children across the rest of the session it was evident that the activities were engrossing, but it was hard to judge how much learning had taken place or to identify creativity in children's thinking. Interestingly it was after the end of the session - when the children were reflecting back their understanding that this became more apparent. For example, Audrey was able to work out that although at first it would appear to be easy if large numbers were used and therefore getting through the board would be quicker, it was more interesting to use smaller numbers and make a longer journey. She did not mention strategies but the implications are that strategies could be employed to make the journey longer and potentially more interesting. This sort of **reasoning** is one of the processes in thinking that is highly relevant to **problem solving** which could be argued is the most creative aspect of mathematics.

Episode 3: Waterproof Materials

Pedagogical framing

The session on waterproof materials was part of a half term science based project on materials and it was fairly near the end of the half term. The context for the session was the need to select the best material to make an umbrella.

The aims for this session were for children *'to carry out a simple investigation and to know some materials are waterproof and others are not'.* Emily also made connections to the following Assessment Foci (AF) from Assessing Pupils Progress in Science (QCDA 2009).

- *AF2 Identify link to science in familiar objects or contexts.*
- *AF4 With prompting make suggestions about how to find an answer. Use senses & simple equipment to make observations.*
- *AF5 Respond to prompts to say what happened*

Emily had set up 6 six jars on each table with a jug of water and a tray. Each jar was covered in the

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same way by a different material (plastic, newspaper, foil, fabric, sugar paper and sponge). Children were provided with a record sheet to help them to plan and communicate how to find out about waterproof materials. It included the following sentences:

These are the pictures of what I will use.

Prediction (what I think will happen). I think ____ will make the best umbrella. What I will keep the same. What I will change?

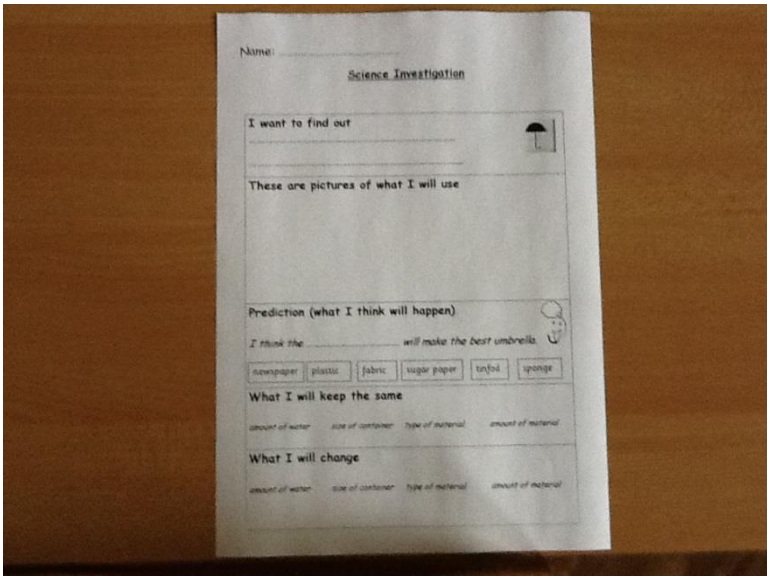

Image 3.1: The worksheet

The children were working in groups of six. Each child had to choose one of the six jars covered in a material to test if it was waterproof. The children had to **collaborate** in testing the materials and to come up with a final decision by **comparing** the different materials on the jars.

Pedagogical interactions

Throughout the session the children were encouraged to be 'good scientists'. Emily talked about what makes a good scientist as someone who investigates a problem (which would be the best material for an umbrella) and in the session encouraged children in advance to **predict** outcomes and to record their work on the sheet as a scientist would to share findings. They were encouraged to work together in pairs and as a group. This task was particularly **collaborative** as they all had to share the tasks between them and agree on the findings. There was considerable time given to **discussion** and **questioning** at the beginning and end of the session when the children were all on the carpet. The children were encouraged to think and **reflect**. Emily **made connections with previous sessions** on materials and their properties. She linked the properties of materials to their **use in everyday life** referring for example to the need for a cloth to wipe up the water not to be waterproof to clear up the water from the table. As in the previous episode, the plenary was **scaffolded** to encourage learning by building up the thinking in small stages.

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Whole class introduction to the session

The session began with all the children on the carpet. Emily began the lesson by talking about the class puppet MAX who needed a new umbrella because he had left his on the bus. (Emily uses the puppet here to elicit ideas from the children.) She said that he needed a material that was waterproof to make a new umbrella. She asked what is meant by waterproof. Clara said: "*Waterproof doesn't mind if it gets wet*". Emily clarified this explaining that a waterproof material stops water or liquid going through it.

Emily then explained that MAX wanted to see them as real scientists who can record. She showed the sheet for recording and the resources. She used **questioning** to help children think about how to conduct their investigation asking "*How would you do it*?", "*How could you find out*?"

April **offered an idea** *"put water on it".* Emily demonstrated what April had suggested and asked, *"How will I know?"* April then **explained** her approach "*Pour the water on top –if it goes through then it is not waterproof".*

Emily explained to the class that she wanted them to find out which material is the most and which the least waterproof to help them decide how to make a new umbrella for MAX. She emphasised that really good scientists write down in advance and that this is what they will do, too. Emily read through the record sheet she had provided. She then asked for predictions. The children offered various suggestions, for example Freddie said "*plastic?"* and Sophia "*material*?" Emily indicated they would now be able to find out.

Carrying out the investigation

The children went to their tables and worked quietly to predict what might happen. After children had made their predictions, they went back on to the carpet to discuss the next step. Emily explained that they always needed to take care to use the same the same amount of water when testing the materials "*You need to keep it as a fair test on your table*". She continued by reminding them that all the jars were the same size and there was the same amount of material on each. She explained that the children would need to share the jars covered with material across their groups, selecting one to test each and comparing results.

Emily: *"We have six cups on each table? What would be fair? One cup each?"*

The children then went back to the tables and choose which materials they wanted to test. Emily helped one group by talking through the task with a group on one table. She discussed the worksheet and what they needed to find out. The children took it in turns to pour water onto their cups with the material on the top. Then they had to write down the results at the end when all the materials had been tested.

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Image 3.2: The table with some of the jars with their coverings of fabric, tinfoil, sugar paper and sponge

The children worked together but found it quite difficult to take turns and wait as illustrated by the following exchange between Anna and Zoe. They talked about what they **observed** and **referred to evidence** in justifying their conclusions about whether a material was waterproof.

Anna: "This is waterproof."
Emily: "What is it?"
Zoe: "Plastic."
Emily: "How do you know it's waterproof?"
Anna: "No water went inside."
Zoe: "It's my go."
Emily: "What is your material?"
Zoe: "Paper."
Emily: "Do you know what will happen?"
Zoe: "It will go through."

Zoe pours the water on top and is pleased to see that it goes through.

Then Theo has a go with his cup that is covered with tin foil. Here there is some disagreement about what they observed.

Theo: "It has gone through."
Emily: "Are you sure."
Zoe: "It is not going through"

They argue for a while. The other children in the group have their turns. (although the session was recorded it was hard to hear individual voices after this). When all had finished testing they went back on the carpet.

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Image 3.3: Lily has her turn

Reviewing the investigation

Emily asked the children to share their **conclusions** about which materials would not make a good umbrella and to **explain** their ideas drawing on their **observations**.

Emily: *"Can you tell me what the puppet should Not use?"*
James: *"Blue fabric?"*
Emily: *"What was the matter?"*
James: *"The water went through."*
Charlie: *"Foil - no." [Some of the children agree].*
Chloe: *"Don't use newspaper."*
Emily: *"Why?"*
Chloe: *"Holes?"*

Emily then commented that you see a newspaper on people's heads when it's raining if they don't have an umbrella and asked "Why does this work?"

Dan: *"Because if you have so many bits it is very strong and water doesn't go through it. It would work for part of the day but then would soak through if it was used all day."*
Emily: *"What else would we not use?"*
Sophia: *"MAX should use plastic."*

Several children agreed. The children continued to discuss what might make the best material for an umbrella, **suggesting ideas** about other properties that might be important.

Billy: *"Sugar paper - it went through."*
Emily: *"So we've got some saying yes to plastic."*
Emily: *"Why?"*

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Clara: *"What's good is it runs off and it doesn't stay on it. Plastic is good."*
Emily: *"What's good about foil?"*
Leo: *"You can't see where you are going. You might crash into people."*
Jodie: *"But foil is sparkly and will make a sparkly umbrella."*
Grace: *"But plastic is better as an umbrella because you can put it down rather than foil. Foil gets all scrunched up."*
Emily: *"Fantastic thinking that makes lots of sense. Which is stronger?"*
Benjy: *"Plastic when you pull it will stretch."*
Emily: *"MAX will read all the scientific reports and see what you found out. The more you tell me the more help he will get."*

They clear up the tables and as there is a lot of water so a dishcloth is used. Emily takes this opportunity for continued discussion about properties of materials, in particular it is useful sometimes to have materials that absorb water and are not waterproof.

Emily: *"Is the dishcloth is waterproof?"*
Tamsin: *"It's a fabric."*
Emily: *"Would it work if it was waterproof?"*
Tamsin: *"No"*
Emily: *"So sometimes it is useful not to be waterproof."*

Opportunities for science learning

The session offered opportunities to address the following elements from the National Curriculum Programmes of Study for Science related to Sc1 Scientific enquiry and Sc3 Materials and their properties:

Sc1 Scientific enquiry: 2 Investigative skills

Planning – c) '*think what might happen before deciding what to do*'

Obtaining and presenting evidence – f) '*make and record observations*

Considering evidence and evaluating' – h) '*make simple comparisons*', i) '*compare what happened with what they expected would happen and try to explain it, drawing on their knowledge and understanding*'.

Sc3 Materials and their properties

1 Grouping materials – a) '*use their senses to explore and recognise similarities and differences between materials*', d) '*find out about the uses of materials and how these are chosen for specific uses on the basis of their simple properties*'.

Opportunities for creativity

The episode illustrates careful planning for the whole class to **investigate** the properties of materials and **share their results**. The scene was set by the puppet and the children were encouraged from the

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beginning to behave like 'real' scientists. Emily provided the **meaningful context** for the investigation of losing an umbrella and needing to find the right material to make a new one. The task was organised so that the children were provided with a **range of materials** and given guidance on how to test them. However they made their own predictions and they needed to **collaborate** in testing the materials and coming to conclusions. The end result was dependent on all the children finding out about their individual materials and then combining their results. The teacher used **questioning** to **scaffold** their learning, encouraging children to offer and **explain ideas** making reference back to their observations. In this way she built up a picture of their knowledge of waterproof materials as well as the ways in which they used evidence from the session and everyday experience to justify their views. She made **connections** to enable them to think more widely about how waterproof properties of materials influence their use. She pointed out that sometimes non-waterproof materials are useful too for clearing up water. Emily created an environment, supported by the puppet MAX, in which children's **alternative ideas** were valued and built upon. For example Emily did not say that the child who suggested tin foil would be best was wrong – she encouraged other views and explanations. This elicited varied reasons why the tin foil might or might not be selected related to other properties of the material.

The practical part of the session was guided by Emily and allowed limited opportunities for creativity as it was a set task that had to be completed and written up on a worksheet. However, children were very **motivated** by the context and showed considerable **curiosity** about the outcomes. There were rich opportunities for **dialogue and collaboration** in testing the materials and discussing the results in the plenary that fostered **thinking** and **reasoning** skills associated with creativity. Reflecting Emily's aims for the session, there were examples of children proposing and **discussing alternative ideas, reasoning** and **drawing conclusions from evidence,** characteristic of creativity in science. There were also examples of children **making explicit connections** between observations (from their testing and from everyday life) and conclusions.

3.11.3 Summary and Conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

What role if any does creativity play in these?

Emily explained in her interview that she has a strong focus in her classroom on **play and exploration**. This is clearly apparent in all of the episodes where careful planning enabled the children to engage in play based and open-ended activities. Creativity was promoted through this approach, for example through the opportunities offered for children to **question** and find things out. They are encouraged to **solve problems** and come up with their own strategies for example in the mathematics episodes. There was a strong emphasis on **dialogue and collaboration** supported by her grouping strategies and **meaningful contexts for learning linked to everyday life.** For example in the waterproof materials episode connections were made to the usefulness of non-

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waterproof materials in relation to cleaning, to measuring at home in the balancing pens episode or to Max's need for waterproof material to make an umbrella.

Emily indicated that she finds teaching science exciting and in the sessions she emphasised the importance of science as a subject and a scientific approach for example in her reference to working like scientists in the waterproof episode. She uses the class puppet MAX as an important partner to encourage the children to offer or **explain ideas** to MAX in discussion or as an audience and purpose for the reports of their investigations. In the 'waterproof materials' episode children were asked put in as much detail as they could in their reports for Max to support his decision-making. Throughout all the science sessions observed she encouraged **positive attitudes** to science and to learning generally. She praised the children and justified her praise. Process skills in mathematics were encouraged through **problem solving** and a lack of emphasis on correct answers.

Careful **scaffolding** is an integral part of Emily's teaching. She builds up new ideas and concepts slowly, drawing on children's suggestions and responses and **allowing the children time** to understand. Then with carefully chosen activities the children continue without the scaffold and progress. This is particularly prevalent in the introductions and plenaries but also when she worked individually with children or with the pairs during activities. An important feature of her mathematics teaching was the carousel of activities that allowed children to encounter and revisit ideas in a **range of contexts**. This encouraged children to make **connections** and apply ideas across contexts, contributing to the development and consolidation of their conceptual understanding.

Questioning is used by Emily to **motivate and to encourage** children to express their ideas and to foster **reflection** on experience. Particularly in mathematics this approach fosters creativity within the subject through mathematical **thinking and reasoning**. Traditionally mathematics is seen as a subject with one answer but by opening up questions and activities opportunities for creative thinking are increased considerably.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

How do teachers perceive their role in doing so?

In terms of children's attitudes in science and mathematics, there was much evidence in the episodes of children's **curiosity, questioning** and **enthusiasm** in the science activities observed in Emily's class. This was encouraged by the class teacher's own enthusiasm for science and also for learning generally. The classroom was full of the buzz of children being involved and enjoying their learning. There were examples of this, too, in mathematics where the children were generally **curious** about why they could not get the scales to balance when weighing the large pens. This did not daunt them they wanted to find out why it was happening. There were many examples of children **collaborating** in tackling problems and discussing ideas.

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In her questionnaire Emily put greater emphasis on process skills than on knowledge and understanding. In all the episodes this was clearly reflected in planning and teaching. Children used a **range of process skills** associated with inquiry in science, such as questioning, predicting, and observing. There were many examples of children **offering ideas** and **explaining their reasoning,** encouraged by the classroom environment and Emily's questioning. This fostered links between processes and concepts in learning as children **reflected** on what they had learned from their experiences. In discussions with the children the emphasis on process skills was apparent in the development of their mathematical understanding.

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3.12 Case Study: 'Lisa'

3.12.1 Context

Where?	Country	England			
	Setting name	EN8 - Lindisfarne			
	Location within setting	Pre-School			
Who? (children)	Year group/age of children	Reception Age 4-5 years old			
	Number of children in class	30			
Who? (adults)	Number of adults	2			
	Role of adults	Teacher / Student Teacher TA who works with the lower ability groups			
	Case teacher role	Lead teacher, sole responsibility for class			
When?		1	2	3	4
	Dates of visits	110213	120213	280213	080313
	Times of visits	11:00-12:00	11:30-12.00	13.30-15.25	9:30-11:00

School / Setting

Lindisfarne Community Primary School is average sized school in a north London borough. There are 241 children on roll (109 girls and 132 boys). The school has an Executive Headteacher, an Associate Headteacher, a Deputy Headteacher and an Assistant Headteacher. It is a community school serving an ethnically diverse population.

The number of children from minority ethnic groups is very high, with children from Black African and Black Caribbean groups making up almost half the school's population. The remaining children come from a wide variety of ethnic groups. The teaching of literacy is the highest priority as 80% of the children speak English as an additional language, with 47 different languages currently spoken in the school. The number of children known to be eligible for free school meals is well above average, at 60%. The number of children identified as having special educational needs and/or disabilities, including moderate learning difficulties, speech, language and communication difficulties, and behavioural and emotional difficulties, is above average.

In 2012 the performance figures for Lindisfarne school show the children achieved a score of 29.7 which higher than the national average (27.5).

Lindisfarne was named Creative School of the Year in March 2012 by the Hackney Learning Trust and an Outstanding School by OFSTED 2011/12. In July 2012 Lindisfarne was designated as a National

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Support school and the Executive Headteacher became a National Leader of Education which means the school can work with other schools to support their development.

Lindisfarne is one of only 150 schools in England to be granted teaching school status in the third wave of schools selected to offer school centred training and development (March 2013).

The school has received a number of national awards, including the Quality Mark for Basic Skills, Arts Mark gold, the International Schools Award and Healthy Schools status.

The children follow the International Primary Curriculum for subjects including Science, Art, Design, Music, P.E. History, Geography and ICT. Also included in this curriculum is the teaching of international understanding and personal and social goals.

In the Early Years, the school follows Early Learning Goals for mathematics (Curriculum Guidance for the Foundation Stage) and the National Numeracy Strategy Reception Teaching Programme. The school encourages parents to be involved and takes part in the 'Ocean Maths' project which involves training parents to support their children with maths homework. The parents are all invited to a workshop led by the classteacher and the maths lead teacher.

In the Reception class, science is taught as an integral part of topic work and makes a significant contribution to meeting the Early Learning Goals developing a child's understanding of the world.

Teacher

Lisa is in her 50s, and holds a BA in Early Years Education degree. Trained as a Montessori teacher, Lisa has taught Nursery and Reception for the most part of her teaching career, which is understood to be between 5 to 10 years.

Lisa's highest formal education level in which she studied science and mathematics is at the upper secondary school level and the Bachelor level respectively. In her teaching training, pedagogy was the main focus, whilst an overview of mathematics, science, creative teaching approaches and children's development of creativity was also provided.

Lisa currently holds a number of senior positions within her school, namely the Foundation Stage Co-ordinator, PSHCE Co-ordinator and Science Co-ordinator.

Classroom

There are 30 children in Lisa's class, 25 of whom have EAL. Many of the parents speak little English.

The children work in 8 ability groups for maths and in mixed ability groups for science. The children do not have fixed seating places in their classroom.

The classroom is well resourced and it has a reading corner, a role-play area, two PCs, an interactive whiteboard and a regular whiteboard. There is also a water tray, a sand tray, a construction corner, a shop corner and an arts and crafts table.

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On the walls are displays of ‘Our writing’, ‘Growth & Seasons’ and ‘Minibeasts’. There are also Table displays of ‘Our Nature Table’, ‘Numeracy Area’, ‘Growing Up’ and ‘Bugs and Minibeasts’.

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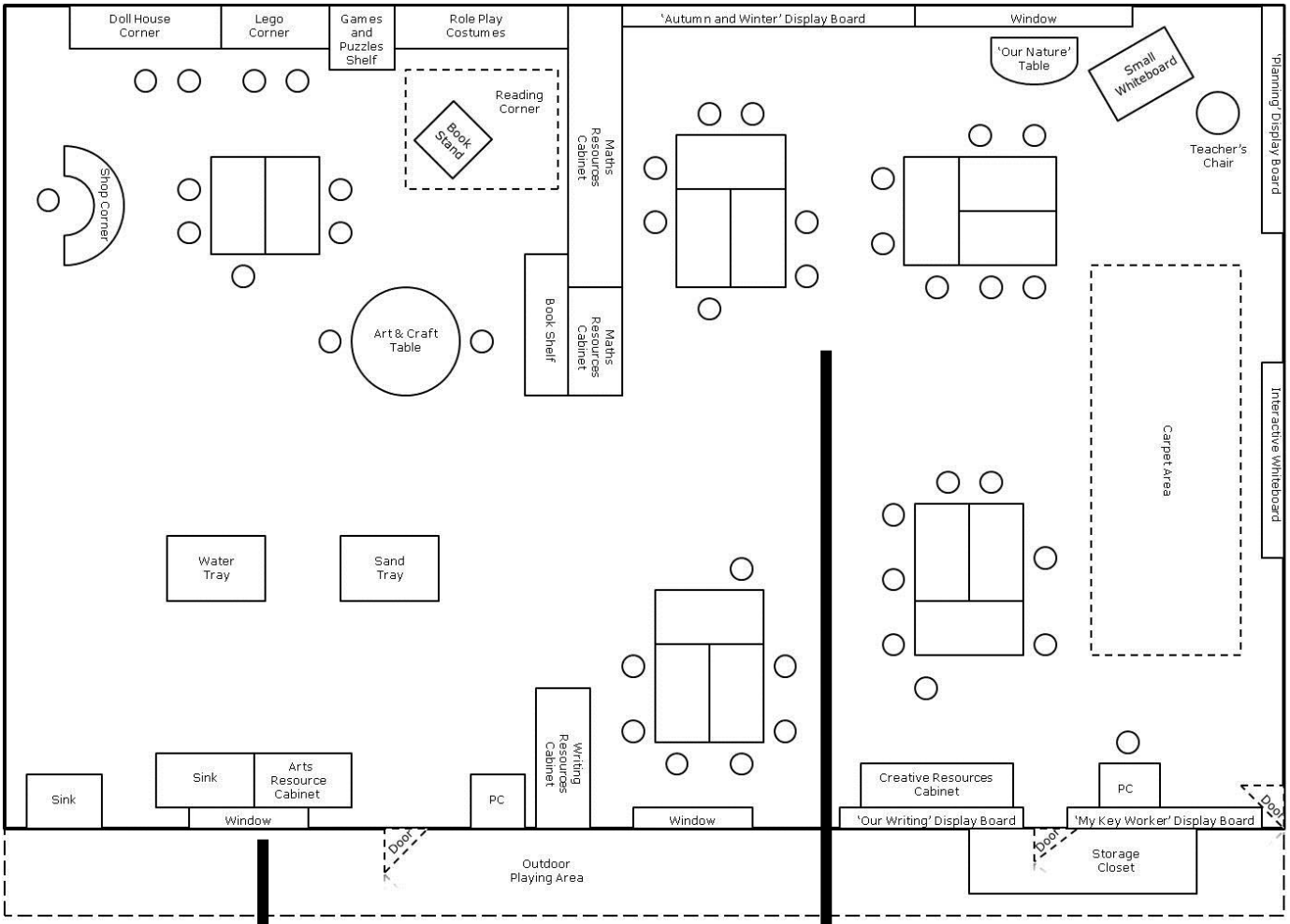
Lisa's Reception Class at Lindisfarne Community Primary School



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3.12.2 Episodes

Episode 1: Push and Pull

Pedagogical framing

Science is taught in the Reception class as an integral part of topic work and relates to the Early Learning Goals (ELG), which underpin the curriculum planning for the Early Years Foundation Stage (EYFS) (School's Science Policy).

Prior to this episode, Lisa had read the story 'The Enormous Turnip' to the children, with characters pulling the turnip. The children started this episode sitting on the carpet. Lisa reminded the children about the story and asked them to name the action needed to get the enormous turnip of the ground. The children were then asked to demonstrate pulling and pushing actions. Lisa demonstrated opening and closing a cupboard door and asked the children if she was pushing or pulling. She asked them *"Does it matter if it's wrong?"* and the children all chanted *"No, because we're learning"* thus indicating that **alternative views are valued**. Lisa feels it is important that the children feel able to make mistakes as this approach is an important factor in facilitating assessment:

> *"I think often they so wanted to just give the answers that you are expecting and that's useless to me, so by giving very open-ended questions 'What do you think?' and constantly reiterating: 'We're learning. We make mistakes when we are learning. It doesn't matter'."*
>
> *"Because so many of them want it to be just right, so that I will constantly, with my teaching assistant, model making mistakes, and then say: 'Oh dear me! I made a mistake!' And now the children are saying [to the teaching assistant] 'It doesn't matter. You're learning'."*

Pedagogical interactions

Lisa set the context for the lesson by telling the children that they were going to be learning about 'How objects move '.

Lisa showed the children various objects **providing a rich physical environment for exploration** (abacus, toy train, doll's push chair, shopping trolley) and **dialogue and collaboration** was facilitated as the children were asked to discuss in their Talk Partners whether the objects needed a pull or a push to move them (Teacher's lesson plan). Next they were invited to come out to the front and demonstrate how the objects moved.

The main task for the children was to sort the objects they had been given in their groups into those objects that needed a pull to move them, those objects that needed a push to move them and those objects that could be moved by a push and a pull. They children were **able to play with the objects** to make judgements about how they were moved.

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The work was differentiated by the method of recording. Some groups were given a table with two columns where they drew the objects they sorted in to Push and Pulls and drew the objects in the appropriate column. Other groups were given Venn diagrams to distinguish the three groups.

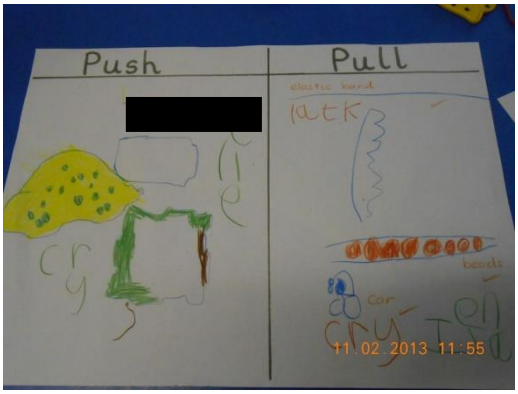

Image 1.1: Recording chart for Push & Pull

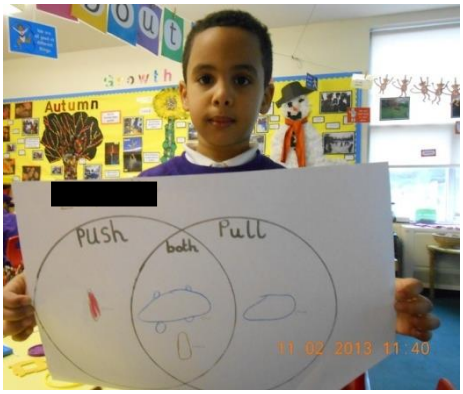

Image 1.2: The 'Push & Pull' Venn Diagram

The children were able to choose which objects to represent and where they placed the objects. As the teacher explained in the interview:

> *"They're looking at them, but that they had the choice to choose whatever it is they're drawing. It's giving them the input, and there's no correct way. They had to put it in the right place, but they can draw it however they see it. Doesn't have to be the right colour. You know, it's open for them to be able to just pick what it is".*

The teacher chose to include the use of Venn diagrams to give the children the opportunity to **make connections** between the different objects.

The second part of this episode, took part on a different date, involved the children **going outside** into the playground with sticky notes. Lisa involved the children in **role play** as she called these sticky notes 'Scientists' Note Pads' and the children were referred to as 'little scientists'. These notes must have engaged the children as two of the parents later asked Lisa for some of the Sticky note pad. Lisa explained that:

> "*Two of my parents have asked me for Post-its, because they wanted … they didn't understand what they had been doing, and the children wanted to show them at home and so again, I feel that that was quite successful that the children had wanted to take them home"*

In the playground Lisa had provided a **rich range of resources**, for example, doll's push chairs, bicycles, trolleys, bats & balls, hoops, climbing frame, slide, space hopper, giant wheel (see images below) and provided the children with a **variety of experiences**.

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Image 1.3: Labelling the trolley

Image 1.4: Pushing the giant wheel

The children were asked to choose objects and to write 'pull' or 'push' on a sticky note and stick the appropriate word to the object. All the children were occupied using the wide range of resources. There were **sufficient human resources** as the children were supervised by the TA and the teacher moved between the classroom and the outside area. The TA and encouraged the children to say whether they were pushing or pulling the objects.

Before the children went back into the classroom they played some singing games on the Astroturf area where they sang and did actions of pushing (the air) and pulling (each other). All the children joined in this activity with enthusiasm and much laughter.

The children were given the opportunities to for **dialogue and collaboration** as they discussed their ideas with their talk partners at the beginning of the activities and throughout the outdoor activity. Social **factors of learning were considered** as the children were expected to share their resources and take turns with the toys particularly in the outdoor area. They were learning by **making connections** between what they were doing to move the objects and the words they had seen written by the teacher – 'Push and Pull'.

The activities took place in **formal and informal** settings, **in the classroom and outside**. The outdoor area **provided sufficient space** as it had a green Astrotuf (imitation grass) area where there was a slide and climbing frame), brightly coloured fencing around the perimeter, 5 trees and on the playground surface were painted the planets (in order from the sun but not to scale) a giant snake with the letters of the alphabet written in, a Bull's eye with numbers 1-12 around the edge like a clock and the board game for Snakes and Ladders(See sketch map). In the paved area just outside the classroom were two covered areas, a sand tray and a 'Bug Hotel'. There was evidence of **integration between mathematics and science** as the topic linked Science (Forces Topic) and Mathematics (Venn diagrams).

The children were **encouraged to play with the resources outside** and explore whether they had to push or pull things to make them move. There was a variety of objects that required pushing with

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hands (bats) and/or feet (bicycles); some they could push with other children inside and some they pushed from inside the object. Many objects could be pushed and pulled to make them move (spacehoppers, trolleys).

Some children explored **informal learning resources**, for example, one child put her sticky note on a rubbish bin. When asked why she had chosen the bin she started to push the bin and it rocked back and forth. This child's action suggests she was **motivated by the activity** to explore alternatives to the resources provided (see the image below):

Image 1.5: Labelling the rubbish bin

At the end of the time outdoors the children enjoyed singing games where they were able to move around and sing as a whole class. The teacher asked the children how they were moving each other (pulling into the centre of the ring) during the Hokey Cokey dance. They had to push the air up when they had to 'shake it all about' (part of the dance) which they all did with enthusiasm, thus **promoting very positive attitudes** to their science learning experiences.

Opportunities for science learning

The Statutory Framework for the Early Years Foundation Stage (Implemented September 2012): Early Learning Goals for: Physical development and Understanding the World:

- Moving and handling: children show good control and co-ordination in large and small movements. They move confidently in a range of ways, safely negotiating space. They handle equipment and tools effectively.
- To know about similarities and differences in relation to objects

Links to the National Curriculum for KS1:

Science Enquiry

- Explore (moving objects) using their senses

Physical Processes:

- that pushes and pulls can be used to move familiar things

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Opportunities for creativity

In this episode, children were able to **make connections** between the concept of pushing and pulling on the one hand, and everyday objects as found in the classroom and in the outside playing area on the other. Children's **curiousity** was aroused as they were encouraged to interact with objects all around them to see if they could be moved by pushing or pulling. Such freedom to experiment with different objects and the fact that children got to freely move around and explore their learning space helped increasing children's **motivation and engagement** levels.

Episode 2: Cubes in the Hoop

Pedagogical framing

The focus of this lesson varied between the different ability groups, ranging from simple number recognition to counting to adding three numbers. More explicit examples of these activities will be highlighted later in this section.

The lesson started with children playing a counting game on the interactive whiteboard, where they had to count, for example, the total number of dots on a cow or the total number of aliens. A number of children were invited to count the objects and match it with the right number on the screen.

During the main development activity, children worked in **ability groups**. Lower ability children were given number shapes (0-9) that were made of different materials (e.g. rubber and foam), and they were asked to match two identical numbers of different materials together.

The (lower) middle ability group were asked to spin the number spinner and write the given number on the small whiteboard and to match it with the right number of counters, while the (upper) middle ability group were asked to spin the spinner twice to generate two numbers and to add them together, and to write the totals on the small whiteboard.

In pairs, the higher ability group were asked to roll three dice. With each throw, the children collected the number of cubes shown on the dice, placed them in a given hoop, and then counted the total number. This activity ultimately presented a degree of **problem solving**.

The episode is drawn from this ability group's activity and it took place on the carpet area **inside the class** within **an informal setting** and with **sufficient learning space**. The lesson was planned by Lisa, although led by a student teacher, David.

Pedagogical interactions

The ten children in the higher ability group were split into pairs, and the target children were Aahil and Yawar. Each pair was given a hoop and they were able to get as many cubes as they liked from the tray of cubes placed in the middle of the carpet.

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Image 2.1: Higher ability group children working in pairs on the carpet

There were several occasions where evidence of **collaboration** and **dialogue** within the observed pair was witnessed, as the following extracts show how Aahil and Yawar checked that they had started counting from the first cube and that each cube had been included:

Aahil: *"One … two … three … four [starting from the third cube in a row]"*
Yawar: *"It was over there [pointing at the first cube in the row]"*
Aahil: *[inaudible]*
Yawar: *"But it was over there."*
Aahil: *"From there?"*
Yawar: *"It started from the green cube [i.e. the first cube in the row]"*

And similarly:

Both: *[Counting the cubes in the row] "One … two … three … four … five … six … seven … eight … nine … ten … eleven … twelve."*
Aahil: *"No. Look. One … two … three … four … five … six … seven … eight … nine … ten … eleven … twelve … thirteen. Because the black one you didn't counted [sic], so thirteen."*

Image 2.2: Aahil and Yawar working together

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Through the aforementioned collaboration and dialogue, the two children constantly learned from each other through **identifying any mathematical errors their partner had made** and offering a strategy to solve the problems encountered.

Additionally, as the children were not given an explicit instruction on how to use the space in the hoop to arrange the cubes, there was evidence of children' **diverse forms of expression**. More specifically, while Aahil and Yawar, for example, chose to arrange their rows of cubes in the middle of the hoop, two other pairs of children chose to arrange their rows of cubes around the circular perimeter of the hoop.

Image 2.3: Aahil and Yawar's arrangement

Image 2.4: Other children's arrangement

In an interview with Aahil and Yawar, they attempted to justify their chosen arrangement of cubes, highlighting the possibility that the observed arrays were based on a strategic decision by Aahil and Yawar:

Researcher:	*"Do you think which would be easier to count? Putting the cubes in rows like that or putting them around the circle?"*
Aahil:	*"That one was more easier [sic]."*
Researcher:	*"Your one's easier? Why?"*
Aahil:	*"Because it's just in a line, but it's two lines, you can't see it [Aahil trying to explain that by putting the cubes around the circular hoop, it was harder to see where a row of cubes begins and ends, whereas it was easier to count the cubes if they were put in separate straight rows]"*

Some interesting strategies also emerged from the follow-up interview. When Aahil and Yawar were asked to illustrate, by drawing on a piece of paper, how the cubes should be laid in the hoop to make it easier for counting, both children similarly put the cubes in arrays. However, the main distinction was that while Aahil just drew the cubes relatively close to each other in two rows, Yawar very carefully drew them right next to each other in a column, making sure that he left no gap in between them.

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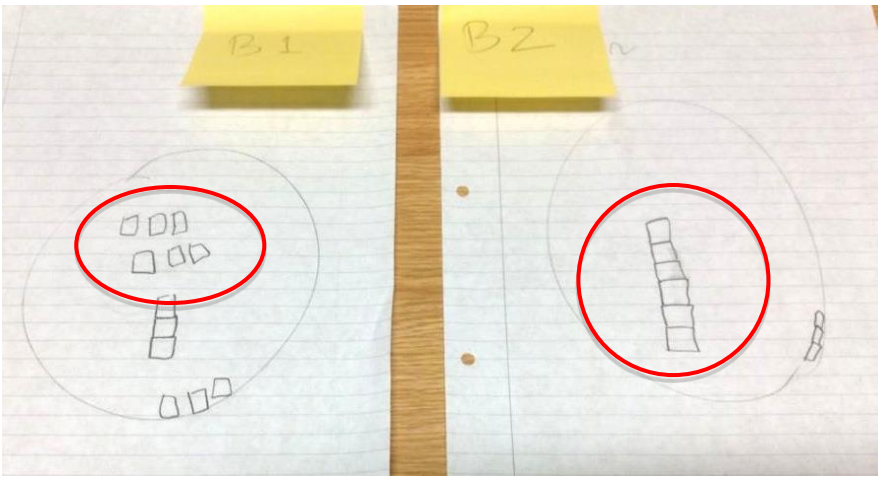

Image 2.5: Aahil's *(left)* and Yawar's *(right)*'s drawings of their counting strategies *(in red circles)*

When highlighting this distinction to Aahil and Yawar, the following were their responses:

Researcher:	*"This is very interesting, because already I can see two different things. One – Yawar's. He put all the cubes very closely together and there is no gap between them. And with Aahil's, there's a bit of gap in between them. Which one do you think it will make it easier to count?"*
Aahil:	*"I think this one [pointing at his own work]."*
Researcher:	*"Why?"*
Aahil:	*"Because you can just do it in a straight line and move to the next line."*
Researcher:	*"What about Yawar's? Do you think it's easier, more difficult, or the same?"*
Aahil:	*"The same."*
Researcher:	*"Yawar, can you tell me why did you all the cubes close together? How come you didn't have any gap between each cube?"*
Yawar:	*"So it can stick … and we know it's sticking … and then we can count it easier."*

From the above attempts at **explaining their ideas**, it appears that Aahil and Yawar placed an emphasis on two different strategies. For Aahil, it was about putting cubes in rows with the same number of cubes in each row wherever possible to make his counting systematic and hence easier. For Yawar, it was about ensuring that all the cubes are closely connected to one another. This was particularly relevant, especially when he noticed how Aahil made a mistake earlier whereby two cubes that were part of a row, but not closely laid next to the other cubes in the row, were not counted.

Finally, from the interview with Aahil and Yawar, they really **enjoyed** the activity citing how they liked working with big numbers:

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Researcher:	*"And how much did you enjoy working on this activity?"*
Aahil:	*"A lot."*
Researcher:	*"Why?"*
Yawar:	*"We enjoyed making big numbers."*
Researcher:	*"And did you enjoy making big numbers with cubes and dice?"*
Both:	*"Yes."*

Opportunities for mathematics learning

Under the Statutory Framework for the Early Years Foundation Stage (September 2012) - Early Learning Goals for Mathematics, the following expectation was reflected in the lesson:

> "Numbers: children count reliably with numbers from 1 to 20, place them in order and say which number is one more or one less than a given number. Using quantities and objects, they add and subtract two single-digit numbers and count on or back to find the answer. They solve problems, including doubling, halving and sharing"

Opportunities for creativity

Through creative pedagogical approaches as planned by Lisa, children's creative dispositions were fostered and their creative thinking developed. For example, giving children a blank canvas (i.e. the hoop) and an opportunity to allow them to *paint* their thinking onto their canvas using practical objects (i.e. the cubes) in whichever they liked made it possible to foster their **creative thinking skills**. The outcome was a **diversity** in children's mathematical representations.

Moreover, by making the activity **engaging and open-ended** through setting mathematical learning in the context of a game helped foster children's **positive attitudes** towards mathematical learning. Equally important, through David's encouragement for children to work either in small groups or in pairs, this created a **collaborative learning environment** where even Reception children could learn from each other as illustrated when Aahil and Yawar took turn to correct each other's counting mistakes, using their **reasoning skills**.

Episode 3: Counting Minibeasts

Pedagogical framing

The overall lesson focused on counting objects and writing numbers, starting with Lisa asking children to help count how many chocolate there were in a bowl. Children were asked to pass the bowl around and to make a guess. A number of children were invited to write their estimations on the board.

During the main part of the lesson, the children worked in **mixed ability groups** on a variety of activities. For example, this episode is drawn from a group of six children who were asked to sort, count and record how many plastic minibeasts there were in a bucket, providing an implicit link **between mathematics and science**, as they were also learning about minibeasts in science lessons in that week. Another group were asked to count how many raindrops there were on different leaf

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images, and to match that with the right number card. Another group were asked to find different ways to make a total of 10 by joining two different Numicon blocks together and to write the different sums on a small whiteboard. For EAL children, they were asked to work with a Teaching Assistant on recognising numbers 0 to 9 using big number cards.

The episode took place on the carpet area **inside the class** within **an informal setting**.

Pedagogical interactions

On the carpet, the six children who were asked to work on the minibeasts counting activity were gathered and given the following problem by Lisa:

> *"I've got lots of bugs here. […] I need to know how many spiders I've got. I need to know how many flies … I need to know how many dragonflies. But I haven't got time to count, so I wondered if some of you could count them for me. And then you can use your paper to tell me how many there are."*

As the instruction did not explicitly dictate which counting strategy should be employed, children were given **an opportunity to choose their own method of counting**. Additionally, since the instruction did not dictate how the data should be recorded, children were given an opportunity to **design their own form of communicating their findings**. Examples of these are given below.

The children were then split into two groups of three children and were **encouraged to work together.** They were given a clipboard with two sheets of blank paper and a pencil each, as well as a bucket of a wide variety of plastic minibeasts for each group.

The three target children, Aahil, Desiree and Eleesha, were grouped together. Aahil started counting the spiders by placing them carefully in rows of five spiders, while Desiree and Eleesha placing all the flies in a single half-circle row. Although once Desiree and Eleesha had seen Aahil's rows of spiders, they started adopting the same formation for their caterpillars and woodlice, the fact that there were initially **different forms of representation** highlights how children were encouraged to **solve the problem** in their own ways.

Image 3.1: Aahil's arrangement of his sorted minibeasts

Image 3.2: Desiree and Eleesha's arrangement of their sorted minibeasts

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It might also be worth noting that Aahil's array did appear to be more strategic than merely aesthetic or accidental. For example, when the girls were arranging their minibeats into rows, their main concern appeared to be ensuring that all the rows were roughly of similar lengths, even when the number of minibeasts across the different rows might be unequal. The opposite was true for Aahil. More specifically, the spiders that Aahil was putting into rows, varied in size. Thus, even when an equal number of spiders were arranged in each row, the resulting row length would still unavoidably be different, and yet this did not appear to deter Aahil from working with rows of five minibeasts.

As there was **sufficient space** on the carpet, children were able to lay different minibeasts in different areas of the carpet and were able to leave them as they were without having to clear their working space each time they finished counting each type of minibeasts. Consequently, this allowed children to learn from one another's work, and for Lisa to examine everyone's work at any point during the activity.

Image 3.3: Pupils were given plenty of space to work with

Collaboration was noted throughout the activity. At one point, Aahil spotted more flies at the bottom of the pile, and was heard asking Desiree and Eleesha if he should help them counting the flies. Aahil was seen handing these extra flies to the girls whilst also helping counting ("14 … 15 …"). Later, Desiree noticed more spiders in the pile and handed them over to Aahil.

Lisa came over to see how the children were getting on. When she spotted how Aahil wrote down only numbers on his paper, she asked him how he could help her know which of these numbers meant spiders. The dialogue below demonstrated how through **a series of guided questions**, Aahil was allowed to arrive at the conclusion himself of how to improve the quality of his data recording:

Lisa:	*"Aahil, how do I know which of those numbers are spiders that you counted?"*
Aahil:	*"'Cause [sic] we write the numbers."*
Lisa:	*"You wrote those numbers? But how do I know those numbers mean spiders, and it doesn't mean the flies."*

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Aahil: *"Because if we write flies and spiders then we know it means they fliers and spiders."*
Lisa: *"Fantastic! Fantastic! Thank you!"*

Another similar example was when Lisa came back to look at Desiree's and Eleesha's work a few minutes later:

Lisa: *"How many were there?" [Pointing at the flies]*
Eleesha: *"21"*
Desiree: *"I've got another one! 22!"*
Lisa: *"So what do you need to do now to remember it's 22?"*
Eleesha: *"Write it down." [Drawing a picture of a flies next number 22]*
Lisa: *"Well done. I think that's a brilliant idea. Desiree, how many of these are there?" [Also, pointing at the flies]*
Desiree: *"22." [Drawing a picture of a flies]*
Lisa: *"So what do we need to do?"*
Desiree: *"Write 22."*
Lisa: *"Well done! I like the way you're doing."*

Through such scaffolding, children were allowed opportunities to **report their findings in their own ways**, with Aahil choosing to write the names of the minibeasts and with Desiree and Eleesha choosing to draw the pictures of the minibeasts next to their respective total numbers.

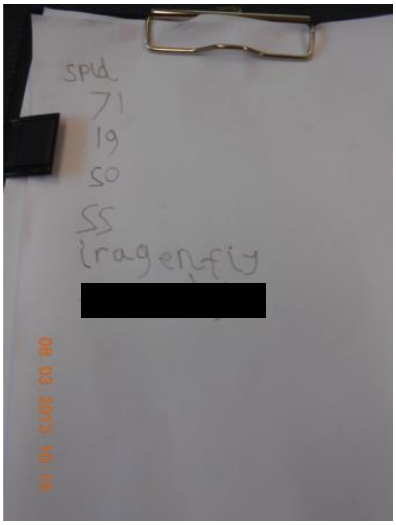

Image 3.4: Eleesha's data representation

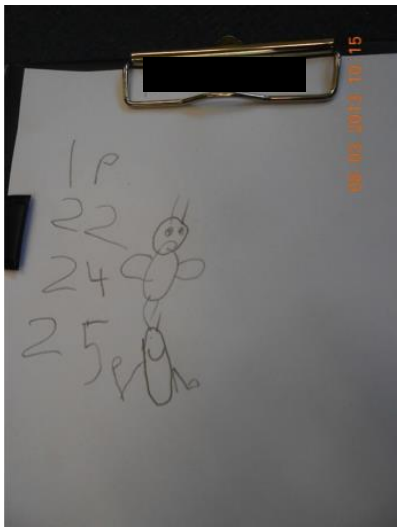

Image 3.5: Aahil's data representation

At the end of the activity, children were asked to place their sorted minibeasts into different plastic bags. During the plenary, all the children were asked to sit in a circle on the carpet and were asked to **reflect** on their learning through **sharing** with the person next to them what they found difficult in their respective activity. Aahil was overheard saying to his talking partner that *"When you're lining them up … 'cause you know when you're lining them up, and there's only one … I don't know where*

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to put it". Looking back at the photos of his work, it was found that he had four rows of five dragonflies and two extra dragonflies, which were placed on both end of the fifth row. Through this reflection opportunity and through the use of **rich practical resources**, it helped highlighting Aahil's creative thinking in dealing with remainders.

Through the interview with Aahil, Desiree and Eleesha, it was clear that they all **enjoyed** working in this activity for varied reasons as the following extract shows:

Researcher:	*"Did you enjoy your work this morning?"*
All:	*"Yes!"*
Researcher:	*"Can you tell me why?"*
Aahil:	*"Because we were counting and we were drawing. I liked it because I enjoyed."*
Researcher:	*"Tell me more."*
Aahil:	*"Coz [sic] we were writing the numbers. That's the part I like."*
Researcher:	*"Ah you like writing numbers and counting as well. What about Desiree? Did you enjoy working on that activity?"*
Desiree:	*"Because I was counting the caterpillars."*
Researcher:	*"What about you, Eleesha?"*
Eleesha:	*"I like putting in the bag."*
Researcher:	*"Can you tell me a bit more?"*
Eleesha:	*"Because I was sorting them out."*

Opportunities for mathematics learning

Under the Statutory Framework for the Early Years Foundation Stage (September 2012) - Early Learning Goals for Mathematics, the following expectation was reflected in the lesson:

> "Numbers: children count reliably with numbers from 1 to 20, place them in order and say which number is one more or one less than a given number. Using quantities and objects, they add and subtract two single-digit numbers and count on or back to find the answer. They solve problems, including doubling, halving and sharing"

Opportunities for creativity

Similar to the *'Cubes in the Hoop'* episode, through a combination of Lisa **standing back** and her encouragement of **diverse expression** of children's ideas, as evidenced in Ellesha's and Aahil's works shown in the previous section, children's creative thinking skills were also fostered in this episode. More specifically, while Lisa set a clear goal for the children (i.e. to count how many different minibeasts there were), she gave them a sense of autonomy in how they were going to solve the problem and report their finding. By giving them sufficient space on the carpet for the children to adopt any counting strategy they liked and by giving them a blank piece of paper to record their finding in whichever way they liked, children' **problem solving skills** and **creative thinking skills** were effectively fostered.

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Closely linked to that, children were also allowed to **take initiative** in solving their own problems, such as when Aahil chose to place the two remaining dragonflies on both ends of the fifth row. Moreover, by using engaging **physical resources** (i.e. colourful plastic minibeasts), children's **positive attitudes** towards mathematics learning was fostered. Finally, through Lisa's asking **scaffolding questions** about how best to record their findings, children's **reasoning and explaining skills** were constantly developed.

3.12.3 Summary and Conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

What role if any does creativity play in these?

In the interview Lisa indicated that she planned activities to engage the children, to **make them curious** and want to find out more. She hides things under covers before the children come into class so they come in wanting to find out what is there. She provides them with open activities with a range **of exciting resources** so they can make decisions about what to do and what to use. Lisa plans for purposeful play and the children have learned that when they are playing in small groups they are expected to be carrying out activities linked to the main activity. For example, when the children go off to the role play corner, the children know that Lisa will expect them to be sorting, matching and classifying.

The children played outside for the Pull & Push lesson and a week later they observed a worm moving and were talking about how it was pushing itself along. Lisa encourages **collaboration** amongst the children by standing back so the children work together. Lisa groups the children so they will be challenged; in the interview Lisa stated that she plans activities to hold their interest and sustain their interest for long enough to allow them to move forward.

Lindisfarne School's Teaching, Learning and Assessment Policy promotes the use of Assessment for learning (AfL). Lisa uses AfL strategies in mathematics and science lessons, for example, she questions the children constantly: 'What did you find difficult?', 'What did you need more help with?', 'What did you enjoy?', 'What would like to do more?'. Lisa says these ***formative assessment strategies*** help her assess not just what interests the children but how well she is teaching her class. The children develop their confidence by knowing that it is fine to make mistakes. Lisa models making mistakes with her TA and she asks the children if getting things wrong matters, the children all chant "*No, because we're learning*". Lisa **promotes children to evaluate their work** by questioning them constantly: 'What did you find difficult?', 'What did you need more help with?', 'What did you enjoy?', 'What would like to do more?'.

The children are given the opportunities **to express themselves and to develop their listening skills**. They work on the activities in **small groups and dialogue is expected**. Lisa expects the children to

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work collaboratively and co-operatively; **sharing is encouraged** and on the door to the outside space is a notice: "*Remember to look after each other in the playground".*

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

Through Lisa's creative pedagogical approaches as discussed above, a wide range of children's creative dispositions and their mathematics and science learning were fostered. For example, as children were encouraged to take risks and not to expect to get all the answers right; they often **took initiatives** in their learning, for example, by choosing how to record their sorted minibeasts in the *'Counting Minibeasts'* episode, and how to arrange cubes to help with their addition in the *'Cubes in the Hoop'* episode. Closely linked to that was an opportunity for children to develop their **creative thinking skills**, designing their own way of recording data.

Additionally, as children were often encouraged to work in groups, they were exposed to a variety of strategies that their peers adopted to execute the given tasks. Subsequently, their **possibility skills** were constantly developed.

As children were also often encouraged to take part in class discussions through the use of Talk Partners and the AfL strategy, such as the use of lollipop sticks to pick who would be asked a question, children's **communicating and reasoning skills** were also regularly extended.

Finally, through the use of rich physical resources across the three episodes, children's **positive attitudes towards mathematics and science learning** were fostered.

How do teachers perceive their role in doing so?

Lisa has responsibility for the Foundation Stage, for PHSCE and for science across the school. She was **confident with the science topic** and allowed time for children to explore and play pushing and pulling objects; then she would introduce new objects and **assess formatively** if the children could apply their knowledge and suggest how to move these new objects.

Lisa encouraged the **children's dialogue** and she tried hard to **stand back** because, as she said in her interview:

> *"... it's so easy when they so little English to do the talking for them. But I feel they learn so much more through doing and through their peers' scaffolding".*

She planned to develop **children's curiosity** in lessons by 'grabbing their interest' in **creative ways** to develop the children's **positive attitudes to science learning**. As she explained to the researcher:

> *"Like today, often I'd hide things underneath their covers, so when they come in, they're already thinking 'Oh, what's that!' and wanting to have a look, so trying to get their curiosity aroused, so that they really want to listen when we begin to do our learning".*

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Lisa also took unexpected opportunities for learning and allowed the children to lead the learning. For example, a week after the lesson on pulls and pushes it was raining:

> *"... lot of worms have came out, so we stopped what we were doing and went outside, because that was they were more interested in, and they were talking about how the worm was pushing themselves along the ground... it was allowing them the opportunity and the time to just be able to use the resources practically ... to choose for themselves what they wanted to do in that particular lesson"*.

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3.13 Case: 'Ella'

3.13.1 Context

Where?	Country	England			
	Setting name	EN8 - Lindisfarne			
	Location within setting	Primary School			
Who? (children)	Year group/age of children	Year 2 (6-7 years old)			
	Number of children in class	30			
Who? (adults)	Number of adults	3			
	Role of adults	Teacher and 2 Teaching assistants			
	Case teacher role	Lead teacher, sole responsibility for class			
When?		1	2	3	4
	Dates of visits	110213	120213	280213	110313
	Times of visits	14:25-15:30	14:25-15:30	11:00-12:20	09:20-10:20

School/Setting

Lindisfarne Community Primary School is average sized school in a north London borough. There are 241 children on roll (109 girls and 132 boys). The school has an Executive Headteacher, an Associate Headteacher, a Deputy Headteacher and an Assistant Headteacher. It is a community school serving an ethnically diverse population.

The number of pupils from minority ethnic groups is very high, with pupils from Black African and Black Caribbean groups making up almost half the school's population. The remaining pupils come from a wide variety of ethnic groups. The teaching of literacy is the highest priority as 80% of the children speak English as an additional language, with 47 different languages currently spoken in the school. The number of pupils known to be eligible for free school meals is well above average, at 60%. The number of pupils identified as having special educational needs and/or disabilities, including moderate learning difficulties, speech, language and communication difficulties, and behavioural and emotional difficulties, is above average.

In 2012 the performance figures for Lindisfarne school show the children achieved a score higher than the national average. Lindisfarne was named Creative School of the Year in March 2012 by the Hackney Learning Trust and an Outstanding School by OFSTED 2011/12. In July 2012 Lindisfarne was designated as a National Support school and the Executive Headteacher became a National Leader of Education which means the school can work with other schools to support their development.

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Lindisfarne is one of only 150 schools in England to be granted teaching school status in the third wave of schools selected to offer school centred training and development (March 2013).

The school has received a number of national awards, including the Quality Mark for Basic Skills, Arts Mark gold, the International Schools Award and Healthy Schools status.

The children follow the International Primary Curriculum (IPC) for subjects including Science, Art, Design, Music, P.E. History, Geography and ICT. Also included in this curriculum is the teaching of international understanding and personal and social goals. The National Curriculum provides the framework for the Science taught at Lindisfarne school. Although Science is taught on a weekly basis strong cross curricular links are mapped out with the IPC.

Teacher

Ella is in her first year in teaching and she is between 25-29 years of age. She has a BA in Media studies and a PGCE from a UK University where she covered an introduction to the teaching of mathematics but did not study science at all. She also studied an introduction to ICT, children's development of creativity and creative teaching approaches on her course. She completed one of her teaching placements as a trainee teacher at Lindisfarne school. She has only worked with the 6-7 year old age group.

Ella's highest formal qualification for mathematics and science is upper secondary education (General). Since starting in teaching in September 2012 she has taken part in professional development courses on science and mathematics which she reports have had a moderate impact on her teaching. She has received mentoring in science and has engaged in informal dialogue with colleagues on her improving her science teaching which had a moderate impact on her teaching. Ella reports that the mentoring and dialogue about mathematics teaching has had a large impact on her teaching.

When taking the register, Ella greets by saying, for example, "Good morning" to the children in their first language. All children respond to the greeting but they choose whether to reply in their first language or in English. The children refer to their teacher as "Ella".

Classroom

There are 30 children in Ella's class. The children have fixed ability groupings for mathematics and there are five group named after shapes. For Literacy and Science the children work in different ability groups settings; there are five groups named after a Circus Theme.

The classroom is well resourced. It is very colourful and packed with wall displays as well as displays on the tables. The carpet has a map of the world as its pattern which links to the current topic: Transport. It has a reading corner and an area with a rocket that children can sit it (linked to transport topic). The walls are covered with displays about transport, a crime scene, making Maps, Electric circuits and the Moon. The groups for reading, for science and mathematics are displayed on the wall as is the reward policy called 'Stay on Green'. The interactive white board (IWB) is regularly

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used by the teacher. There is a Teaching Assistant who works with one of the pupils with behavioural difficulties and another TA who support the lower ability groups.

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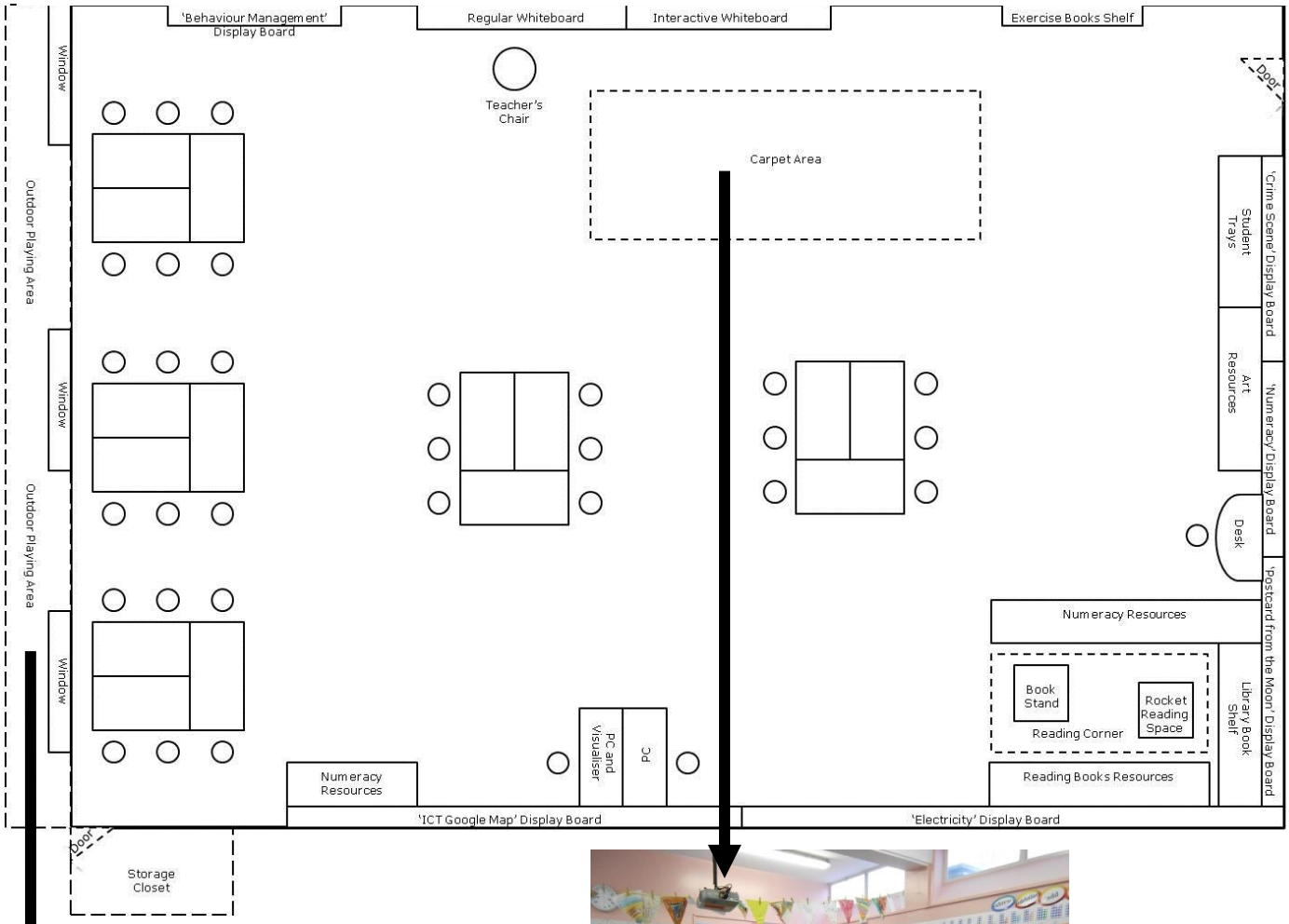
Ella's Year 2 Class at Lindisfarne Community Primary School



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3.13.2 Episodes

Episode 1: Egg Carriers

Context

The school follows the International Primary Curriculum (IPC). Each IPC unit incorporates a range of subjects including Science, History, Geography, ICT, Art and PE and provides many opportunities to link literacy and numeracy. The school's curriculum map is devised to forge strong cross curricular links between subjects (School's science policy document). The IPC schemes of work provide each subject with a number of learning tasks to help teachers to help children achieve a range of IPC learning goals (IPC Science Task 1 Unit: From A to B).

The IPC unit the class was working on was 'From A to B, Travel and Transport'. As part of this unit the children had travelled around London to see as many different modes of transport as possible: overground train, DLR train, underground train, cable car, boat, bus, aeroplane and helicopters. They had made a display of their travels in the classroom as shown below.

Image 1.1: The Transport Project display

The content of this episode focuses on an activity where the children had to design and make an egg carrier to transport a fresh egg safely when dropped from a height. The children were expected to draw on their observations of modern modes of transport as well as studying the structure of the Wright brothers' first aeroplane and so **make connections** with their prior learning. The teacher did **not rely on the IPC scheme** for this activity as she had adapted it for the adults to **step back** to enable the children to learn by trial and error.

> *Ella:* *"I think it's nice to say 'Right, here are your resources, go and experiment' and allow them to use their creativity and their knowledge, previous learning to, sort of, come up with what they want. ... if they have got a solid foundation from previous lessons, we've had a whole topic around it [transport], I think they had the knowledge there to be able to go and use their creativity and imagination to create fantastic egg carriers, and it worked."*

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The resources set out on the tables provided a **rich source of materials for the children** to choose from: cardboard boxes (various sizes), plastic bottles (various sizes), straws, string, balloons, various fabrics, plastic shopping bags, rulers, scissors, sticky tape and glue. The children worked individually and could **make connections** with a previous topic on Materials as they knew the properties of some of the materials.

Image 1.2: Resources for the Egg Carrier

Pedagogical framing

The children began the lesson by sitting on the carpet and discussing the **problem to be solved**: How to make a carrier for the egg. They knew they would be trying out their carriers in the next science lesson **outdoors**. The teacher **valued collaboration between the children** and **dialogue between them** as she prompted discussion about the properties of materials required to protect something fragile:

> *Ella:* *"What's going to protect it when it hits the floor? What could we use? Think of different kinds of materials... what's soft?... what's hard?"*

and she asked the children to think about how structures for air transport could help with their design of an egg carrier encouraging them to **make connections** with their work on materials. Her questions *fostered reflection and reasoning* about the properties of the materials the children were working with.

> *Ella:* *"What about if you design an aeroplane? What materials can you use?"*

Ella encouraged the **children to solve the problems themselves** as the children were able to choose which mode of transport to use as a basis for their egg carrier and what resources to make it. The children were not restricted as to how to make their carriers and **informal learning resources** were encouraged.

> *Ella:* *"Now, I'm not going to say much more. You guys are fantastic designers, fantastic scientists and brilliant artists"*.

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Pedagogical interactions

The children worked on their **ability group tables** but worked independently or in pairs. The lesson allowed the children to work at their own pace in an **informal setting** as they constructed and tried out the structures they had made.

The children's **questions were fostered** as they explored questions such as*:* What's a light material? What would glide better? What would stick it together better? What would be a soft material to cover the egg to protect it?

Jameel designed an egg carrier with a hole stuffed with tissue paper, when asked by the researcher what the tissue paper was for he replied: "*So we don't break it".* He joined two plastic straws together with some masking tape, as shown in the photograph below, to make wings. Jameel **planned the design** of his structure using prior learning:

Researcher: *"How did you know to use straws to make wings?"*
Jameel: *"In Brown class [Year 1 last year] we did an experiment to see which material was best."*

Image 1.3: Jameel's Winged Egg Carrier

Ella noted how Jameel's design seemed to have based his carrier on the Wright brothers' aeroplane and indeed the structure of the wings was similar to a photograph of the aeroplane on the classroom display.

Ella described how Jameel:

> *"... was very creative He very quickly realised he had to cut a hole out of his coke bottle for the egg. He knew he wanted to do an aeroplane so very cleverly; he came up with his own way of making the wings.* [...] *I think that shows real creativity. He didn't cut out a piece of cardboard like most of the children did. He thought about the structure of the aeroplane. We'd looked a lot about the Wright Brothers with their first aeroplane and you can see he has almost copied their ideas of the wings."*

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Ella had planned for the children to draw on previous experiences and ***make connections*** with the transport topic and Jameel's design is clearly linked. Another child designed a structure based on a hot balloon.

Researcher:	*"So when you were choosing your materials to make your carrier, what made you choose particular things?"*
Tolga:	*"My brain"*
Researcher:	*"What did your brain tell you to do?"*
Tolga:	*"It told us to get a balloon and tie it on to a bottle."*
Heri:	*[inaudible]*
Researcher:	*"Why did you choose a balloon?"*
Tolga:	*"I was trying to make a hot air balloon."*
Researcher:	*"So when your brain was telling you to choose the balloon, why was your brain telling you that a balloon would help stop the egg crack?"*
Tolga:	*"Like it would make it slow until the egg. The air would go by the side of the balloon."*
Researcher:	*"What happened to your egg?"*
Tolga:	*"It didn't break".*

Image 1.4: Tolga's Hot Air Balloon design

Other children also had made the connections and they were able to use their prior learning to justify their design of egg carrier. At the end of the lesson, when the teacher asked the children to **explain their evidence** and they were able to say why they had used a particular material:

Carla:	*"I used a red string for the seatbelt to hold the egg"*
Zeynap:	*[using an elastic band] "So it can hold the egg on the cotton wool"*
Natasha:	*"I used the balloon... to make it slower."*

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At the end of the lesson the teacher asked the children to **assess formatively** their egg carriers and to make **a prediction** "*Whose invention will protect the egg? Which will not?* Again the children **communicated their explanations** for their predictions, for example:

Sonia: *"I think [Faith's] one will protect the egg because she has put soft materials and put soft materials on it [the egg]."*

Olafemi: *"Mine is going to break because, when I dropped it, it dropped like that"*

Karen: *"I think Chantal's one is going to be secure because she put lots of cotton wool and the egg won't break*

Evaluation of the egg carriers

To test the effectiveness of the egg carriers in protecting the eggs the children dropped their carriers (one by one) from the top of a flight of steps **outdoors**. The children were involved in formative **self assessment** as they reflected on the success of their carriers after they had tried them out to see if their structure protected the egg or not. Assessment for Learning strategies such self and peer assessment are identified as part of an 'excellent learning experience' in the schools 'Teaching, Learning and Assessment Policy' which states that:

> *"An excellent learning experience... will include Learners understanding and sharing standards, self and peer assessing, receiving meaningful feedback about what has been achieved and agreeing next steps to improve*."

> *Ella: "Abiola, he was particularly good, he made the one here I think he finds creativity quite hard, in some ways; he's not the most creative of children. I think he's tried to mix quite a few together. He's got the wings which are the hot air balloon, the body that was the aeroplane and he had a helicopter slight thing on it. I think he struggled. He's almost tried to be too creative, to get too much in there but he learned from that. On the evaluation, after we'd done the experiment and did the evaluation forms, he said he would choose just one transport rather than, I think he thought he'd be creative and that he could use all three [types of transport] and it would be three times as good."*

One of the girls, Karen, made a carrier made from a cardboard box but not based on a form of transport. However, when the carriers were tested Karen's egg did not break. In the interview the teachers said that, in her evaluation of her carrier, Karen was able to say why her egg had 'survived' but also how she could have improved her carrier to make it a form of transport. This engagement with evaluating their own work involves the children in ***formative assessment***.

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Image 1.5: Karen's Box design

In the interview Ella explained how she could use the discussion to *assess* children's learning:

> *Ella: "So although the creativity of making it can sometimes highlight children's learning, lack of understanding, she knew by the end of it what had worked and what hadn't. So you assess that from the discussion and then them going off and writing about it."*

From her own evaluation of the lesson, Ella considered that allowing the children so much freedom to choose how they made the carriers and with what materials had made the lesson a memorable one for the children:

> *Ella: "I think from this I will definitely try more often to give them more freedom with their work in terms of letting them lead or create their own learning in some ways. And to have more opportunities like this where they can invent, create ... because I think it encourages creativity and also it gives them ... they have a lot of pride in their work and they are learning by doing rather than necessarily writing or sitting and listening. It's a lot more hands on. This is one of the lessons I know they will think about and look back on and it's nice because they've learned from it and they still refer to it now – you know the different transports and so on."*

In discussion with the researcher, the children also highlighted the motivating context by the need to protect the egg and the opportunity to do something new and for themselves.

Researcher:	*"So how did you sort out your choices by yourself? Did you talk to other children? Or other adults?"*
Tolga:	*"I just used ... My only partner was my head and my brain."*
Heri:	*"I just did the same thing as that"*
Int:	*"Would you say this lesson was using your creativity?"*
Tolga & Heri:	*"Yes"*
Researcher:	*"What does creativity mean to you?"*
Tolga:	*"Creativity means like .. that .. that you are creating something..."*

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Heri:	*"... that you've never created before"*
Tolga:	*"Exactly"*
Researcher:	*"So what was new to you in this lesson?"*
Tolga:	*"The new thing about it was how the eggs don't break. I'd never done an invention like this"*
Researcher:	*"You've never done a lesson like that? What was different about this lesson?"*
Heri:	*"The eggs"*
Tolga:	*"Exactly, there was eggs involved and messy stuff"*

Opportunities for science learning

The lesson provided opportunities for learning related to the following National Curriculum requirements:

Sc1 Science Enquiry

1. The importance of collecting evidence by making observations
2. a Ask questions (What if...?)
   b use first hand information
   c think about what might happen before deciding what to do

Sc 4Physical Processes:

Forces and Motion

2. a to find out about movement
2. c to recognise that when things slow down there is a cause

Opportunities for creativity

Children's learning

In this episode the children were given the opportunity to use their **initiative** as they chose the design and materials when making their egg carrier. The activity engaged the children in exploration and prompted them to **make connections** between the science they had learned in two topics 'Materials' and 'Transport'. Their **curiosity** was fostered as they had to find out which design would protect an egg when they dropped it from the top of the stairs. The competition to produce a successful egg carrier **motivated** the children to think carefully about their designs. They had to think about how modes of transport for humans protect the passengers and translate these ideas to use in their own structures. The questions posed by the teacher encouraged the children's **reasoning skills** as they had to explain why they had selected different materials to make their egg carrier and justify their judgements when assessing the quality of each other's structures . The children were able to use their **initiative** as they could choose to work with partners or individually.

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Teaching Creatively

The teacher planned the lesson so that the children had a specific **problem to solve**: making a carrier to transport an egg safely when dropped from a height. Her aim was for the children to work creatively as they were able to choose how to construct their egg carrier and to select materials from a range of different resources. The teacher planned for the children to work **independently,** however, the teacher also valued children's **collaboration** as the children were encouraged to talk to each other and use resources of each other's tables.

The teacher prompted children to think about the properties of different materials without indicating one type of material was better than another thus **leaving the final decisions to the children**. One of the children's egg carrier was not based on a mode of transport (she just used a padded box) but this structure was tested with all the other structures and not rejected from the test.

In the interview Ella explained that she preferred the children to evaluate the success of the egg carriers in a discussion rather than giving them a worksheet with questions to answer. **Peer assessment** was encouraged at two stages of the investigation – when the carriers had been constructed and after they had been tested.

Episode 2: Habitats

Context

Prior to this lesson the class had been working on the topic 'Habitats and the Environment' and the learning intention for this episode included some specific **scientific content** i.e. for the children to learn that some animals use camouflage to help them survive.

At the beginning of the lesson the children were sitting on the carpet and they were asked to 'Put on their (imaginary) science jackets and goggles' and talk to their partner about the meaning of 'Habitat'.

Ella is ***confident in using ICT*** and used a computer program on the IWB that showed five minibeasts and an image of an environment with four different habitats (See photograph below). **Dialogue and collaboration** were encouraged as the children were asked to discuss in pairs where each minibeast would live in this environment. One child was chosen to suggest where the teacher should drag the minibeast to on the IWB. The other children were asked to give a 'thumbs up' sign if they agreed. This is a **formative assessment strategy** that involves the children in **peer assessment.** The teacher did as the child suggested and if it was incorrect, the minibeast would run to its most suitable habitat. The children laughed and were clearly engaged by this activity.

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Image 2.1: Habitats Computer Game

The children were then shown a series of images of animals in their natural environment and they were asked to think whether it was well camouflaged or not and whether it was a predator or a prey linking the topic of camouflage to work on food chains and **making connections** between topics (See photograph below). The children were asked to be prepared to justify their answer and so communicate their **explanations**.

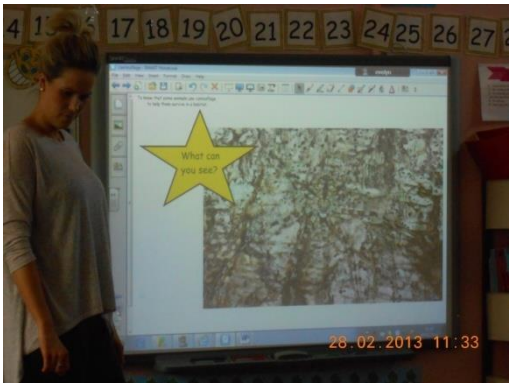

Image 2.2: Picture of camouflaged spider on a tree trunk

The teacher introduced the work of the American artist Abbott Handerson Theyar (1849-1921). She had selected the following three paintings to show on the screen as all showed the animals in a background of a similar colour and pattern to the animal:

- Peacock in the Woods
- Copperhead Snake on Dead Leaves
- Male Wood Duck in a Forest Pool

The children were asked to see if they could tell what animal it was and think why they couldn't easily see the animal. Questions posed by the teacher ***encouraged the children to express their own views:*** What animal has he (the artist) painted? How has he made it look camouflaged? What do they like/dislike? The teacher pointed out the colours the artist had used to paint the background – the same colours as the animals. The children were asked to name the colours used in each picture.

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Class activity

The task set for the children was to produce a picture of an animal camouflaged in its environment. Pastels in a range of colours were provided and the children were asked to use just three different colours to create the background environment and so make it hard to see the animal in the picture. The photograph below shows Aydin with his picture of a partridge and his three chosen colours: red, white and yellow.

Image 2.3: Aydin's picture and his coloured pastels

The teacher had prepared differentiated tasks for three ***small groups*** as she explained in the interview:

Researcher: *"How did you differentiate the groups?"*

Ella: *"The Reinforcement (lower) groups were given an image on a sheet (of an animal) so they already had an animal, insect or minibeast. Some of them had it enlarged so the patterns were bigger and clearer. They could work on a larger scale involving less fine motor skills."*

The Cores had a different selection of images but required more thought and skill in the pattern in the camouflage of the animal

The Extension (Higher) groups had to choose their own animal, minibeast or creature. Thinking about those which would need or use camouflage and create both themselves. They had freedom of choice."

The teaching assistant worked with one of the Reinforcement Groups reinforcing key vocabulary such as: predator, prey, camouflage and disguise (See photograph below).

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Image 2.4: Key Vocabulary

The children worked at their tables grouped by ability but they produced individual pictures. Half way through the lesson Ella modelled a **peer assessment** strategy by selecting two children's pictures to show to the rest of the class on the screen using the visualiser. She asked the children to identify the three colours used to colour in the background of the animal picture. Were these the colours of the animal? Did these colours help hide the animal? Later Sadik was upset as other children had criticised his picture of a black spider which he had scribbled over with a black pastel. Ella stopped the lesson and put his picture on the visualiser. She asked the children if they could see the animal on the picture; they replied "no". She asked them why they could not see the animal and the children agreed it was because the background hid it so well. She praised Sadik for choosing the right colour but asked him how he could have improved his work. He said that he would not scribble right over the spider next time but just shade in the background.

The children were involved in further **peer assessment** at the end of the activity. They were asked to lay their pictures on their tables and go and look at each other's pictures as if they were at an art gallery. They had to find things they liked about the pictures and one thing they would suggest to improve the picture.

For the plenary the children sat on the carpet again. Three children were chosen from volunteers and were given science glasses to wear and a clip board, the **role play motivated and encouraged** the children to take part. The children had to read out the information (prepared by the teacher) about an animal's camouflage and the children had to guess which animal it was from the description.

The teacher explained that sharing ideas on the carpet inspires the children more:

> *Ella: "It brings their creativity out. It encourages that enthusiasm which you need for creativity."*

From the finished pieces of children's work the teacher reflected on the way she had grouped the children for this activity as some of the children had produced unexpected outcomes. A child in the higher ability groups had not been able to complete the activity as expected; the child had drawn a

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fish but without a background to show an understanding of camouflage. Karen, a child in the lower ability group had produced a picture of a frog camouflaged in its environment:

Image 2.5: Karen's Camouflaged Frog

The teacher commented on children's creative abilities:

> *Ella: "...the Extension group in science – does not necessarily mean they are creative. In some ways, children on my Reinforcement table were more creative than the Extension. You presume that the more able children can be more creative but it doesn't... in most ways creativity has nothing to do with ability. Creativity has more to do with other aspects, I feel so anyway."*

She indicated she would change the way she did things next year:

> *Ella: "I think next time I would group them by creativity in terms of their ability creatively... so their art I would say. I think they all understood the objective; they all understood what camouflage was ... that it is to protect the animals. So next time I would group them by art rather than by science."*

Opportunities for science learning

The lesson provided opportunities for learning related to the following National Curriculum requirements:

Sc2 Living Things in their environment

5b identify ways in which the environment affects the animals that are found there

Opportunities for creativity

Children's learning

The children's **imagination** was captured when looking at the Theyar's paintings of the camouflaged animals. The peacock paining was particularly of interest to the children as it was difficult to see the peacock at first. The children's **initiative** was encouraged as they were able to

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choose the colours for the background of their own animal painting and, in some cases, choose the animal to be the subject of the painting as well.

Being asked to look at each other's work developed a sense of **curiosity** as they were given time to go round and look at all the pictures.

Although the children were encouraged to choose just three colours to create the background, they had a range of brightly coloured pastels provided and different coloured animals (e.g. blue frog, green frog, giraffe, spider, lizard, and a partridge) on their pictures. This range of colours **motivated** them to look carefully at the most suitable colour to choose.

The children enjoyed the dressing up as scientists (with science glasses and clipboards) and being referred to as 'Scientist Gloria' and 'Scientist Miguel'. This role play inspired the children's **imagination** and **motivated** them to take part in the discussions**.**

Teaching creatively

The teacher planned for the children to talk about their own ideas in their Talk partners and when they wanted to tell stories about animals they had seen she allowed them time to do so and adapted her lesson accordingly:

> *Ella: "I think creatively ... letting them share their ideas and not going exactly with every slide (PowerPoint presentation) you have made and go off at a tangent and let them tell what they have and the stories they have heard*." (Teacher interview)

The teacher considered that children's talk is an important part of children's learning as it can inspire the children and:

> *Ella: "At Lindisfarne you can veer off and listen to the children and let them guide you. Also I think creatively, if you let them share on the carpet it inspires them more. It brings their creativity out. It encourages that enthusiasm which you need for creativity."*

The lesson was resourced to support all children and target groups as she had devised different levels of support for the different groups of children.

Episode 3: Block Graphs

Context

The Mathematics lesson followed the National Numeracy Strategy format with a mental starter, a main teaching activity and a plenary session (School's Policy for Mathematics).

Prior to this episode the children had completed some work on Block Graphs in Year 1 and they had done some work the previous week transferring given information on to a Block Graph the week before. The teacher was confident that all the children knew how to construct a Block Graph.

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Ella explained that although the main aim of the lesson was about using a block graph and recording accurately she was looking for creativity in sorting as, prior to this lesson, the children had not had the experience of choosing their own criteria for sorting.

Ella:	*"I think the real learning was about how adventurous they were, how creative they were in sorting their objects "*
Researcher:	*"What sort of sorting would you see as adventurous?"*
Ella:	*"The Prey/Predators – it's not numeracy linked but she [a child] linked in to science. So she linked it to previous learning."*

Pedagogical framing

The topic of the lesson - Block Graphs – was introduced. The aim of this lesson was written on the IWB: 'To use a Block Graph'. The teacher planned for the children to choose how to sort given objects and to transfer that information on to a Block Graph.

The teacher asked "*What did we say a Block Graph was? What did we use them for?*" The teacher gave time for the children to **work collaboratively** and to discuss their answers in talk partners. The answer summarised by Ella from the children's responses: 'To sort out information'.

The teacher introduced some vocabulary: Block graph; axis; sort; label. The use of mathematical vocabulary is encouraged to help children use the correct terms in their verbal and written explanations (School's Policy for Mathematics). The children were asked to state what the words mean. The answers were given as:

Block Graph:	*Selim: "Boxes and numbers down the side"*
Sort:	*Roni: "Like when you put things into groups"*

The teacher demonstrated sorting brightly coloured sweets of various shapes and sizes on the visualiser (See photograph below). The children were **involved in solving the problem** as they were asked to suggest criteria for sorting the sweets. To make their choices they had to observe the differences and similarities between the sweets and **gather evidence by observing.**

Image 3.1: Sorting the sweets

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The Teaching Assistant sorted the sweets as the children suggested and the children could see the groups of sweets being sorted on the IWB screen via a visualise.

The children's positive **attitudes to science encouraged** as each child's suggestion for sorting the sweets was acted upon. They suggested visual differences between the sweets e.g. colour, shape, size as well as characteristics based on experience such as fizzy or not fizzy, or hard and soft. The teacher was pleased by the children's suggestions as the children thought of groups she had not considered herself

> Ella: "*If you give an open question like that it's nice, you get things you hadn't thought of. They are very creative, adventurous*."

The teacher demonstrated completing the beginning of the Block Graph using the criteria size. The Teaching Assistant sorted the sweets into Large, Medium and Small size sweets. The teacher asked the children to count the large sweets all together. She then asked a child to complete the Block Graph for the large sweets on the IWB by drawing the block and colouring it in and so **engaged the children with using ICT.**

Pedagogical interactions

The teacher then explained that the children are going to have objects to sort to create their own Block Graph. **Collaboration was expected** as the children **worked in small groups**. Ella stated that she had **specifically planned for creativity** to be part of the lesson as the children were to make their own choices:

> *Ella: "I am not going to tell you how to sort them. You are going to choose. No way is wrong. You can decide."*
> *Ella: "You are going to work in pairs so you need to share".*

There was a **variety of objects** for the children to sort. The children were able to physically put the objects in groups – they were not just pictures.

The teacher planned for the children to **work in ability groups** and had selected different resources for the different ability groups and the lower ability groups were supported by a Teaching Assistant **making good use of human resources**.

- Spheres (Extension group): model minibeasts with smaller size graph paper
- Cylinders & Cuboids (Core groups): plastic shapes with larger size graph paper
- Cubes (Reinforcement group) with TA: Plastic animals with larger size graph paper (See photograph below)
- Cones (Reinforcement group) with TA: plastic shapes with larger size graph paper

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Image 3.2: Plastic animals and large graph paper

The children sorted their objects by finding the differences and similarities between their objects. They **gathered evidence by observing** and they decided how to sort them based on these observations and created their Block Graphs to communicate their categories and the number in each category.

The teacher circulated and observed what the children were doing. Two boys in the Cubes group were sorting the plastic animals. They had sorted them by colour. The teacher asked the boys "*What have you got there?*" thus using questions to **scaffold the children's thinking**. They looked at the animals in the colour groups and then said to the teacher "*We could do it by the animals we've got*":

Image 3.3: Sorting by animal type

The Spheres group (highest ability) sorted their minibeasts in different ways although Ella had initially asked the children to sort their objects in one way. The Sphere group drew two Block graphs on one piece of graph paper as shown below. To use the graph paper to draw more than one block graph was the children's own idea and had not been anticipated by Ella in her planning.

- By type (ladybird, grasshopper, spider etc)
- By pattern (Spotty, stripes, bumps etc)

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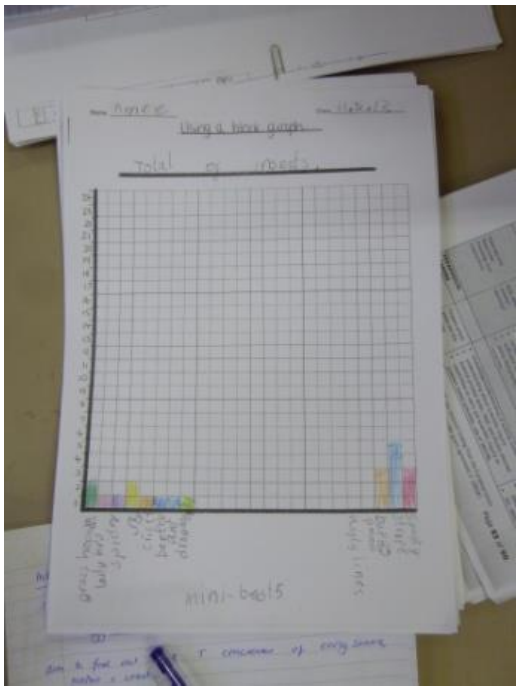

Image 3.4: Two block graphs on one page

Another pair of children in the Spheres group sorted their minibeasts into three alternative groups using visual categories e.g. dark and light colours and categories based on experience such as poisonous/not poisonous or scary/not scary. They drew three graphs on one sheet of graph paper as shown in the photograph below:

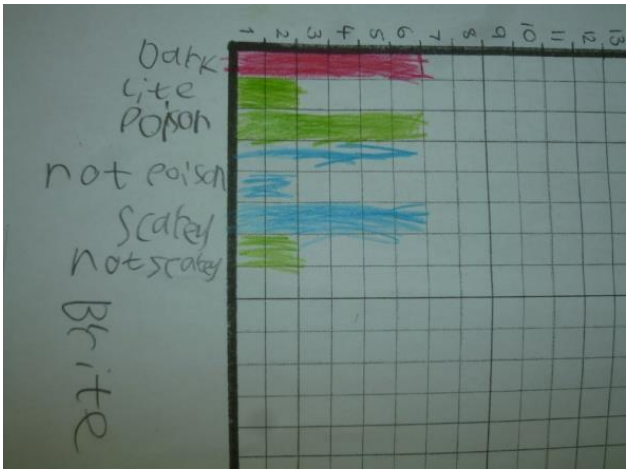

Image 3.5: Three block graphs sorting minibeasts

Plenary

At the end of the session the children came to sit back on the carpet for the plenary. The teacher explained that 'The Spheres had a tricky one to do'. She asked them to hold up their model minibeast and asked the other children to make some suggestions as to how to sort the minibeasts. The children gave ideas based on visual characteristics:

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Heri: *"How many legs do they have?"*
Olafemi: *"If they have wings or not"*

Some suggestions for groups were based on prior knowledge e.g.:

Declan: "Predator or Prey?"
Tolga: "Where they come from."
Jose: "If they are poisonous or not."

The teacher praised the links with science and **fostered the children's reasoning** by praising their thinking skills:

Ella: "Well done, linking Maths and Science. I like how you're thinking."

The teacher planned to **assess summatively** the children's learning by looking at the children's graphs:

Ella: "I will sit and I am going to look at their work and see if they have understood and used their previous learning. Have they labelled their axes? Have they grouped in a way that can be shown on the block graph and have they been able to, the Extension [Higher ability group], say what had the most, what had the least. Can they read their graph? Can they tell me what they have learned from their sorting?"

Opportunities for science learning

The lesson provided opportunities for learning related to the following National Curriculum requirements:

Ma2 Number

Processing, representing and interpreting data

Pupils should be taught to:

a. solve a relevant problem by using simple lists, tables and charts to sort, classify and organise information

b. discuss what they have done and explain their results.

Using and applying number

Pupils should be taught to:

Communicating

e. use the correct language, symbols and vocabulary associated with number and data

f. communicate in spoken, pictorial and written form, at first using informal language and recording, then mathematical language and symbols

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Reasoning

i. explain their methods and reasoning when solving problems involving number and data.

Opportunities for creativity

Children's learning

The children' **curiosity** was stimulated by the pile of brightly coloured sweets easily seen on the screen via the visualiser. Being asked to describe a number of ways to sort the sweets allowed children to use their **initiative** and suggest categories based on the appearance of the sweets as well as categories based on their own experiences.

As they could easily see what the Teaching Assistant was doing when sorting the sweets they were **motivated** to direct the Teaching Assistant to sort the sweets in different ways.

When one of the children was able to use the interactive whiteboard himself to create the beginning of a Block Graph the class were stimulated to **make connections** between their previous work on drawing graphs.

The variety of resources provided for the sorting activities colourful objects which they could manipulate and physically put them into groups. The number of different categories chosen by some children indicates their **curiosity** had been aroused as they had explored more than one way to sort their objects.

Teaching creatively

The learning intentions had been communicated to the children as 'Steps for Success' and this **formative assessment strategy** had been planned to identify those children who had been able to meet these learning intentions.

Children's **metacognition was encouraged** as they were praised for their way of thinking and children were encouraged to contribute to both small group and whole class discussions.

3.13.3 Summary and Conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

What role if any does creativity play in these?

As the school follows the IPC a **cross-curricular** approach is used and this was evident in the episodes observed: Egg Carriers (Science & Design and Technology), Habitats (Science & Art) and Block Graphs (Maths & Science). Ella encourages children to draw on previous experience by planning activities that links ideas together.

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ICT was a strong feature is Ella's lessons and she used the interactive whiteboard in the starter activities and plenaries. She mainly used the interactive whiteboard to show children images to stimulate discussions, for example, the artist's paintings where the animals were so well camouflaged it was difficult to see them.

The visualiser used to good effect during the lesson as images of children's work could be seen instantly. Ella modelled how reflect on the quality of the work as she encouraged all the children comment on the strengths of their peer's drawings, for example, and make suggestions for improvements.

Ella also used the IWB to share decisions made in the sorting activity (Block Graphs). She asked the children to come to the front of the class to use the interactive whiteboard to demonstrate activities and the children were keen to do so. This was the only occasion where the children were observed to be actively involved using the interactive whiteboard themselves.

Ella used **summative assessments** to reflect on the quality of the children's leaning and makes plans for future improvements of her teaching. After reviewing the children's camouflage pictures for the habitats lesson she decided she would group the children in different way when she carried out the activity again. As the children took great pride in their egg carriers work and were talking about the topic a week later, Ella said that she would "*... definitely try more often to give them more freedom with their work in terms of letting them lead or create their own learning in some ways*" .

Assessment for Learning strategies are used in the classroom. Ella always identifies 'Steps for Success' on the IWB so the children are aware of what is expected of them during the activities. However, she allows the children to follow their own choices, as for example Karen made an Egg Carrier that was just a box and not a mode of transport. Ella did not intervene and let Karen make and try out her carrier but then Ella brought out the learning points in the evaluation of the egg carriers. **Peer and self assessment** is embedded in the lessons and children are encouraged to identify positive points about their own and each other's work and to suggest ways of improving the work. The children were praised for their thinking, their contributions to discussions and for their comments when assessing their peers' work.

A sense of excitement is brought about in the classroom in simple ways, for example, in the naming of the science groups which are linked to a Circus Theme: Ringmasters, Magicians, Fire breathers, Acrobats and Jugglers.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

How do teachers perceive their role in doing so?

Children's **initiative** can be fostered by giving them choice and Ella gives her class choice in the way they solve problems, the resources they use and the way they present their data. The children chose ways of doing things and **made connections** with other topics that Ella had not anticipated, for

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example, the children drew on their science subject knowledge in the mathematics sorting activity. In the interview Ella explained how she facilitated learning by giving the children "*the key pointers and then leaving them to do it.*" She believes that having to make choices develops children's independence and encourages creativity.

The exciting resources and use of the outdoors for the activities **motivated** the children as all children took part in the discussions and completed the tasks set with enthusiasm. The children did not need reminders to get on with their work and they were fully engrossed throughout the lessons. Children who worked faster than others chose, in the Block Graphs episodes, to repeat the task with different ways of sorting without instructions from Ella.

The classroom with its bright wall displays, tables where there were objects laid out the children could safely handle and the huge cardboard rocket (made for the Transport topic) where they could sit inside all contributed to a sense of wonder and stimulated children's **imagination** and **curiosity.**

In discussions the children's contributions may lead the flow of talk as, for example, when Ella used a well prepared power point presentation for the Habitat lesson she had to abandon some of the slides as the children's wanted to talk about different animals they had seen. By having their contributions valued children's **curiosity** about a topic is enhanced as the conversation revolves round the children's interests.

The role play activities fostered children's **imagination** as they acted out being scientists. Ella asked children to put on imaginary science coats and science glasses and think about a science question. In the Habitats lesson she provided the children with real glasses and clip boards when they were taking part in one activity and the children appear to enjoy this approach of 'dressing up as scientists'.

During discussions the children were expected to justify their answers and opinions thus developing their **reasoning skills**. The AfL strategies adopted by Ella promoted the children's critical reflection as they identified strengths and weaknesses in their work.

Exploratory play, as in the Egg Carrier lesson, also stimulated children's **curiosity.** They played with the materials to find how their properties would or would not make a suitable structure to protect an egg being dropped from a height. Ella's questioning encouraged the children to try things out and explore in their own ways which inspired the children's **problem solving skills**.

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3.14 Case: 'Alice'

3.14.1 Context

Where?	Country	Northern Ireland			
	Setting name	NI1 – Country Park Nursery			
	Location within setting	Pre-School			
Who? (children)	Year group/age of children	Ages 3 to 4			
	Number of children in class	26			
Who? (adults)	Number of adults	3			
	Role of adults	one lead teacher and two full time assistant nursery staff			
	Case teacher role	Lead teacher			
When?					
	Dates of visits	28 01 13	30 01 13	26 02 13	27 02 13
	Times of visits	Morning	Morning	Morning	Morning

School / Setting

County Park Nursery is an oversubscribed nursery situated in a small town in central Northern Ireland. It caters for approximately 75 nursery aged children, ages 3 to 4, across the two classrooms. There is a shared space between the two. One classroom is full time (25 children), while the other has groups of 25 children that attend for half a day each day. Children come from a range of socio-economic backgrounds and works hard to build relations with both families and the community. There are often visitors to the school, such as farmers bringing lambs or individuals from the local animal shelter bringing in hedgehogs. Parents and former-parents are invited to contribute their skills and where possible, leading to a variety of activities for the children such as felt-making workshops to a workshop on Chinese culture lead by one of the Chinese parents. They also run parents days and also grandparents where the adults are invited to join the children for part of their day. This actively involves the family in the education process.

It is well resourced, with a large outdoor play space which includes an adventure climbing frame, a covered sand pit area that contains a climbing frame as well as a 'nature area' where children are able to grown plants and vegetables in the spring and summer months. This ties in with the schools' approach to teaching and learning – the school does not work to short-term 'themes' in their learning that might be seen in other schooling environments, rather they focus on the four seasons as their themes over the course of the year.

The nursery professes to have a strong Reggio Emilia influence. As such, the nursery has a stated aim on developing independence and creativity in the children. This can be seen in many of the activities

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(three of which are described in more detail below), the independence that children are given throughout the day

This belief is espoused not only by the headteacher but also all of the support staff. There is a small staff of six practitioners – two classroom teachers and four nursery assistants – who all work closely to develop teaching practice. The staff all have a deep knowledge of the children and aim to build strong relationships with their families.

Teacher

Alice has been headteacher at the nursery for ten years and has been at County Park Nursery for 14 years. She has strong beliefs about Reggio education and has been on a number of courses and workshops, both in Northern Ireland and in Europe, to develop her skills in this area. Ongoing CPD is very important to her and, as the headteacher, makes room in the school budget to ensure that all members of staff (both teachers and nursery assistants) are actively involved in this. The Reggio philosophy extends throughout her practice; fostering children's independence and creativity are perhaps the two main drivers

Classroom

Alice taught the full time class. All the children who are entitled to free school meals (one third of the intake) are in this class. Rather than teaching based around a particular short-term topic (such as, say, 'pirates', or 'dinosaurs'), County Park Nursery's teaching is based on the current season – this is used as the 'theme' or 'topic' for learning. The classroom is well-resourced, with a role-play area (a 'garage' on the first visit, a 'bakery' on the second), water tray, sand tray, art easels (see map) and a well-stocked library. In addition, there are a wide range of educational toys placed in strategic areas around the classroom. These rotate according to popularity (that is, popular toys will stay out longer). These might include jigsaw puzzles (often linked to the current season), construction cubes, and craft materials.

At any one time during the day, there are a number of different activities taking place, some that are practitioner-initiated and others, such as the role play area, which are more child-initiated. Children are free to choose their activities throughout the day and are not required to stay at any activity for any period of time. This does mean that the children participating in any given activity may change a number of times during a particular learning session, or indeed over the course of an observation period. This is in itself a deliberate approach taken in order to foster and develop children's independence and agency.

There is a strong sense of teamwork in the classroom, with the two nursery assistants, Mary and Jane (pseudonyms), providing much support to the practitioner. In many cases, Mary and Jane will actively take on similar roles to the lead practitioner, initiating activities and providing the ongoing scaffolding support as the activity continues.

Alice indicated in the interview that the school aimed to develop strong relationships with parents/carers. This was done through documenting and demonstrating activities so that "*parents*

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can see they [the children] are learning". In both classrooms, there were a number of posters which provided pictures of the children engaged in activities as well as explaining the purposes of the activity in which the children were participating. These might explain the benefits of the water tray, the sand tray, the role play corner or the mark making table. The general theme of these was to allow children the freedom of expression, rather than focus on explicit learning goals or targets. As will be seen later in this case study report, these posters proved to be very useful in the data analysis process as they gave an intimate insight into the aims and objectives of teaching and learning.

3.14.2 Episodes

Below are described three episodes which come from Alice's full-time nursery classroom. These are a 'gloop episode', which looks at children mixing cornflour and water in a large plastic tray, a 'shaving foam episode', which examines a group of children's activities when using shaving foam in the empty water tray and finally a 'bubbles episode' that identifies just one child and his exploration of a science-themed toy. Each of these episodes identifies observation and exploration in particular as key features of pedagogy, evidenced in similar ways through differing activities.

Science context for the episodes

The Northern Ireland preschool curriculum provides minimal guidelines for early years science education. Science is to be found in the short 'World Around Us' section of the curriculum, which is divided into four areas; Interdependence, Place, Movement and Energy and Change Over Time (*Northern Ireland Revised Curriculum*, 2006, p. 38). In the curriculum, all of these areas are introduced by the phrase "*Pupils should be enabled to explore*". There is little to no emphasis in the curriculum on children learning what may be termed 'scientific facts' in any meaningful sense of the word. This certainly appeared to be reflected in the activities observed over the duration of the data collection, where the practitioners did not appear to focus on children learning facts, rather on encouraging them to observe and experiment with various phenomena.

Episode 1: Shaving foam

The shaving foam activity was one that the class had done on a number of previous occasions. Indeed, Alice noted that "*we have realised over the last couple of years that importance of revisiting and revisiting… it's not how many things we do, it's what we do… and that would be our whole sort of ethos".* It was a relatively simple activity to set up, with shaving foam being squirted into the empty water tray. On this occasion, the nursery was using special 'child-friendly' foam designed for this type of activity bought from an educational resources supplier rather than using traditional bathroom shaving foam. The product itself was similar however the child-friendly foam was a less strong perfume and was also available in different colours (not seen in this episode). In the past, the activity had been carried out directly on one of the tables in the classroom. On this occasion, there were a number of other activities in the classroom meaning that there was not the space for this. On reflection, all three practitioners suggested that the activity works better on a table as the children did not have to reach so far into the tray and therefore had greater access to mark-making activities.

Through sensory play, children were able to explore and observe the changing texture of the shaving foam; the children were able to squeeze the foam between their hands and fingers, 'draw' in the

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foam at the bottom of the tray using their fingers, hands or the tools provided. Children worked in small groups of no more than four (the maximum that could fit round the tray) and were allowed to spray more foam into the tray as and when they felt the need. This varied over the course of the activity, with some children wanting lots of foam, while others were happy to explore and play with the 'melted' foam at the bottom of the tray. Toys and tools were introduced to the scenario, such as plastic animals and rubber-tipped paintbrushes.

In this activity, there was documentary evidence of the activity being undertaken on a previous day through the form of a photographic display of some of the children engaged in the activity. This display was part of the nursery's attempt at involving the parents in the teaching and learning process by explaining the purposes of different activities. This could be seen by the text on a poster that accompanied the pictures. One sheet explained the benefits of playing with shaving foam;

> Sensory play with shaving foam is a really fun way to develop
>
> - An awareness of texture
> - The motor skills necessary for writing
> - Pattern making – part of mathematical development
> - The ability to work with small tools – rubber pens, combs etc.
> - To explore colour
> - To communicate with each other when in a group setting

The focus here then is on the activity itself and the pedagogy inherent and the multiple opportunities it provides for children.

Pedagogical framing

The shaving foam activity was one that had been undertaken previously in the classroom and indeed there were pictures of the previous time the children had taken part in this activity on one of the classroom walls. This photographic display was particularly useful as it explicitly outlined the learning aims and objectives of this activity. Analysing the aims and objectives using the *Creative Little Scientists* framework, we can see that a number of the objectives highlighted by the nursery can be equated to those identified as important by *Creative Little Scientists*.

Starting with the initial statement in the poster, promoting sensory play as a "*really fun way to develop*" a wide variety of skills and dispositions highlights the impact that **affect** and the importance of promoting **positive attitudes** towards learning in the children. This could be seen in the reactions of many of the children, who were giggling and smiling throughout. Furthermore, by looking to provide a 'fun' avenue for children's mathematical development, as well as working with tools and **equipment** and exploring colour all within the same activity, we might suggest that the practitioners were planning for **creativity** within the activity. This activity also provides children with a number of **cross-curricular** activities, looking to develop mathematical skills (such as pattern

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making) with science skills (such as sensory development.) Finally, suggesting that the activity was a way that children might develop their abilities "*to communicate with each other when in a group setting*" suggests that the **social** features of learning are an important objective in this activity. Examples of these positive attitudes and groups settings can be seen in Image 1.1 below. Here, children are sharing in their similar experiences and

Image 1.1: Children at the water tray with shaving foam

As noted above, the notion of 'revisiting' concepts and ideas to reinforce learning was one that was central to County Park Nursery. This may be done for two reasons. The first is that revisiting activities allows children to consolidate skills and abilities learnt during the previous attempt. A second reason, and one highlighted by Alice was that the activities the practitioners selected were so rich. She suggested that "*you could cover all areas of learning with that one [foam] activity because you have got that great dynamic*" and thus revisiting the activity may provide opportunities for children not only to consolidate previous skills but also develop new ones.

Pedagogical interactions

As is a feature of many of the activities in Alice's classroom, children were given a large amount of freedom in their choice activity and when subsequently involved in the activity. Those children that had elected to participate in the foam activity then were free to **play** with the shaving foam in whichever way they saw fit. Since the activity provided avenues for the development of a wide range of skills, as described above, there was little direction or interruption from any of the practitioners to focus on any one particular activity or task (say, pattern making). There was an emphasis on children exploring the materials themselves rather than being guided through the activity or provided with a remit. This left children as the **agents** of their own learning, and ultimately had control over the direction in which they would take the activity (Image 2.1). One particular aim however was to foster **collaboration** between children during the task, and become *joint*-agents of their learning, with Alice

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suggesting that not only was the asking of questions was a specific aim in all of the activities, but involving each other in this questioning was important to; "*we are trying to get them to pose the questions and pose the questions to each other so it deepens that [learning]*". Alice suggested that this activity also provided a "*fabulous opportunity*" for the children to develop their language. Practitioners need not necessarily be actively involved in this development since this was developed in the communication with their peers. This language then was less particular terminology, but more descriptive language and talking about what they are experiencing. What was interesting in this activity however was that there was very little emphasis on **explanation**. The lack of active involvement from practitioners in this language development meant that question such as "why are these changes occurring?" did not appear to be happening, other than when strongly prompted by the researcher.

Image 1.2: Zoe playing with the foam

Opportunities for science and mathematics learning

As noted at the start of this episode, the posters in the classroom had identified that shaving foam play was a "*really fun way to develop… pattern making – part of mathematical development*" on a sheet accompanying pictures of the children engaged in a previous foam activity. Looking to the mathematics curriculum, the introductory comments to the mathematics and numeracy section suggest that;

> Children will acquire early mathematical concepts through activities that involve matching, comparing, classifying and making patterns and sequences in a variety of contexts. These

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> activities should involve children in playing, exploring and investigating, doing and observing, talking and listening and asking and answering questions

(from *Revised National Curriculum*, 2006, p. 23)

The two previous sections, discussing pedagogical framing and pedagogical interactions, have identified that play, exploration, investigation, observation and communication (talking and listening) were all central components of the children's activity during this episode.

In addition, the curriculum emphasises that mathematics should be developed not only as an independent activity but also together with other areas of learning. It is possible to identify links with science when we refer to the curriculum. The introduction to the science curriculum (in the form of the World Around Us area of learning) suggests that children should have "opportunities to use their senses in order to develop their powers of observation, their ability to sort and classify, explore, predict, experiment, compare, plan, carry out and review their work". Again, as discussed in the previous two sections, the shaving foam activity was one that explicitly provided opportunities for observation, exploration and experimentation.

Opportunities for creativity

The focus of creativity in this episode is from a pedagogical perspective. As has been noted above, Alice highlighted that the activity was one that "*you know, you could cover all areas of learning with that one activity because you have got that great dynamic*". The practitioners can be seen to be providing activities in which all the children have opportunities to have access to all areas of the curriculum. Alice it phrased it most succinctly when discussing the picture below (Image 1.3):

> *there could be a child who will get nothing more out of that activity that the sensory aspect, but that in itself is good… like Ryan (pseudonym), he loves anything sensory and there is obviously… he needs that [development], whereas Rosie (pseudonym), here she'll be taking it as a much deeper level, understanding the science of what is going on, that is why we do these types of activities.*

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Image 1.3: Two children gaining different learning experiences with the foam

Thus we can identify creative pedagogy here – pedagogy that is designed to elicit different ideas and strategies and outcomes in different children from the same activity. This activity is one that is revisited frequently by practitioners in order to consolidate the skills learnt, as well as develop new ones. By varying the setting of this activity (the photographic evidence showed the activity had previously occurred on desks) and varying the tools available, Alice provides the children with a changing and engaging environment that is designed to engage them in a number of different ways, both educationally (as described above) and also emotionally. A number of the children were engaged in long discussion with the research about where the foam had 'gone'. This led to a wide range of responses, with some children relating it to their experiences, "*It's melted, like the snow in my garden*" and others taking a more imaginative approach, "*It's magic'ed away… to Disney Land!*" The activity provided an outlet for both imaginative thinking and also more critical thinking.

Episode 2: Gloop

This episode comes from children making 'gloop' – mixing water and corn flour in a large plastic tray that had been placed on a desk. The activity was initiated by one of the nursery assistants, Mary, rather than Alice however the activity was largely child-led and as with many of the activities observed the children had a large degree of autonomy. The activity ran for the whole morning session (approximately 45 minutes after circle time at the mat) and the children were free to attend and leave the activity as they pleased (with a maximum of six children at the activity at any one time), thus this group of children changed as the over the course of the 45 minute session. The children were largely autonomous in their activity however there was a great deal of communication between individuals throughout the whole activity. After approximately 15 minutes, Mary places a number of different tools – spatulas of varying sizes, rubber paint brushes, a funnel – into the tray to further provoke interest and exploration.

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Practitioner intervention was limited to brief, sometimes less than 15 second visits by the three practitioners in the classroom. These visits served to allow the practitioners to observe the children's activity, engage in discussion with the children and ask open-ended questions. This meant that the children were exploring largely by themselves or with one another (pairs or threes). Often, activity initiated by one child (such as running the gloop through their fingers) was quickly imitated by their partner and then by the whole group. Children building on the ideas of others might be described as 'joint exploration'. The classroom assistants and Alice would return to observe the children at regular intervals, often noting what individual children were saying and doing on Post-It notes to be later written up more formally as part of their on-going formative assessment.

The main focus in this episode is Ryan (Image 2.1), who was remained at the activity for almost 45 minutes – over 15 minutes longer than any other child. The staff members were surprised at this, and indeed very pleased as he was known to often have a short attention span. He was deeply engrossed in the activity, observing the changes that were occurring, using different tools in different ways, keen to add more water or cornflour at different times and predict what might happen. He was frequently asking questions, to himself, his peers and any nearby adults and could often be heard speaking out loud his observations. This speech did not appear to be directed at anyone in particular, rather part of his thought processes and exploration.

Image 2.1: Ryan working with the spatula

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Pedagogical framing

This episode provides similar learning aims and objectives to those in the shaving foam activity described above. While there was not the same documentary evidence as for the shaving foam activity, it is possible to infer a number of the same aims and objectives from the observations and subsequent discussion with practitioners. Indeed Alice discussed the foam and the gloop activities in similar terms, framing the shaving foam activity as "*another slant on the gloop essentially, as [they're both] sensory*" activities. The documentary evidence for the shaving foam activity discusses how it may develop "an awareness of texture, motor skills necessary for writing, pattern making… the ability to work with small tools… [and] to communication with one another in a group setting." Each of these can be observed in aspects of the 'gloop' activity (see three photos).

Firstly, an overarching framing of this activity appeared to be to provide an engaging and **stimulating** activity that would capture the **interest** of all the children involved. This could be evidenced in nearly all the children who participated in the activity. The emphasis is on developing the sensory aspect was clearly enjoyable to the children as they laughed and excitedly provided answers to Mary's initial questions about what the powder felt like in the bag, what it felt like when poured out onto the tray and finally when adding the water. Later in the activity, the most apparent evidence for the stimulating and **affective** activity was Ryan who, as described above, remained at the activity for the whole 45 minutes session and, even as his peers left, returned and then left again, continued to focus on his own learning activities.

The cornflour and water mix was thick enough such that it held its shape long enough for patterns to be made in it, either using the tools provided by Mary or using their fingers. Unlike, say, working on paper, there was no requirement for children to work in a prescribed method with the tools, allowing the children to develop their motor skills, with a view to developing mark making and writing. The activity then specifically planned for **creative** outcomes, allowing children to use these tools in potentially new and novel ways. This was seen most clearly in Ryan's actions with the tools and is discussed in further detail below.

Finally, and of particular importance in this activity, appeared to be the development of **social** and **communicative** skills and collaborative exploration and learning. As with the shaving foam episode, the development of language was a feature identified by Alice as important in these types of activity. As the activity went on, different children arrived at the table and the changing attendees meant that there was a large amount of discussion between individuals in the group.

Pedagogical interactions

In addition to the framing of the activity provided by the aims described above, we can also look more closely at the activity itself to identify further learning activities and pedagogical approaches. The first, and most clear, was the development of children's sense of **agency** – indeed this was apparent in many of the activities in the classroom through the independence that the practitioners aimed to foster. There was largely an emphasis on '**standing back'** in this episode – once the activity had been initiated, the adults in the classroom played a minimal role in continuing it. Aside from Mary starting the activity and brief visits from practitioners later during the activity, the children

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were largely left to the task free from practitioner-intervention. There was a judicious intervention, often prompting more open ended questioning from the children, **scaffolding** their learning.

As part of this then, there would have to be an attempt on the part of the practitioners on developing **affect** in the activity in order to maintain children's interest and motivation towards the task, and indeed this was apparent. As well as remaining at the task for an unusually long period of time, at various points in the activity Ryan could be heard singing to himself, content and clearly enjoying himself. This emphasis on was also apparent in the other children, who could all be seen **playing** with the cornflour and water mix, excitedly talking to one another, and showing each other the outcomes of their explorations.

Interestingly, children's ability to use **equipment** in the activity was, it appeared, secondary or at least an additional outcome. That is to say, the practitioners did not necessarily force or encourage children to use particular tools, rather the various pieces of equipment were placed in the tray with the already-mixed cornflour and water after approximately fifteen minutes. Some children chose to use the spatulas and rubber-tipped paintbrushes, particularly Ryan, however a number of children did not, focusing more on the sensory aspect of, for example, running the cornflour mix through their fingers or mixing it in the tray with their hands.

Social and **communicative** skills, as noted above, were ones that was identified as potential skills that could be developed during these types of activity in the accompanying poster (see above). Providing an open-ended opportunity for **collaboration** between the children in their explorative approaches meant that children were able to discuss with one another, share what they were doing and indeed **observe** what other children were doing and imitate and develop on these ideas. This was described above as what might described as 'joint exploration'. An example of this can be seen in Image 2.2, which shows two girls Erin and Zoe (pseudonyms) working together.

Image 2.2: Ryan, Erin and Zoe

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The pedagogical framing section above highlights that there were a number of more developmental objectives to be found within the activity, such as fostering mark-making through drawing in the gloop, making (mathematical) patterns by sweeping their hands through (Image 2.3) and aiding development of motor skills by introducing tools. These all appeared to be **assessed** using **formative** methods, with all three practitioners making notes on notable activity from the children, such as specific goals achieved.

Image 2.3: Ryan straining gloop with his hands

Opportunities for science and mathematics learning

Sensory development was identified by Alice as the most important specific feature of this activity. From a more general perspective, as with the shaving foam episode described above, we can look to both the mathematics and science areas of the curriculum in order to identify curricular links and the same quotes from the curriculum are of use here. The introduction to the mathematics and numeracy section of the Foundation Stage curriculum suggests that;

> Children will acquire early mathematical concepts through activities that involve matching, comparing, classifying and making patterns and sequences in a variety of contexts. These activities should involve children in playing, exploring and investigating, doing and observing, talking and listening and asking and answering questions

(from *Revised National Curriculum*, 2006, p. 23)

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The discussion above identified children engaged in **exploration** of the physical properties of everyday objects, such as spatulas and paintbrushes in the cornflour and water mix, in investigation, using their **senses** in **observation** and exploration of the changing states of the cornflour from solid to liquid, and how the texture of this changed as more liquid was added. As with many of the activities noted in Alice's classroom, **communication** and **collaboration** were both highly visible aspects in this episode. Nevertheless, the activity was flexible enough that it provided an opportunity for children to work alone, as in the case of Ryan.

Opportunities for creativity

As noted above, the task was very open-ended, with few restrictive parameters. The practitioners all stood back and provided only occasional and brief support, proffering open-ended questions to further continue the activity. There was no particular activity that the practitioners wanted the children to undertake with the cornflower and water mix and this allowed Ryan in particular the freedom to explore it as he wished.

When attempting to identify features of creative activity, it was possible to see a number of different indicators. What we can see most clearly in this episode is Ryan's **purposive** actions in the activity. Ryan was clearly **immersed** in the **playful** task. He remains at the table for the full 45 minute session while his classmates arrive, leave and return a number of times during this time. He can be seen focused on his activity (Images 2.1 and 2.3), closely observing cornflour and water mix, stirring it, straining it through his fingers, pushing it and scooping it up with the spatulas, or drawing in it with the rubber-tipped paintbrushes. He could be seen to be asking creative questions – '**What can I do with this**'. This was particularly apparent when analysing Ryan's observable contemplation and subsequent use of tools in the tray. At one point, he was moving gloop across the tray with a wide spatula in his right hand, then trying to stop its return flow using a rubber paintbrush in his left hand. At another point he was scooping up the cornflour mix with the spatula and slowly dribbling it on to his forearm and hand (Images 2.1 and 2.2). This generation of **alternative strategies** and ways to use the tools provided, often novel and unexpected, outcomes that relate closely to the aims of the task outlined on the poster ("Developing the motor skills necessary for writing" and "The ability to work with small tools – rubber pens, combs etc"). This would suggest then that the outcomes of the activity were of **value**. This immersion, development of motor skills through tool use and of exploration would all suggest that this was an extremely valuable and worthwhile activity for Ryan.

Episode 3: Bubbles

This activity follows the actions of just one child, and it is Ryan again (see 'gloop episode' above) who provides a demonstration of the access that children have to a wide range of resources, as well as the time and space they are afforded in order to follow their own interests. This episode does not come from a particular teaching activity or activity set up by the practitioners, rather it comes from Ryan's interaction with one of the science-based toys that had been left out as a deliberate provocation by the staff (Image 3.1). This may seem a potentially strange episode to have chosen given the wide range of other activities that were occurring in the classroom during the observation

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period however it demonstrates the freedom that children have in the classroom to explore even small activities

Image 3.1: Ryan examining the tube

Of course, it is not possible to establish precisely Ryan's thought processes throughout this activity. The researcher's observation of his activity was subsequently followed by a period of discussion with Ryan. During this time, the researcher attempted to explore Ryan's thought processes through discussion and open ended questioning. Conversation topics ranged widely, from the task at hand, to him going to church on Sunday, to his dream of being in a bubble and floating to the ceiling, even within the short time period that the conversation took place (approximately four minutes), highlighting the variety of thought processes that may have been going through Ryan's head as he worked.

Pedagogical framing

There are a number of science- and mathematics-based toys and activities around the classroom that the children have access to on a day-to-day basis. These include large wooden blocks, smaller plastic cubes that children might construct towers from and activities such as jigsaw puzzles and mathematics puzzles. While there is little use of technology, many of these toys are brightly coloured and visually stimulating. For example, small construction blocks are enclosed by mirrors on three sides to enhance children's awareness and **interest** in these. Children were free to choose these activities as they wished and, as with the episodes discussed above, spend as much or as little time on each as they pleased. Here then, was a 'science toy' that had been left out for children to play with. There was no explicit prompt to Ryan to use the tube from any of the practitioners and

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this appeared to be an entirely self-motivated activity in an **informal setting**. Ryan had then found the toy which then sparked his interest and curiosity – so much so that he spent a long time stood observing the toy disregarding all activities around him and indeed the other children and it is this freedom to choose whichever activity he finds most attractive that is an important feature of pedagogy in Alice's classroom.

Pedagogical interactions

There was little to no practitioner-interaction with Ryan during his time of observation – indeed the most direct interaction he had with an adult during this time was when discussing his actions with the researcher after his period of **observation** and exploration (Image 3.2). This was, it transpired, a deliberate ploy by the practitioners, who ensured the Ryan had ample time to personally **explore**, **examine** and **reflect** on his observations. His focus was solely on observing the bubbles and their movement in the tube and practitioner-intervention at an early stage could potentially have hindered this exploration. This did mean that any **explanation** that occurred from the activity was in fact incidental or unplanned. Indeed, had the researcher not had the discussion with Ryan, it is unclear whether or not a practitioner would have interrupted him during this activity. Explanation, particularly of science or mathematical concepts appears to be infrequent at this age group and rarely noted during the observation period.

Image 3.2: Ryan observing the tube

One important reason for including this episode is that it highlights the wide **range of materials** that the children have access to. As well as the practitioner-initiated activities, the role-play area, and larger activities such as block-play, there are a number of more **informal** learning experiences in which the children can participate. These informal, open-ended tasks served as a means of fostering **creative dispositions**, **curiosity** and questioning in the children.

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Opportunities for science learning

Unlike the two episodes discussed above, this episode was not explicitly planned for or practitioner-initiated. Indeed, there was no practitioner-intervention at all throughout the course of the activity. It may be difficult then to suggest particular aims of the curriculum that the practitioners were working towards with this activity. Nevertheless, it is possible to infer possible curriculum aims by looking at the outcomes of the activity.

Again, if we look to the introduction to the World Around Us area of learning in the curriculum, it suggests that children should have "opportunities to use their senses in order to develop their powers of observation, their ability to sort and classify, explore, predict, experiment, compare, plan, carry out and review their work". In this episode, a number of these activities can be identified, most notably Ryan observing, exploring, experimenting, comparing and planning, carrying out and reviewing his work (Images 3.1, 3.2 and 3.3). While these may not have been explicit in terms of written or verbal outcomes, it is possible to infer that at each stage of his activity he might be reflecting critically on the outcomes of the previous stage and planning his subsequent approach (Image 3.1). He is certainly observing and exploring the science toy and his progression from shaking to twisting to spinning would suggest that he is working in an iterative, experimental fashion.

Opportunities for creativity

Again, despite not necessarily being deliberately planned for or practitioner-supported, the activity nevertheless appeared to provide a number of opportunities for creativity. As Ryan was fully immersed and engrossed in his task, two main avenues that could be seen for creativity. The first was based on Ryan's ongoing and developing understanding of the toy, how it worked and the science that was inherent within it. During his exploratory activity, Ryan could be observed, as he later explained, attempting to make the bubbles emerge and slide down faster. Initially, he was shaking the toy up and down in order to see which might solve his self-posed problem. When this first attempt did not appear to work, he then tried twisting it around its vertical axis. He then tried spinning it faster (Image 3.3). It is possible then to note how he has observed a phenomenon and subsequently posed himself a problem ('How can I make the bubbles go faster?') He then tries a number of **alternative approaches**, refinements on the previous attempts, in order to solve this problem.

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Image 3.3: Ryan experimenting with the tube

The second avenues was how this activity provided a platform for Ryan to develop an imaginative world, which he then discussed with the researcher – an imaginative or playful version of creativity, not necessarily linked with science or mathematics education, but one that may be considered as creativity nonetheless. It is possible to identify a number of different 'worlds' through the discussions. Firstly, there is a 'science' world in which Ryan reflects and rationalises in order to develop (possibly scientific) explanations to his observations and explorations. Secondly, there is the 'everyday' world to which Ryan relates these scientific concepts, which subsequently leads to a third 'fantasy' or 'make-believe' world in which anything is possible. While it may not necessarily fit with the *Creative Little Scientists* interpretation of creativity, this final version of creativity falls more within the remit of other wider definitions of creativity in creativity, which centre more squarely on the imagination rather than perhaps strategic or critical thinking.

3.14.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years? What role if any does creativity play in these?

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics? How do teachers perceive their role in doing so?

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Alice was keen to highlight her belief in the importance of 'block play' in her classroom, and indeed this was a prevalent activity throughout the observation period. While she acknowledged that "*I think it is harder though in terms of developing creativity through science and maths, it does tend to be more teacher initiative*", one way that creativity in science and mathematics could be identified was through block play.

> *"I mean there is a lot of child led stuff, especially in the blocks, because that to me, I mean that is full of science and maths there, I mean I am very passionate about block play… I am nuts about block playing, I love block play and the blocks are out all year round and it never grows stale and that, you know I can identify creativity there".*

Unfortunately, with so much rich activity happening in the classroom throughout the day, it was not possible to observe this in any detail. This certainly highlights one limitation of qualitative research in that the researcher chooses where to observe and ultimately selects both what and why data is collected, how it is analysed and subsequently how it is presented.

- Group activity – collaboration, communication
- Assessment – post it notes, key outcomes from number of children OR following children round looking for attainment targets
- Freedom, range of materials, access to materials, rotation
- Children being in charge of their own learning – agency
- Lots of explorative play, developing affect – positive attitudes towards (science and mathematics) learning

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3.15 Case: 'Maeve'

3.15.1 Context

Where?	Country	Northern Ireland			
	Setting name	NI1_Country Park Nursery			
	Location within setting	Pre-School			
Who? (children)	Year group/age of children	Nursery, aged 3 to 4			
	Number of children in class	25			
Who? (adults)	Number of adults	3			
	Role of adults	1 teacher, 2 full time nursery staff			
	Case teacher role	Lead teacher			
When?					
	Dates of visits	28 01 13	30 01 13	26 02 13	27 02 13
	Times of visits	Afternoon	Afternoon	Afternoon	Afternoon

School / Setting

County Park Nursery is an oversubscribed nursery situated in a small town in central Northern Ireland. It caters for approximately 75 nursery aged children, aged 3 to 4, across the two classrooms. There is a shared space between them. One classroom is full time (25 children), while the other has 25 children that attend every morning, and a separate cohort of 25 children who attend in the afternoon. The nursery is open five days a week. Children come from a range of socio-economic backgrounds and the nursery works hard to build relations with both families and the community. There are often visitors to the school, such as farmers bringing lambs or individuals from the local animal shelter bringing in hedgehogs. Parents and former-parents are invited to contribute their skills and where possible, leading to a variety of activities for the children such as felt-making workshops and another on Chinese culture. The nursery also runs parents' and grandparents' days when these adults are invited to join the children for part of their day. This actively involves the family in the education process.

It is well resourced, with a large outdoor play space which includes a climbing frame, a covered sand pit area as well as a 'nature area' where children are able to grown plants and vegetables in the spring and summer months. This ties in with the school's approach to teaching and learning – the nursery does not work to short-term 'themes' in their learning that might be seen in other education environments, rather they focus on the four seasons as their themes over the course of the year.

The nursery professes to have a strong Reggio Emilia influence. As such, the nursery has a stated aim to develop the children's independence and creativity. This can be seen in many of the activities (three of which are described in more detail below) and the independence that children are afforded

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throughout the day (such as an emphasis on being responsible for their own actions and encouraging children to put their own coat on to go outside, as well as selecting their own activities).

This Reggio approach is espoused not only by the headteacher but by all of the staff involved in the nursery. The staff comprises six practitioners – the headteacher (who works as a classroom teacher), one classroom teacher (Maeve) and four nursery assistants – who all work closely to develop teaching practice.

Teacher

Maeve was based in the classroom that catered for the two part-time classes. She taught two cohorts of children, one group attending for just the morning, the second just the afternoon. Maeve had been teaching at County Park Nursery for four years. Previous to this, she taught in England for four years, having moved from Northern Ireland to England to study for her BA in education. Maeve was clear that in recognition of the Reggio approach, she sought to enable learners to develop agency:

> *If we want children to become independent learners and think for themselves its best that they learn for themselves … then for us to start that off. They're actually in there to learn and to be inquisitive and to explore*

Classroom

In addition to Maeve, there were two full-time nursery support staff, Paula and Barbara (pseudonyms), who played an active role in the day-to-day activity. The availability and diversity of materials and resources in this classroom play a significant part in the learning opportunities which are made available to the children. As the map indicates, there are many 'stations' and places to play and materials to use and investigate, including cooking materials, implements, a till, money, shopping bags and loaves of bread in the bakery for instance. These semi-permanent resources (albeit the role play area changes each term) are significantly supplemented on a daily basis by specific additional resources related to the school's seasonal curriculum focus which are placed in the room or the outside area to interest the children ,foster enquiry and prompt learning. These might include jigsaw puzzles, picture books and changing toys in the water tray that reflect the seasons (such as polar bears and penguins in the winter or farm animals in the spring)

There are multiple 'planned activities' happening at any one time in the sense that specifically chosen additional resources have been laid out and practitioners wait and watch for children's interest in them and then move to offer support them, In addition, there are multiple opportunities for children to initiate their own activities making use of the role play area or other freely available resources such as the blocks. Children are free to move from activity to activity as they please. This means that the children at an activity may change several times over the course of a session, or indeed over the course of a research observation period.

The support staff and Maeve are very aware that through watching, standing back and observing the children's engagement with resources they can see where their interests lie. They seek to capitalise

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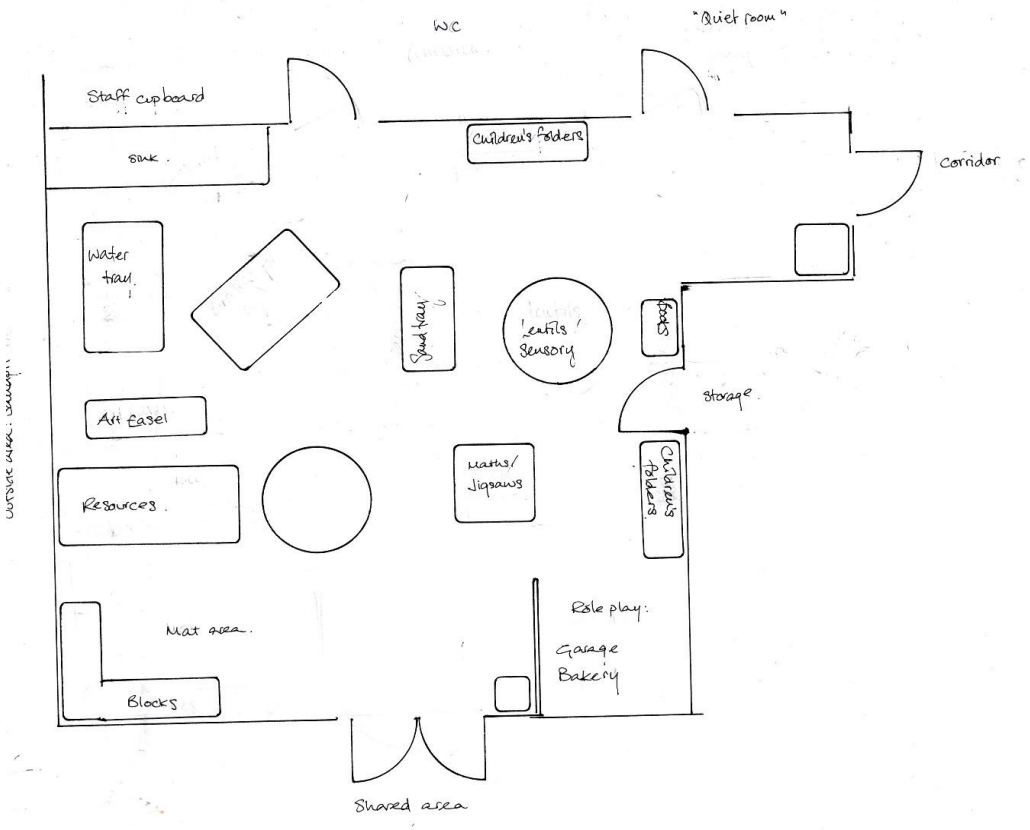
upon this and develop the learning intentions through it. In this way a complex interplay is evidenced between pedagogical framing, pedagogical interactions (staff standing back and then moving to question for example) and the children's learning in science and mathematics. This is partly described by Maeve who observes:

> *What happens is that in nursery when you are maybe doing one activity, so the bird cakes for example, you are going to get the science of the melting out of that, you are going to get knowledge of the seasons, birds need to be fed during, you are getting to get the maths of counting out the amounts, so you could write four or five learning intentions that might meet, and maybe lots more that would meet that specific activity. But you have to choose maybe the one that you really want, because although lots of learning will come out of that, you watch for everything.*



Occasionally, however rather than observing activities in order to respond and support the learners on one, Maeve may sit with one child at a particularly activity in order to formatively assess particular skills. During the observation period, this was particularly the case at the jigsaw table, where Maeve sat with a number of children, with Maeve taking notes about how they attempted to solve particular puzzles.

A layout of the classroom can be seen below.

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3.15.2 Episodes

There are three episodes described below. These are drawn from different scenarios and as such demonstrate the wide number of possible learning environments present in the classroom. The first comes from a set of resources organised and initiated by Maeve, this was a free choice activity; the second from a child-initiated activity in the outdoor play area and the third from an activity using materials that had been left out as a form of provocation for the children to explore.

Episode 1: Ice

Introductory Comments

This session linked to previous explorations during the curriculum focus on the winter season. The activity was initiated by the teacher, who had frozen multiple ice blocks of different sizes and shapes and placed these in a large green water tray on one of the desks in the classroom. They contained various toy animals (such as walruses, penguins and other ice creatures) and coloured glass beads inside. Additionally, a number of the blocks contained food dye of various colours (pink, blue and purple) and/or glitter. This provided a range of stimuli, aiming to appeal to different children, as the teacher noted colour was often used to attract different learners to free-choice activities. For example, in relation to a previous floating and sinking activity, she noted "*we have obviously added the coloured water, added the glitter and we started off with blue water which was sort of attracting lots of boys, moved onto reds and pinks [for the girls].*"

Of the children who initially gathered around the empty water tray and looked on with interest, some put on aprons and stayed to investigate, others moved on or returned later. The first group of five remained there until Maeve suggested they see what might happen to the ice if it was left for 5 minutes. A large timer was set and other children then arrived, later 3 of the original group of 5 learners returned. This episode does not focus on one set of interactions around this resource, but on a series of mini-episodes which occurred across the morning as the ice began to melt. At the close of the half-day session, the teacher led a plenary discussion with the children about their learning, including the changing nature of the ice. Taken together these mini-episodes demonstrate a great deal about the way in which Maeve's pedagogical framing and her interactions fostered sustained interest, on-going science learning and opportunities for the learners to engage creatively.

Pedagogical framing

Maeve was the core practitioner in the classroom for this activity. Her intention as to provide a science based activity which might interest the children and which, if it did so, would afford opportunities for them to develop and reinforce their **understanding and knowledge** of liquids and solids, the forms these might take and the ways in which they might change. **Resources** for this activity were set out for the children, ice blocks in which as noted earlier, ice animals and glitter and jewels were embedded, specifically to initiate and maintain the children's **interest and motivation**. The children were encouraged to engage alongside one another and their observations and comments were encouraged and scaffolded by their teacher who was present throughout. Her pedagogical aim was evidenced both through the children's responses and curious engagement with the ice blocks and through the plenary session at the end of the morning.

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This was a fairly typical activity, which as Maeve described, was planned to be pitched at developing the children's skills, and enabled children to work collaboratively "*in group situations where they might be, and where they are going to sort of lead off*". This did happen in the series of mini-episodes documented here. As various children took the initiative and others followed their lead, they were supported in their journeys by their teacher. In particular the idea, as Maeve noted, was that "*the children would have as many experiences of the same sort of scientific idea but in different ways.*" This was borne out through the observational data over time in this classroom.

Pedagogical interactions

The teacher set up this **informal playful opportunity** in order to nurture the children's motivation to understand their world. Maeve not only enabled the children to playfully investigate the melting properties of ice over the course of the morning's session, she also enlivened this exploration with the presence of appropriate animals from the Arctic and the use of glitter and colour. Additionally, she made clear her own involvement and personal **affective engagement** and demonstrated this through wide eyes, expressions and gasps of excitement and wonder. This served to further motivate the children who could see their teacher found the ice fascinating and engaging.

Maeve's pedagogical interactions in this series of mini-episodes indicate she was sensitively attuned to the interests and attention of the learners. Once the ice blocks had been shared round the 5 learners, she tended **to stand back and observe**; only intervening with occasional **questions all but one of which built on their comments.** Most frequently she responded to the learners' comments by **making connections** to previous curriculum activities or to their experience of ice, both in the home and on the roads. She paid close attention to the children's actions and comments regarding their cold fingers for example and highlighted the contrast with her own warm fingers.

At the close of the morning's half day session, some 80 minutes after the series of mini-episodes, Maeve drew the class's attention back to the ice tray and their involvement and learning. Her reflective questions at this point tended to be more possibility narrow as she sought to assess the children's knowledge and understanding. This was ably demonstrated with children noting the ice melted as '*The classroom was too hot*' and referring to such points as '*the sun*' – '*lights*' and '*heating*'. It was clear that at this point they remained affectively engaged and interested, eager to communicate their observations and findings.

Opportunities for science learning

As has been noted in other *Creative Little Scientists* deliverables, science in the early years in Northern Ireland is presented as part of the 'World Around Us' curriculum area. It is particularly loose in its statutory guidelines and focuses on developing children's questioning, although it does outline some generic areas of knowledge, understanding and skills that children should develop. In this session, dealing with the change state from solid to liquid, it is possible to see that Maeve was facilitating one particular area of the curriculum, namely that :

Teachers should enable children to develop knowledge, understanding and skills in relation to:

Change over Time:

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Pupils should be enabled to explore:

- How do things change?
- What kind of changes happen, have happened or might happen?
- How can we make change happen?"

(DENI, 2006, p. 38)

In addition, there were multiple opportunities for the children to develop their 'communication and language', largely through responding to teacher questions or engaging in related conversations which drew on their own life experiences. This aim reflects the 'communication and language development' area of the early years curriculum, described as:

> **Communication and language development** involves giving children opportunities to experience a rich language environment; to develop their confidence and skills in expressing themselves; and to speak and listen in a range of situations.

(from http://www.nicurriculum.org.uk/docs/key_stages_1_and_2/northern_ireland_curriculum_primary.pdf, accessed 11th April 2013)

In this series of mini-episodes, it was possible to directly observe a number of different areas of learning that the practitioner sought to foster during the activity – both scientific and non-scientific, which clink to the curriculum objectives and factors identified in the *Creative Little Scientists* research.

- **Observation/exploration** of changing states (solid to liquid)
- (Experimental) use of equipment and resources – a feature highlighted in the *List of Factors*
- **Use of senses** (e.g. watching the ice melt, feeling the cold ice on their hands and the jagged edges of broken ice in contrast to the smoothness of the glass beads inside)
- Knowledge/understanding of science content (with regard to change over time from solid to liquid)
- **Questioning and communicating** findings
- Use of an **emergent scientific language**
- Active and sustained **affective engagement** with the task

The teacher's questions during the activity tended to be in response to actions or comments on the part of the children. For example:

C: "It's freezing"
T: "Is it? How do you know it's freezing?"
C: "Cos it's not melted"
T: "It's not melted?"
C: "No!"
[Teacher gasps]

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C: "Feel my hands"

As can be seen in this interchange, Maeve responded to a child's comment that '*It's freezing*' by enquiring how she knew that. Later she mirrored the child's words by repeating her response 'It's not melted?' with a rising intonation to convey it as a question and thus inviting response. When the child suggested her teacher felt her hands, most of the group moved to enable their teacher to feel theirs also, which she did so, making gasps each time. Then when she had felt all but one of the children's fingers, Maeve observed, as she rubbed her hands together "*Mine are lovely and warm*".

This was voiced to highlight the contrast and trigger new learning or connections (Maeve noted later) and resulted in the last child then feeling her hands. As she did so the three year old looked at them and then back at the ice and smiled knowingly. It was as if she knew or perhaps was realising why her teacher's hands were warm (she had not been handling the ice and had been rubbing them together). Her smile was one of delighted knowing, almost conspiratorial. Maeve looked as if she would comment on this possible non-verbal connection, but another child arrived and the moment for making explicit the potential creative/scientific connection slipped away.

Opportunities for creativity

There was evidence across the session of a number of the *Creative Little Scientists* 'creativity enabling' indicators as well as several examples of **creative dispositions,** in particular **connection making, motivation, imagination,** and **curiosity.**

The 'mini-episodes' of creative engagement during this science activity fell largely into two types, one where like the last example, the potential for creativity was not fully capitalised upon, and the second in which making connections was the dominant theme, with Maeve supporting this through building on the novel connections and creative contributions made by the children, although not all of these were related to scientific knowledge.

Another example of the unrealised potential for creative engagement within the science activity occurred when one child, expressing dislike of the cold, decided to go to dry his hands on the hot air drier in the cloakroom. He was rapidly followed by his peers from around the ice tray who all dried their hands and then returned to handling the cold ice blocks. It is possible that the first child chose to dry his hands simply to warm them as he was cold, it is also possible he was hypothesising, albeit implicitly, that with warmer hands he might make the ice melt quicker. The teacher raised her eyes in approval and pleasure to the researcher, but did not enquire of the child (or any of those who returned with warm hands) if this made any difference to the ice melting. Later she commented to the researcher that it had been a clever idea, suggesting that she credited the child with this imaginative action, but the potential of the moment remained unrealised. The practitioner stood back, in role perhaps as Hyvönen (2008) suggests as an 'allower', but did not step forward to help the children realise - in the sense of making real and coming to understand- their potentially emergent scientific knowledge.

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In relation to the **teacher's scaffolding,** in this session it was not related to the structure of the task, as this was an open ended activity, but it was visible through this and the other mini-episodes in the way in which Maeve listened, watched and then responded sensitively. She orchestrated standing back with making connections and mirrored the children's words, denoting her interest and response. Maeve was acutely aware of trying not to intervene or instruct in such open ended learning contexts:

> *"I'm very aware of just letting them explore for themselves and not to be over-questioning and during their learning, so let them explore, try not to hinder their learning."*

Nonetheless the exploratory context of ice blocks melting over time afforded other, more fully recognised opportunities for fostering creativity in scientific learning which Maeve did help the children partially realise. For example, when handling the ice and noticing the changes in it as it melted, several of the children commented upon the emerging shapes being formed and made metaphorical connections. These included, for example:

C: *"It's like a bun, big and round"*
T: *"With a cherry on the top"*

And

C: *"This is like a tooth, This is a mountain"*
T: *"I think you right it has sharp pointed edges"*

As can be seen on each of these occasions with different learners, the teacher added to and affirmed the children's imaginative connections and whilst these did not connect specifically to their developing scientific knowledge, did affirm their generative and lateral thinking. As such their ideas reflected creativity as defined by the project; they demonstrated imaginative activity generating outcomes (new connections) that were original and valuable for each of the learners in the context of this activity.

There were two occasions when Maeve in conversation with the young four year olds, moved to create and affirm connections to ice and frozen liquid in the children's own life experiences. In this way she was working towards helping them make creative connections between ice as a solid and different forms of melting ice, and thus changes over time. In one the teacher enquired about how the bear had got into the ice as follows:

T: *"How do you think it got in there?"*
C: *"You did it"*
T: *"Did what?"*
C: *"Put it in the fridge"*
C: *"There are yoghurts in our fridge"*
C: *"Princess yoghurts"*
T: *"Are they cold like this?"*
C: *"That's the freezer"*

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In this instance the children's responses indicated they understood there was a difference between the fridge and the freezer and their life connections were again capitalised upon by the teacher. On another occasion the teacher and one child made connections between the slippery wet within the water tray (once the ice had begun to melt) and their own experience of slipping in the wet snow on recent class walk. The child went on to make additional connections with regard to cars slipping on the roads, due to ice and the precautions that his family had taken to prevent this.

> *C: "We have chains to help you go through the ice."*

Though it is clear the children were engaged in making connections between related ideas and the last child did offer some sense of reasoning with regard to the use of chains to prevent slippage, this was not directly connected to the changing state of solid to liquid by the teacher. Rather the focus remained on making connections with regard to the winter season, thus the scientific understanding focused on the 'world around us' in a fairly general manner.

In all these mini-episodes, the teacher demonstrated skill in oscillating between responding to the children's motivated and creative engagement and standing back so as to comment upon it or mirror their words and help them make connections. In this way she sought to **scaffold their learning** about the process of transformation (DENI, 2006). However, she did not as some practitioners in the study did, make much use of the subject specific vocabulary and was very focused on showing professional restraint. To an extent the potential for developing scientific knowledge was not fully realised, though the children were engaged and at time demonstrated their creativity through making imaginative connections.

Maeve highlighted that for her the challenge of standing back was both more layered and more complex than it might appear.

> *"Sometimes as educators you intend and want to teach, you want children to learn, but I think stepping back and allowing children to discover and find things for themselves is no simple matter."*

In terms of the synergies which the Consortium identified between mathematics, science and creativity (D2.2 Conceptual Framework, pp. 7-8), the children and the teacher demonstrated the following in and through the mini-episodes.

- **Play and exploration** – of the resources and their changing states
- **High levels of motivation and affect** – triggered in part by the potential for releasing the trapped ice animals, by the teacher's own engagement and the novel opportunity to experiment with ice blocks
- **Dialogue and collaboration** – (to an extent) in the ways in which ideas/actions were developed and then emulated, less verbal collaboration
- **Problem solving and agency** – (to an extent) of how to release the animals and how to speed up the melting process,

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- **Questioning and curiosity** – throughout the task
- R**eflection** – in their comments during the activity when making connections and in the plenary at the end of the lesson
- **Teacher scaffolding and involvement** – evident in her responsiveness to the learners' comments and engagement rather than any desire to 'cover' the given curriculum

Episode 2: Outdoor sandpit

Introductory comments

As noted briefly above, the nursery has a large covered outdoor sandpit area. In this, there is a large wooden climbing frame, on which there are a number of pulleys with buckets to fill with sand, ramps and a conveyor belt. The children have outdoor play everyday and would use the covered sandpit area three to four times a week. Due to the climbing frame, children needed adult supervision while in the sandpit area. When the whole class were in the sandpit, all three practitioners (Maeve and the two nursery assistants) would be supervising the children.

The focus here is one child, Patrick aged 4, and his explorative use of the pulleys that are attached to the climbing frame. In the example for this episode, Paula was standing close to Patrick for the whole session (Image 2.1). From this point, Paula was talking to the children who were acting out a pirate ship scenario, as well as being able to interact with Patrick. As can be seen in each of the photographs, one of the pulleys has half-tyres on each end, which can be filled with sand. Patrick was filling one of the tyres up then pulling on the other chain (Image 2.1) in order to lift the sand up to the higher platform. When he let go of the chain, the tyre fell to the floor. After two repetitions of this, Patrick then started to fill the other half of the tyre. After a process of trial and error, Patrick managed to fill the second half of the tyre such that they balanced. He then tried again to lift the sand to the higher platform, but since the tyres were of equal weight, this did not work. Eventually, through careful observation and refining his approach, Patrick succeeded in his apparent aim to get one full half-tyre of sand to the higher platform on the wooden climbing frame.

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Image 2.1: Patrick with Paula in close by

Pedagogical framing

The practitioners at County Park Nursery all repeatedly acknowledged how lucky they were to have such facilities that provided not only an entertaining environment for the children, but also one with so many learning opportunities. The open nature of the covered and ample space area meant that children were able to be involved in individual activity or work in groups of any size. The facilities provided by the climbing frame and sandpit meant that activities could be particularly rich in the wide range of possible aims and objectives that might be identified.

Within Patrick's individual activity in the sandpit, we can see how he might be developing scientific and mathematical knowledge, through his exploration of weights, as well as his experience of science problem solving and inquiry-based learning skills. As with many of the learning experiences at County Park Nursery, this was largely an **informal** learning experience and was driven by the child's own **interest** rather than any formal or compulsory activity that necessitated children being at one place for a specified amount of time.

Pedagogical interactions

During the time in the outdoor sandpit area, a number of different activities could be observed from different children – children involved in imaginative worlds (pretending the climbing frame was a pirate ship, playing with toy diggers), children involved in construction (digging, making sandcastles) and the science-based activity described in this episode. There were a **wide variety of resources**, as well as a **rich physical space** that allowed each child to **play** and **explore** in their own various and

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often personal ways. Indeed, play and exploration appeared to be central to many of the activities observed, not least the activity described in this episode. Children were given the time and space to develop their own ideas and investigative activities. Practitioners would often observe what the children were doing and, where appropriate, ask very general open-ended questions, such as "*Oh wow, what might you do next?*" in order to further the activity or investigation. Where children were involved in imaginative play, the practitioners would become immersed in this world with them, fostering and encouraging this further. This approach by the practitioners was common to many of the sessions seen as part of the Reggio Emilia philosophy and a direct attempt at developing children's independence, both in activity and in thought.

For this episode, as noted above, Paula could be observed talking the children at the top of the climbing frame who were involved in imaginative play, with the climbing frame as a pirate ship. Patrick was to her right and was focused on his task. This meant that Paula could observe Patrick and contribute and discuss at appropriate times, without interrupting his problem solving activity. This type of interaction with the children was typical of that seen over the course of the observation period. Patrick's activity itself featured much use of **equipment** (see for example Image 2.2) while also requiring him to **plan**, refine and **reflect** on his practical activity. This was an independent activity that required him to take an active role in his learning, as he chose the learning activity and direction in which it would head.

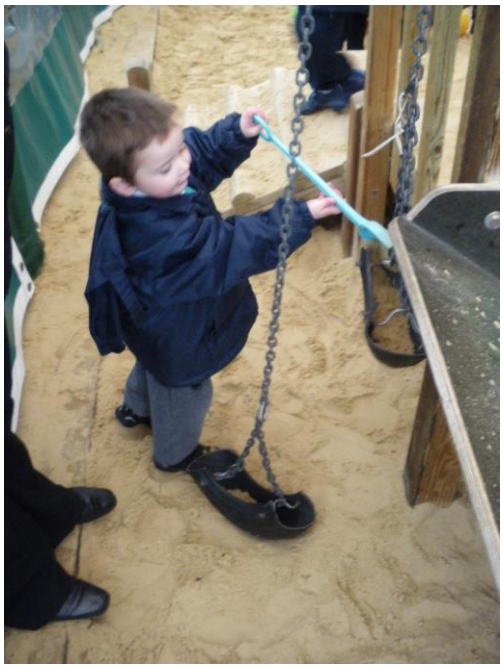

Image 2.2: Patrick filling one of the tyres with sand

Opportunities for science and mathematics learning

There are two areas of the curriculum that this activity appears to be covering, one in science and one in mathematics. While it is not possible to suggest that this was specifically planned for on that day, the rich variety or resources available to the children means that these sorts of opportunities

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are readily available to the children on a regular basis. Learning experiences are planned for in the activities that the children undertake on a daily basis and the ongoing formative assessment, discussed above, ensures that all children have access to the various areas of the curriculum in order to make progression in areas of development.

The introduction to the World Around Us area of learning (in which science education is situated) states that children should have "opportunities to use their senses in order to develop their powers of observation, their ability to sort and classify, explore, predict, experiment, compare, plan, carry out and review their work". The previous two sections, on pedagogical framing and pedagogical interactions, both described how the activity described in this episode allowed Patrick to develop his observation and exploration skills. We can also infer from his apparent trial and error method that he would have been comparing the two amounts of sand and subsequently planning, carrying out and reviewing his investigation throughout this activity.

In addition, we can also look to perhaps more specific aims of the curriculum. While in the World Around Us area of learning there are no specific content-based curriculum, there are particular topics that practitioners are encouraged to explore. One of these is described as 'Movement and Energy' and its aims include "enabling children to explore… How do things move now and in the past? Why do things move? [and] How do things work?" (from http://www.nicurriculum.org.uk/docs/key_stages_1_and_2/northern_ireland_curriculum_primary.pdf, p. 38, accessed 11th April, 2013).

In exploring the workings of a pulley, how it functions, how each side moves and so on, we can see Patrick fulfilling a number of the developmental goals outlined in the curriculum.

In contrast to the World Around Us area of learning, there are more specific, content-based aims and objectives in the mathematics and numeracy section of the curriculum. Mathematics and numeracy is divided into different areas; Number; Measures; Shape and space; Sorting and; Patterns and relationships. Looking to the 'Measures' section of the mathematics Area of Learning in the curriculum there are two particular statements that are of interest. Firstly, it states that children should be encouraged to:

> compare two objects of different length/weight/capacity/area; understand and use the language of comparison, for example, longer/shorter, heavier/lighter, holds more/less, covers more/less, covers more/less surface;

And also that children should:

> Begin to explore the notion of conservation of length, weight, capacity in practical situations, engage in discussion about their observations.

(both from http://www.nicurriculum.org.uk/docs/key_stages_1_and_2/northern_ireland_curriculum_primary.pdf, p. 25, accessed 11th April, 2013)

Patrick appeared to be doing exactly this in his attempts to solve his self-posed problem. He is developing his own understanding of weights and measures, balance and heavier and lighter through his observations as he loads one side with sand (e.g. Image 2.3). Language is, to a certain

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degree, somewhat secondary – this appears to be the case in many of the activities observed during the course of the observation period. It is possible then to see how this one activity covers a number of different areas of the curriculum.

Image 1.3: Patrick standing back and observing the two ends of the pulley

Thus, as was noted above, while the activity may not have been specifically planned, the resources that are openly available to the children in the sandpit facilitate these types of activity and thus for these curriculum objectives to be addressed. Other mechanical features of the climbing frame might also provide further avenues for addressing curriculum objectives. For example, the conveyor belt too may help children develop an understanding of 'how things work' (as noted in the Movement and energy section of the World Around Us area of learning)

Opportunities for creativity

One of the key themes that appears to run through this episode is the freedom that the children have in the task. This activity was entirely self-selected by Patrick and any problem solving was based on problems posed by Patrick himself. Patrick then is the agent of his own learning here, and through posing and solving his own problems, can be seen to be looking for alternative strategies, generating new ideas and engaging in purposive, and ultimately enjoyable, activity. His actions show all the hallmarks that might be associated with creativity.

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Episode 3: Shapes

Introductory comments

On one table in the classroom (see classroom map) Maeve would leave out a number of different jigsaws and shape puzzles. The nursery had a wide range of these puzzles available and the selection would change on a daily basis. These were of various difficulties and designed variously to develop children's awareness of shape and space and develop motor skills. Maeve would often observe individual children at the puzzle table as a way of formatively assessing children in these two areas of development.

On the occasion described in this episode, the puzzle chosen by a girl, Amy aged 4, involved placing a number of coloured rods, in a set order, within a frame to make an equilateral triangle. There were a number of different coloured rods such that there were sequentially different coloured triangles within the frame making a rainbow. After completing it for the first time, Amy noticed as she was taking the pieces out of the frame that the pink equilateral triangles from another puzzle on the table could replace the blue triangle and would fit exactly in the centre of the one she was working with (Image 3.1). This moment of realisation then led to an intense period of concentration, during which time Amy continued to disassemble the puzzle, but kept the extra triangle in the other frame, turning it, pushing it various corners and seeing how other rods might fit around it. Amy was engrossed in this activity for 23 minutes, before she completed moved on to the next activity.

Interestingly, Amy was silent for almost the whole activity, focusing intently on manipulating the shapes in front of her, talking only to dismiss the interruption of another child. Other than this, she appeared to be largely unaware of the children around her and indeed unaware of the researcher making notes and taking pictures. She did not comment on the activity or her actions as she was undertaking them and only said a very quiet "*Yay*" when she had completed the initial task. Of course, this makes it difficult to determine precisely what she was thinking throughout the course of the activity. Nevertheless, a large number of photographs were taken during the activity, from which it may be possible to infer some of her thought processes. Despite the large number of photographs taken, only illustrative pictures are used here.

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Image 3.1: Amy notices the similar sizes of the equilateral triangles

Pedagogical framing

This particular episode was somewhat fortuitous – that the pink triangles from another puzzle fitted in the one that Amy was working on was entirely coincidental, and thus it cannot be claimed that the creativity present in this activity was something that was 'planned for'. However, by providing a wide **variety of resources** on the table, Maeve is providing a **rich physical environment** that firstly provides a motivating environment for children to engage in play and **exploration** and secondly increases the chances that these sorts of coincidences might happen. What was planned for was the development of mathematical skills and abilities through **inquiry-based approaches**. The activities available to the children range from number games to simple jigsaw puzzles that allow children to develop special awareness, to the more complex activities seen here that, albeit inadvertently, allow for a more open and exploratory approach. Children are encouraged to choose the activities that interest them the most.

Pedagogical interactions

The activity that Amy selected was one that was designed to provide children with an understanding of the properties of equilateral triangles and also to develop an understanding of length. Children would have to recognise the rods of the same length (or the same colour) in order to complete the task. Amy was proficient at this. From a mathematics perspective then, we can see that this activity aimed to develop some mathematical **knowledge**. However, from the perspective of the project, Amy's subsequent activity was far more interesting, and was less about developing this mathematical knowledge, as will be discussed in more detail in the following section.

Amy can be seen to be moving them around, placing them in different orders, as well as introducing the solid triangle from a different activity. This might be described as **exploratory play**, where she is making **observations**, **reflecting** on these and developing her ideas and actions as a result. Image 3.2 shows Amy deep in thought, considering her next move. It is important to remember of course that

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this is inference, for as discussed in the introduction to this episode, Amy was silent throughout her investigative work, and entirely engrossed in the activity. What we can suggest then that there is a strong sense of **affect** involved here, where the activity has stimulated and maintained Amy's interest in the task and kept her focused and engaged for a sustained period of time.

Image 3.2: Amy reassembles the puzzle using the new pink triangles

In this case, Maeve had noted from afar the basics of what Amy was doing (manipulating shapes, constructing patterns) and, seeing that she was engrossed in the activity, opted not to intervene, rather observe and make short notes for the purposes of **formative assessment**. These notes would indicate that Amy had been observed undertaking a number of curriculum objectives from the mathematics and numeracy area of learning (for example, making patterns is identified as a curriculum objective). As a result of this standing back and not intervening, Amy was able to develop a strong sense of **agency** and ownership over the task – so much so that she was frustrated when others tried to join her or suggest possible actions for her.

Opportunities for mathematics learning

As noted above, the initial puzzle has a number of mathematical aims inherent within it – developing understanding of the properties of equilateral triangles and of length. Beyond this however there are further mathematical areas of learning that we can identify, particularly during Amy's more exploratory activity once she had completed the initial puzzle. . There are two parts of the mathematics curriculum that are particularly relevant here. The first focuses on the overall aims of the curriculum, which is described in the introductory statements to mathematics. This states that;

> Children will acquire early mathematical concepts through activities that involve matching, comparing, classifying and making patterns and sequences in a variety of contexts. These activities should involve children in playing, exploring and investigating, doing and observing, talking and listening and asking and answering questions

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(from http://www.nicurriculum.org.uk/docs/key_stages_1_and_2/northern_ireland_curriculum_primary.pdf, p. 23, accessed 11th April, 2013)

Her activity, as has been outlined above, can be described as exploratory play, and cCertainly in Amy's playing and manipulating of the triangle pieces, it is possible to identify her matching, comparing and attempting to make patterns with the shapes. Interestingly, Amy was not heard talking throughout this activity, and any questions that were asked were either inaudible to internalised.

Opportunities for creativity

The activity that Amy chose was not, at first glance, an overly open-ended task. The rods fit in a set order into the frame to make a rainbow coloured triangle. Completing the task as it was designed may be considered a fairly closed task. This is not to say that it is not challenging or interesting for children, rather that it has limited goals. Amy however was able to find a way to adapt and modify the task using resources from another puzzle. It is here that we can identify creativity, changing the straightforward task into one that is more open-ended and exploratory with a wide range of possible outcomes and finding patterns to be made with the pink triangles and the other rods (Image 3.3 and 3.4).

Image 3.3: Amy has started disassembling the other rods and starts making patterns

Image 3.4: Amy continues making patterns in the now-empty frame

As has been previously noted, it is not possible to suggest that this activity was planned for. However, Maeve's overarching pedagogical approach did allow Amy's creativity to develop and flourish. Maeve allowed all the children in the class a freedom to explore so, rather than intervening and, say, suggesting to Amy that she use the correct resources, by Maeve standing back Amy was

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allowed to develop not only her creative ideas but also have an opportunity to experiment with making patterns and develop a deeper understanding of the nature of shape and space.

3.15.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

What role if any does creativity play in these?

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics? How do teachers perceive their role in doing so?

- Freedom a major part in this classroom – driven by the children: "*the needs and interests of the class, we try and keep that mostly in mind and, you know although we have learning intentions that we have to sort of fulfil in terms of curriculum… we still move on with the interests of the children because that is where they are at, that is where they are ready learn, that's what they are interested in… as long as you know you have covered that learning intention you can do it whatever way you see fit within your classroom, and obviously, I mean, we can do floating and sinking, lots of different avenues to go down with different things and obviously the summer lends itself nicely to doing lots of stuff with water outside*"
- Reinforcement through multiple routes, for example, about solids and liquids, related to winter using ice/snow. 'Revisiting' an important factor (discussed frequently by the other teacher, Alice, in this site.)
- Facilities/resources – diversity and rotation, coupled with freedom of choice leads to a sense of novelty in activities. This avoids 'revisiting' being seen as 'repetition' and therefore not boring etc.
- Providing stimulating activities that are accessible to all on a number of different levels – for example, outdoor play area accessible on a number of different levels, regardless of age/ability/gender/etc.
- These also allow for communication between children as and when appropriate
- Practitioner scaffolding important – judicious questioning/prompting/standing back. Seen in all three activities – to varying degrees.

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3.16 Case: 'Siobhan'

3.16.1 Context

Where?	Country	Northern Ireland			
	Setting name	NI2 – Ashford Integrated Primary School			
	Location within setting	Primary School			
Who? (children)	Year group/age of children	Primary 1			
	Number of children in class	29			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher, 1 full time teaching assistant			
	Case teacher role	Lead teacher			
When?					
	Dates of visits	24 01 13	29 01 13	26 02 13	28 02 13
	Times of visits	Afternoon	Afternoon	Morning	Morning

School / Setting

Ashford Integrated Primary School is a highly overly subscribed integrated primary school in a small town in Northern Ireland. Integrated schools are required to take an equal number of children from Catholic and Protestant families, as well as children from other religions. This is in contrast to Catholic and Maintained schools in Northern Ireland which are more homogenous in their intake. It has won a number of awards for its inclusion policy, including the Inclusion Quality Mark, one of very few primary schools in the country to do so. It has been recognised as an outstanding school by the Education and Training Inspectorate, the governmental inspection organisation, for both teaching and pastoral care. Ashford Integrated is an EcoSchool, has schemes for healthy eating and its teachers and support staff have won national recognition. The school has a 'buddy system' for the Primary 1 children and the Primary 7 children (aged 10 to 11).

There are 200 children in the school, with one form in each year group. There is a large playground which all children in the school share however there is also a dedicate play space for the early years children (classes Primary 1, 2 and 3) which includes a playhouse, climbing equipment, a slide and outdoor musical instruments such as chimes and drums.

Teacher

Siobhan has been a teacher at Ashford Integrated for nine years and has taught at all three age groups (Primary 1, 2 and 3, from ages 4 to 8) in the school. She is the early years coordinator at Ashford and has overall responsibility for planning across the three classes. She has been consistently rated as an outstanding teacher nationally and as a result has been involved in work for

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the Department for Education-funded CCEA (Council for the Curriculum, Examinations and Assessment) in filming exemplars for best practice in literacy and numeracy.

In addition, there was one teaching assistant, Sinead. The teaching assistant would work with one group during the Learning Centre time (described below) as well as providing extra supervision and preparing extra resources.

Classroom

The classroom shares a space with the Primary 2 class (see Andrea Case Study) where there is a water tray and large role play area. While the classrooms share the space, the children from the two classrooms are rarely in the room at the same time.

Teaching was based around cross-curricular themes that would permeate all aspects of learning. Themes would last two to three weeks. The two themes observed during the observation period were the Gingerbread Man story and 'Push, Pull and Twist' (forces). This allowed for learning activities such as investigating sinking and floating (for getting the Gingerbread Man across a 'river') or looking at different types of exercises that use different forces.

Numeracy and literacy were taught as whole-class subjects, with short introductory sessions of the overall topic before children then went to their desks and worked in ability-determined groups of five to six children. Assessment was largely formative, and these groups often changed according to children's progress during the term. During numeracy sessions, the teaching assistant often worked with the least able group, while one group would work directly with Siobhan.

During the rest of the day, the children were taught in what were called 'Learning Centres'. These Learning Centres might include activities based on mathematics, art, World Around Us (including science, geography and history), and construction and all were largely based on the current theme or topic. Each day, groups of five or six children would work at one of five 'Learning Centres', meaning that over the course of a week all of the children would have worked at each of the Learning Centres. Again, children were grouped for Learning Centres according to (a formatively assessed) ability, thus were fluid and were subject to change.

This format was reflected in the Primary 2 class teaching set up.

3.16.2 Episodes

Below are described two episodes from Siobhan's lessons. Both episodes come from the 'Learning Centre' time. As children were often presented with a more open activity in the Learning Centre time, there appeared to be more time for investigative activity, reflected in the data collected.

The Gingerbread Man theme provided a number of rich investigative activities for the children over its two week duration and in fact all three episodes described below draw on this topic. Indeed, it was acknowledged by Siobhan that some topics were more conducive than others at providing opportunities for science and mathematics learning. In contrast, others might provide greater opportunities for children to develop, say, music or drama skills. Detailed planning on a weekly, half-

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termly and yearly basis meant that over the course of the academic year, the choices of topics and their accompanying strengths would ensure that children had access to all areas of the curriculum.

Episode 1: Gingerbread Man investigation

Context

This activity formed part of the cross-curricular Gingerbread Man theme. The children were, by now, all familiar with the Gingerbread Man story where at one point, he must cross a river to escape all those who are chasing him. He hitches a ride on a fox, to his ultimate demise. The investigation here then was to explore "What would happen if the Gingerbread Man had swam across the river by himself?" using a water tray and real gingerbread men. They gingerbread men were dropped in the water and observed after ten minutes and after 20 minutes, with the children drawing what they saw at each point on an investigation sheet. Image 1.1 (below) shows one of the completed sheets. The activity was led by the teaching assistant, Sinead, as Siobhan was working with other groups during this time.

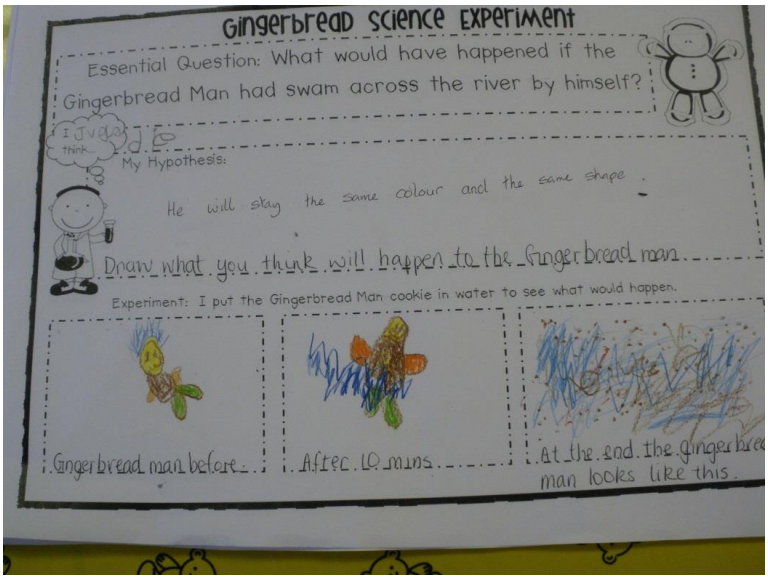

Image 1.1: A completed experiment sheet (Note: Sinead wrote their predictions rather than the children drawing them. This was due to time restrictions caused by external activities.)

Pedagogical framing

This scaffolded and somewhat structured activity appeared to be aimed at developing the children's **science process skills**, that is to say, the investigation was set up in such a way so as to allow the children to undertake a science investigation in a structured and ordered manner. Children were assisted and led through the various steps – prediction, carrying out the experiment, observation (Image 1.2), and recording – of the (science) investigative process. The actual content of the investigation – how the gingerbread man disintegrated – appeared to be of less concern, therefore actual inquiry-based learning appears to be of less importance. What was apparent however was the impact of the context on the children. The motivational **affect** that gingerbread man story context

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had on the children was notable in their predictions (using 'he' rather than 'it' – see below) and ensured that the children saw a sense of purpose in the activity.

Image 1.2: Children observing the gingerbread men after ten minutes in the water tray

Pedagogical interactions

Children were asked to make **predictions** as to what might happen when a Gingerbread Man was left in the water (Image 1.2). Each child came up with a different answer, which the teaching assistant transcribed for them. The predictions from the six children were;

- 'He will stay the same colour and the same shape'
- 'I think he will come alive and get out of the water'
- 'He will change colour and stay the same shape'
- 'He would sink and stay at the bottom but he would change shape'
- 'He will not change – someone might eat him'
- 'I think he will melt when he is in the water too long'

Following their predictions, the children then had to draw what the gingerbread men looked like before being dropped into the water. The children all then move to the sink area where the teaching assistant, Sinead, had set up a large bowl of water and the children each dropped a shop-bought gingerbread man into the bowl. They returned to observe the tray after ten minutes and again after twenty minutes (Image 1.2). After each trip, they returned to their seat and drew what they had

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seen (Image 1.3). Here we can see children using **observation** and **recording** skills in order to complete the worksheet. They were encouraged by Sinead to "*look carefully*" at the tray and to "*try and remember what you saw*" so that they could draw their observations when they returned to their seats. As in many of the early years settings in Northern Ireland, and indeed England, there was little emphasis placed on explanation of these results. While there was a brief discussion amongst the group as to why the changes occurred, this was not recorded on the investigation sheets.

Image 1.3: Children drawing their observations

As can be seen by the wide range of responses, the children were all actively engaged in the topic and the story-context in which the investigation was set clearly sparked children's **curiosity** and **playful imagination**.

Opportunities for science learning

The Northern Ireland primary curriculum identifies science education within the overall aims of the 'World Around Us' area of leaning and it is discussed in terms of questions and exploration of four themes (Interdependence, Place, Movement and Energy, and Change Over Time), rather than through particular subject matter. Rather than identifying science facts and knowledge that children should know, the curriculum suggests that "the purpose of learning about The World Around Us within the Northern Ireland Curriculum is to provide opportunities for children to develop… self-confidence and self-esteem in expressing and sharing their thoughts and ideas and developing an appreciation of the beauty and wonder of the world… an awareness of themselves and their place in the world, as well as of other places, cultures and the environment… [and] an awareness of Information and Communication Technology and its impact on society and the world around them." (from http://www.nicurriculum.org.uk/docs/key_stages_1_and_2/northern_ireland_curriculum_primary.pdf p. 85, accessed 4th April, 2013)

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The curriculum is open and allows for practitioners to identify the children's interests and explore concepts through these interests. Learning is identified in terms of progression through a number of qualitative goals rather than quantitative outcomes. The curriculum outlines seven qualitative progression goals as children move up through Key Stage 1 and Key Stage 2. Most appropriate for this science activity appears to be the first second and third, which state that children should progress;

- *from* making first hand observations and collecting primary data *to* examining and collecting real data and samples from the world around them;
- *from* identifying similarities and differences *to* investigating similarities and differences, patterns and change;
- *from* recognising a fair test *to* designing and carrying out fair tests;

(from http://www.nicurriculum.org.uk/docs/key_stages_1_and_2/northern_ireland_curriculum_primary.pdf p. 85, original emphasis, accessed 4th April, 2013).

In this activity, Sinead is scaffolding children in their progression in these qualitative goals; from merely making the observations about the gingerbread men to making the observations and recording them on the structured investigation sheet; from noting the changes in the gingerbread man as he spends time in the water, to recording these changes and relate them to their predictions; and finally helping the children to carry out a investigation in a structured way.

Opportunities for creativity

In this episode, it is creativity in the pedagogy that is identified rather than necessarily in the children's work or outcomes. The task itself was, at first glance, quite prescribed and one in which the children were led through by the teaching assistant. The children had pre-made worksheets to complete and apparently few choices in the way that the task was structured. Nevertheless, as noted above children were able to use a variety of inquiry-based skills within the task such as prediction, observation and reflection on the results.

It is possible to see across the six investigation sheets six different predictions (including the intriguing "I think he will come alive and get out of the water"). All were welcomed and valued as contributions to the discussion, and Sinead wrote each child's down without apparent judgement or a desire to guide the child towards a 'correct' prediction. Thus we can see that this activity, led by Siobhan, led to the generation of a number of **alternative ideas** that were **original** (all six children came up with differing answers) and were of **value** as they provided a starting point for the children to explore and reflect on their hypothesis.

Episode 2: Gingerbread Man raft

Context

This activity involved the children identifying and sorting objects into those that either sank or floated. The premise for testing items was based around the theme for the class learning – the story of the gingerbread man, who hitched a ride on a fox to cross a river. Previous classroom experiments

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(also observed during the data collection period) had seen the children placing gingerbread men in water – for this they had predicted what might happen and observed the changes that occurred at various time intervals, while recording their hypotheses/observations. Having noted in this experiment that gingerbread men disintegrate when they get wet, it was agreed that a boat would be needed for it to cross a 'river'. This provided the pretext for this activity as the children needed to make a boat or raft so that the gingerbread man could cross the river, as in the story, to avoid the fox trying to eat him. The focus here is on one child, Leila (pseudonym) aged 5, who extended the task, applying the gingerbread man story context to the activity in a way over and above what might have initially been expected or planned for.

Following her experiments with a number of different objects, she focused on the clear plastic tray (used for chicken…) Leila then returned to the table that had the items and began to look over what remained (Image 2.1). Here she found green paper towels – none of which had been used by any of the other children. She was observed holding the paper for several moments, before laying it over the tray containing the gingerbread man and returning to the water tray. She could then be heard telling the other children "*Look, I've got a protector blanket!*" When queried by the teacher as to what the protector blanket was for, she replied "*To stop the gingerbread man getting wet*." Following this, a number of the other children copied her activity, some using paper, and another using tin foil. Leila's actions during this activity were welcomed by Siobhan, who later asked Leila to explain to the rest of the class what she had done in the final plenary session.

Image 2.1: Leila (on the far right) looking through materials to extend the task, and holding what became the 'protector blanket'

Pedagogical framing

As noted above, this activity was undertaken during the 'Learning Centres' time of teaching and learning. This meant that children were working in (roughly) **ability-based groups** of five to six children (in this episode, six children). The activity was planned in such a way so as to allow children the freedom to explore the various concepts of floating and sinking, reinforcing or consolidating that **knowledge**. In addition, the children were developing, independently, problem solving and

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investigation skills. Unlike other tasks observed, and indeed in the episode described above, there was an emphasis on structuring investigation-based learning so that children might learn these inquiry skills. Here however this was not the case and the children were free to undertake **inquiry-based science learning** through a more experimental, experiential approach of using and playing with the physical materials to establish which floated and which sank. This allowed children the freedom and space to start **making connections** to previous knowledge, as may be seen in Image 2.2, which saw one child attaching lollipop sticks to a sieve in order to make a raft (see Image 2.2). The child here was connecting their knowledge of floating materials in their problem solving approach. Finally, the activity was situated within a **motivating** and **engaging context** – the fairytale story – that captured the children's imagination, and as will be described below, led to one child, Leila, making a creative and valuable connections between the task and the context in which it was set.

Image 2.2: Making a raft from sieve and lollypop sticks

Pedagogical interactions

This activity, one of the 'Learning Centre' activities that week, was to sort a selection of items into those that sank and those that floated through experimentation in the water tray. All of the children in the class would do this activity over the course of the week. Objects provided to the children included:

- Numerous food trays, such as those that hold fruit/meat from the supermarket
- Lollipop sticks, along with rolls of masking tape
- Items from the home role play corner, including rolling pin, sieve, plastic foods, tin foil
- Plastic piping
- Foam dominoes

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Children were also free to go around the room and find other items that they might like to try. In order to relate the activity to the Gingerbread Man story, the children also had small (approx. 5cm long) plastic Gingerbread Men toys that they could use to balance on the various items (as can be seen at the top of Image 2.2). This provided a contextual factor the activity and also a further challenge, for example when using the plastic piping. As the activity took place in the shared space between the two early years classrooms, it was not possible for Siobhan or Sinead to be present for the duration of the activity. Children were largely left to the task, while Siobhan and Sinead each occasionally visited the group to discuss with the children their findings and to prompt further exploration and investigation. This meant that children were free to approach the task in whatever way they felt was most appropriate and were able to **plan their investigations** accordingly. They were then able to **gather evidence** through **observation** in the process of classifying the materials as either sinking or floating.

The lack of teacher intervention also led to a great deal of interaction and discussion between the children, with individuals offering suggestions to one another (such as "*Why don't you try this bit?*") and a variety of expressions of interest and surprise (such as "*Oh, that didn't work!*" and "*Look at this, it's floating!*") Children therefore were presented with a strong sense of **agency** in this activity that provided them with the space to extend the task, and develop their own investigations and inquiries, as well as developing their **communicative** skills between one another.

Opportunities for science learning

As noted above, science education is framed within the World Around Us area of learning – an area that includes science, geography and history – and progression is based on qualitative goals rather than quantitative outcomes. The aim is develop inquiry skills rather than particular facts or knowledge. The curriculum is framed in such a way so as to allow teachers to choose topics that ensure that children are "active participants in the learning process" and that interest or motivate the children in order to explore the various aims and objectives outlined (p. 84).

In this episode, the scientific activity revolved around exploring the concepts floating and sinking. This in itself is not identified as a particular learning objective in the curriculum. What is outlined however is how children should be encouraged to make progress in a number of more general areas. These are outlined below;

Teaching should provide opportunities for children as they move through Key Stages 1 and 2 to progress:

- *from* making first hand observations and collecting primary data *to* examining and collecting real data and samples from the world around them;
- *from* identifying similarities and differences *to* investigating similarities and differences, patterns and change;
- *from* recognising a fair test *to* designing and carrying out fair tests;

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- *from* using everyday language *to* increasingly precise use of subject specific vocabulary, notation and symbols;
- *from* developing a sense of place using maps *to* locate places to using resources such as atlases, maps and digital sources to identify and describe places and environments investigated;
- *from* using tools, components and materials to design and make *to* combining, designing and making skills and techniques with knowledge and understanding in order to present solutions;
- *from* sequencing events and objects on a time line in chronological order *to* developing a sense of change over time and how the past has affected the present

(from http://www.nicurriculum.org.uk/docs/key_stages_1_and_2/northern_ireland_curriculum_primary.pdf, pp. 84-85. , accessed 4th April, 2013)

Looking to the content of the activity then, it is possible to see how the children are fulfilling a number of these objectives. They are making first hand observations – something noted in the previous two sections – and identifying similarities and differences between the objects at their disposal. Image 2.2 shows how one of the children was using resources at hand in order to make a floating raft and so on. All these activities occurred within the context of an engaging story that, in addition with the autonomy afforded the children, enabled all of the children to be active participants in their science learning.

Opportunities for creativity

The creative activity in this episode can be seen in Leila's extension of the task and application of 'real life' concepts to the abstract task. When looking to the definitions of creativity outlined by the *Creative Little Scientists* project, we can see that this episode fulfils many of the criteria, such as 'generating an alternative idea'. It is imaginative and relevant to the original premise (i.e. keeping the gingerbread man dry) and provides an alternate, or perhaps extra, and valid solution to the context. It may be argued that she has veered away from the underlying task – sorting materials into those that float and those that do not – however she has applied her knowledge of other situations and extended the task beyond the original task. In extending the task and finding inherent possibility within the task, she exploring and generating alternative possibilities for the objects at her disposal, moving into a 'What can I do with this?' space. Leila then appears to be working in both the science based world, identifying materials that will float, but also within the make-believe world of the fairytale, where other, additional objectives (such as keeping the gingerbread man dry) are also of concern.

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3.16.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years? What role if any does creativity play in these?

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics? How do teachers perceive their role in doing so?

- Learning Centres – rotation of activities allows for sharp focus from practitioner (working with small groups) and also maintains interest etc. for children over course of the week (doing different things each day)
- Setting up of activities that give a structure for inquiry-based activities such as prediction and observation
- Valuing and welcoming of various ideas and/or responses – discussion, though not necessarily *justification*, of these in the group
- Discussion of reasons for outcomes a features but not necessarily *recording* these reasons – e.g. there were discussions re: hypotheses vs. observations in the gingerbread man experiment, but this was not part of the investigation worksheet
- Context – gingerbread man context providing stimulating environment etc. This context/theme work seen during other observations – Siobhan acknowledged that not all themes are equally accessible for each of the areas of learning (i.e. some provide more opportunities for science learning that others, other may provide more history, for example)
- Use of teaching assistant – Sinead valued as a practitioner and integral to Siobhan's pedagogy

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3.17 Case: 'Andrea'

3.17.1 Context

Where?	Country	Northern Ireland			
	Setting name	NI2 – Ashford Integrated Primary School			
	Location within setting	Primary School			
Who? (children)	Year group/age of children	Primary 2			
	Number of children in class	25			
Who? (adults)	Number of adults	3			
	Role of adults	1 teacher, 1 full time teaching assistant, 1 full-time assistant to a wheelchair-bound child with spina bifida			
	Case teacher role	Lead teacher			
When?					
	Dates of visits	24 01 13	29 01 13	26 02 13	28 02 13
	Times of visits	Morning	Morning	Afternoon	Morning

School / Setting

Ashford Integrated Primary School is a highly overly subscribed integrated primary school in a small town in Northern Ireland. Integrated schools are required to take an equal number of children from Catholic and Protestant families, as well as children from other religions. This is in contrast to Catholic and Maintained schools in Northern Ireland which are more homogenous in their intake. It has won a number of awards for its inclusion policy, including the Inclusion Quality Mark, one of very few primary schools in the country to do so. It has been recognised as an outstanding school by the Education and Training Inspectorate, the governmental inspection organisation, for both teaching and pastoral care. Ashford Integrated is an EcoSchool, has schemes for healthy eating and its teachers and support staff have won national recognition. The school has a 'buddy system' for the Primary 1 children and the Primary 7 children (aged 10 to 11).

There are 200 children in the school, with one form in each year group. There is a large playground which all children in the school share however there is also a dedicate play space for the early years children (classes Primary 1, 2 and 3) which includes a playhouse, climbing equipment, a slide and outdoor musical instruments such as chimes and drums.

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Teacher

Andrea was a recently qualified teacher, having studied for a PGCE in England and returned to her native Northern Ireland to teach. She has been teaching at Ashford Integrated Primary School for all three years of her teaching career. She was a music and drama specialist and ran a number of after-school clubs in this. In contrast, she felt she was less confident in science and mathematics, both in terms of content and in terms of teaching. She had taught the class the previous year and so had been with this group of children for 18 months at the time of the data collection period. This meant that she had built up a strong relationship with the children, making it a fun and friendly classroom to visit.

There were two full-time teaching assistants, Deidre and Fran. Fran was the full time assistant to the child in a wheelchair, while Deidre worked more generally, often working with one group of five or six children during teaching and learning time (as described below).

Classroom

Teaching was based around cross-curricular themes that would permeate all aspects of learning. Themes would last two to three weeks. The two themes observed during the observation period were the story of the Gingerbread Man and 'Growing plants'. This allowed for, for example, children to work with coordinates (on a map to get the Gingerbread Man 'home') or learn about and identify parts of a growing flower.

Numeracy and literacy were taught as whole-class subjects, with short introductory sessions of the overall topic before children then went to work in ability-determined groups of five to six children. Assessment was largely formative, and these groups often changed according to children's progress during the term. During numeracy sessions, the teaching assistant, Deidre, often worked with the least able group, while one group would work directly with Andrea.

During the rest of the day, the children were taught in what were called 'Learning Centres'. These Learning Centres might include activities based on mathematics, art, World Around Us (including science, geography and history), and construction and all were largely based on the current theme or topic for that week. Each day, groups of five or six children would work at one of five 'Learning Centres'. This meant that over the course of a week all of the children would have worked at each one of the Learning Centres. Again, children were grouped for Learning Centres according to (a formatively assessed) ability, thus were fluid and were subject to change throughout the term. This format was reflected in the Primary 1 teaching set up at Ashford Integrated.

The class also shares a space with the Primary 1 class (see Siobhan Case Study) that is situated between the two classrooms in which there is a water tray and large role play area. While the two classes share the space, the children from the two classrooms are rarely in the room at the same time.

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3.17.2 Episodes

Children spend a portion of their time as a whole class sat on the mat (see classroom map), however the much of the teaching and learning time in spent in small groups of five or six children. The episodes below come from group work.

Episode 1: Flowers and food dye

At the time of this observation, the theme for the class was 'Growing plants'. Previously in the term (prior to the observation period), the children had learnt about the parts of a flower, learning to label the roots, stem, leaves and petals on a flower. This food dye experiment is a well-known experiment that illustrates how liquids travel up the stem of a plant and vividly demonstrates the structure of the veins of petals. Cut flowers are placed in food dye and after a period of time (often 15 to 20 minutes, depending on the length of the stem, the type of flower used and so on) the colour of the food dye can start to be seen in the petals.

Following a brief period sitting on the carpeted area of the classroom, groups of children went to work at their respective 'Learning Centres'. This Learning Centre focused on science. Six children were each given a white flower with varying length stems, which had been prepared earlier by Andrea. At the table, there were bottles of red, green and blue food dye and plastic cups. Andrea introduced the experiment as one to "*show you how the stem works.*" The children then discussed the role of the stem and various parts of the flower (roots, leaves and petals). In discussion with Andrea, the children made predictions about what might happen if the flower stems were placed in the food dye, focusing particularly on using language such as 'petals' and 'stem'. They then had to draw these predictions, with Andrea encouraging them to "*use colours to tell me where [you predict] the food dye will be [at the end of the experiment].*" (Image 1.1). Children were then allowed to choose which flower, which colour food dye and how much food dye they put into the cup, and then had to make predictions about what might happen. Three children predicted that the bottom of the stem (that is, the part placed in the dye) would be the only part to change colour. The three others made predictions about the petals changing colour. The children were also encouraged to provide a justification for their prediction. These are all discussed in more detail below. The flowers were then left in the pots of food dye at the front of the classroom. The children returned to the flowers to observe the changes at each of the predicted times – at two minutes, 'after morning break', an hour and so on. They were also left overnight in order to see the long-term changes the following morning.

There were a number of results that were unexpected for the class in this experiment. Firstly, only the blue food dye led to a visible result – those flowers placed in red and green food dye did not show up on the flowers at all. The focus in this episode is the responses gathered from the children and the explanations for the unexpected results. Secondly, the rate at which the blue food dye showed in the flowers varied from flower to flower. All six children in the group then are the focus in this episode as they individually and collaboratively attempt to make sense of their observations.

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Image 1.1: Children drawing their predictions

Pedagogical framing

While these were not made explicit, there appeared to be two main learning objectives behind this activity. From the outset, it was apparent that the first learning objective of the session to use this investigation as an opportunity to reinforce particular areas of **knowledge** about plants, learnt earlier in the week. Before the children placed the flowers in the dye, Andrea interjected, "*Very quickly, so we're all clear, where is the stem? Where are the petals? Do we have any leaves on this flower or anything like that? Good.*" Following this, the children then started their investigation.

The second more implicit learning objective that was apparent in the activity was the children developing their inquiry skills. Children were learning about these scientific concepts through **inquiry based approaches**, which they were developing through a **planned** and **scaffolded** activity. The investigation was initially led by Andrea, with her encouraging children to make hypotheses, to draw these predictions and then asking the children questions throughout. Andrea talked to the children about the definition of a prediction "*trying to use science, [to make] a guess, but you're using your brain to get a close guess…*" and attempted to ask the children open-ended questions as the activity went on. After 20 minutes, the shortest of the flowers had started to show the blue food dye in the petals. This was recorded on a small whiteboard (Image 1.2) and Andrea brought in another opportunity for the children to make some predictions, asking them to arrange the flowers in the order in which they expected the dye to appear in the petals. She was therefore providing a number of opportunities for children to develop their **inquiry skills** throughout the task.

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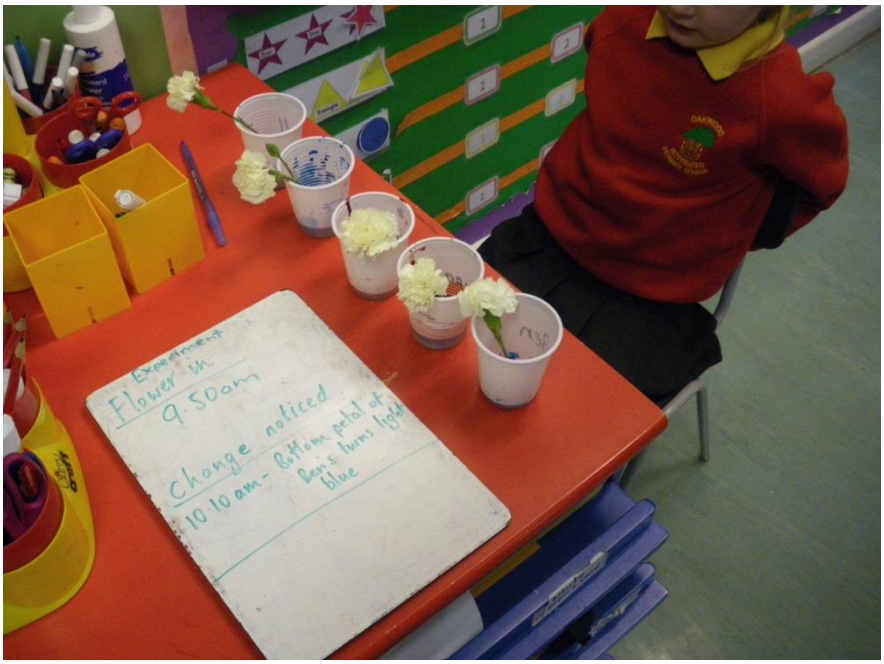

Image 1.2: Flowers and recording observations

Pedagogical interactions

The structured activity provided children with a number of **inquiry-based learning skills**. The task was initiated by Andrea, however children had the freedom to **plan** the task as they wished, being allowed to use the materials as they saw fit, being allowed to pick the colour, the length flower and to dilute the food dye if they wished and so on. Before the start of the activity, she encouraged them to make **predictions** both about what the flower might look like at the end, and also make some predictions about how long it might take for the petals to change, if they were to change at all as some children predicted no changes would occur. They were then to carry out the investigation, and **gathering evidence** on their findings. Throughout the activity, Andrea was prompting children's **reflection** and encouraging them to think about what might happen and make **ongoing predictions**. As the children were undertaking the task and waiting for the dye to show, Andrea asked them, "*It's quite interesting because we've got some big flowers and some small flowers. Do you think it will work quicker or slower on the big flowers or the small flowers? What do you think?*" Some children could be seen to have an increased focused on the activity following these questions rather than necessarily responding verbally, while others suggested answers such as "*Slower on the big flowers and then shorter on the small flowers*". This ongoing **dialogue** and periods of deep concentration would suggest that the children were all highly engaged in the task and motivated by the task.

As noted above, the preparation work involved Andrea reminding them of the scientific knowledge involved – discussing the parts of the plant. As the activity went on, Andrea continued to ask questions. At one point, Andrea asked the children, "*What colour do you think will show up the most, red blue or green?*" While a number of children merely stated one-word answers, this open form of questioning allowed Rosie (pseudonym) to think critically about the question, and use her existing knowledge of plants, responding with, "*I would say blue or red because green is the colour it*

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already is". The researcher too, in discussion with the children, attempted to prompt the children's thinking, and asked one child, Colm (pseudonym) "*Why do you think the petals are blue and the stem is still green?*" He responded, suggesting "*Because the stem's the thing, it sucks it up, into the flower bit*". Here we can see how both Rosie and Colm are **making connections** between their observations and previous knowledge of plants.

Towards the end of the investigations, once some of the flowers had started to show signs of the dye, the children were again encouraged to **reflect** on why there were differences between the different flowers and suggest some possible **explanations** for these observations. This was in contrast to many of the other activities seen in the classroom, and indeed the site, where explanation in science and mathematics teaching and learning was not a highly prioritised activity.

Opportunities for science learning

As had been noted a number of times, science is framed under the 'World Around Us' Area of Learning in the National Curriculum, with four sections to explore; Interdependence, Place, Movement and Energy and Change Over Time. The emphasis is on 'exploration' rather than the development of particular scientific concepts or facts, and practitioners should aim to develop inquiry skills. Looking to the observations then, the area that this episode seems most relatable to is 'Interdependence', which includes in its 'Possible Key questions' 'Who am I?', 'What am I?', 'Am I the same as everyone else?', 'How do living things interact with each other in the environment?' and '*How do living things survive*?' (from http://www.nicurriculum.org.uk/docs/key_stages_1_and_2/northern_ireland_curriculum_primary.pdf, p. 87, accessed 4th April 2013, emphasis added). Andrea appears to be working towards the 'How do living things survive?' key question that is suggested in the curriculum, by exploring how plants grow. .

It is interesting the that there appears to be an emphasis on facts in this investigation – on naming the parts of the plant – despite the apparent lack of discussion of facts in the curriculum. Of course, the curriculum is deliberately non-prescriptive, instead allowing teachers the freedom to explore the notion of 'Interdependence' (and indeed the other three areas) and these 'Key Questions' as they deem appropriate.

Opportunities for creativity

Throughout the activity, Andrea asked the children a wide variety of questions that provided children with opportunities to think about the science activity. These were a mixture of closed questions, such as reminding children about the part of the flower, to more open-ended questions, with varying degrees of inherent possibility. This was particularly the case when asking children to make predictions. At the start of the activity, Andrea asked what the children thought might happen. Aiden (pseudonym) suggested that "*I think the food dye might just ruin the flower but the water will help it to grow… food dye is for food and I don't think it might be healthy for real flowers*". It is possible to identify how Aiden is relating his existing knowledge of plants, such as root systems and plants needing water to grow, to the current experiment and **reasoning critically** to come up with a hypothesis

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After break, many of the flowers with blue food dye had changed colour, however one flower that had a bud with it (see Image 1.2, second flower from top) took much longer to change colour. The flowers had been placed at the front of the classroom for the whole day and it was later in the day that one of the children, having observed and studied the flowers suggested that it might be taking longer because the flower bud was "*sharing*" the food dye with the open flower. Again, it is possible to see how the child was **thinking critically** and trying to come up with explanations for the events observed.

The context of the activity meant that even questions that, at first glance, may not appear to be particularly open-ended allowed for children to **think and reason critically and creatively**. The activity provided a sustained interest for the children and provided many avenues for the children to make and test predictions, and providing them the space to think critically and develop possible explanations for their observations. This meant that they were able to generate a number of alternative ideas which related both to their findings and their existing scientific knowledge. Interestingly, this activity was unlike many of the others observed in the site, in that it was infrequent that children were required to provide explanations for their observations.

Episode 2: Outdoor measuring

As with the Learning Centres, for numeracy children were split into ability-based groups of five or six children and undertook one of five different activities. Over the course of a week then, each group would have completed each activity. The activity described here occurred outside, using a number of different items to be found in the playground. Five children the accompanied the teaching assistant, Deidre, outside to measure objects and distances – the children were observed measuring the length of a bench, the length of a shed and the width of the playground.

These had been decided before leaving the classroom by either Deidre or Andrea (unfortunately it was not clear by whom) and the children had little input as to the things that they might measure. They were to select the most appropriate tools for each, such as a metre ruler, their feet or a trundle-wheel. Deidre would ask the children "*How might we measure this [bench]?*", but she was looking for a particular answer, rather than necessarily seeking possible ways of measuring it (e.g. Image 2.1). At the end of the activity, it became apparent that the three distances chosen had been chosen according to what was available – the bench using the metre rule; the shed using feet; the width of the playground using the trundle wheel. Carrying a clipboard, the Deidre recorded the children's measurements on a pre-drawn results table. Interestingly, the children did not observe this table throughout the whole activity.

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Image 2.1: Measuring the bench

The focus of this episode is Ronan, aged 7. After measuring the items that had been chosen by the practitioner(s), Ronan announced that he wanted to measure the perimeter of the playground. Deidre, perhaps aware that this would take a long time, was initially not keen, however eventually allowed Ronan to do this (Image 2.2). The other children either went back inside or found other things to measure, such as the width of the door using the metre ruler. Ronan's activity following the initial measuring activity led by Deirdre highlighted the challenges faced by practitioners when considering creativity in the early years classroom.

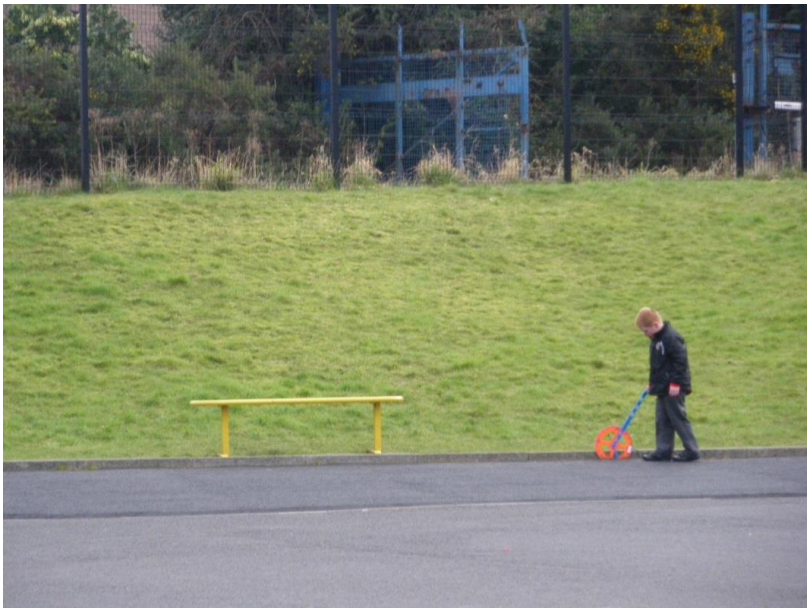

Image 2.2: Ronan measuring the playground

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Pedagogical framing

When reflecting on the features of the *Creative Little Scientists* project, there appear to be few of the characteristics identified present in this lesson. The emphasis was largely on developing mathematical knowledge; how to use measuring **equipment**, often through practitioner-assistance or demonstration (Image 2.1). However, since the children were not recording their results, there was no need for them to, say, consider different units (such as centimetres and metres) and how they relate to one another or contemplate how they might like to record their various measurements. There was a very limited interpretation of 'knowledge' then, and no apparent avenues for problem based learning could be identified. The children were working **outdoors**, in their Learning Centre groups – **small groups**, based loosely on formatively assessed **ability**.

Pedagogical interactions

This task appeared to solely be about selecting and using measuring **equipment** in order to gather data. Deidre had brought out a number of metre rulers and trundle-wheels for the children to use and the children were to measure the items that were specified on the record-sheet held by Deirdre. There was little opportunity for children to undertake inquiry-based learning in any meaningful sense as the activities were supervised by Deirdre, and she took the lead on recording the measurements that they gathered. As such, there appeared to be little opportunity for children to take much ownership or agency within the activity. Assessment here took a **formative** approach, based on the participation in the activity.

Opportunities for mathematics learning

This activity focused strongly on measuring. At Key Stage 1, the National Curriculum outlines a number of aims under the heading of 'Measures', detailed below:

Pupils should be enabled to:

- understand and use the language associated with length, weight, capacity, area and
- time;
- use non-standard units to measure and recognise the need for standard units;
- know and use the most commonly used units to measure in purposeful contexts;
- make estimates using arbitrary and standard units;
- choose and use simple measuring instruments, reading and interpreting them with
- reasonable accuracy;
- sequence everyday events; know the days of the week, months of the year and
- seasons; explore calendar patterns;
- recognise times on the analogue clock and digital displays;
- understand the conservation of measures.

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(from http://www.nicurriculum.org.uk/docs/key_stages_1_and_2/northern_ireland_curriculum_primary.pdf, p. 62, accessed 4th April, 2013)

It appeared from the observation that the focus was very much on developing their measuring skills. In contrast to science, the emphasis in the mathematics section of the curriculum describes in more detail particular facts and skills that children are expected to have acquired at various ages. This appeared to be reflected in the activity observed where the children were focusing on developing set skills and knowledge that could be found in the curriculum. Interestingly, there were a number of potential opportunities that would have allowed for further development of different mathematical skills. As noted at the start of the episode, all the results were recorded by the teaching assistant and the children did not observe how this was done, nor did they look at them once they had returned to the classroom. Recording data is an explicitly mentioned part of the primary curriculum (p. 63).

Opportunities for creativity

This was an interesting episode in that it highlights the challenges to creativity in mathematics that might be faced by both children and practitioners during teaching and learning scenarios. The activity set for the children had a clear order and structure – children were to practice using measuring instruments in a number of given situations. This Learning Centre activity was prescribed and (though not observed) similar every day of that week in order that all the children had the same experience of using the measuring equipment. This would mean that the all the children would have the same access to learning over the course of the week. As such, deviating from this task may lead to the perception that this group of children, or indeed other groups of children would, potentially, not have that same access.

Nevertheless, it is possible on reflection to identify an opportunity here for creativity to be embraced and fostered in this example. As noted above, while at first Deidre was hesitant to let Ronan expand and continue his own activities, she did let him measure the perimeter of the playground. We can see him **extending the task**, and undertaking **purposive activity** that was relevant to the original task – he using the trundle wheel as intended when measuring the playground, using the correct units of measurement and so on, and in addition he had moved the task on to predicting, developing predictions based on his observations. Importantly however Deidre did not record Ronan's measurements, nor did she discuss them with him once he returned with his answer or try to relate his findings to other measurements made. This could be interpreted as a lack of valuing of these outcomes in contrast to those from the set task.

Buoyed by the success of his measuring the perimeter of the playground, and with no follow-up discussion about these results, Ronan then ran off from the group to measure another object, measuring a post in the playground using the trundle-wheel (Image 2.3), shouting out, "*This is two metres!*" before running off to measure the next object he could find. This then came to be seen as disruptive behaviour from Ronan as he was distracted from Deirdre's instructions to come back to the group and discuss their use of metre-rulers and trundle-wheels. His ideas were sporadic and unfocused and needed some way of being directed into more productive outcome. This subsequent activity from Ronan showed how it may potentially be difficult to focus or guide this sort of creative

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activity, particularly when it is not expected or planned for. While he was generating alternative approaches, it would perhaps be injudicious to suggest that there was a lot of critical reasoning behind them. Thus while there is the *potential* for further creativity here, this was not seen in this instance.

Image 2.3: Ronan measuring a pole

3.17.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years? What role if any does creativity play in these?

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics? How do teachers perceive their role in doing so?

- Learning Centres – rotation of activities allows for sharp focus from practitioner (working with small groups) and also maintains interest etc. for children over course of the week (doing different things each day)
- Science appears to be far more investigation based than mathematics? An emphasis on instrumental skills and knowledge in mathematics over and above more investigative approaches – reflecting the curriculum?

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- Mathematics appears to be focusing on one 'area' at a time – e.g. developing measuring skills only, not including recording
- Interesting that the mathematics example shows an example of *possible* creativity, opportunity missed
- Interesting that there was an emphasis on explanation/reflection in this classroom – not seen in other early years settings in Northern Ireland (or England). Creativity seen in these responses – ability to reason/reflect/think critically about the outcomes.

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3.18 Case: 'Martha'

3.18.1 Context

Where?	Country	Scotland			
	Setting name	SC1 - Braes School			
	Location within setting	Pre-School			
Who? (children)	Year group/age of children	Nursery 3-4 years old			
	Number of children in class	30 morning and 25 afternoon children			
Who? (adults)	Number of adults	4			
	Role of adults	1 teacher and 3 Early Years Officers			
	Case teacher role	Teacher, Literacy Leader and School Mentor			
When?		1	2	3	4
	Dates of visits	22/02/13	23/02/13	06/03/13	
	Times of visits	All day	All day	All day	

School/Setting

Braes school is situated on the periphery of a town in Scotland. The school is state funded and includes a nursery with a roll of 48 as well as a primary school attended by 187 children. The school has a lower than average number of children eligible for free school meals and serves a catchment area with a predominantly White Scottish population. The school was opened in 1974 and has an open plan design that allows flexible use of space.

The integrated inspection of care and education in the nursery class in 2005 highlighted the '*welcoming and caring environment; the hard working committed staff and the positive relationships with parents and support for children and their families'*. The programme for knowledge and understanding of the world was rated as good. In particular they commented on the use of the nursery garden and everyday routines to support learning '*Staff made good use of the nursery garden to help children learn about planting and harvesting. Children cared for nursery pets and observed snails and caterpillars. They used grapes at snack time to count numbers and some sorted potatoes collected from the nursery garden'*.

There is a strong emphasis across the school, reflected in their practices and the school booklet, on celebrating each child's talents and on consulting children about their learning and all aspects of school life.

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Teacher

Martha has been teaching for more than 20 years. She has a Bachelor Level Degree in Biology and is a trained teacher with a Post Graduate Certificate in Education. She has taught in both primary and pre-school phases of education and is currently the Teacher in the nursery working in collaboration with three Early Years Officers. Alongside her strong confidence and interest in science stemming from her science background, Martha is also Literacy Leader at the school and a School Mentor.

Formal and informal discussions with Martha during school visits and her responses to the Teacher Survey underline the high importance she gives to fostering positive attitudes to science as well as the development of children's process skills and conceptual understanding. She demonstrates a strong interest in children's ideas, and commitment to the provision of opportunities for inquiry in the curriculum. She has a clear sense from her own science background of the potential for fostering conceptual development through play and everyday experiences both indoors and out.

Martha plans cross-curricular topics each term based on seasonal events and informed by children's interests. Connections between indoor and outdoor experiences are fostered and Martha often draws on her expertise in literacy to make links between her planning of science and mathematics experiences and children's literature. However she emphasises that these act as a starting point only.

> *"You can set this up but you can set this up – and it may be that the children have no interest at all and don't go near it or it maybe that they turn it round into something else and you have to go with that, following their interests and then you might build on that"*

Each day the team of nursery staff plan a combination of focus group activities with planned adult support, alongside general provision for informal activities for children to interact and improvise. Martha highlighted in her interview the value of team working.

> *"It is nice working in a team because you can bounce these ideas around - a lot of nursery planning is in the moment – again it is different from planning if you are further up the school"*

The staff team undertake on-going evaluation of activities across each week drawing on post-it notes about children's responses and comments noted on the weekly planning sheets. Assessment information is shared between staff through regular recording of observations and tracking of progress in class records and children's profiles.

Classroom

The nursery consists of one large classroom divided into different areas with general provision planned to support a wide range of activities. One large area allows space for exploration of materials (including sand, water and malleable materials), designing and making activities and painting. Areas are set aside for construction, small world play, mark making, number games and puzzles. There is a large role-play area and a comfortable reading corner. Resources are well organised and accessible so that children can select additional materials to support their explorations. Displays related to the termly topics are developed to foster interest and record

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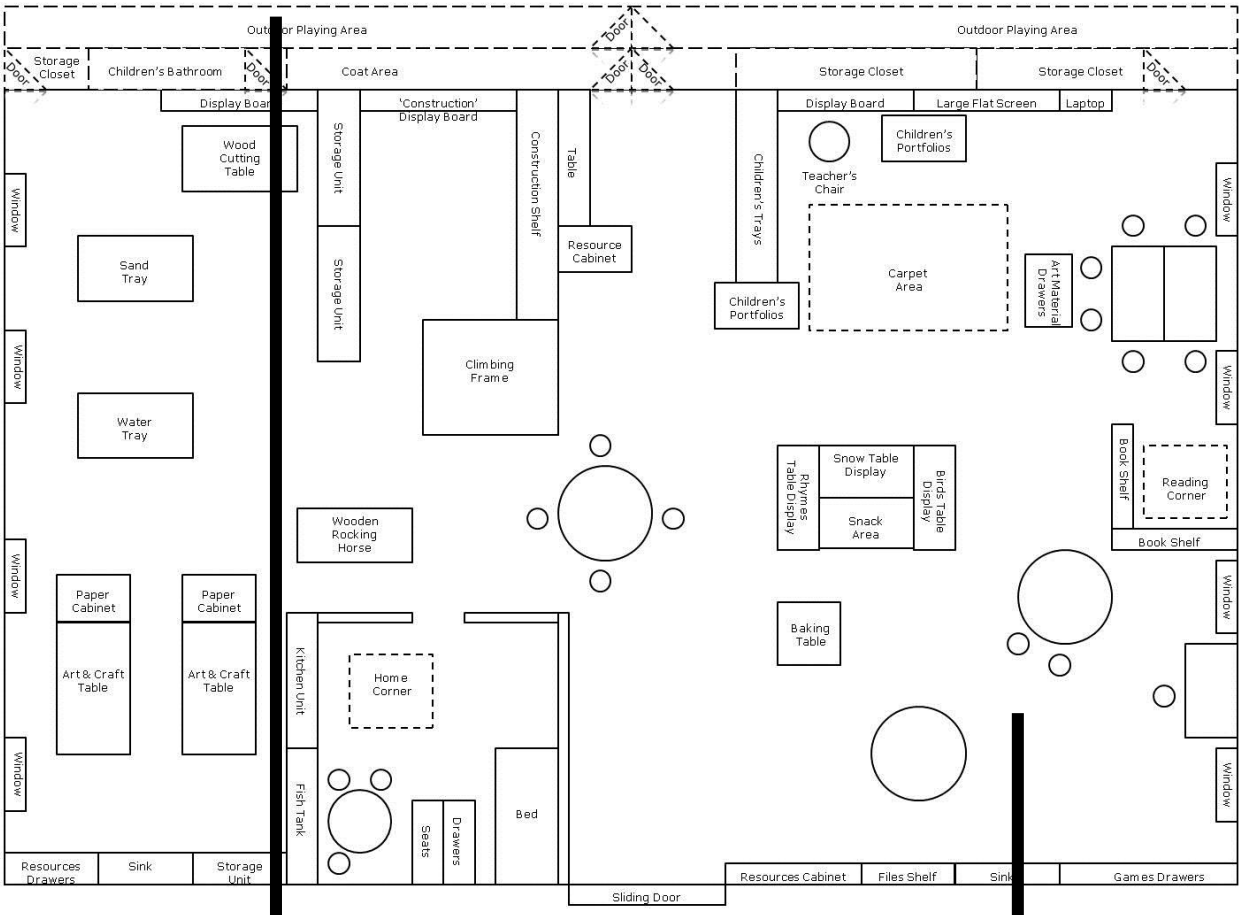
children's experiences. The nursery has its own dedicated outdoor area with grass and paved sections, trees, a sitting area and play-house.



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3.18.2 Episodes

Episode 1: Melting and Freezing

Context

In days prior to this episode children had spent time outside observing snow and ice in the nursery garden and had noticed animal footprints. Indoors they had put snow and ice in the water tray and watched it melt. These activities provoked discussion about how animals might survive outside in these wintry conditions and whether it would be possible to turn the water back into ice.

The content of this episode relates to two activities Martha designed to capitalise on these experiences, ***Bird Cake***, making bird cake to leave outside for the birds in the garden and ***Ice Balloons***, observing yoghurt pots and balloons filled with water and left in the freezer overnight. Both these activities provided children with opportunities to explore the reversible processes of melting and freezing as a result of heating and cooling in different contexts. The activities were adult planned, but built on children's prior experiences and ideas. Examples of children's developing ideas recorded by staff on a class record sheet were used to inform planning (See the Appendix). Children and staff were very excited by these activities and keen to participate. Martha's aims for these activities, shown in her planning focused on the development of

- Key Skills – investigating, observing, describing and measuring and
- Key Knowledge and understanding – Know that water can be changed into ice. Understand that winter is a season and describe the weather in winter.

Bird cake activity – pedagogical framing

The bird cake activity was set up on a side table and had adult supervision at all times for safety reasons.

Image 1.1: Lara and Anna mixing ingredients

Image 1.2: Robert observing melting lard

The recipe and ingredients for making bird cake (seeds, bread, raisins and lard) were set out to be readily accessible for the children alongside the equipment needed including a mixing bowl, measuring spoons, a warming plate heated by tea lights and a saucepan. Making the bird cake

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involved adding spoonfuls of the dry ingredients into the mixing bowl, melting the lard in a saucepan over the warming plate, mixing the melted lard into the dry ingredients, then spooning the cake mix into a yoghurt pot to be left out to set. The activity took place throughout the day. Children worked in small groups to make their own cakes.

Bird cake activity - pedagogical interactions

(for some further details see Appendix)

Children had opportunities to **observe** the lard melting. They noted for example the solid lump of lard getting smaller and bubbles appearing in the pan as illustrated by this exchange between Jackie and Martha:

Jackie: *"Still melting bubbling at the sides"*
Martha: *"What colour did it start off with?"*
Jackie: "Brown"
Martha: *"This is what you put in" [pointing to the lard].*
Jackie: "White"
Martha: *"What colour's the liquid?"*
Jackie: "Black – pan is black – can't see?"
Martha: *"Tricky to tell – when we pour it out we might be able to see."*
[...]
Martha: *"What do you notice now? Is it getting bigger or smaller?"*
Jackie: *"Thinner and very in in in ..."* [hands moving together to demonstrate]

Children also suggested that the melted lard looked like water and oil as suggested by Lara:

Martha: *"You tell me when it's ready."*
Lara: *"Think it's actually ready."*
Martha: *"Shall I pour it – you can stir – hands out of the way just now in case it's hot – What does that remind you of? What does that look like?"*
Lara: *"Looks like water and oil."*

The children **raised questions** about what was the melted lard – Was it in fact water? What was lard – Was it the same as butter or cheese? This resulted in discussion about how they might find out.

Children **offered explanations** for what was happening, making associations between heat and melting and cold conditions and cooling for example Jackie said "*It's a bit hot …that's very cold and that's very hot and the hot heats the air and then it melts all this down*." Later he commented "*Guess what – it's got very a bit cold. If it goes on the cooker it gets really hot and then if you leave it, it gets really cold*". Lara said, "*it's melting because it's a hot pan."*

Adults **supported** children's making of the bird cakes by reminding them of the recipe and stages in the process and supervising the heating and pouring of the lard into the mixture. They drew attention to changes in appearance of the melting lard and bubbles that appeared in the saucepan.

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Questioning was used to encourage children's observations and predictions and explanations related to what would happen to the ingredients and why. Examples of common questions included:

"Now what's happening here?"
"What do you notice now?"
"What do you think is going to make it melt?"

Children's recordings subsequent to the activity show elements in the process of making the bird cake. In their commentary on their drawings children shared their ideas about the process of melting for example Sean said " *melting is something like a wee drink and fall on the floor*" He explained that something melts " *when you put it in a pot and count to 23 and it melts*". (See appendix.)

Ice balloons activity – pedagogical framing

This second activity carried out in a different part of the room also offered experiences related to melting and freezing. At the start of the day adults and children went to collect the balloons full of water and yoghurt pots that had been left in the freezer overnight. They placed in a tray near the water tray for the children to explore freely. Salt in a pot, pipettes and balance scales were set out nearby. Adults visited the table from time to time to ask about how children were getting on. Two children in particular took ownership of the ice at the start of the day and spent time showing other children and taking the tray round the classroom for others to see what the ice looked like and the changes taking place.

Images 1.3 and 1.4: Robert and Alara observing the ice balloons

Ice balloons activity - pedagogical interactions

(for some further details see Appendix)

Children had opportunities to **observe** features of the ice balloons and the ice in the yoghurt pot. For example they noticed that the surface of the ice balloon felt sticky and the ice in the yoghurt pot made a cracking noise as it began to melt. They **made comparisons** between glass and ice and between ice and salt crystals. They **offered ideas for investigation**.

Robert: *"Mine is a ball of ice! Wow! Ice is so sticky what happens?" [screaming]*
Alara: *"And it's sticky and cold – there's snow inside [on the rough surface] crystals inside."*

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[...]

Alara: "Ice this is what I was looking for [holding it up]. Do you think it's glass?"

Robert: "It feels like glass."

Alara: "You can see inside it – if you shake it what will happen? It's moving a wee bit. I feel the ice there."

Robert: "I've got a bigger one than yours that's why."

Alara: "Let's try and get the ice out of it – let's see what happens if you do that [puts salt]."

Robert: [He puts it in the dent at the top of the ice balloon] "Keep it in there – see what happens."

Alara: "I'll try on mine now."

Robert: "Remember when the ice cracked? I heard it crack and then."

Alara: "Mine's gone now [salt]."

Robert: [Calling to a friend] "Come and look at this. Look at that it's ice."

The children **observed** that the ice began to melt for example:

Robert: "Watch it – see what it does – melting."

Alara: "Getting like water. I can see through. You look after them and see what happens – and I'll see if anyone wants to do it." [She took a try with her ice balloon round the classroom to show]

In an interview with Alara after the activity she **explained** to her friend Evie as follows:

Alara: "That was my one and that was Robert's melting."

Researcher: "They put a lot of water inside here and put it in the freezer to see what would happen."

Alara: "Yeh but we don't know what happened when we putted it back in the freezer – but we think it would freeze again."

The adults' roles in the activity were mainly associated with the pedagogical framing, in setting up the task.

Martha: "I was remembering – do you remember we put some things to freeze? What do you think's going to happen to the water we put in the freezer?"

Alara: "Cold freeze"

Martha: "Let's have a look. Let's get a tray."

Alara: "It's going to melt because it's warm."

Interactions between adults and children took place from time to time, expressing interest and excitement in the shared experience of the balloons as they were taken round the classroom. In the afternoon in response to questions about whether the water could be turned back into ice and where it would need to go to freeze, Vera (one of the nursery officers) brought out a thermometer

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that had a scale from red (hot) to blue (cold) and with the children set out mapping the cold and hot places indoors and out to help decide.

Opportunities for learning in science

The activities provided opportunities for addressing the following Sciences Experiences and Outcomes from the Scottish Curriculum for Excellence (www.curriculumforexcellence Scotland). SCN 0-05a *Investigate how water can change from one form to another, I can relate my findings to everyday experiences*. They also encouraged a range of Inquiry and Investigative skills in particular observing and exploring, asking questions, being open to new ideas and linking and applying learning, developing skills of reasoning.

Opportunities for creativity

Children showed evidence of a range of process skills and positive attitudes associated with scientific inquiry that can be linked to creative dispositions. For example their observations and questions suggest **curiosity** and **motivation**, also indicated by their focused engagement with activities. Children's predictions and explanations reflected their growing awareness of ways of making things freeze and melt (and that these processes are reversible). These suggested capacities for **reasoning** and for **making connections** between the repeated experiences in different contexts of heating and cooling, melting and freezing.

Creative approaches to teaching are reflected in particular in setting a *motivating and* **meaningful context for the activities described in this** episode that allow opportunities for **physical exploration**, and fostering **connections** between experiences, making links for example: between **learning indoors and outdoors**, to children's prior learning and **everyday life** and between adult led and child directed activities. Adults showed interest in children's explorations and shared their own excitement. **Questioning** was used to elicit ideas and encourage *reasoning*. Assessment processes also played an important role in enabling staff to build on children's responses and emerging ideas.

Episode 2: Water Play

Context

In the nursery provision is made each day for the **exploration of materials** including water, sand and malleable materials. Adults vary the resources provided in the water tray over time based on their observations of children's interests and wider events in the life of the nursery. Children also have free access to trays of resources nearby to extend their observations. The **organisation of space** allows easy access for groups of children. The episode reported here concerns the sustained and focused explorations of one child, Anna.

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Image 2.1: The setting for the water tray

Pedagogical framing

A **wide variety of resources** were available to support children's explorations. Measuring jugs of various sizes, boats, whisks and spoons were in the water tray alongside plastic pipes and syringes that had been collected by children as activity began to develop at the start of the day. Staff had placed balance scales and pipettes on a table right next to the water tray intended to support the exploration of ice balloons. These resources too were incorporated by children into their water play.

Pedagogical interactions

Children were mostly left to explore on their own or in collaboration with others throughout the morning. Adults interacted occasionally to show interest or ask questions in response to the direction of children's activities. For example when the children moved the balance scales into the water tray Vera, one of the nursery officers, came over to see what was happening and suggest ideas.

Anna:	*"Too much water" (on one side, commenting on balance tipping)*
Vera:	*"Will you put some on the other side as well?"*
Anna:	*"Need to put some here."*
Vera:	*"Good idea."*

The episode reported here concerns Anna who came to the water tray when others had left. Across the episode she engaged in a series of repeated activities, showing focused attention throughout. In the first phase of her explorations she repeatedly poured water into the bucket on one side of the balance and then the other – gradually filling each side to the top and making the two sides balance.

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Image 2.2: Anna pouring water into buckets on the balance scales

Anna noticed **connections** between the level of the water in the bucket and whether it was heavier or lighter, "*heavier when it's higher".*

Image 2.3: Filling the bucket with a syringe.

Image 2.4: Trying to fill the pipette with the syringe

She then started filling the bucket with the syringe. Following this her focus of attention shifted to the pipette. She tried various ways of filling the pipette, first trying to fill it with the measuring jug and then by attaching the pipette to the syringe, but she could not manage to attach it securely. Eventually she asked the researcher what the pipette was and was shown how to fill it.

Next she used the whisk to create bubbles in the water – singing away as she did so *"swish, swish, swish"* and watching closely the bubbles produced. She returned to the whisk on several occasions during her time at the water tray.

A further activity that gained her close attention was using one of the balance scale buckets to fill a measuring jug. She filled the jug very slowly and carefully until no more water could be added saying "*careful, careful and pour" "put one here put one there" "all of the water in there"* feeling the rounded surface of the water in the jug. She repeated this several times.

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A final focus of activity that provoked Anna's attention and commentary was watching the water flow through holes, through the bottom of a bucket with holes and through the holes in a plank that ran across the water tray. She articulated her **observations** for example *"Going through the holes - – shhhhh''* (pouring water through the hole in the middle of the plank). She made connections between her actions and the water flow for example *"If you pull this up it comes out the bottom*" (the bucket with holes).

These different phenomena and events also featured strongly in the interview with Anna afterwards about her experiences in the water tray. For example in discussing the photographs she explained

> *"I was putting the water in to see which one was the heaviest" (balancing activity)*
> *"I was squirting – yeh something happened and it squirted in my face" (syringe).*
> *"I was it put through the little tuber and it didn't work' … 'it kept slipping off, slip, slip, slip" (trying to fix the pipette on to the syringe.*

When asked what she found most interesting she quickly referred to "*the tuber*". When asked what she thought was new or special she commented on her **observations** of water flow – the sound it made and its appearance:

> *"Well the special thing was the water goes woo, woo, woo"…. "the water glows a wee bit".*

Key equipment and events also feature on her reflective recording of the activity with annotations dictated to the researcher. The drawing highlights the balance scales, the holes in the board, the incident with the syringe and the pipette *"I was trying to squirt it down the tube"* and her observations of moving water "*water sparkled and sparkled and sparkled*".

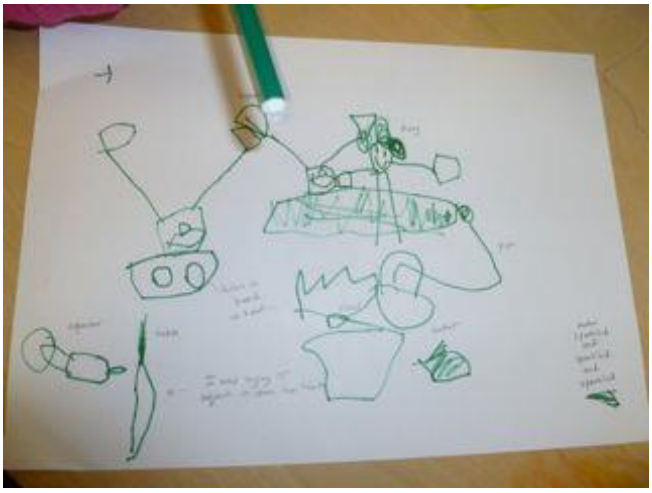

Image 2.5: Anna's drawing of her experiences in the water tray

Opportunities for learning in science

Anna's explorations in the water tray provided opportunities for addressing the following Experiences and Outcomes from the Scottish Curriculum for Excellence (www.curriculumforexcellence Scotland). Her activities enabled her to use and develop a range of

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Inquiry and Investigative Skills such as observing and exploring, asking questions, being open to new ideas, selecting resources, linking and applying learning and developing skills of reasoning. She also explored the properties of water (linked to Sciences: SCN 0 -15a) and the use of the balance scales (linked to Numeracy:MNU 0 -11a).

Opportunities for creativity

Anna showed evidence of process skills and attitudes associated with creativity. First of all, her sustained attention provided evidence of her **curiosity** and **motivation** to explore phenomena and events. **Sense of initiative** was suggested by the focus and direction of her explorations. She was able to make **connections** between observations (related to balancing and water flow) and showed willingness to explore alternative solutions in relation to the pipette associated with **problem solving**.

A number of creative features of the pedagogical framing of the episode made contributions to the opportunities for children's creativity – in particular the **space and time** *to* **explore** and the **variety of resources** freely accessible to children. In terms of pedagogical interactions staff encouragement of children's explorations reflected the **value given to play** and their **willingness to stand back** and respond with interest to directions in which children might take their explorations.

Episode 3: Cake Shop

Pedagogical framing

As one of the visits took place during the school's 'Money Week' whereby every class did some work on issues related to money, there were a number of activities in the nursery class that aimed to introduce the concept of money to the nursery children. These activities were led by, Vera, one of the Early Years officers.

One of the activities, for example, was an adult-led 'shopping list' game where five children were each given a shopping list card that contained around six to seven pictures of the different shopping items. Faced down on the table were picture cards of all of the individual items shown on the shopping list cards. The children took turns finding the individual shopping items from the faced-down picture cards that matched those shown on their shopping list. Once they found the matching item, they then had to read out the price stated on the picture card.

The Cake Shop corner was another activity, which this episode is drawn from. The corner was situated **inside the classroom** within an **informal learning setting,** where children could **play the roles** of a shopkeeper or a customer. There was **a wide variety of informal learning resources** made available to the children. For example, a till of plastic coins, a bowl of real coins, an abacus, a number book, a cake stand full of plastic cakes, price tags, shopping baskets, a notepad, a pencil, an opening hours sign, a wallet, and a stand-alone **computer keyboard** for children to become familiar with computer equipment found in shops. All these resources provided a **rich physical environment for exploration** that allowed children to **make connections** between the class activity and their out of

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school learning. From an informal chat with Vera, she hoped to take children out **to visit a local shop** in the following week to allow them an opportunity to see how money is used.

To ensure that there was **sufficient space** inside the shop, there were usually **a few children** playing at the shop at any given time, and they were allowed to play in the Cake Shop corner **as long as they liked**.

Pedagogical interactions

Whilst Vera and her Early Years Officer colleague were around all the time to provide any support when required, they chose to **stand back** and let the children explore the different learning resources within the Cake Shop themselves most of the time. For example, without any prompting from Vera, David was seen counting the cakes on the cake stand by himself. Pointing at each cake, he counted: *"One … two … three … four … five … six … eleven [sic] … eight … nine … ten … sixteen [sic]".* Such a child-led learning opportunity could provide an invaluable insight into children's knowledge of the number sequence (e.g. David could count relatively confidently up to 10, though mistaken 'eleven' for 'seven'). Additionally, through observing his hand movement when counting, his ability to associate one number with one object and to keep track of the objects counted could also be noted, for instance.

Image 3.1: David was seen counting the cakes himself without being prompted by the Vera

When the Vera was initially present at the Cake Shop corner, she was working with a few children - asking them to help her count the number of chocolate chips on the biscuits, and to help her choose price tags for the cakes on the cake stand. By asking children to read numbers on the price tags, she was able to **formatively assess** children's number recognition as illustrated in the exchange below:

Vera:	[Vera going through cake price tags to display around the cake stand] *"Do we have cookies?"* [showing children the price tag for cookies]
Ronan:	*"Yes"*
Vera:	*"Do you know how much they are? What number is that one?"*

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Ronan: *"Two! Seven!"*

Vera: *"So that was 7 pence. So you need that one."* [handing over the price tag to Ronan]

Image 3.2: Vera working with Ronan and his friend to find relevant price tags to display around the cake stand

Additionally, the Cake Shop learning environment also had a potential to provide an opportunity for children to **make connections between mathematics and scientific concepts**, related to properties of materials through **observing** and **explaining**. For instance, Bram was seen sorting coins that had been left all over the carpet into either a bowl of real coins or a till of plastic coins. When asked to explain what he was doing, he explained:

Bram: *"This is real money and this is not"* [pointing at the bowl of real coins and the till of plastic coins respectively].

Researcher: *"How do you know this is real money and this is not?"*

Bram: *"Because real money is cold."*

Researcher: *"What about the plastic ones? Is it cold?"*

Bram: *"No."*

Researcher: *"What does it feel like?"*

Bram: *"You feel it!"*

And during the follow-up interview:

Researcher: *"Just now, Bram, you told me that there are two types of coins: the real coins and the not real coins. Can you repeat what you said about them? You said you know they are real coins because they are ..."*

Bram: *"They are hard."*

Researcher: *"And ...?"*

Bram: *"Cold!"*

Researcher: *"How do you know that? How do you know that real coins are hard and cold? Who told you that?"*

Bram: *"No one. Because I even feel pennies when I was a baby."*

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Image 3.3: Bram was sorting coins into real and plastic ones

Another interesting mathematics learning opportunity emerging from the Cake Shop corner was how children were given an opportunity to **express and record** their transactions to an audience, using a given notepad and a pencil. As there was no instruction as to what or how it should be written on the notepad, some children **took initiative** by writing the prices of the cakes being bought on the notepad.

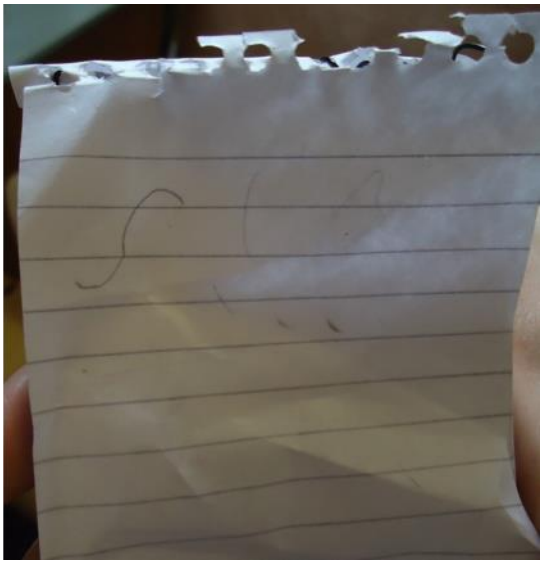

Image 3.4: A child (a shopkeeper) used the notepad to record the price of the purchased cake (£2).

Finally, during the observation, it became clear that some children were more familiar with the concept of buying and selling than others. Some children had a misconception that sellers have to give money to buyers when they sell things as illustrated by the examples below:

Researcher: *"Hello. Can I buy a strawberry cake, please?"*

[Bethany handing another piece of cake to the researcher]

Researcher: *"Is that for me?"*

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[Bethany nodding]

Researcher: *"Do I have to pay for it?"*

Bethany: *"No."* [Bethany handing the researcher a coin]

[…]

Researcher: *"I would love to talk to you about the cake shop corner. Can you tell me what do you have to do in the cake shop corner?"*

Bram: *"Work on the computer. Take out the money."*

Researcher: *"Who takes the money?"*

Bram: *"Joe* [a shopkeeper] *and I* [also a shopkeeper]."

Researcher: *"The shopkeepers or people who want to buy cakes?"*

Bram: *"The people who want to buy cake."*

Researcher: *"OK, so they take the money, and what else do they have to do?"*

Bram: *"They have to pick what they want and* [inaudible]."

Researcher: *"If I found the cake that I want to buy, how would I know how much do I have to pay for this cake?"*

Bram: *"None. None penny."*

Researcher: *"None penny? How come? How come do I get it for free?"*

Bram: *"Because. Because I said so."*

Other children were aware that buyers needed to give sellers some money, but were still at the stage of learning about giving change. For example, Daisy came up with a creative solution to the following problem posed to her:

Researcher: *"So this piece of cake is £2. If a customer gives you £5, what would you have to do?"*

Daisy: *"I'd give them that one* [an extra piece of cake]*."*

Researcher: *"Why?"*

Daisy: *"Because it costs that much."*

However, it appeared that through **role play** and **dialogue**, these children developed their understanding of how the buying and selling system works. As the example below shows, even if Emma had not realised that, as a buyer, she had to pay for her cakes, she learnt that fact right after being confronted by a very direct shopkeeper friend:

Emma: *"Hello, shopkeeper. Hello, shopkeeper."*

Ronan: *"You not have* [sic] *any money."*

Emma: *"Hello, shopkeeper."*

[…]

Emma: *"A biscuit with red, and two cookies, please."*

[Initially, Ronan handing Emma only two cookies, then gave her a biscuit later]

Emma: *"Thank you."*

Ronan: *"Now pay!"*

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[Emma handing over some coins to Ronan]

Image 3.5: Emma being confronted by a direct shopkeeper friend

Opportunities for mathematics learning

As previously mentioned, this episode took place during the 'Money Week'. As such, the focus of the observed activity was linked to the Scottish Curriculum for Excellence guideline's MNU 0-09a expectation – 'I am developing my awareness of how money is used and can recognise and use a range of coins'. Linking to that is a broader aim of enabling learners to 'understand that successful independent living requires financial awareness'.

Opportunities for creativity

In thinking back about the purpose of the Cake Shop corner which was to introduce to the children the concept of how money is used in everyday lives, it might be argued that the observed pedagogical strategies allowed children to meet that learning intention whilst also helping them develop their creative dispositions. More specifically, for example, the combination of the nature of the Cake Shop corner, which provided opportunities for children to engage in **role play** and **physical exploration**, and the decision of Vera and her colleague to **stand back** and let the children become the **primary agents of their own learning**, allowed the children to develop **imaginative** thinking skills and fostered **positive attitudes** to mathematics learning.

By providing a wide range of **rich physical resources**, Bram was, for instance, able independently to **make connections** between mathematics and the scientific concepts of properties of materials through observing the differences between real and fake coins. Additionally, through using the notepad, the children were **taking the initiative** in recording transactions by writing prices of purchased cakes on the notepad.

Finally, with the suggestion that her buyer would be given an extra piece of cake if they gave her too much money, Daisy has shown the potential of scaffolding questions in prompting her to use **creative thinking skills** to **solve a problem** and **explain** her method.

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3.18.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

What role if any does creativity play in these?

The **variety of provision** in the nursery provides **rich opportunities for children's explorations**. The episodes reported in this case reflect the dynamic combination of adult initiated and child initiated activities that took place each day. Martha's planning identified **meaningful contexts** for learning building on everyday events. **Connections** were fostered **between learning indoors and out**. The direction and development of planned experiences over time is responsive to **children's interests**, drawing on on-going **sharing of assessment information** across the nursery staff team.

Martha fostered a climate of sharing ideas and enthusiasm between children and adults and across the nursery staff team. Nursery staff **modelled their own excitement** in learning and showed serious interest in children's ideas and explorations. Adults took on varied roles, at some times **standing back** and showing interest (in relation to water play or ice balloons), and at others using **questioning** to motivate children, to encourage children to express their ideas, to **foster reflection and reasoning** and links across experiences (making bird cake).

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

How do teachers perceive their role in doing so?

There was much evidence across the episodes of children's **curiosity** and **questioning** and **motivation** for the activities observed in mathematics and science. They showed **independence and initiative** in developing their own directions for inquiry. Children employed a wide range of **process skills** associated with inquiry. There was evidence of children's developing knowledge and understanding related for example to **properties of materials** and **processes of melting and freezing** in science and **money** and **number** in mathematics, fostered by the range of practical and exploratory experiences provided.

In the interview with Martha about the role of the adult, she highlighted the importance of children's agency but also the role of the teacher listening carefully to children's ideas and a having sense of the potential for extending learning based on their responses. "*You have to have a starting point but where you go from there is very much dependent on the children's interests and what they do.*" She emphasised the need for varied contexts and experiences for introducing ideas "*You have to think of lots of different ways if you are trying to focus on something.. having lots of different contexts to revisit ideas*'. This is illustrated by the plans of the nursery team building on children's responses to the Bird Cake and Ice Balloon activities.

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" There were two things that came out of it (discussion in the team) one was the talk that the lard was like cheese and butter and let them have a look at that as well, and then just going on with the melting, to go on to make crispie cakes and build on it. Keep the language going and if there is an interest build on it and think about how we can extend it.. talking to the children and what would you like to do next."

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3.19 Case: 'Mary'

3.19.1 Context

Where?	Country	Scotland			
	Setting name	SC1 - Braes Primary School			
	Location within setting	Primary School			
Who? (children)	Year group/age of children	P1 Age 5-6 years old			
	Number of children in class	30			
Who? (adults)	Number of adults	Two			
	Role of adults	One teacher and one teaching assistant			
	Case teacher role	Lead teacher, sole responsibility for class			
When?		1	2	3	n/a
	Dates of visits	210113	240113	050313	n/a
	Times of visits	09:00-15:00	09:00-15:00	09:00-15:00	n/a

School/Setting

Located on the periphery of a university town in Fife, Scotland, Braes Primary School is a state-funded nursery and primary school, serving 186 children from age 3 to 12 years. Only thirteen children across the school are eligible for free school meals. While the official ethnicity breakdown across the school is not available, it is noted for its predominantly white demographic makeup.

The school follows Scotland's recently-introduced 'Curriculum for Excellence', a national framework which claims to provide "a coherent, more flexible and enriched curriculum". Under this framework, each school gets to design their own curriculum to reflect their particular needs and circumstances.

According to the school's 'Information for Parents and Carers 2013-2014' booklet, it stresses the fact that "*children are fully consulted about all aspects of school life including their own learning. They decide some of what they will learn and how best to learn it*". Towards the end of the 2011/2012 academic year, the school undertook a large consultation exercise to review the school's vision and values, one of which is to 'nurture creativity'. The school enforces six school-wide Golden Guidelines for behavior management, and one of these Guidelines (i.e. 'We listen') arguably helps to create a learning environment where children's possibility thinking skills can be fostered.

In terms of assessment, Braes operates a school-wide '*4 lens approach*' taking into account: 1) *professional judgement*, or on-going assessment which is done in class; 2) *moderation* where 'staff discuss what the standard is for certain levels using guidance provided by the service or nationally to enable parents to be sure the levels assigned to their child is accurate'; 3) *progress history*, where

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'*staff track pupil progress over a longer period of time to ensure development is taking place at the correct pace for each individual pupil*'; and 4) *external assessments* where '*standardised information which benchmarks against national norms*' are required by the service.

The school was last inspected by HM Inspectors at the end of 2004, and its leadership; teaching process; children's learning experiences; children's attainment in mathematics, and the structure of the curriculum, among others, were judged to be 'good'.

The school and the nursery are housed in a fairly modern open plan building with eight open teaching areas for the eight classes, each with its own small adjacent sideroom for whole-class sessions. The school has a very large multi-purpose hall and extensive school grounds which children access for leisure and learning

Teacher

Mary is in her 40s, and holds a BA in Fine Art degree and a Post-Graduate Certificate in Education (PGCE). Over the last four years of her 11-20 years of teaching, she taught children from 4 to older than 8 years old.

Mary's highest formal education level in which she studied science and mathematics is at the lower secondary education level. In her initial teacher training, she studied mathematics, science and pedagogy in a broad overview.

Over the last 18 months, she took part in several professional development opportunities, the majority of which she rated as having a large impact. Examples of such opportunities included a workshop on mathematics; participation in networks of teachers formed specifically for mathematics and science teachers; as well as mentoring and/or engaging in peer observations and coaching of mathematics teaching, among others.

From the interview with Mary, she talked about her planning, the learning process and assessment. Concerning the former, Mary made use of transitional documents (e.g. her children's Nursery files and observation records and their standardised test scores on visual and auditory memories as well as their English, maths and science scores at the beginning of the P1 academic year) to help her plan appropriate teaching and learning activities and ability groups. Another pedagogical approach that she regularly uses is the 'Phone-a-Friend' option for when some children get stuck when Mary asked them a question, and they would like their peers to help them. Mary said this approach encouraged her to give children more time to think and could help increase class dialogue participation.

In terms of the learning process, Mary always encouraged children to be the primary agent of their own learning. She did this through a system called 'Brain-Book-Buddy-Boss', whereby if a child stuck and needed help with their work, they would have to try to think about the question themselves again ('Brain'), and try to look at their works ('Book') from a different angle. If those two steps did not help, then they should discuss the problem with their peers ('Buddy') before approaching her for help ('Boss'). Mary said most of the time when the children follow through these steps, they would be able to come up with the solutions themselves.

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Concerning assessment, Mary regularly encouraged children to the 'traffic light' system to self-assess and to get them to reflect the areas that they could or wanted to improve on.

Occasionally, Mary would also invite parents of her P1 children to 'play' with their children in the class. She said this was useful in helping parents to better understand how everyday activities or games like jigsaw puzzles or construction blocks could also be linked to their children's mathematics learning.

Classroom

There are 18 children in the class, with 12 boys and 6 girls. The dominance of boys in the class could have an interesting impact on the type of learning activities, as Mary highlighted in the interview that children, especially boys, learn better when *"they learn with their body"*, implying the use of different senses, particularly kinaesthetic. She also said that children were more engaged and focused when they learn with their body and *"not just with their brain"*. In mathematics and science lessons, four additional children in the neighbouring P2 class also joined the P1 children. Children work in ability groups in both mathematics and science.

In terms of the classroom setting, the classroom is housed in a very spacious open-planned space, with a larger area being used for grouped activities and a smaller breakout area in the adjacent room being used for whole-class introduction and plenary sessions. In the interview, she also acknowledged that the outside playing area provided excellent opportunities to foster children's creative thinking, though such area was not used as much as she would have liked to.

The classroom is well resourced with rich mathematics artefacts, puzzles and games, a reading corner, a 'construction' area, and an interactive whiteboard at the front of the adjacent breakout room. A few times a week, children get to spend the first 30 minutes in the morning for free play where they can choose if they want to go to the book corner or play with construction blocks. This feature highlights the Scottish 'play-based' approach to teaching and learning that extends until the end of P2 (6-7 years old children).

There are five main clusters of desks in the main learning area and the walls are well displayed with 'Light and Dark' and 'Tropical Fish' board displays. Relating to those displays are 'What do we want to find out' mindmaps, which show different questions that children want to learn more about the 'Light and Dark' and sea creatures topics, such as 'How animals see in the dark' and 'How do dolphins and whales jump without feet?'. Such pedagogical features resonate well with the school policy of fully consulting with children about what they want to learn, as mentioned in the School Setting section. Linking to the 'Light and Dark' topic was a small, yet carefully-constructed, in-class wooden tent where children can explore what they can see in the dark with torches and reflective materials.

Finally, there is the 'Aim High' display where targets for individual children are set, and such targets can be academic-or social-related. In the interview with Mary, she gave some examples, such as 'I'm

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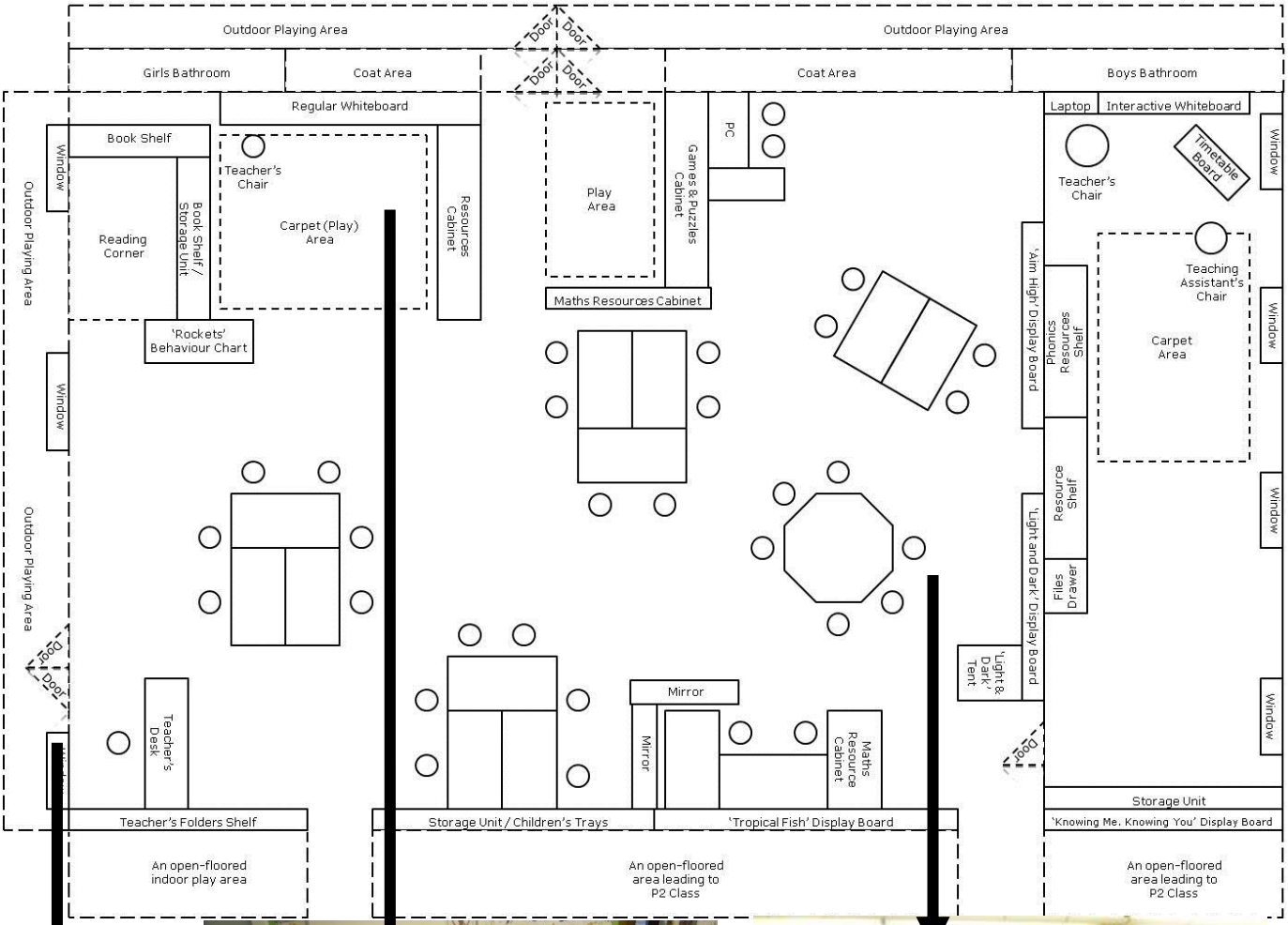
Mary's P1 Class at Braes Primary School



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3.19.2 Episodes

Episode 1: Sorting and counting

Pedagogical framing

The focus of this lesson was on sorting and counting. This session followed previous lessons during the week, in which the class had worked on strategies that could help them count more effectively. Whilst children were asked to **collaborate with their peers** within the same ability grouping, the material resources and the nature of the task were the same across all **ability groups**. For the main activity, each group was given a bucket of **a wide variety of physical objects**, which were different in kind, size and colour (such as teddy bears, cubes, cotton reels, and chains, among others) to explore and sort.

The main focus of this episode was drawn from teacher-child interactions during the introductory part of the lesson as well as the interaction between Gordon and Donald in the middle ability group during the activity.

Pedagogical interactions

The lesson started with Mary showing children large, medium and small teddy bears in pink, red, blue and green colours on the **interactive whiteboard**. Children were asked to sort them however they liked. The first pupil volunteer, Alastair, sorted the bears by their colour, whilst the second child, Cameron, sorted them by their size though by putting all the bears in a row from the largest to smallest. It might be worth noting that whilst the former only took around 30 seconds to do his sorting, the latter took up nearly five minutes, and yet the teacher was happy to **stand back** and **wait** until he had completed his sorting.

Throughout this introduction, Mary also constantly provided opportunities for children **to explain their ideas** (e.g. *"How has Alastair sorted the teddies?"* and *"So how do you think he decided which bear to put in which box?"*, etc.). Additionally, if when being asked a question a child did not know the answer, they were offered a chance to '*phone a friend*' following an option found in a game show, whereby they could nominate one of their peers to help answer that question on their behalf. Arguably, this pedagogical feature created a learning environment which promoted dialogue and wider participation.

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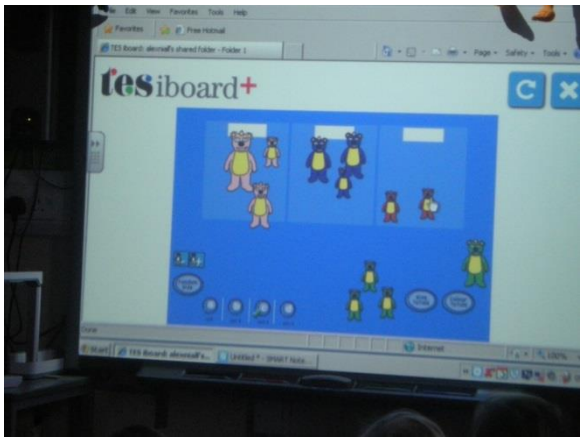

Image 1.1: Alistair sorting teddy bears by their colour

As previously mentioned, for the main activity, each group was given a bucket of a wide variety of physical objects to explore and sort. The observed children were Gordon and Donald who were working on the same table with two other boys in the middle ability group (Aengus and Neille). While Gordon and Donald were counting only teddy bears, Aengus and Neille were counting everything else in the bucket.

As it can be seen below, while Mary's overall instruction to the task was intentionally left very open-ended to allow room for children's creative thinking, two important emphases were highlighted, namely **the focus on children working together and listening to others' ideas** as well as the expectation for children to give the teacher **their reasons** for sorting objects in a certain way, as the following extract shows:

Mary: *"I've got a big challenge for you this morning, are you listening.* […] *On your table, you've got a big round box of things, and there are all different things in it, and I want you to work together to make them into groups, ok? Just sort them. Now, there isn't a right way or a wrong way to do it, but what you do have to do, when you're working together, is to what?"*

Rae: *"You have to listen to one another and you have to share ideas."*

Mary: *"And I'll come around and I'll ask you why you sorted them in a certain way."*

As the above instruction shows, while the main focus was on children sorting objects, Gordon and Donald **took their own initiative** to *count* their sorted objects too, in addition to sorting their teddy bears by colour and size in straight rows. Once they had both finished sorting objects by colour and size as well as well as counting them, Gordon **took another initiative and** proposed a creative way to 'measure' them by using the plastic chain links:

Gordon: *"Now let's put them in green ones with green ones. Sort them out in colour now."*

Donald: *"Let's see who has the biggest family [of bears]."*

Gordon: *"Right, we have to count the families when we're done."*

[…]

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Gordon: "Hey I'm going to put them in a line and measure them with chains."

Image 1.2: Gordon and Donald working together to sort and count their teddy bears

Children were then asked **to record** their sorting on a blank piece of A3 paper. As Mary was intentionally unspecific about what she wanted to see recorded (i.e. *"I'll give you a piece of paper. I want you to draw a picture of the different groups that you've got"*), this allowed for **diverse forms of expression**. This ranged from children recording exactly how they believed Mary had asked them to do, namely drawing *'pictures of the different groups'*, as in the case of Gordon who was heard talking to himself: *"I'll write it down 'chains' [i.e. plastic links] or should I draw the picture [of the chains / plastic links] …"*:

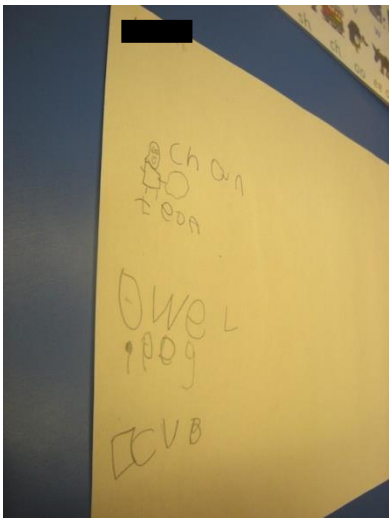

Image 1.3: Gordon's record of his work using labels and drawings of a single unit for each of his sorted objects

to children attempting to include either a graphical representation (in the case of Donald) or numerical representation (in the case of a Sarah and Blair in the higher ability group) of the quantities of their sorted objects:

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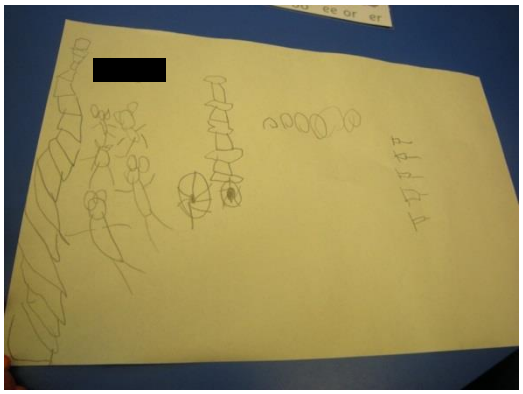

Image 1.4: Donald's record of his work, using graphical representation to indicate the number of his sorted objects (according to type)

Image 1.5: Sarah and Blair's record of their work, using numerical representation to indicate the) number of sorted objects (according to colour)

Opportunities for mathematics learning

The focus of this lesson was on counting and sorting, which resonates with the Scottish Curriculum for Excellence's Experiences and Outcomes for Numeracy related to Data and Analysis, MNU 1-20b *'I have used a range of ways to collect information and can sort it in a logical, organised and imaginative way using my own and others' criteria'*. There were also links to the broader goal of enabling learners to '*apply skills and understanding creatively and logically to solve problems, within a variety of contexts*' that applies across the Experiences and Outcomes for Numeracy.

Opportunities for creativity

Due to the **very open-ended nature of the task**, it provided an opportunity for children to develop their **creative thinking skills** in coming up with different ways to sort the given objects, while the **rich hands-on material resources** and the **informal learning environment** also encouraged children to develop **positive attitudes** towards mathematics learning and fostered **motivation**.

Through Mary's **reflective questions** (e.g. *"Why did you sort the teddy bears this way?"*), children's **reasoning skills** were extended. This also allowed other children in the class to develop their possibility thinking skills through being exposed to the range of strategies their peers had adopted for sorting objects during the **class discussion and dialogue.**

Episode 2: Day and Night

Context

This session was taught by Petra who teaches all the science sessions in this class in consultation with Mary the class teacher. This episode took place as part of a planned topic on Day and Night. The overarching learning intention for the topic was as follows: '*children will learn about the earth, moon, sun and stars. They will observe the sun and moon at different times and relate their findings to the concept of time'* (school planning document).

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Pedagogical framing

In a previous session children had discussed and recorded their ideas and questions related to Sun, Moon and Stars. These were displayed for reference for both children and staff. The book corner contained a number of stories and non-fiction texts related to Earth in Space. A dark tent had been set up in a corner of the classroom. This contained various torches and objects, including items made of reflective materials to enable children to explore what you can see in the dark, differences between objects that are sources of light and objects that reflect light. Children were **free to explore** these materials during times in the day allocated to freely chosen activities. In particular the period of free play introduced by Mary at the start of each day allowed opportunities for this and the tent was well used. This **variety of resources** in the classroom environment served to promote and sustain children's interest in the topic.

Planning for this particular session highlighted the following experiences and outcomes from the Scottish Curriculum for Excellence SN 0-06a '*I have experienced the **wonder** of looking at the vastness of the sky and can recognise the sun, moon and stars and link them to daily patterns of life*'. The session content had a particular focus on children **knowing** that the sun is a source of light on Earth and that the Earth spins on its axis. It was intended that these ideas would provide a foundation for developing an **understanding** of why we get day and night.

The **variety of resources** prepared for the session were designed to foster enthusiasm for the topic and introduce new ideas. They included an app used to show high quality images of the Sun and the Moon and an animation of the movement of the planets round the Sun, a globe and torch to model why we get day and night, photographs of animals and human activities in the day and the night and a range of materials for children to represent their ideas, including crayons and plasticine.

Pedagogical interactions

At the start of the session Petra read a story called '*The Park in the Dark*'. She posed questions including "*What is it like in the dark*?" "*What do you like about the dark*?" "*What do you not like about the dark*" "*Why do you think it gets dark*?" to elicit discussion about children's experiences and feelings about the dark. She used a container of lollipop sticks each marked with a name of the child in the class to encourage responses to her **questioning** and **dialogue** across the class. Children's comments made reference to their everyday experiences at this time of year (winter in the UK):

Donald:	*"[I like the dark] because you can still see and you don't need to go to bed for a long time."*
Evan:	*"[I don't like the dark because] When I close the door and turn the light off I get so scared."*
Marion:	*"[It gets dark] so you can go to sleep."*

Petra then explained that they would be finding out what is happening to make day and night time:

> *"The reason it is daytime is because the sun is giving us light and we are going to talk about the fact that when on Earth we are facing away from the Sun it's going to be dark and going*

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to be night time. We are going to be talking about how the Earth turns round, rotates each day."

She took out a globe and stuck a little picture of a person on the globe where the school is located. She then invited a child, Gideon, to be the sun. He was given a sun hat and a torch to hold and shine at the globe.

Image 2.1: Modelling day and night

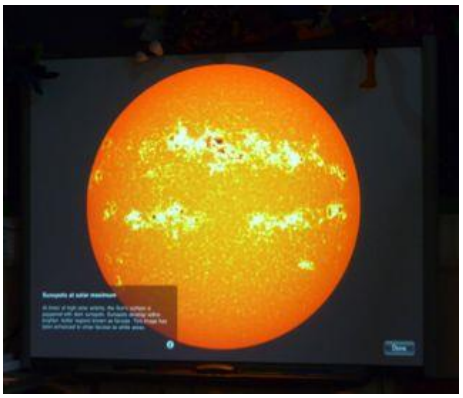

Image 2.2: Photograph of the sun

As she turned the globe the children were asked to say whether the little person was experiencing day or night "*is it daytime or night-time*?" She asked "*how much time do you think has passed between daytime once and getting dark and daytime?*" Children gave varied responses "*quite short", "about two weeks" "I think it's a day*".

In response to this the teacher then linked the turning of the globe to their experiences during each day:

Petra:	*"So it is daytime just now and when you go home to have your dinner it is going to be night-time – then you are going to sleep all night and get up in the morning and its is going to be …?"*
Children:	*"Daytime"*
Petra:	*"So the world or the Earth rotates once a day – do you see that? Well done for being the Sun* [to Gideon]."

In the next phase of the lesson Petra introduced her new Space app on her iPad. First she shared some high quality pictures of the Sun. These prompted much excitement, comment and sharing of new ideas and enthusiasm between the teacher and the children as they read the captions from the different images together for example:

Lewis:	*"You can see the fire and its burning!"*
Petra:	*"This says the surface is peppered with sun spots … wow – so you do not normally see the sun like that do you?!"*

Petra then showed an animation of the solar system. This also provoked interest and enabled the class to revisit ideas about the Earth turning on its axis:

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Petra:	*"There's the sun that's at the centre of the solar system and you can see all the different planets that are moving round the sun ... this planet here's called Mercury ... then what's this?"*
Children:	*"Earth"*
Petra:	*"Can you see how its turning round so when the light is shining on this part it is going to be daytime ... and what's it going to be like in this part of the world away from the sun."*
Children:	*"Night-time"*
[...]	
Macey:	*"There's one ball moving round the Earth."*
Petra:	*"Does anyone know the ball that's moving round the Earth?"*
Lewis:	*"The Moon"*
Petra:	*"We'll look at that in a little more depth ….So if we go back to what we are learning today – I know that the earth goes round the sun and it is rotating to give us daytime and night-time."*

Petra then set up four different activities in the classroom

- Drawing pictures of how we get day and night using colouring pencils
- Sorting photographs of animals into those that come out in the day and those that come out in the night
- Sorting activities according to whether they take place at daytime or night-time
- Making models of the Moon and Sun using plasticine – this table was also given reference books on the Solar System to support their work.

This episode focuses on the drawing and modelling activities both of which offered opportunities for children to **express** and **reflect on** their ideas in different ways. Petra showed interest in children's progress and encouraged them to talk about what they were doing but did not direct children's responses. Children's representations reflected the inspiration from their experiences in the earlier part of the lesson. For example in discussions with Ronald during and after the session he explained what his drawing showed as follows: *"There's lots of solar flares Earth is so far away you can never reach that… got explosions – that's the light shining at the Earth.. This shows all the planets are – going round and round. That was Jupiter and one next to Jupiter – and Saturn – closest to the sun. The blue bits are the sea and the green bits are the land".*

In sharing her drawing Macey said "That's the sun – these are black spots - that's the moon – its grey smaller than the sun – these are the lines from the sun".

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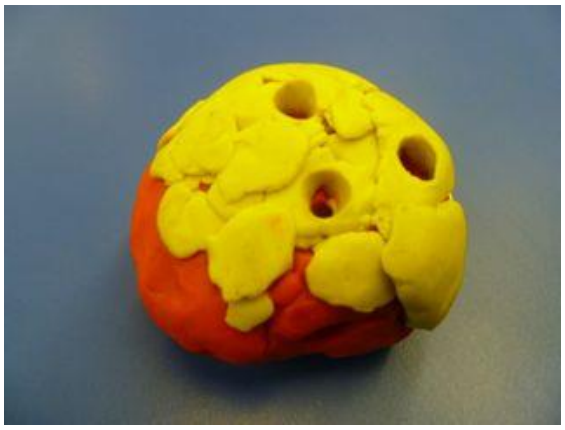

Image 2.3: Ronald's drawing of the Sun

Image 2.4: Donald's model of the Sun

Donald explained his model of the sun "*That's fire coming and they're the holes and that's all the lava ... the sun is boiling hot fire".*

Image 2.5: Gideon's diagram of the solar system

Independently Gideon, who had taken the role of the Sun, during the modelling of day and night, made his own diagram of the solar system.

Opportunities for science learning

As indicated in Petra's planning, the session provided opportunities to address aspects of the Scottish Curriculum for Excellence. Session content related to Experiences and Outcomes associated with Planet Earth (Space) SCN 0 06a '*I have experience the wonder of looking at the vastness of the sky, and can recognise the sun, moon and stars and link them to patterns of everyday life.'* The session also encouraged *Scientific analytical thinking skills* in particular '*being open to new ideas and linking and applying learning*' in developing new and exciting knowledge of the solar system and in making sense of why we get day and night.

Opportunities for creativity

Creative teaching was shown in particular in the **rich resources** and experiences organised for the session. Ideas about day and night were presented in a **variety of ways**. Petra encouraged engagement through sharing her own enthusiasm for sharing the wonders of the solar system. The

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opportunities for children to **represent their ideas in their own ways** promoted **reflection** on experiences.

The range of learning and teaching approaches adopted fostered children's **interest** and **curiosity** in the solar system. They showed imagination in the development of their models and drawings. In dialogue with peers and with adults they **raised questions** and began to **make connections** between the pattern of their experiences of day and night and the rotation of the Earth on its axis.

Episode 3: Counting Money

Pedagogical framing

This lesson was led by the head teacher, Pauline. She started the lesson by asking children to tell her what they would buy with their money. They gave a range of responses such as ('Juices', 'Healthy food', 'Bed'. , etc.) Using plastic coins, the teacher then asked children to identify different coins, followed by a range of comprehension questions (e.g. 'How many one penny coins would you get for a 5p coin?', 'Who have more money between [a girl] who has a 5p coin, and [a boy] who has five 1p coins?', and 'How many 1p coins are there in a £1 coin?', etc.)

Children then played a matching game on the interactive whiteboard whereby a range of price labels (from 2p to 9p) and images of combinations of coins were randomly placed on the screen, and children had to try to match the right price label with the right combination of coins, and vice versa. Throughout this game, Pauline allowed plenty of **time** for each pupil child volunteer to think, as well as asking them **scaffolding questions** to help structure their thinking.

After the introduction session, children were sent to work on different worksheets tasks according to their **ability groups**. In the high ability group, the target children were identified as Murray and Corey. The following episode is drawn from an observation of the interactions of these two children.

Pedagogical interactions

Both Murray and Corey worked, **largely independently**, on a worksheet-based problem-solving task, called the 'Mystery Money Grid', whereby they had to work out the missing coins in each row and column. There were meant to be six coins in each row as well as in each column. The total of each row and column ranged from 7p to 10p.

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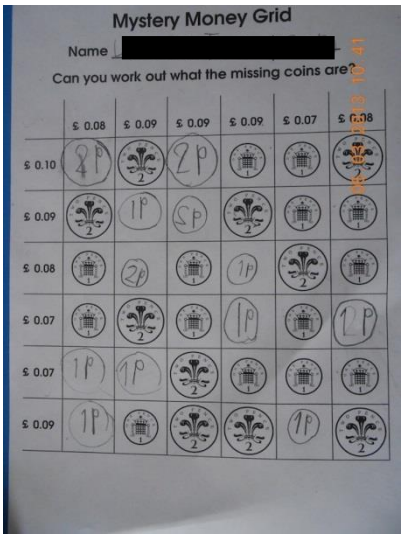

Image 3.1: The worksheet for the high ability group 'Mystery Money Grid'

Murray was found counting coins on his worksheet using the a 'pairing' counting strategy whereby he was using two fingers to count and add the value of two more coins at a time. For example, the third row was comprised of 1p, 2p, 1p, 1p, 2p and 1p coins – in that particular order. He started counting backwards by pointing two fingers at the last 2p and 1p coins and said 'three'. He then moved his two fingers to the two 1p coins in the middle, and said 'two'. Then, he started from the end of the row again. Still pointing his two fingers at the last two coins, he said 'three' *[adding the last 1p and 2p coins]* … 'five' *[after adding the two 1p coins in the middle]* … 'and eight' *[after adding the remaining 1p and 2p coins from the beginning of the row]*.

In the fourth row of six coins with the total value of 7p, it comprised of a 1p coin, a 2p coin, a 1p coin, a missing coin, a 1p coin, a missing coin. Murray was counting backwards from the end of the row using just one finger this time: *"1p, 2p, 3p, 4p, 5p, 6p." [Incorrectly thinking that one coin, regardless of its value, represents 1p]* He later said: *"It needs to be 7p, so one of them has to be a 2p. I'm gonna go with a 2p at the start [i.e. at the end of the row]*."

Murray was drawing a 2p coin at the end of the row, and then a 1p coin in the middle of the row. His row now looked as follows: 1p, 2p, 1p, 1p, 1p, and 2p. When Murray was asked how much money he had in the row, Murray he was once again employing employed his pairing strategy to work out the total value of the six coins. Pointing his two fingers at the first 1p and 2p coins, he said '3p'. Then, pointing his two fingers at the two 1p coins in the middle, he said '5p' *[having already mentally added the 2p to the previous 3p].* Pointing his two fingers at the last 1p and 2p coins, he said '8p'.

When Murray was asked how many pences he had too much, given the total target for that row was only 7p, Murray was immediately seen checking his calculation using his pairing counting strategy again. He did this by very quickly moving his two fingers along the row from the beginning to the end of the row, covering two coins at a time. Pointing at the last 2p coin, he said, *"So we'll need to make that one a 1p".*

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Image 3.2: Murray's counting strategy

There was also a degree of **collaboration** during this activity, for example, when Corey spotting spotted Murray counting his row of coins using his fingers, Corey said: *"You don't need to use your fingers. There you go, Murray"*, whilst pointing at the number line, to which Murray responded *"I don't need one. You have it."*

In addition to the number line, children at in the higher ability group were also supplied with small pots of **plastic coins** where they could use to help them explore and solve the problems on the worksheet. At one point, Murray and Corey were seen comparing two long rows of coins. During the interview after the activity, when asked to explain what they were doing, Corey said they were trying *"To see which one chained the most"*. And when asked whether they were doing it to help them with their work on the worksheet, they said no as according to Murray – *"counting money is more interesting"*. Their responses highlighted how both boys wanted to **design and plan their own investigation**.

Image 3.3: Murray and Corey's conducting their own investigation

In the middle of the interview, Murray abruptly asked the researcher if he could do something quickly. He said "*I'm going to count my money*". With two 50p coins and six £1 coins, he started putting them in a straight row: *"50 [50p coin] … adds one [£1 coin] is 51 adds one [£1 coin] is 52 … adds one [£1 coin] is 53 … adds one [£1 coin] is 54 … add one [£1 coin] is 55 … add one [£1 coin] is 56 … add one 50 [50p coin] is … […] Is it 106? I know what I can do!"*

Murray decided to count a new set of coins, where he was putting each of the following coins in a straight row: 50p, 50p *("100")*, 50p *("150")*, £2 *("152")*, £1 *("153")*, £1 *("154")*, £1 *("155")*, £1 *("156")*,

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£1 *("157")*, £1 *("158")*, £1 *("159")*, £1 *("140")*, £1 *("141")*, £1 *("142")*, £1 *("143")*, £1 *("144")*, £1 *("145")*, £1 *("146")*, 20p *("What's 146 plus 20? 166")*, 1p ("167"), 20p *("187. What's 187 adds 20 …. is 220")*. While it was not apparent from his arrangement of the coins whether Murray necessarily associated coins with bigger size with bigger value, it was clear that he did not make any distinction between the pound and pence units.

Image 3.4: Murray's first attempt at counting how much money he had by putting both pence and pound coins in the same row and treated them as though they were of the same value.

However later Murray demonstrated child-initiated **self-reflection** in reviewing his calculation, when prompted by the researcher. For example, when Murray was later asked how he could check the answer, he exclaimed: *"I'm not right. I'm not right. They are pound coins!"*, whilst pointing at the £2 and £1 coins and rearranging all the coins. This time he was grouping and counting only the pence coins first, then counting the pound coins later. For the pence coins, he had three 50p coins, four 20p coins, and one 1p coin, totalling *"231p"*.

Murray was heard whispering to Corey: "Let's count all the pounds and pences altogether and see how much it makes! […] We just put all the pounds altogether and all the pences altogether. I need to count my pounds first though." With one £2 coin and fifteen £1 coins, Murray correctly worked out the total sum of "£17".

Image 3.5: Murray's second attempt at counting how much money he had by sorting pence and pound coins into two groups

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When asked to add up the two sums amounts (i.e. 231p and £17), Murray said *"I have to start with the highest number. 231 adds 17 will be 248!"* When asked whether the total would be in pence or pound, he said *"pences and pounds? […] I don't get it".*

While Murray was evidently still not able to fully distinguish the value of the pound and pence units in his final calculation, it was very interesting to observe the development of his counting techniques from laying all the coins in a straight row by placing a sole emphasis on the sizes of the coins (i.e. from the largest coin to the smallest one), to his subsequent technique of sorting coins into a pound row and a pence row before counting them separately. To an extent, this illustrated Murray's problem-solving skill in coming up with a new strategy to solve the task of calculating how much money there was. What made this progression even more interesting was that it largely occurred through Murray's own **self-reflection** and **self-assessment** with minimal input from any adult. When asked why he changed his technique, Murray said *"Because it makes sense".*

Opportunities for mathematics learning

As one of the visits took place during the school's 'Money Week' whereby every class did some work on issues related to money, there were a number of activities in the P1 class that aimed to develop children's understanding of money and coins. More specifically, the activities were linked to Scotland's Curriculum for Excellence's MNU 1-09b outcome – *'I have investigated how different combinations of coins and notes can be used to pay for goods or be given in change'*. Linking to that is was a broader aim of enabling learners to '*understand that successful independent living requires financial awareness*'.

Opportunities for creativity

The immediate availability of hands-on resources, such as plastic coins, allowed children's **curiosity** to be aroused and **motivation** towards mathematics learning increased, as it was noted when Murray and Corey wanted to know who had more money whilst they were meant to be working on their worksheet. Through children' **taking initiative**, it was possible for them to develop their understanding of money calculation through **making connections** between counting and sorting strategies on the one hand and money units on the other.

The subsequent money counting task that the children set for themselves during their interview also fostered their **creative thinking skills** and **problem solving skills** by coming up with different counting and sorting strategies to address the distinction between the pound and the pence units.

3.19.3 Summary and Conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

What role if any does creativity play in these?

Some of the more predominant pedagogical approaches found across the three episodes include the **use of ICT** and **physical objects**. ICT was employed in the form of games played and digital photos

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shown on the interactive whiteboard, and was often used to help introduce concepts to children during the introduction sessions, while the use of physical objects often manifested during the group activities to help children develop their understanding as illustrated in the *'Sorting and Counting'* and the *'Money Counting'* episodes.

Linking to that, while the use of ICT in the '*Sorting and Counting'* episode was to develop children's mathematical skills of sorting, the use of ICT in the *'Money Counting'* and *'Day and Night'* episodes appeared to help children recognise a variety of coins and help them to see how the planets rotate around the Sun and how such movement cause day and night.

Embedded within the use of ICT and physical exploration were efforts made by Mary and Petra to make the teaching and learning activities **relevant to children's everyday experiences**. For example, in the '*Day and Night'* episode, Petra linked the turning of the globe to the children's experiences during each day. In the '*Money Counting'* episode, children were asked what they would buy with a given sum of money, whilst in the '*Sorting and Counting'* episode, children sorted everyday objects, as mentioned in the above paragraph. Not only would this help to make learning less abstract for children, it has also been argued that such connection "makes it easier for children to state their own opinions and work imaginatively with the tasks given" *(see D2.2 Conceptual Framework, Section B3.1.2)*.

Ultimately, these elements came together to help create an **informal** and **enjoyable** learning environment, conducive to **foster learners' positive attitudes** towards mathematics and science learning, and creative dispositions. For example, the ICT introductory activities helped to fascinate, engage, interest and arouse children's **curiosity**, especially in the case of the '*Day and Night'* episode, when children were evidently in awe when they saw actual high-quality images of the Sun, in some cases for the very first time. The animation of the solar system with different planets rotating at the same time helped improve the quality of children's representations of and subsequent discussions about the solar system.

In the case of informal **play-based, exploratory** approaches, research has shown that such contexts enable young children to feel safe to experiment, push boundaries and take risks – important ingredients to foster children's **creative thinking** *(see D2.2 Conceptual Framework, Section B3.1.1)*. Additionally, the provision of a wide-range of hands-on **materials** can offer different ways for young children to **represent and express** their ideas and thinking processes. This was particularly the case in the 'Sorting and Counting' episode, where Gordon came up with his own idea of measuring rows of sorted teddy bears with plastic links or chains, as the latter also happened to be there lying around in the bucket as part of objects to be sorted. Arguably, his mathematical skills were thus extended beyond just sorting and counting.

Additionally, in both mathematics and science episodes Mary and Petra sought to encourage children to offer ideas through the use of 'phone a friend' or 'lollipop sticks'. Such approaches can help to encourage wider class discussion and participation.

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Another influential pedagogical approach found in the episodes was the provision and encouragement of **diverse forms of expression** for example in the 'Sorting and Counting' episode where children got to record their sorted objects however they liked, and in the 'Day and Night' episode where a variety of representational forms (e.g. making models, drawing, and sorting out pictures) were made available. Such provision is crucial as children's ideas and understanding may not always be represented verbally. By incorporating diverse forms of expression, the teacher varied opportunities to identify children's creative thinking.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

In brief, all of these pedagogical approaches and learning activities helped create a learning environment where learners felt safe to develop their creative dispositions, such as taking risks and showing initiative in coming up with different imaginative ideas and solutions; and being constantly curious and motivated to explore new concepts or phenomena around them.

How do teachers perceive their role in doing so?

In the interview with Mary, she repeatedly stressed the importance of grabbing children's interests by making learning and teaching activities fun and engaging. To achieve this, Mary (and Petra), for example, shared their sense of enthusiasm with the children, especially Petra in the 'Day and Night' episode, and through Mary's provision of rich hands-on exploratory learning materials for children to work with across all three episodes.

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3.20 Case: 'Sarah'

3.20.1 Context

Where?	Country	Scotland			
	Setting name	SC2 - Forrest Children's Centre			
	Location within setting	Pre-School			
Who? (children)	Year group/age of children	3-5 years old			
	Number of children in class	32/33			
Who? (adults)	Number of adults	6 with varied shifts to cover opening hours from 8.00am to 5.45pm			
	Role of adults	Teacher, Deputy Head and Nursery Nurses.			
	Case teacher role	Teacher			
When?		1	2	3	4
	Dates of visits	04/0213	05/02/13	11/02/13	12/02/13
	Times of visits	All day	All day	All day	All day

School/Setting

Forrest Children' s Centre is situated at the heart of a large city in Scotland. It takes children aged 6 weeks to 5 years and is open from 8.00am to 5.45pm. The intake comes from across the city and includes children from a range of cultural, social and ethnic backgrounds. There are different rooms for children up to 2 years, children from 2-3 years and children from 3- 5 years, however children are free to move between rooms and interact with whom they choose.

There is a strong whole Centre philosophy, underpinned by Froebelian ideas, that highlights the importance of children's "*well-being, happiness and holistic development*" (Centre booklet). The importance of the processes of learning and learning through play are underlined. This is illustrated in the range of booklets for staff and parents that spell out the rationale and learning potential of various aspects of play provision including for example block play, malleable play, baking, small world play, modelling and gluing with links identified to the Curriculum for Excellence (www.curriculumforexcellenceScotland.gov.uk). There is an emphasis on importance and quality of the environment both indoors and out, and a commitment to the use of the wider environment to support learning reflected in the episodes included in this case study. The school has Eco School status.

Activities and experiences at the Centre are based on the needs of each individual child. Children's on-going interests and ideas are recorded in individual Learning Folders, drawing together

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photographs of significant events, staff observations and children's reflections on their experiences. These are used to inform provision at the Centre. They also provide a focus for dialogue with parents about their children's learning.

The report of the most recent inspection of the Centre by the Care Commission and HM Inspectorate of education highlighted the '*outstanding quality of staff interaction throughout the centre to support children's learning* and 'the *excellent progress of children in all aspects of their learning*'. In their commentary, they noted that:

> "*Their extensive knowledge of how young children learn enable them to interact very effectively and offer children a stimulating and challenging learning environment. They were exceptionally responsive to children's needs and interests and made skilful judgements when supporting play. Questioning and dialogue to support children's thinking was consistently of a very high standard.*"

Teacher

Sarah has been teaching for over 10 years. She has a Bachelor Level Degree and is a trained teacher with a Post Graduate Certificate in Education. She has taught in both primary and pre-school phases of education and is currently the Teacher working in the room for the 3-5 year old children in collaboration with the Deputy Head and a team of Nursery Nurses. She has strong interest and confidence in fostering learning both in and through the environment and the promotion of citizenship, informed by her own background in biology, participation in Forest School training and her MA studies.

In her interview Sarah underlined key elements in the Centre's philosophy. In particular she referred to the importance of the physical environment, the need for children to join in taking responsibility and for adults to set an example " *we cannot hope to encourage care and citizenship if we are not modelling it*". Sarah indicated ways in which children were consulted about developments " *we would normally consult then and get them to do drawings*". Indeed children's ideas played an important role in the design of the outdoor area at the Centre. A second theme across the interview was the key importance of physical experience of phenomena in fostering inquiry in science, alongside its benefits in developing children's physical confidence.

> "*You can see then exploring things like our slopes – they can change the slopes, see how they influence the run of water – and there was a spate of going down the slide with various different kinds of materials which they realised ... sat on the shiny coat (for example) ... I think we have to trust that children are experimenting…they were doing it, living it being it.*"

The Centre is involved in the training of teachers, nursery nurses and speech therapists. Sarah expressed concern about challenges of current policy context in which students often felt pressures to cover the curriculum. She indicated the importance of teachers recognising their role in interpreting the curriculum and the need for specific training for work in early years settings.

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Classroom

The room for 3-5 year olds has a central kitchen area for baking and sharing snacks. The room is organised to provide areas for a range of different play activities including role play, block play, gluing and model making, water play, mark making and small world play. There is a comfortable sofa and book corner. Resources are well organised and so that children can access them independently. The Centre has an outdoor area with climbing equipment, a swing, sand and a play-house. Children are free to move between spaces.

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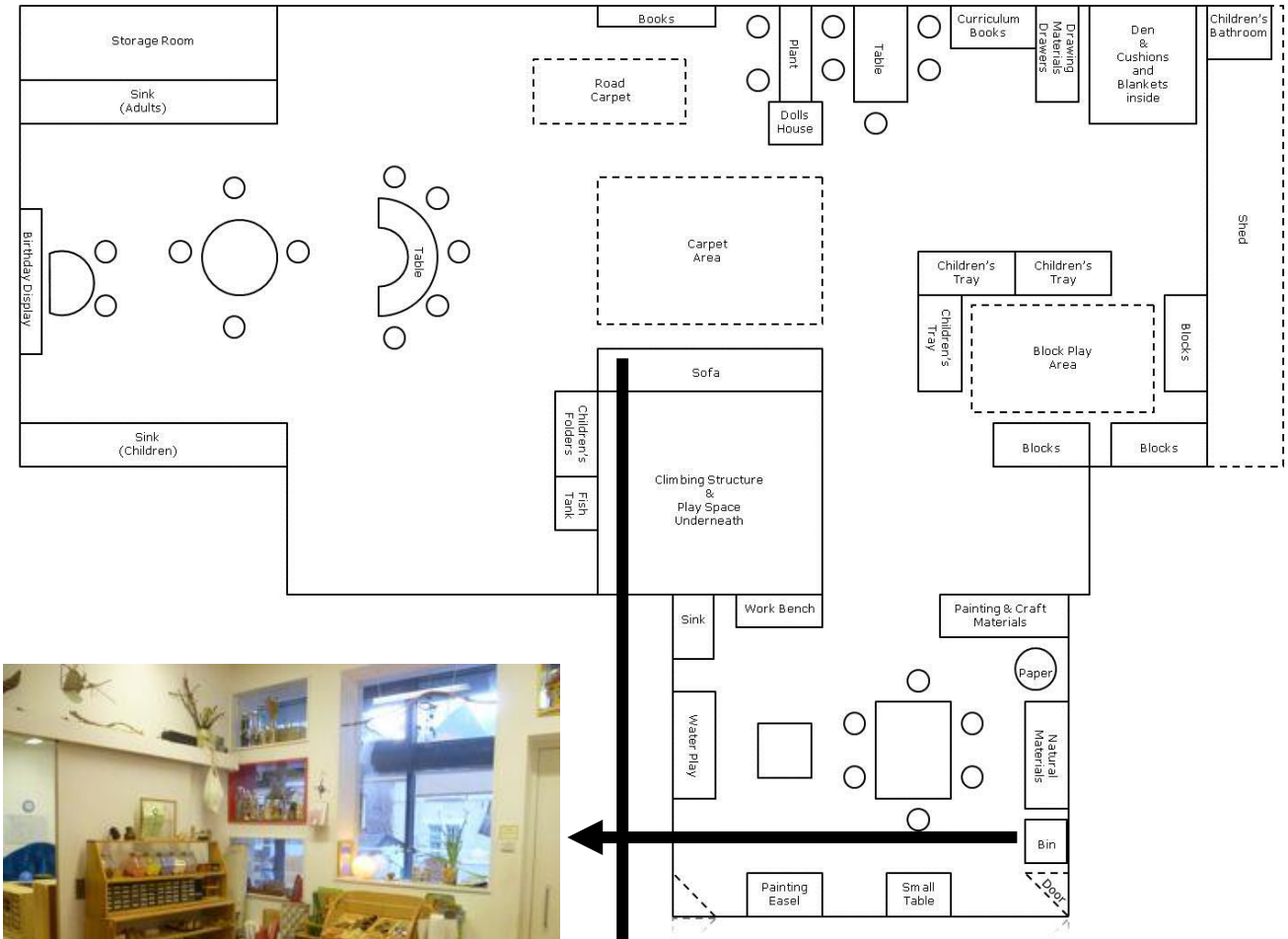
Sarah's Nursery Class at Forrest Children's Centre



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3.20.2 Episodes

Episode 1: Baking

Context

Baking is one of the regular routines at the children's centre and plays an important role in daily life at the centre. It features prominently in documentation for staff, parents and visitors. This highlights the meaningful opportunities provided for children to gain feelings of "*competence and control over their situation*" (Centre Booklets), as well as addressing many aspects of Scottish curriculum policy through **measuring** ingredients (Mathematics), **observing** properties and changes in materials (Science) or **refining fine motor skills** (Health and Well-being) (www.curriculumforexcellenceScotland.gov.uk). Photographs and commentary in children's profile records also make frequent reference to baking activities. This episode illustrates ways in which the centre staff seek to use the routines surrounding baking to foster children's independent action and to take advantage of incidental opportunities for measuring and counting building on the potential for dialogue grounded in this shared experience.

Pedagogical framing

Baking takes place on a table in front of a kitchen area set up in one corner of the classroom. In the session observed, bread making began at the start of the day (from 8.00am) as children were beginning to arrive. A laminated booklet provided information to support children's bread making with words and symbols to indicate the ingredients needed and each stage in the process. Ingredients as outlined in the recipe, balance scales, mixing bowl and spoons were set out on the table.

Image 1.1: Ingredients from the booklet on Baking Bread.

A **variety of additional resources** such as rolling pins, baking trays and name labels were accessible nearby for children to collect as they needed The organisation of resources was designed to **foster independence**.

Pedagogical interactions

This episode involved a child Amelie and Lara the Deputy Head. At each stage in the bread making process Lara focused Amelie's attention on the **recipe booklet** encouraging her to articulate what

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had to happen next and using **questioning** to **scaffold observation** and **accuracy in measuring** as illustrated in the examples below. Amelie took an active part in dialogue with Lara, **asking questions** to clarify what she needed to do and to check the **measurements** she was making She showed determination to do as much as she could herself using **equipment** with confidence. This dynamic is illustrated in the examples below.

At the start of the bread making Amelie began measuring out the flour, spooning it into the balance tray and watching its changing position. She **asked questions** and engaged in conversation with Lara to check her **measurement** of the amount of flour needed. In **scaffolding** Amelie's measuring Lara drew Amelie's attention on the visual appearance of the scales and **encouraged her to make predictions and reflect** on what she thought might happen:

Amelie: *"Do I need all of this?"*
Lara: *"Think we might do - Keep an eye on it – see if it balances."*
Amelie: *"If does not balance will we have to pour it into the bowl?"*
Lara: *"What do you think – maybe we might wait?"*
[...]
Lara: *"Let's have a look - are they balanced yet?"*
Amelie: *"No – I think we should put some more."*

Once balanced Amelie poured the flour into the mixing bowl. A similar process followed in weighing the margarine:

Lara: *"What's the next bit?" [Referring to the recipe]*
Amelie: *[Turning over the page] "Points."*
Lara: *"Now need 25g margarine [turning over the page] – So we don't need all of these weights – we just need a 20 and a 5 – that's a 20 and there's a 5. You watch out for the balancing."*
Amelie: "Balance!" [She pours the margarine into the mixture.]

Image 1.2: Amelie adding the flour

Image 1.3: Amelie adding the yeast

This was followed by mixing together the flour and the margarine and adding the yeast. Again Lara **fostered independence** by **scaffolding** the use of written instructions.

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Lara: *"What's the picture telling us here?"*

Amelie: *"Mix with your hands. [She starts putting in some of the extra flour that has spilled out.]"*

Lara: *"If you add all the extra flour what will it do to the recipe? We can use this later when we are kneading. What does our book show us?"*

[...]

Amelie: *"I am going to do that I can do both of them. [She cuts the top off the yeast packet.] Then I just mix it with my hands. I'm going to mix it. I think it will turn into bread. If we pour the water in we have to put our hands in after and into the oven."*

Then finally the water was added:

Lara: *"What's our next part? – Check [pointing to the recipe booklet]."*

Amelie: *"We put the water in, now you mix it - put a wee bit in then a wee bit in and then you put more water in. [She puts more in mixing with a spoon.] Put all the water in."*

Amelie then fetched a rolling pin to roll out her dough. In the final stages of the process Amelie made **observations** of the changes in shape and appearance of the dough and the fat melting on the hot baking tray prepared for her bread.

Sharing baking at snack time

A related episode later in the day added to the significance of the baking activity in the life of the Centre and indicated the **meaningful** opportunities offered by another important centre routine, associated with sharing bread and cakes at snack time, for supporting children's mathematical development. Children were helping to set out the table by the kitchen with spaces for six children. Teacher **questioning** throughout was used to **support** children in counting how many items were needed or how many spaces were available at the table.

Image 1.4: Sharing bread and cakes at snack time

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Opportunities for mathematics and science learning

Baking provided opportunities for addressing the following Numeracy Experiences and Outcomes from the Scottish Curriculum for Excellence (www.curriculumforexcellenceScotland.gov.uk) MNU 0-11a *I measure or weigh using appropriate instruments and units*. It also encouraged a range of *Inquiry and Investigative skills* in particular observing and exploring, asking questions, developing skills of reasoning and in offering opportunities for exploring materials and change made links with the Science Experiences and Outcomes related to Materials SCN 0 -15a.

Opportunities for creativity

Creative approaches to teaching are reflected in particular in offering **motivating and meaningful contexts** for learning linked to the everyday life of the nursery. The physical resources and environment for baking were attractive and well organised providing grounding for **dialogue** and language development related to balancing and number. **Scaffolding** of baking processes through nursery routines, the use of recipe sequence books and practitioner **questioning** was used to **foster** children's **independence and confidence.** The Centre routines provide a predictable context that offers possibilities for **questions and reflection** around this shared experience.

The responses of the child in this episode provide evidence of the child's **curiosity and motivation**, shown in her **active engagement** in dialogue with the practitioner and her determination and growing confidence in handling equipment. The child's active interest in baking and her growing understanding of the processes and purposes of measuring were further illustrated by subsequent visits. As indicated in the introduction to the case, the nursery actively encourages children to follow their interests over time. The child chose to engage in baking bread or cakes on each day we visited. In an interview with her about her baking experiences she highlighted her growing understanding of the processes of measuring and their importance.

> *"I'm putting in the flour - The scales weigh the flour – When you need how much - Then you put in the bowl. It balances when it goes like that (demonstrating with her arms and hands, showing them at the same level). You know it's enough. Then it goes in the bowl. Then you have a big jar full hot water - tells you how much – pour it all in the big bowl. It matters how much, it tells you how much."*

Episode 2: Forest School

Context

The setting for this episode is a protected wildlife area in the city walking distance away from the Centre that offers a variety of opportunities for exploring the natural world. The fact that it is 'hidden' away right in the heart of the city contributes to making it a special place for the children. For example it has open areas of vegetation, woodland and a pond. There are piles of rotting logs and a composting area. A walkway has been set up to offer access to different parts of the site. Children visit the site on an eight-week cycle. They are able to see change over time as highlighted in the interview with Sarah:

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"seeing that place and being there in all weathers that's very important in schools – going to the same place and up the same road to get there – of course every time is different – they are affected by the weather, by the temperature, they notice that things that were here last week have been eaten or whatever that is."

Sarah indicated that the children also bring ideas and materials back to the centre, for example ideas for moving water or a hammock in the outdoor area and physical materials such as water samples from the pond or plant material fostering on-going links between contexts.

Image 2.1: Forest School Setting

Image 2.2: Making a shelter

Activities and routines at the site have been developed over time, influenced by children's responses as well as incorporating common Forest School activities. These include making a shelter, litter picking, making a fire for cooking, climbing and balancing using ropes, as well as observing changes in the natural environment.

Pedagogical framing

On the day of the visit it was snowing. Centre staff, in partnership with parents, organise clothing and resources carefully to enable visits in all weathers. All children had waterproof clothing, hats, gloves and boots. Mats, blankets, thermal clothing, warm drinks and snacks were taken to help children keep warm and comfortable. The outdoor trip, in harsh weather, offered the chance to encourage reflection on needs for survival, including warmth and shelter. A **variety of equipment** was packed to support activities at the site, including tarpaulin and ropes for making a shelter, magnifiers, binoculars and a camera to support observations, litter pickers and spades. Sarah was joined by two other adults on the visit, Marta and Gareth.

Pedagogical interactions

Conversations between adults and children on the way to the site focused on **observations** of the feeling of the wind and ice particles on their faces. Adults **asked questions** to encourage children to articulate their **observations** and to speculate on possible **explanations** for grit and salt on the paths. When they arrived at the site they collected together to count who was there and to sing their Forest School song, a routine at the start of the visit. Sarah suggested various activities children might undertake including making a shelter, litter picking, climbing with ropes and observing ice on

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the pond. Children were encouraged to pursue their own interests. During the morning one group led by an adult made a shelter where children had their snacks in the course of the morning, another set off litter picking and a third group remained by the pond. At the end of the morning, adults set up and supported a climbing activity with ropes.

This episode follows the explorations of Ian to illustrate the opportunities provided for children to follow their own interests and make connections to their previous experiences at the site. His immediate focus was the pond. He poked the ice with a spade. He **observed** holes in the ice and collected some water in his spade to look at it more closely. Sarah **built on his interest** drawing attention to the differences in the pond compared to the previous week and suggesting that he might look at the water more closely with a magnifier as indicated in the dialogue below:

Sarah: "It wasn't frozen last week was it?"
Ian: "It's got a little hole there."
Sarah: "I wonder why that is? Can we find a reason why?"

Ian pokes the ice with a spade and picks up some water in the spade to look at closely:

Sarah: "Very muddy water isn't it? Full of all sorts of things. Possibly if we had a really good look with a microscope we might see something?"
Ian: "I know we can put some water in and put the top back on."
Sarah: "You mean in one of these ones [a magnifier] – if you put something in you can look through the top – try that one."

Ian put some water and ice in the magnifier – and held it up to show – *'sample of water – it's a little piece of wood'*. He took another scoop of ice and water with his spade to look at.

Some time later he was still at the pond. This time he was poking at the ice with a litter picker.

Marta (a Nursery Nurse) asked him about what he was noticing, **encouraging him to explain** what he was doing. Ian talked about his **observations** and the **reasoning** behind his actions.

Marta: "What can you see?"
Ian: "Bubbles"
Marta: "Where do you think they are coming from?"
Ian: "Animals – may be frogs? Maybe air coming up?"
Marta: "You're doing a good job – the animals will be really pleased. Can you see the bubbles moving around?"
Ian: "Putting more air for the animals."
Marta: "Feeling softer now [ice changing to water]."

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Image 2.3: Ian breaking up the ice with a litter picker

Image 2.4: Bubbles in the pond

Ian was splashing round the edge of the pond now, breaking up the ice.

Ian:	*"Can see big bubbles – when you hit the bubbles it makes much more."*
Marta:	*"Why are you rescuing the animals?"*
Ian:	*"So they can breathe – whole pond nearly dug up now – saw breathing."*
Marta:	*"How do you know?"*
Ian:	*"Saw bubbles"*
Marta:	*"What do you think it would be?"*
Ian:	*"Maybe a frog?"*

Later Ian took the researcher to photograph the different fungi he had noticed, another developing area of interest over time.

Image 2.5: Ian's photograph of fungi

In a conversation with the researcher about this visit to Forest School later in the afternoon Ian highlighted these two activities, **making connections** with previous experiences at Forest School.

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Ian:	*"When I went to Forest School it was brilliant. I liked the most taking pictures [of fungi] and that was the best thing I did there."*
Researcher:	*"So the best thing was taking pictures?"*
Ian:	*"And lots of smashing ice on the pond."*
[...]	
Researcher:	*"What were you doing in smashing the ice – what were you doing that for?"*
Ian:	*"So the animals could breathe under the ice?"*
Researcher:	*"Have you been there another time? Have you seen any animals?"*
Ian:	*"I think I been there a long time ago."*
Researcher:	*"What did you see?"*
Ian:	*"I think I saw frogs in the summer – and before I saw frogspawn."*
Researcher:	*"That sounds exciting what was it like?"*
Ian:	*"It was sort of jelly – and tadpoles inside the ball of jelly."*
Researcher:	*"Wow"*
Ian:	*"Not the kind of jelly from what you eat and got tadpoles inside it."*

During the afternoon, photographs taken by Ian in collaboration with Sarah were included with Ian's reflections (**self assessment**) in his profile.

Opportunities for science learning

Activities at Forest School provided opportunities for addressing the following Science Experiences and Outcomes from the Scottish Curriculum for Excellence (www.curriculumforexcellenceScotland.gov.uk)

SCN 0 – 01a '*I have observed living things in the environment over time'*

SCN 0 – 05a '*By investigating how water can change from one form to another I can relate my findings to everyday experiences'.*

It also encouraged a range of *Inquiry and Investigative skills* in particular observing and exploring, considering risks and hazards, asking questions, developing skills of reasoning.

Opportunities for creativity

The visit to Forest School offered rich opportunities for fostering creative dispositions including **motivation, curiosity and sense of initiative** reflected in Ian's active pursuit of his interests and observations. He showed **imagination and made connections** to his prior knowledge and experience in seeking to explain the bubbles he noticed in the pond and his actions in breaking the ice.

Features of creative teaching were reflected in the opportunities for learning in the **outdoor environment** made possible by careful organisation and preparation of **materials** to support **explorations** and ongoing assessment with children of the potential risks involved (for example in climbing or breaking the ice). Adult interactions fostered children's **own interests actively encouraging explorations**, **questioning** was used to encourage children to extend observations and **articulate explanations**.

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Episode 3: Scout Camp

Context

The context for the episode is a visit to a 26 acre wild space at a scout centre just at the edge of the city. The site includes a variety of features including open grassland, wooded hillsides and a river. Children from the Centre visit on a regular basis in a minibus. Children choose whether they wish to go in collaboration with parents and staff. Photographs of visits to the site feature frequently in children's profile records and informal conversations. The site offers experience of a broader range of environments than the Forest School site described in the previous episode and children visit over longer periods of time to offer extended opportunities for the development of ideas. It provides opportunities for adventurous and challenging physical activities and for close **observation** and study of the natural world. The place of visits to the site within planned Centre activities also reflects the priority given to prompting the holistic development of each individual child based on their **interests** and fostering **citizenship and environmental awareness**. On this occasion the visit was led by two staff members Tamara and Linda.

Image 3.1: The Base Camp

Pedagogical framing

As in the previous episode, routines associated with the careful organisation of appropriate **materials**, including suitable clothing, blankets, mats, food and drink are essential to keep visits safe and comfortable at all times of year. There is an enclosed base camp area with a yurt to allow a sheltered space to collect and eat in winter. The camp also includes a fire pit and a barbeque area. During their visits adults and children set off in a group to explore different areas within the site. There are clear structures to ensure safety with set stopping points for everyone to collect together and assess possible risks ahead. There is a strong emphasis on the **involvement of children** in the evaluation of risk. Snacks and drinks are shared too at regular intervals. This provides time to rest,

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get warm and plan ahead. Activities undertaken at the site are less structured than at Forest School, often prompted by **children's observations and ideas** as they **explore** different parts of the site during the day. In some cases there is joint activity involving both children and adults but in general the adults **stand back**.

Pedagogical interactions

During the course of the day there were rich opportunities for children's **observation, questioning** and **planning** indicated by the focus and direction of children's explorations. In some instances children made **connections** between observations or with previous experiences. The wide range of experiences over time allowed for impromptu conversations between children and between children and adults about a wide range of issues as illustrated by the examples below.

At the base camp, following a snack in the yurt, Ian followed by Vanessa started rubbing twigs against the metal structure over the fire pit, trying to get the bark off "*to see if there are any beasties"* **questioning**). Later children began running up and down the mounds of chipping in the enclosed base camp area. Mark noticed "*it's easy if you go down and then up"* (**making connections between observations**).

Image 3.2: Vanessa trying to find 'beasties'

Image 3.3:Running up & down the mounds

In their first walk round parts of the wider site adults and children went up the hill towards the river. On the bridges across the river Tamara encouraged the children to **listen** to the sound of the water. This reflected an important emphasis throughout the visit on the use of senses of touch and hearing – not just sight. Amelie collected fir cones to take back to the Centre (again providing a bridge between experiences in the wider environment and activities back at the Centre). Beth and Karla picked up twigs and waved them around as they walked. Beth **made comparisons** between their sticks "*I've got a bendy stick – mine's a fishing rod – yours is a straight one"*. Vanessa noticed a big hole in a tree and stopped to stare up and **questioned** "*maybe someone inside?"* She is lifted up to look.

Following a return to base camp and snacks, the group set off to higher ground and a stopping point in another part of the site. There were muddy patches on the slope as they climbed up that were

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crunchy with ice. Callum spent time stamping up and down on them, **listening** to the sounds he was making. Towards the top of the hill there was a grass sledge run. Children spent time climbing up and then running down, mirroring their actions with the smaller slopes at base camp.

Image 3.4: The grass sledge run

Image 3.5: Ava pulling Vanessa on the rope swing

The next stopping point was even higher up. Here some children explored the roots of an upturned tree. Ian commented "*looking to see if I can find any beasties*". This was an enduring area of interest shown in removing the bark off twigs at base camp and in his activities the previous week at Forest School. Linda and a group of children went to set up a swing using ropes slung over a fallen tree. Linda encouraged the children to show her how to tie the ropes to the tree. Children took turns to sit in the rope swing and be pulled. Vanessa sat on the swing with Ava pulling her backwards and forwards. It was hard work and Ava was pulled down the hill as she released the rope each time. Linda suggested "*pulling gently Ava*" so she could keep her footing. On the way back down to base camp there were further opportunities for **exploration and observation** for example to find sticks with pine cones, **smell** the sticky resin from a pine tree or make a den inside a clump of rhododendrons.

Throughout the day adult interactions with children focused on encouraging them to observe using all their senses and **follow their own interests and explorations**. There were informal opportunities for conversation and for **sharing their own enthusiasms** for the natural environment. However in general the adults **stood back** and took an organisational role in relation to the structure of the visit, safety and the management of resources.

Opportunities for science learning

Activities at Scout Camp provided opportunities to address elements within the following Science Experiences and Outcomes from the Scottish Curriculum for Excellence (www.curriculumforexcellenceScotland.gov.uk)

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SCN 0 – 01a '*I have observed living things in the environment over time'*
SCN 0 – 07a '*Through everyday experiences and play with a variety of toys and other objects I can recognise simple types of forces and describe their effects'*
SCN 0 – 12a *'I can identify my senses and use them to explore the world around me'.*

They also encouraged a range of *Inquiry and Investigative skills* in particular observing and exploring, considering risks and hazards, asking questions, developing skills of reasoning.

Opportunities for creativity

Rich opportunities were offered for the promotion of children's creative dispositions, in particular **motivation, curiosity and sense of initiative** in pursuing their own interests. Activities such as stripping bark, running up and down slopes and investigating the roots of a tree, were initiated by children, often drawing in others to join them.

In addition to the focus on children's **explorations** and **agency**, other key features of the creative approaches of staff at the Centre include the **connections** they notice and foster between experiences at the Scout Camp, Forest School and the Centre as well as encouraging children to make links with prior experiences and experiences over time. Fieldnotes from observations at Scout Camp, Forest School and the Centre, and photographs and comments in children's profiles provided evidence of the persistent interests of individual children across the three different settings, such as climbing and swinging on ropes, finding 'little beasties', or exploring slopes. The interview with Sarah indicated ways in which children's experiences have brought new ideas and materials back to the Centre and influenced the development of resources in their outdoor area. For example the swing has been replaced at present by a hammock. Loose branches have been added in parts of the outdoor area site and a water pump installed to give the sounds of moving water. There are plans for a dry riverbed in progress.

> *"They brought back ideas for things like water here – they wanted water to be here – we already had the little pond but that's when we got the pump and they wanted that to be moving water because the sound lends itself – we hadn't had the sounds – that has led on to now wanting a dry riverbed which we have sort of started to do…. bringing their ideas of we need to have something to swing on here so that's why we've got the – we had a swing which was made by children with Dan and that has been replaced by the hammock at the moment. Even the things like having the loose branches – this has influenced us and we have brought branches from Scout Camp."*

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3.20.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

What role if any does creativity play in these?

Visits to the Centre, Centre documentation and discussions with staff and children provide evidence of the strong focus on **play** and on children's **agency** in the approaches to learning and teaching adopted by Sarah and the other staff at the Centre. There is an emphasis on children's use of all their senses to **explore** the world around them and encouraging **questioning, curiosity** and allowing **space and time** for children to develop their own interests. Children were encouraged to participate in **taking responsibility** for the care of the Centre and in assessing risk in tackling physical challenges associated particularly with outdoor learning.

Staff at the Centre give importance to the provision of a rich and supportive **physical and emotional environment** and to the need to **model positive attitudes** and interests. In general their approach is to **stand back** and to trust that children will experiment, explore **on their own initiative**. Centre routines (such as those associated with baking) are used to foster children's **independence**. Assessment information and dialogue with children associated with their Learning Folders are used to track children's interests and to inform and extend provision.

Opportunities for **learning in the outdoor environment** are central to the experiences for children provided at the Centre. This includes for example visiting museums, shops and the local recycling centre as well as Forest School and Scout Camp as described in the episodes above.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

How do teachers perceive their role in doing so?

Observations in the Centre provided evidence of children's **curiosity** and i**ndependence** in developing and pursuing their own interests over time. Children **raised questions** and **made observations.** There were examples of children **making connections** between experiences and events – between home and the Centre, indoors and outdoors and between experiences over time as they developed their ideas about **living things, materials and physical processes**. Dialogue between children and adults associated with children's Learning Folders encouraged **explanations** and **reflection on learning**.

As suggested above, Sarah emphasised her role in providing a **rich range of experiences** at the Centre and the **wider environment** to foster children's interests in the world around them. She indicated the value of Centre routines and organisation in supporting children's independent action. Sarah also underlined the need to recognise and have confidence in children's capabilities, giving

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them **space and time** to pursue their own **explorations**. Sarah expressed the importance of fostering children's holistic development and encouraging **positive learning dispositions**. In particular she highlighted the need for adults to model care and citizenship and the importance of involving children in responsibility and decision making at the Centre.

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3.21 Case: 'Maria'

3.21.1 Context

Where?	Country	Scotland			
	Setting name	SC3 - Lorna			
	Location within setting	Primary School			
Who? (children)	Year group/age of children	P2 Age 6-7 years old			
	Number of children in class	30			
Who? (adults)	Number of adults	One adult in two of the three episodes, and two in one episode			
	Role of adults	Teacher only, but in one episode a student teacher was also present			
	Case teacher role	Lead teacher, sole responsibility for class			
When?		1	2	3	4
	Dates of visits	060213	070213	200213	210213
	Times of visits	09:00-15:00	09:00-15:00	09:00-15:00	09:00-15:00

School/Setting

Located within an affluent residential neighbourhood of a large city in Scotland, Lorna Primary School is a state-funded non-denominational nursery and primary school, serving around 500 children from age 3 to 12 years. According to the school's website, its vision is to be *"a caring, nurturing community where everyone can develop skills for life, learning and work"*.

The school was last inspected by HM Inspectors in 2005, and its teaching processes, pupils' learning experiences and self-evaluation were judged to be 'good', while the school's leadership, its pupils' attainment in mathematics and its expectations and promoting achievement, among others, were judged to be 'very good'.

Teacher

Maria is in her mid to late 20s, and holds a BA in Psychology degree and a Scottish post-graduate teaching qualification (PGDE) in Primary Education. Of her four years of teaching, she had taught P1 classes (5-6 years old) in the first three years, and the current academic year is the first time that she has taught a P2 class (6-7 years old).

The highest formal education level at which Maria studied science and mathematics is at the upper secondary education level. In the survey, she self-reported her confidence level for knowledge and understanding of important scientific ideas, processes and scientific inquiry, as well as her

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competencies to carry out scientific inquiry and her knowledge of mathematics pedagogy to be high. During the previous 18 months, she had taken part in a professional development course on mathematics subject matter.

From the interview, Maria identified "*discussing, talking and learning*" and "*allowing children to express themselves in different ways*" as being very important pedagogical features to help foster children's creative thinking.

In terms of planning, once the curriculum outcomes have been established at the beginning of the term (e.g. to know about senses), Maria said that she would normally ask her children what they already know and want to find out about the topic. This was illustrated through the science board display, which, at the time of the fieldwork, showed four main questions about the *senses* topic that were reduced from around thirty questions put forward by the children. Examples of the main questions included 'What are our senses and how do they work?' and 'Why are our senses important?'

Classroom

There are 30 children in the class, with 15 boys and 15 girls. Of the 30 children, the majority are 'White Scottish' or of 'other White' backgrounds, 8 children are EAL; only 2 children are eligible for free school meals; and only 1 child has special educational needs.

From the interview with Maria, children are grouped by ability in mathematics, and Maria used her children's mathematics assessment information from the previous academic year to help inform her initial grouping decisions. Children can be moved up and down in their ability groups as the year progresses, and according to the Maria their grouping "is constantly evolving". There are three main ability groups in mathematics, namely the Purple (extension), Orange (core), and Yellow (reinforcement) groups. In science, children work in mixed ability groups, and sometimes, they are grouped by their behaviour. Each child has both Numeracy and Science individual profiles with all their homework and in-class worksheets kept in them.

In terms of the classroom setting, the classroom is spacious with typical Victorian-period tall windows, starting from around 1.5 metres off the floor and going all the way to the ceiling. This is useful in terms of letting the natural light into the classroom, without children being distracted by what is happening outside.

The classroom is well resourced with an interactive whiteboard at the front of the classroom, next to the teacher's computer and printer, and a traditional whiteboard at the back of the classroom, which the teacher uses to display the day's date and learning objectives of all the lessons on that day. There are four main clusters of desks and an arts and crafts table in the back corner of the classroom. There were displays round the walls including 'Our Five Senses' display, featuring key topic terms, such as 'sight', 'dark', 'light' and 'dim', as well as a list of key questions about the topic about which pupils wanted to find out more, for instance, 'What are our senses and how do they work?' and 'How can we make different sounds?' There was also a 'Numeracy' board display, where

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several number bonds of 10 were shown, as well as various 2D shapes; while 'Our Golden Rules' and 'Behaviour Rockets' board displays acted as a reminder to children about how they should behave to create an effective and collaborative learning environment.

In addition to a small reading corner with a few books in the shelf, there was also a small home corner on the side of the classroom with a small dining table, a kitchen sink, a kitchen cabinet and a microwave present. The existence of the home corner in Maria's class – a P2 class - reflects the Scottish *play-based* approach up until the end of the P2 level.

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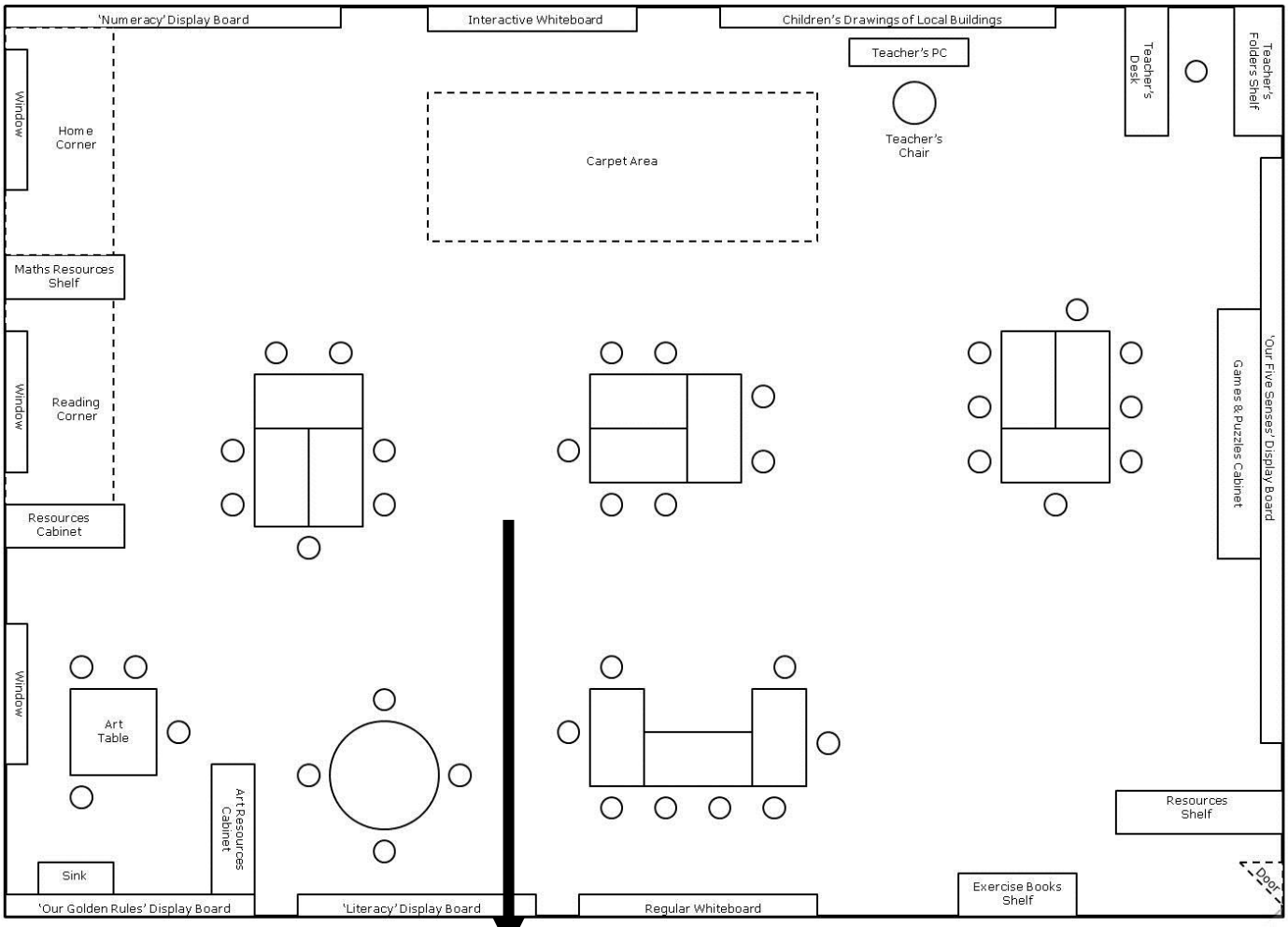
Maria's P2 Class at Lorna Primary School



3.21.2 Episodes

Episode 1: Alien Challenge

Pedagogical framing

The focus of this lesson was on counting in twos. For the two top **ability groups**, this learning intention was extended to counting in twos and threes (Orange group), as well as fives (Purple group).

Drawing on the Alien Challenge game (*see below*) that the Yellow (reinforcement) and Purple (extension) groups had played previously, the teacher introduced the concept of counting in twos using a number line. This connection was made to help pupils progressing from counting in twos (objects that were clearly presented in pairs) to working with numbers on the number line where the *pair* boundary is no longer explicit, as illustrated in the exchange below:

Maria: *"So we've been looking at our towers of two objects. We've been counting in twos. How else have we counted in twos? What else have we used to count up in twos?*

[…]

George:"Aliens"

Maria: *"Yes. How have we used aliens to count in twos?"*

Linda: *"You drew the picture."*

Maria: *"You drew the picture and how did you count it up?"*

Linda: *"The arms"*

Maria: *"Yes, the arms. So we know that one alien has …?"*

Children: *"Two arms"*

Maria: *"Two aliens have …?"*

Children: *"Four arms"*

Maria: *"OK and so on. [inaudible] The other way that we can count in twos is by looking at a number line. OK, so usually we start at zero or we start at one and then go to the next number, but when you count in twos, starting from zero, we have to miss out a number. Zero to …?"*

[Maria drawing a two-number 'jump' line from zero to twenty]

Children: *"Two … four … six ... eight … ten … twelve … fourteen … sixteen … eighteen … twenty."*

Maria: *"Right, OK then. So this way, instead of counting in the lots, you can count the jumps, can't we?"*

The following episode is drawn mainly from two children in the Orange group, identified as Tom and Talisha.

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Pedagogical interactions

After the carpet session, the Yellow and Purple groups were sent to their tables, while the Orange group were asked to remain on the carpet so Maria could explain the task to them. The full transcript of the Maria's explanation of the task is included below to provide the background to subsequent discussion of the opportunities afforded for the development of Tom and Talisha's creative dispositions:

Maria:	*"OK, so you [the Orange group] are going to do the Alien Challenge today, ok? And once you've done … may be five times doing it with two arms, may be you can do some aliens with three arms, and see if you can count up in threes, OK Orange group? So can somebody from the Orange group explain to me how to play the Alien Challenge?"*
Sally:	*"Roll the dice [inaudible]."*
Maria:	*"So you roll the dice. What number are we going to pretend we roll? May be […] five?"*
Sally:	*"Five."*
Maria:	*"Five. OK, so you've rolled the dice and you've got five. So how many aliens do you need to draw?"*
Sally:	*"Five."*
Maria:	*"Five aliens. And how many arms should each alien have?"*
Sally:	*"Two arms."*
Maria:	*"OK and then underneath you've got to write [on the small whiteboard] 'Five aliens have …' How many arms altogether?"*
Children:	*"Ten arms."*

Children in the Orange group were asked to work in pairs, and each pair was given a small whiteboard, a marker pen, a rubber and a dice.

By the time the researcher came to observe Tom and Talisha, Tom had nearly finished drawing his four aliens, whilst Talisha was waiting for her turn to roll the dice and to draw her aliens on the whiteboard. In accordance with Maria's instructions, Tom drew aliens with two arms, but since Maria did not say anything about the aliens' eyes, he decided to decorate the aliens with several eyes each. The first, second, third and fourth aliens had three, four, five and six eyes respectively. Talisha looked on carefully while Tom counted the number of the aliens' arms and **communicated** his calculation by writing: '4 aliens with 2 arms is 8'.

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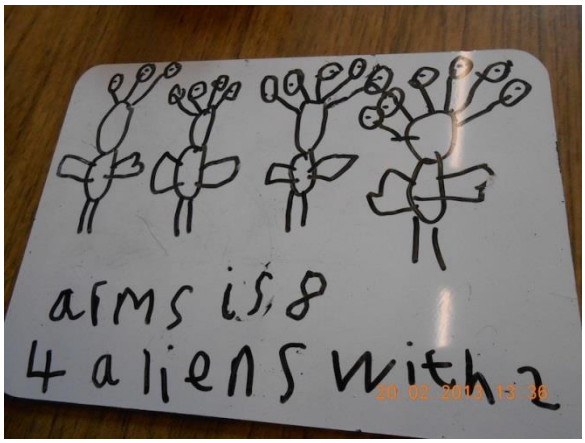

Image 1.1: Tom's drawing of the aliens

When it was Talisha's turn, she rolled the dice and got number 3. She adopted Tom's idea (Tom: "*See! She's doing the same as me, aren't you?")* and gave her aliens different numbers of eyes: the first, second and third aliens had two, four and six eyes respectively. However, instead of counting the aliens' arms, she decided to count in twos the aliens' eyes. This example indicated that while it was Tom who was the first to introduce number sequence into the task, it was Talisha who was actually **making a meaningful connection** between counting in twos and the number sequence*:*

Researcher:	*"So, how come this alien only has three eyes, four eyes, five aliens, and this one has six eyes?"*
Tom:	*"Because it's going up."*
Talisha:	*"Yes … two … four … six … eight like that."*

The fact that Talsiha had already listened to Maria's explicit instruction; had observed Tom counting his aliens' arms and writing the total number of the arms on the board; and had already been told by Tom to count the arms instead of the eyes: and yet still decided to count her alien's eyes and wrote down '3 aliens with 2 arms is *[sic] 12 [eyes]'*, demonstrated how she took the initiative in **designing her own investigation**:

Talisha:	*"I've done three aliens."*
Tom:	*"With two arms. Let me count: two … four … six.* [Using two fingers to point at each alien]"
Talisha:	*"Two … four … six … eight … ten … twelve.* [Using her pen to point at each pair of the alien eyes]"
Researcher:	*"Twelve what? Twelve arms? Twelve eyes or twelve feet?"*
Tom:	*"Two … four … six. No it's two arms.* [Using two fingers to point at each alien]"
Talisha:	*"I only count the eyes. Two … four … six … eight … ten … twelve."*

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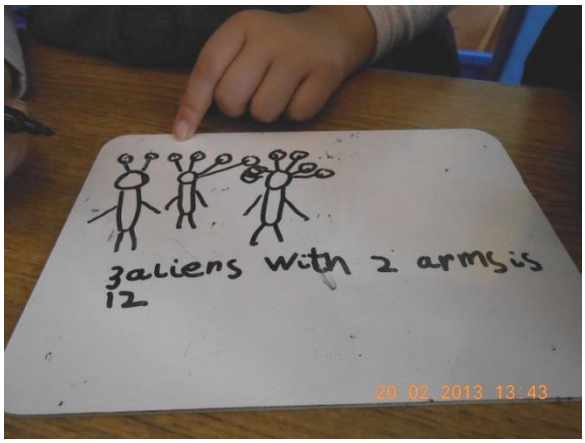

Image 1.2: Talisha's drawing of the aliens

The fact that children were paired up did not just mean they were taking turns in rolling the dice and drawing on the board, a degree of meaningful **collaboration** and **dialogue** was also noted, for example, when Tom tried to explain to Talisha that she needed to count the aliens' arms instead of their eyes; when Talisha reminded Tom to write the summary ('4 aliens have 8 arms') below his drawing, and helped him with the spellings; and when Tom helped to count Talisha's aliens' arms.

Moreover, it was also noted that both Tom and Talisha adopted different finger gestures when counting in twos. Whilst Talisha chose to use her pointing finger to point in the middle of each pair, Tom chose to use both his middle and pointing fingers to point at pairs of aliens' arms, creating a boundary of where a pair begins and ends. Such variety of counting techniques meant both children were exposed to and could learn from each other's techniques.

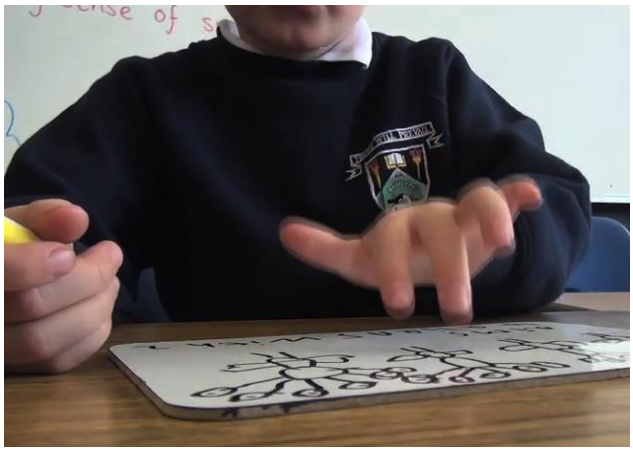

Image 1.3: Tom's counting-in-twos strategy

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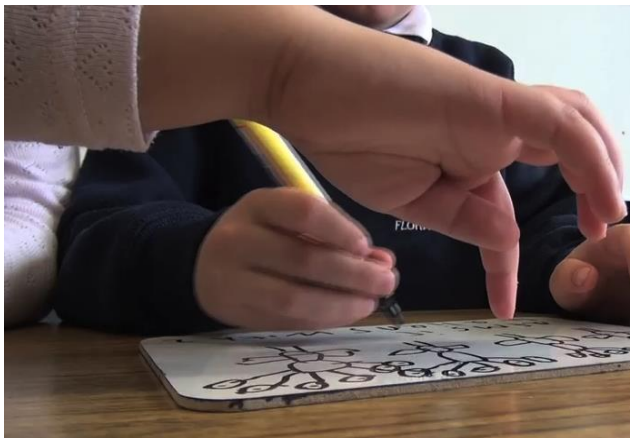

Image 1.4: Talisha's counting-in-twos strategy

Given the **informal** nature of the activity, which was presented as a game, the children were **highly engaged**. The problem solving aspect of the game also allowed children to become the **primary agents** of their own learning, without intervention from the teacher.

Image 1.5: Children working in pairs

Opportunities for mathematics learning

The focus of this lesson was on counting in twos, which resonates with the Experiences and Outcomes for Numeracy found in the Scottish Curriculum for Excellence's expectation within the 'Number and number processes' section: MNU 1-03 * **'***I can use addition, subtraction, multiplication and division when solving problems, making best use of the mental strategies and written skills I have developed'*. There were also links to the broader aim of enabling learners to '*apply skills and understanding creatively and logically to solve problems, within a variety of contexts'*.

Opportunities for creativity

Whilst not planned, the fact that Maria did not make explicit what to do with the aliens' eyes and how she chose to **stand back**, allowed children some freedom to **take their own initiative** in designing number sequences related to their aliens' eyes, and hence helped foster their **creative thinking skills**.

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More importantly, this then led to children **making connections** between counting in twos and number sequence. Arguably, this created a more challenging task than simply counting the arms, as whilst the arms were clearly presented in pairs, the eyes were not grouped in that manner.

Finally, Maria's creative use of alien characters allowed for children's **imaginative thinking**. Had the children been asked to draw, for example, human characters instead, the chance of Tom and Talisha creating number sequences by giving each human character three or four eyes would have been less likely.

Episode 2: Price Prediction

Pedagogical framing

The learning intention of this lesson varied across the three **different ability groups**. For the lower ability group (Yellow), they were expected to be able to describe and compare different coins, whilst the middle ability group (Orange) were also expected to be able to order coins according to their values. For the higher ability group (Purple), not only were they expected to order coins, they were also expected to be able to predict how much things cost.

The lesson started with a whole-class discussion about how money is used. A number of topics were briefly considered, ranging from the purpose of money to alternative ways of payment, such as the use of credit cards and on-line payments. Using images of the different coins on the interactive whiteboard, children were asked if they could recognise any of them. Large cardboard coins were later used to get children to put them in order of their value. The children were then asked to describe the coins using their colour and shape before being sent to their different tables to work on different tasks.

The following episode is drawn from the subsequent interaction between Maria and the Purple group during the that group's introduction activity, which involved the use of a variety of physical objects, such as a CD player, a DVD, a book, and a bottle of water. Additionally, the episode is also drawn from the child-to-child interaction of three pairs of children, identified as: George and Jonathan; Linda and Anna; Kavita and Radha.

Pedagogical interactions

Sitting in a circle and in an **informal** learning setting, children in the Purple group were shown a **variety of objects**, such as a CD player, a DVD, a book, and a bottle of water, as well as the £150, £9.99, £4.99 and 99p price tags. Children were asked to **discuss with their talk partner** the price of the different objects. Most agreed that the CD player was the most expensive with explanations ranging from it being *"the biggest thing"* to "*all gadget stuff are expensive"*. Later when a question arose about what was more expensive between a DVD and a bottle of water, a pupil said a bottle of water and **explained** that it was because water *"will help you more*", suggesting that the price of an item should be based on how useful it is to one's health.

Each time a child was invited to identify an object that was the most expensive; second most expensive; second cheapest and cheapest, other children were also asked to give a thumb up if they

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agreed with their peer's answer; a thumb down if they disagreed, or a thumb side if they were not sure.

Image 2.1: Maria using physical objects to explain the worksheet to a group of pupils

Image 2.2: Children's attempts at predicting the price of each object

The children were then given a worksheet, which showed images of eight different items with three different price options next to each of the items. Examples of these items ranged from a holiday abroad and a football to a computer and a hardback book. In order to provide a **rationale** for their own pricing decisions, it soon became apparent that children adopted different strategies, such as drawing from basic **observations** of the items in question to drawing from their **out-of-school knowledge and experiences**.

An example of the former strategy would involve simply associating 'heavy' and 'big' properties and a large quantity with the notion of expensiveness:

Researcher:	*"Can you tell me why do you think it would cost £150 to buy a bike?"*
Radha:	*"Because it's heavy."*
[…]	
Researcher:	*"Can you tell me why do you think it costs only 15p to buy a sweet?"*
Kavita:	*"Because it's just one thing and it's just so tiny."*

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Additionally, there was a range of examples of the second strategy whereby children drew from their out-of-school knowledge and experiences:

Researcher: *"For the holiday abroad, how much do you think it cost?"*
Linda: *"I think it would cost £260."*
Anna: *"£260."*
Researcher: *"Why do you think it wouldn't be just 78p?"*
Linda: *"Because I've been on a flight to Geneva, and it was like [inaudible] I know it was very expensive, so I did the highest score."*
[---]
Researcher: *"Do you find the laptop question tricky?"*
Linda: *"No, because my dad has three of them and he looks after them very well, and so it must be very expensive."*
Researcher: *"I heard you [George] explained something to your friend [Jonathan] about that [the price of the holiday abroad]. Can you tell me a bit more about that?"*
George: *"Because my dad said that it would be even expensiver [sic] to go on a boat, so I did that [chose that price] for the plane."*

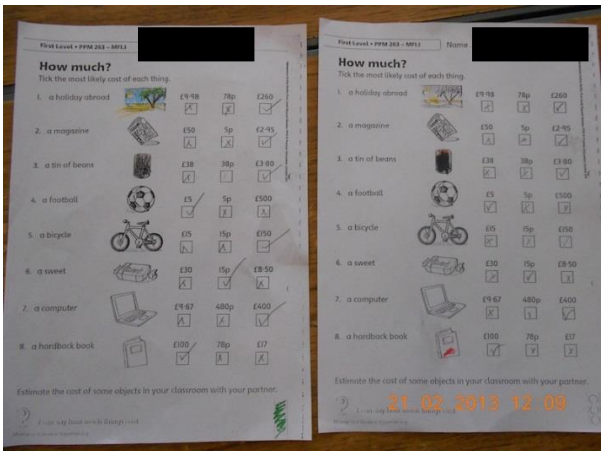

Image 2.3: Examples of children's work

Through the researcher's questioning, it was found that some children's rationale for their pricing decisions went beyond simply observing the items' basic descriptions or drawing from their direct experiences of encountering those prices. In the case of George, for example, he was arguably able to justify his decision using some principles of the market:

Researcher: *"What about the football? You said £5. Why?"*
George: *"Because no one really likes football. […] It's mostly like rugby that they liked."*
Researcher: *"So if this was a rugby ball, would it be more expensive than £5?"*
George: *"It would be that much [pointing at £500]."*
Researcher: *"Really? Why it would be that much for a rugby ball?"*

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George:	*"Because they're trying to get people to really like football."*
Researcher:	*"So if you want to get people to really like football, what do you do with the price? Do you make it cheap or do you make it expensive?"*
George:	*"They'd make the football cheap and they'd make the rugby ball really expensive."*

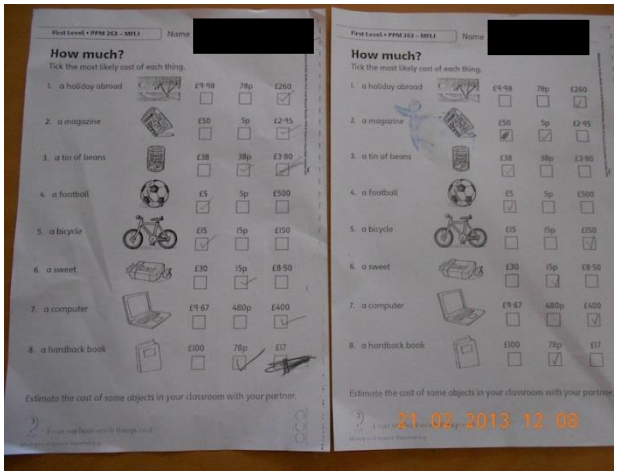

Image 2.4: Examples of children's work

Furthermore, throughout the activity, a degree of **collaboration** and **dialogue** was evident, and not only did such interaction among children allow them to learn from one another, it also provided an answer checking mechanism. For example, when George was asked to explain why he had indicated on his worksheet that a hardback book should cost only 78p:

Researcher:	*"What about the book? You said 78p [George] and you said £17 [Jonathan]."*
George:	*"Because every time when I go to the library, it doesn't cost that much."*
Jonathan:	*"Well that's only borrowing them!"*
George:	*"Oh yeah!"*

Image 2.5: George and Jonathan working together

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On the bottom of the worksheet, children could also **self-assess** through indicating how well they understood the task through the use of the 'traffic light' system, whereby the green colour would indicate that they understood the task and could complete the task independently; the yellow colour would indicate that they understood the concept, but could use a little bit more support; and the red colour which would indicate that more support was needed to help with their task.

Opportunities for mathematics learning

The focus of this lesson was on knowing the values of coins, being able to put them in the right order, as well as being able to predict how much things cost. Such objectives resonate with the Experiences and Outcomes for Numeracy found in the Scottish Curriculum for Excellence's MNU 1-09b expectations within the 'Money' section: '*I have investigated how different combinations of coins and notes can be used to pay for goods or be given in change*' and MNU 2-09a expectation: '*I can manage money, compare costs from different retailers, and determine what I can afford to buy*'. There were also links to the broader aim of enabling learners to '*understand that successful independent living requires financial awareness*'.

Opportunities for creativity

During the introduction, Maria's creative use of **a range of physical everyday objects**, such as a CD player and a bottle of water, allowed children to enhance their observational skills to order the objects' monetary values. Moreover, the use of such objects also made it possible for children to **make** extensive **connections** between the task itself and their knowledge and experiences outside school. Furthermore, being exposed to a variety of reasons for charging different prices for the same object fostered children's **creative thinking skills**, in terms of seeing different possibilities.

Finally, through the researcher's questioning of the observed children, their underlying thinking became evident. Arguably, this highlights the potential of teachers' **scaffolding questions** in helping develop children's **reasoning skills,** in becoming better in being reflective and in articulating their ideas to an audience, in ways that the worksheet alone might not be able to achieve.

Episode 3: Touch Activities

Pedagogical framing

The learning intention of this lesson was '*I can explore my sense of touch through different activities*'. There were several different activities taking place during this one-hour lesson, and each group of children got to spend around ten minutes at each activity before being asked to move on to a different one. At the '*Feeling Words'* table, children got to pick a feeling word (i.e. 'hard', 'hot', 'smooth', 'soft' and 'cold') and to think of and draw examples that match that description. For example, a child might draw a picture of ice cubes for the 'cold' label.

At the '*Describing Worksheet'* table, a selection of various objects was provided, such as a stone, cotton wool, a pine cone, a furry toy, sand paper, a wooden block. Children had to feel each of these objects and describe whether they were 'rough', 'smooth' or 'soft' by ticking the appropriate boxes on the worksheet.

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At the '*Collage*' table, children were asked to create a collage using a wide range of materials. For the '*Black Bag'* table, a selection of objects had been placed in a black bag. Working with a teaching assistant, children were asked to feel an object inside the bag and to describe it to their peers and to guess what it was.

Image 3.1: Children at the 'Collage' table

These activities provided children with **a wide variety of rich physical resources to explore** within an **informal learning setting**. As children got to **move around** from one activity to another, this allowed them to experience a variety of learning experiences. Consequently, children appeared to be **engaged** and focused on exploring the activities.

Pedagogical interactions

Right from the beginning of the lesson, Maria tried to create **a learning environment conducive to fostering creative thinking**. For example, whilst explaining the 'Feeling Words' activity, she said:

> *"I would like you to write the 'feeling' word at the top of paper and then draw something that go with that word. So may be if you would want to write 'hot', you would do a hot cup of tea. May be you would do 'cold', you could draw a cold ice lolly. […] If you finish your picture, you can turn it over to the other side and draw another 'feeling' word. I'd be interested to see if anybody could draw a picture of something that nobody has thought of."*

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Image 3.2: Children at the 'Feeling Words' table

Image 3.3: An example of a child's work

Additionally, when Maria was explaining the '*Describing Worksheet*' activity, she also tried to encourage children to think independently and encouraging them to consider how they would describe the given objects:

Maria: *"So in this tray, we've got lots of different kinds of objects. We have a stone, cotton wool, a pine cone, a furry toy, sand paper, a wooden block. […] So, it [the worksheet] says 'Touch the objects in the bag. How do they feel? Complete the table with crosses and ticks'. So, for example, when you pick up cotton wool and you'd say first of all does it feel rough?"*

Children: *"No."*

Maria: *"What would you put in here [in the Rough column]?"*

Children: *"A cross"*

Maria: *"Smooth. Does it feel smooth?"*

Children: *"Yes. No."*

Maria: *"[Picking up the cotton wool] It's not really. Usually if it's smooth, it's a bit shiny and flat. It's not really, is it? But may be … I'll let you choose, because it's your experiment, so you're feeling with your senses … with your hands. Then you decide."*

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Image 3.4: A variety of physical objects for children to explore

As previously mentioned, a wide variety of activities allowed children opportunities to touch and describe different materials in **different modes**. This ranged from, for example, verbal description at the 'Black Bag' activity and written communication at the 'Feeling Words' and 'Describing Worksheet' activities to artistic expression at the 'Collage' table. This aspect of the lesson was crucial in Maria's view. When asked to identify some of the teaching and learning features that she thought were most effective in fostering children's creative thinking, Maria said *"allowing opportunities for them to express themselves in different ways".* Building on that, when asked which of the observed science lessons she believed as being most effective in fostering children's creative thinking, she said:

> *"I thought the 'touch' lesson where they had the different activities kind of … foster creative thinking. It allowed them time for kind of … to independently think of … things from their own … kind of life that what's it like to… their experiences of touch … there was an art activity for them to kind of putting together different materials.… and … yeah they had to work together … as well to foster creative thinking. Lots of exploring. Different materials. Kind of using our sense of touch in different ways to identify different things."*

With the exception of the 'Black Bag' activity when an adult was present, Maria chose to **stand back** across the other activities and allowed children to be the **primary agents** in their own learning. At the 'Black Bag' activity, the student teacher used **scaffolding questions** to help children develop appropriate language to describe their objects and to improve **communication of their explanations**. Through such **dialogue**, children were able to learn from others through listening to how other children in the group described their chosen items in the bag, and hence fostering their **possibility thinking**:

Student Teacher:	*"What do you think it is?"*
Krishna:	*"I know. I know it's a cup!"*

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Student Teacher: *"What makes you think it's a cup?"*
Krishna: *"Kinda small."*
Student Teacher: *"Really?"*
Krishna: *"Kinda feel likes the cup that I have at home."*
Student Teacher: *"What shape?"*
Krishna: *"A cylinder."*
Student Teacher: *"Like a cylinder? Round?"*
Krishna: *"Yes."*
Student Teacher: *"Have a look."*
[Krishna taking out a cup]
Student Teacher: *"Well done."*
[---]
Student Teacher: *"What do you think it is?"*
Lisa: *"A dinosaur."*
Student Teacher: *"What makes you think it's a dinosaur?"*
Lisa: *[Inaudible]*
Student Teacher: *"And is it rough or smooth?"*
Lisa: *"Rough"*
Student Teacher: *"And what type of shape is it?"*
Lisa: *"A dinosaur shape."*
Student Teacher: *"OK, let's have a look."*
[Lisa taking out a dinosaur model]
Student Teacher: *"Well done."*

Image 3.5: Children at the 'Black Bag' activity with a student teacher

Across the different activities, children constantly used their **observation skills** to complete their tasks, and to **make connections** between the task at hand and their out-of-class knowledge and experiences. From the transcript above, Krishna, for example, was able to draw from his observation of the shape of cups found at his home and the one he was feeling in the black bag.

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Opportunities for mathematics learning

The focus of this lesson was on exploring the sense of touch, which resonates with the Experiences and Outcomes for Science found in the Scottish Curriculum for Excellence's expectation within the 'Body systems and cells' section: SCN 1-12b '*I have explored my senses and can discuss their reliability and limitations in responding to the environment*', as well as the expectation within the 'Properties and uses of substances' section: SCN 1-15a *'Through exploring properties and sources of materials, I can choose appropriate materials to solve practical challenges'*. Building on these expectations is a broader goal of enabling learners to '*develop curiosity and understanding of the environment and my place in the living, material and physical world*' and '*develop the skills of scientific inquiry and investigation using practical techniques'*.

Opportunities for creativity

The use of creative pedagogical features as found in this episode arguably helped to foster children's creative dispositions in a number of ways. For example, given the nature of the activities, which was highly **hands-on and diverse**, pupils were seen to be **motivated and engaged** with their tasks. Opportunities for them to **make connections** between their tasks and their knowledge and experiences outside the classroom, especially concerning the properties of different **everyday objects** were also evident.

Furthermore, at the 'Black Bag' activity, children's **reasoning skills** were developed through answering the student teacher's **probing questions**. Similarly, at the 'Feeling Words' activity, children's **creative thinking skills** were valued and fostered as Maria made it explicit at the beginning of the lesson that she would be interested to see if children could draw a picture of something that no one else had thought of.

3.21.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

What role if any does creativity play in these?

One of the most predominant pedagogical approaches adopted in Maria's class was the use of **physical hands-on** resources. Sometimes, such resources were used during the introduction session as in the case of the '*Price Prediction'* episode, and on other occasions, they were used as part of the main learning activity, as in the case of the '*Alien Challenge'* and the '*Touch Activities'* episodes.

Additionally, as a result of Maria choosing to focus on working with one group of children during the activity session in each lesson, whilst letting pupils in other groups got on with the activities themselves, this resulted in her **standing back** and allowing children outside her focus group to take initiative in their own learning.

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In terms of assessment, Maria regularly encouraged children to reflect their level of understanding in both mathematics and science lessons via a number of opportunities for **self and peer assessment.** Self-assessment was often found in the form of the traffic light system at the bottom of her worksheets, whereby children coloured the light green if they fully understood the task, red if they struggled and needed lots of help, and amber if they only needed a bit of help. In terms of **peer assessment**, this was usually in the form of getting children to show her a thumb up or thumb down if they agreed or disagreed respectively with their peers' answers.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

When physical hands-on resources were in place and when Maria stood back, children's creative thinking manifested itself. For example, in the *'Alien Challenge'* episode, the observed children were **making connections** between counting in twos and creating number patterns in the form of the aliens' eyes themselves, and one of them went further and **designed her own investigation**, choosing to count in twos the aliens' eyes as opposed to their arms, as explicitly instructed by the teacher.

Linking to the practical hands-on nature of most learning activities found in Maria's class was the feeling that learning is fun and is taking place in an informal setting. For example in an interview with George, he said he liked it when "*the teacher takes out little toys and teach you something about counting*". In both the '*Alien Challenge'* and '*Touch Activities'* episodes, the level of children's engagement with the learning activity and **motivation** was high, judging from the amount of time they spent on task.

Similarly, through the inclusion of **everyday examples** in the learning activities, especially those found in the *'Touch Activities'* and the *'Price Prediction'* episodes, children were able to **make connections** between their tasks and their everyday life experience, and hence making learning more meaningful to them. That said, the very fact that the Alien Challenge game was not related to their everyday life, in terms of the use of alien characters, allowed them to use their **imaginative thinking skills** to give different aliens different numbers of eyes. The same opportunity for such imagination might not have been possible if pupils were expected to draw human bodies instead of the aliens' ones.

How do teachers perceive their role in doing so?

From the interview with Maria, she said that to help promote children's creative thinking in mathematics and science lessons, it was important to provide lessons that cater to children's different learning styles by *"having visual, auditory and […] kinaesthetic angles on it"* and to allow the children to *"answer questions in a variety of different ways"*. Additionally, she said it was important for the children to *"drive the learning"* in terms of what they want to find out and to keep them all motivated.

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From the observations, Maria did indeed provide a range of learning activities to suit different learning styles from more hands-on investigative activities in the '*Touch Activities'* episode to more visual- and auditory-typed activities in the other two episodes. Such diversity engaged children and kept them motivated. Moreover, Maria's science display board also showed four broad questions about what children wanted to learn about senses, and this illustrated her fulfilling her role as providing an opportunity for children to drive the learning, as previously mentioned.

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3.22 Case: 'Joanne'

3.22.1 Context

Where?	Country	Wales			
	Setting name	W1 – Berrymede Primary School			
	Location within setting	Pre-School			
Who? (children)	Year group/age of children	Reception (aged 4 and 5 years ofage)			
	Number of children in class	22			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher and 1 Teaching Assistant			
	Case teacher role				
When?		1 & 2 2 researchers		3 & 4 2 researchers	
	Dates of visits	31/01/13	31/01/13	08/03/13	08/03/13
	Times of visits	09:00-10:00	11:00-12:00	09:00-10:00	1000-1100

School/setting

See Denise for school details

Teacher

Joanne is a recently qualified teacher in her early to mid-thirties and works part-time as a class-teacher for four days per week. Within school both mathematics and science are taught for more than four hours per week. The school believes that the following purposes are important in the teaching of science:

a. To provide a foundational education for future scientists and engineers.

b. To develop socially and environmentally aware and responsible citizens.

c. To enrich the understanding and interaction with phenomena in nature and technology.

d. To develop more innovative thinkers.

e. To develop positive attitudes to science.

f. To develop important attitudes and dispositions as a foundation for future learning.

The following learning/teaching contexts and approaches are frequently used in school:

- Working in small groups

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- Physical exploration of materials
- Using outdoor learning activities
- Taking children on field trips and/or visits to science museums and industry
- Integrating science with other curricular areas
- Building on children's prior experiences
- Fostering collaboration
- Encouraging different ways of recording and expressing ideas – oral, visual, digital, practical
- Encouraging problem finding – e.g. children asking questions
- Encouraging problem solving – e.g. children solving practical tasks
- Encouraging children to try out their own ideas in investigations
- Fostering classroom discussion and evaluation of alternative ideas
- Fostering imagination
- Relating science to everyday life
- Using questioning as a tool in science teaching
- Using digital technologies with children for science teaching and learning
- Fostering autonomous learning

A teacher-led approach is evident in Joanne's practice in science; an approach where children openly investigate scientifically oriented questions, analyse evidence, formulate explanations based on evidence, connect explanations to scientific knowledge and communicate and justify explanation and to provide guidance in giving children priority to evidence and when reflecting on the inquiry process and their learning.

The school is felt to be generally very well resourced in science, with instructional materials (e.g. textbooks), audio-visual resources, equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks), computers, ICT resources (e.g. computer applications), other digital technologies (e.g. interactive whiteboard, camera) and a budget for supplies (e.g. paper, drawing materials). Less well resourced are relevant library materials (e.g. story books). The resourcing situation is much stronger in mathematics, with all the above resources being available.

Classroom

The classroom is a fairly typical Reception classroom with hexagonal working tables joined together to make longer tables and areas of the classroom partitioned off to provide different areas for quiet work, play etc. (see plan below).

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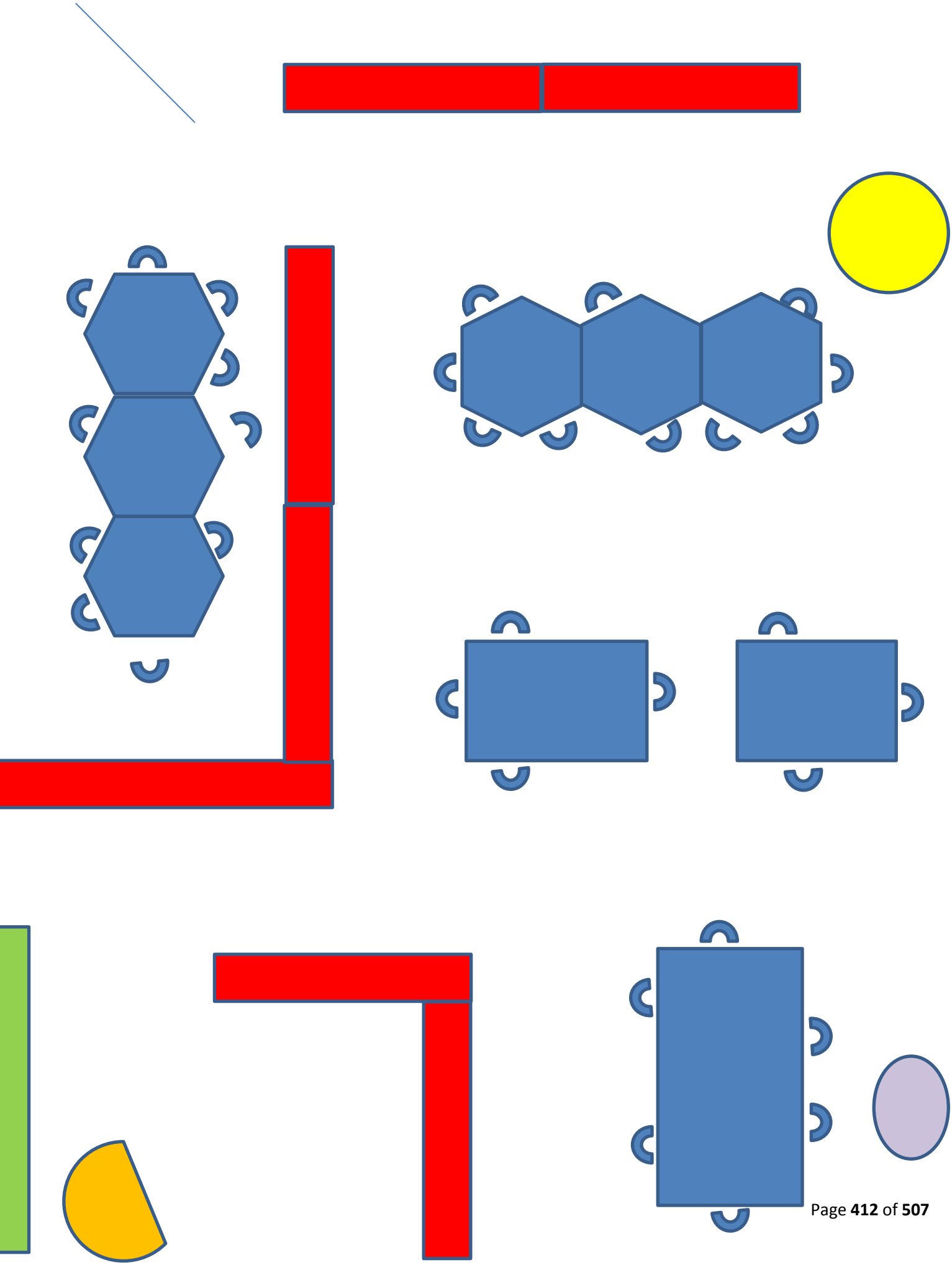

3.22.2 Episodes

Episodes were gathered during morning visits by two researchers working in parallel and observing different activities in the same classes, including some joint observations. The episodes in this case study illustrate the part played by teacher questioning and interaction on creative scientific and mathematical development.

Episode 1: Jelly

This episode took place in Joanne's class, during a morning session and was observed by one of two researchers in the classroom. The lesson was in three parts; an introduction, exploratory, small-group activities and a plenary. The small group activities were:

1. Cooking: Joanne leads the cooking activity, making flapjacks (as in the next episode).
2. Writing: Recording the jelly-making process.
3. Painting: Colour-mixing
4. Model making
5. Playing with Flubber.

Pedagogical framing

The activity started as a whole class introduction to the morning's activities (with thirty 4 and 5 year old children), led by Joanne. It continued alongside the cooking activity led by Joanne (as described in Episode 2), as part of the free-flow play activities, focusing on how materials change when mixed, heated or cooled, thus focusing on the same learning objectives as in the earlier episode. The episode finishes with a whole class plenary that focuses on all the activities, which share common learning objectives.

Pedagogical interactions

Joanne led both the whole class introduction and plenary parts of the lesson. The free-flow play activities were teacher-initiated but the children could decide which activity to engage with and how to engage with it.

Opportunities for science learning

At the start of the episode, all the children are sitting on carpet and Joanne recalls the process of making the jelly the day before, questioning the children and modelling appropriate language.

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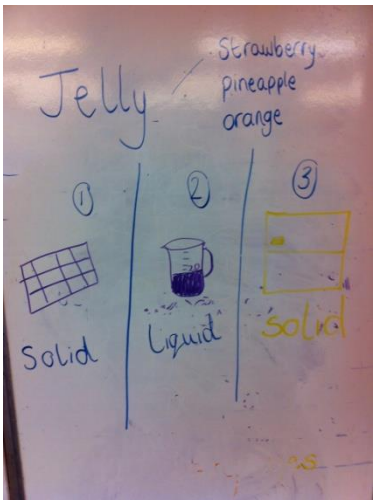

Image 1.1: Notes recalling previous learning on making jelly

She encourages the children to use words like “solid” “liquid” and “states” and further to use “questioning” and “predictions” in their explorations. She asks how the jelly was made and focuses on how the hot liquid dissolves the solid jelly making it liquid before it becomes solid jelly again. She encourages children to interact and predict, asking “what will happen if I try to put this jelly on a flat plate?” One child identifies that, “it will fall out”, while another says, “it will wobble”. All children are engaged in exploring the ingredients and Joanne asks, “what will happen if I drop this knife on the jelly”, to which a child replies, “it will bounce off”. Joanne continues with her questions by asking what will happen if she cuts the jelly with a knife and a child responds that it is better to do this with a spoon “cos we can eat it then but we mustn’t put knives in our mouths …that’s dangerous”.

Image 1.2: Predicting the properties of Jelly through the language of science

Joanne then gives the children an overview of the group tasks and activities, showing them the opportunities to work with solid and liquid materials on each table and then to write about it on the recording table. The activities planned are:

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1. Cooking: Joanne leads the cooking activity, making flapjacks (as in the first episode).
2. Writing: Recording the jelly-making process.

Image 1.3: Jelly Display for recording the jelly-making process with three different types of jelly (strawberry, pineapple and orange)

3. Painting: Colour-mixing
4. Model making
5. Playing with Flubber

Image 1.4: Flubber tray

The researcher focused in this part of the episode on the interactions between the children in the flubber tray.

Child 1: *"Let's put some water with this… shall we?"*
Child 2: *"It will make it sticky"*
Child 1: *"Yeah sticky-icky"*
Child 2: *"But the water won't make it into a liquid will it…?"*
Child 1: *"No…It will still be a sticky solid"*
Child 2: *"It's good for making stuff…look I'm making a dinosaur"*
Child 1: *"I'm making nothing I'm making cake"*
Child 2: *"We could make a flap jack but it won't be nice to eat"*

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Child 1: *"Let's put some glitter in it"*
Child 2: *"That won't taste nice"*
Child 1: *"I like glitter…you can pour it out…and make sprinkles and shake it like this …" [A pot of glitter is emptied into modelling material]*

Both children rush to feel it and mix it into flubber and continue to knead and squeeze the flubber.

Image 1.5: playing with glitter and mixing

The episode finishes with a whole class plenary, with everyone sitting on the carpet, during which Joanne's expectations were sustained and reinforced in a challenging way and it was possible to see that this had a positive and motivating effect on the children. Joanne used examples of the outputs from each activity and discussed what they had found using scientific vocabulary. It was possible to discern that the children were encouraged to use their scientific imagination to produce something of value to their learning in terms of immediate gratification and the satisfaction of eating "home produced" food in the form of flapjacks.

Opportunities for creativity

There were opportunities for the development of creative dispositions, (*D3.1 List of Mapping and Comparison Factors*) through:

- **motivation** in all parts of the observed episode,
- the encouragement of **curiosity, connections making** and **reasoning skills** in the introduction and plenary sections of the episode,
- **a sense of initiative** and **problem solving skills** in the small group exploration of the 'flubber'.

Through the activity, the children were demonstrating a number of synergies between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10). Joanne utilises both free **play and exploration,** with activities that encourage **questioning and curiosity**, with **reflection and reasoning** developed through **teacher scaffolding and involvement**. **Motivation and affect** are evident in the

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children's responses and play. **Dialogue and collaboration** are evident in both the teacher-led introduction and plenary, where Joanne reminds children to interact with their peers, as well as the small-group explorations.

Assessment was not overt but in the whole class introduction and plenary conceptual ideas and vocabulary are recorded (see Image 1.1: Notes recalling previous learning on making jelly), help evaluate the activity, but not necessarily enable individual and formative assessments.

Episode 2: Cooking flapjacks

This episode took place in Joanne's class, during a morning session with a group of eight children aged 4 and 5 years of age. It occurred alongside the small-group activity described in Episode 1 and after a whole class introduction that focused on the conceptual understanding in the learning objectives.

Pedagogical framing

The children were working with Joanne in a cooking activity, which involved exploration of flapjack ingredients and making flapjacks, with a scientific focus on the state of materials and how they change when mixed or heated or cooled.

Pedagogical interactions

Joanne focused on the small group cooking activity, whilst the rest of the class (22 children) were doing a paint mixing activity (with the Teaching Assistant) and free-flow play activities.

Opportunities for science learning

Joanne began the small group activity by identifying the ingredients needed to make flapjacks and then looking at what state the ingredients were in "liquid, a solid, and gas…." One child responded to the reference to gas by saying, "you could call it steam". Joanne focused on the oats and used questioning to structure the activity by asking if they were liquid or solid. This is actually quite a complex concept for children of this age as oats will flow through your hands and take the shape of a container, like a liquid. However, the children all identify the oats as solid. Joanne repeats the question, asking, "are oats 'Liquid' or 'solid?'. The children then explore the oats, interacting and communicating with each another. As they explore, Joanne scaffolds learning saying, "its dry not wet, it's a solid not a liquid". One child replies that it "pours like a liquid", whilst a second child says "glitter" (presumably inferring that glitter acts can be 'poured' but is a solid like the oats).

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Image 2.1: Joanne questioning the children about the ingredients

Joanne gives each child a pile of oats and encourages the children to explore them by asking how they feel and using key vocabulary as she builds up the selection of ingredients in front of each child "dry", "sticky", "wet". As she puts the raisins in front of the children, one child says, "OOHHH I love raisins!" and another child agrees. Joanne asks them what raisins are and one child says, "they're like grapes".

Image 2.2: Child exploring a 'pile' of oats

Joanne goes on to look at the sugar and says the word 'sugar' in both English and Welsh asking, "is this a liquid or a solid?", using her questioning to encourage the children to make connections, by liking the sugar to glitter, which also has "little tiny bits". She asks, "is it a liquid? Would it make a puddle? It looks like were pouring it but its teeeny tiny pieces". The children, however, do not focus on the questions and one asks what the next ingredient will be, while another returns to the raisins and says, "raisins are dried grapes, they look old". Joanne responds to the latter comment by saying, "they are a solid, grapes are juicy, The sunshine dries them out applies heat to them and they become raisins". One child links this too syrup and identifies that "too much syrup is not healthy for you".

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Image 2.3: Children exploring and discussing

Joanne moves on again to look at the butter and again asks the children what state it is. One child starts to talk about cheese, which is not one of the ingredients and Joanne lists the ingredients they have been given, "sugar raisins butter oats" and asks how many solid things there were now. She then gives out some syrup and identifies that it is a liquid. The children mix the syrup into the mixture of dry ingredients, taking turns with stirring.

Image 2.4: Taking turns to stir the mixture

Joanne encourages the children to further observe and explore the mixture, asking what has happened to the butter. One child exclaims, "look at my butter! "Its melting", whilst another child says, "the butter sticks it together". Joanne starts to melt butter on the stove and asks, "what's happening now?" identifying that "it's getting smaller and smaller".

Joanne then counts spoonfuls of sugar "*1 2 3 ..*" and adds to the liquid butter identifying that it's "*dissolved*". She urges the children to "*think*" and the children respond together "*it's changing, changing colour*". Joanne asks, "*can you see it? The liquid is the hot butter*" and says the word "*temperature*" and further, "*what's happened to the butter now? I'm stirring it and stirring it*". She adds two spoonfuls and a child says that it is "*messy*". She then adds the raisins, identifying them as "died out grapes", encouraging the children to count as they take turns adding to the mixture and stirring.

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Image 2.5: Child counting on his hand

Joanne adds the hot butter and sugar liquid, urging the children to think and identify what will happen to the raisins and that the children will " need muscles to stir this". One child puts out cake cases and counts, "1….2….3…" Once all the children have had a turn at stirring, Joanne tells them to wash their hands and then the children put the mixture in the cake cases, while Joanne continues to question them about the state of the mixture, "what is our mixture now a solid or liquid?" to which one child says that it is like "a glue".

Opportunities for creativity

The episodes identified a number of creative dispositions (see D3.1 List of Mapping and Comparison Factors), in particular **motivation**, by **making** a product and through the encouragement of **curiosity**, as the children explored the ingredients. Through the exploration of the ingredients, the children were **making connections** (for example by connecting dried fruit and grapes and looking at the physical state of the different ingredients) and using **reasoning skills** (for example, when hypothesising why the mixture changes when heated).

Through the activity, the children were demonstrating the following synergies between mathematics, science and creativity (D2.2 Conceptual Framework, pp. 9-10).

- **Exploration** – by leading the children through the exploration of the ingredients.
- **Motivation and affect** – throughout the activity, by encouraging **questioning and curiosity,** with **reflection and reasoning** developed through **teacher scaffolding and involvement**.
- **Dialogue and collaboration** –is evident in the teacher-led exploration**,** where Joanne reminds children to interact with their peers.

Episode 3: Shop role play

This episode took pace during a morning session in Joanne's class with twenty 4 and 5 year old children and two adults; Joanne, the class teacher and a Teaching Assistant.

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Pedagogical framing

The episode focuses on mathematical development that occurred in the role play area, which was set up as a shop, where a group of girls are playing.

Pedagogical interactions

The activity was free-play and occurred whilst Joanne, the class teacher was working with a small group making Mother's Day cards and the Teaching Assistant was working at the art table. There was no planned adult interaction during the play, although towards the end of the observed episode the researcher interacts and pretends to buy some items from the shop.

Opportunities for mathematics learning

A group of children were playing in the shop.

Image 3.1: Group playing in role in the shop

Girl 1 says to Girl 2 "Hello can I have a look in your shop?" Girl 2 is choosing items very carefully for her trolley, while Girl 3 is at the till.

Image 3.2: Girl with trolley

Girl 1 and 2 look at items in shop and Girl 3 is still at the till with a purse. Girl 2 says to her "shopkeepers don't have purses", to which Girl 3 replies " yes they do". Girl 2 takes coins from the

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till and says, “this is going to be my money” She takes coins from till and shares it out after Girl 3 says, “ I give some to you, you give some to me”.

Image 3.3: Sharing out the money

Girl 1 asks “can you weigh this please?” and if she can buy a newspaper, but she is ignored. She then puts pot on the scales and plays happily with the scales for five to ten minutes.

Image 3.4: Girl focusing on the scales and weighing

Meanwhile Girl 3 is still at the till and pressing buttons, while Girl 1 weighs jars on the scales. Girl 2 (with same trolley full of shopping) asks, “may I buy my stuff?” and is ignored as both other girls are engrossed in the till and scales. She tries again, “I want to buy something now….” but is ignored and yet again, “can I buy something from my trolley?” She waits showing the other girls coins from the till, but Girl 1 and Girl 3 seem reluctant to ‘process’ her shopping and she leaves the role play area. Girl 3 is happy as she has the purse back.

A fourth girl arrives looks around and then leaves. Girl 3 tells her she can play in the shop, but the fourth girl ignores her and leaves.

Girl 3 is still at the till and says “you can buy that”, “hello would you like to buy that?” and “hello what would you like to buy?” pointing to the trolley full of shopping. Then the two remaining girls put all the shopping back on the shelf, ordering the boxes, big small. Girl 1 says “see now you can buy something” and “look at the mess on this floor”, so both girls tidy up the shop floor.

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After tidying the shop, both girls get some paper and make books and start writing in them. Then Girl 3 goes back to the till, pressing numbers on the till and counting "7….8…..9……".

Image 3.5: Girl at till

Girl 1 is at the scales again and banging on them says, "5 degrees … zero degrees. It's your turn to buy stuff now" as she sorts the boxes. She then weighs boxes saying, "zero degrees". As she sorts the boxes, she moves them around, comparing and weighing them.

Girl 3 in parallel play, presses the buttons on the phone and counting "1…3…2…8."

Girl 5 arrives wanting to buy something and motions to a box and the till. Girl 6 arrives saying "I knew you'd be the weigher " to Girl 1. Girl 3 replies, "I'm on the phone" and then joins in the role play by saying, "hello what would you like to buy today?" and repeats "I'm on the phone". Girl 6 replies "ummmm chocolate". She then selects shopping naming her selections a she goes.

Girl 6 talks to Girl 3, telling her that "shopkeepers don't have purses, so I can't play" (meaning the shop keeper shouldn't have the till and the purse). She then leaves.

The researcher interacts and pretends to buy some items from the shop, selecting some items from the shelf putting them in my trolley and paying with pretend money and Girl 3 identifies that they need paper money.

Opportunities for creativity

The episode indicated opportunities for children to use their **initiative** and **make connections** through **imaginative** play. Free play is highly **motivating** and the children were motivated to consider problems and come up with **innovative** solutions through **creative thinking** and **reasoning** (*D3.1 List of Mapping and Comparison Factors*).

Through the activity, the children were demonstrating the following synergies between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10).

- **Play and exploration** – throughout the activity.
- **Motivation and affect** - evident in the children's responses and play.

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- **Dialogue and collaboration** – are less evident in the role play, where the children are more likely to engage in parallel play, unless an adult plays with them, modelling behaviours.
- **Questioning and curiosity** – is encouraged, as is **reflection and reasoning**, although would have been improved through teacher scaffolding and involvement**.**

3.22.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

In Joanne's class, teacher-initiated exploration as well as free play and exploration are used as pedagogical approaches. The small group activities follow on from teacher-led introductions, which focus the learning objectives and introduce and reinforce the scientific vocabulary. These, follow-on, small group activities are mainly exploratory and involve collaboration and cooperation in the exploration of physical materials.

What role if any does creativity play in these? This would include the exploration of opportunities and challenges for development of skills and attitudes associated with creativity.

Creativity occurs in Joanne's practice through enabling children to play and explore mathematical concepts that allow children to create and explore scientific and mathematical vocabulary, ideas and concepts in their play. It is also evident through more teacher-led explorations that enable children to make connections and engage in reasoning, albeit at a simplistic level.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

Motivation and affective development are important aspects of Joanne's practice and evident in all three episodes in this case study. Children ideas are praised and valued, although on some occasions their ideas are not built upon because of the pace of the activity; this however, does not deter the children from engaging.

How do teachers perceive their role in doing so?

Joanne facilitates learning and development through:

- Planning small group exploratory activities that stimulate interest and curiosity in the children.
- Ensuring adult interaction focuses on the learning objectives and scaffolds learning.
- Making connections between previous and new ideas, reinforcing and revisiting scientific concepts and experiences and drawing attention to connections between concepts.

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- Developing scientific and mathematical vocabulary through adult encouraging and interaction and through role play.

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3.23 Case: 'Denise'

3.23.1 Context

Where?	Country	Wales			
	Setting name	W1 - Berrymede Primary School			
	Location within setting	Primary School			
Who? (children)	Year group/age of children	Year 3 Class: 7 and 8 years old			
	Number of children in class	30			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher and 1 teaching assistant			
	Case teacher role				
When?		1 & 2 2 researchers		3 & 4 2 researchers	
	Dates of visits	31/01/13	31/01/13	07/03/13	07/03/13
	Times of visits	0930-1000	10:50-11:50	09:00-09:50	1000-1100

School/Setting

Berrymede Primary School is a Church in Wales Voluntary Aided School. The school is situated at the heart of a village. Most of the pupils attending the school live in the village or in the nearby villages; some children travel to school by bus and the school also has a "walking bus" service for those living locally.

The school was built on its present site in the 1970s and there have been additional classrooms and other facilities added in a separate block. The infants and junior sections have separate playgrounds. The school gardens have been developed to include a wild life garden, Easter garden, multi-faith section and Stations of the Cross.

The school has a one form entry. There are 172 pupils in the school, of which 1 boy and 2 girls have statements, 18 are on the School Action or School Action Plus register. 1% of pupils are first-language Welsh speakers, 1% are of Dutch origin. The school has 7 classes with 7 teachers and 1 PPA teacher. 2% of learners are eligible for free school meals, which is well below the LA average of 11.9% and the all-Wales average of 18.8%.

The school has a distinctive Christian character and is praiseworthy in developing all the pupils' personal qualities and achievements. The school is very well led and managed as a Christian school. Its pride in the collective worship which is at the heart of its ethos is well founded. Berrymede's established strengths are: Its acts of collective worship, which are inspirational, and can be uplifting and reflective; its highly distinctive Christian character, which is supported by the governors and all

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members of the school and local community. Christian gospel values clearly underpin the daily life of the school; its support from the local church and priest; its nurture and care of pupils, which is rewarded by happy children who show care and respect for each other. The school prospectus for Berrymede Primary School identifies that it aims to:

- **provide** a caring, exciting and stimulating environment for all pupils, which encourages each individual to achieve his/her own potential – academically, socially, physically, morally and spiritually; so that all move on with confidence and positive memories of their time at school.
- **deliver** an education of the highest possible standard across the whole curriculum, which will provide all our pupils with a firm base for future academic development.
- **encourage** the spiritual development of all in the school community, both through the special character of the school's religious education and Christian worship, and incorporation of Christian values and beliefs in all teaching and learning in school. This includes teaching an awareness of and respect for other major faiths.
- **build** strong links between school, home and community, emphasising that education is a partnership between home and school.
- **develop** confident, eager and responsible learners who value themselves and each other, treating others with respect.
- **foster** a greater awareness and care of the environment and local community in which we live.

At Berrymede Primary School, they believe that the spiritual, moral, cultural, social and physical development will be based upon the virtues and values of the Judaeo-Christian tradition. At the school these values and virtues permeate throughout the curriculum, the character and life of the school. The spiritual development policy fully recognises the religious character of the school and this is explicit through the curriculum, the building and the daily act of worship. Pupils are encouraged to question and reflect on the teaching of Christ. All pupils are encouraged develop in confidence and character in order to have the courage to do what they feel is right and to challenge what they know is wrong. The pupils are given the opportunity to learn about their own and other cultures through Cwrricwlwm Cymreig, Literacy, Religious Education, Music and Art. Pupils are taught to respect all faiths, cultures and societies in school and in the community beyond the school. The school encourages each pupil to reach their potential mentally, socially and physically through a broad, balanced and inclusive curriculum.

The last inspection was in 2010 and the inspection report identified that Berrymede was a good school. The significant features of the inspection report are that:

- The majority of children who begin in reception have skills and maturity which are generally above those found amongst the majority of children of this age. No pupil has English as an

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additional language (EAL) and one pupil has Welsh as the language of the home. Nearly all are from Welsh or English backgrounds.

- The school holds the Eco-Schools Green Flag Platinum Award, Investors in People (2008), The International Schools Award (Intermediate Level), Basic Skills Quality Mark and the Healthy Schools Award.
- Nearly all children enter the reception with above expected levels of basic skills and maturity. They generally make good progress and are well prepared for the next phase of their education. Nearly all meet the predictions made for them at the ages of seven and eleven.
- Across the school learners with SEN are very well supported and as a result often exceed the targets set for them. However**,** those who are identified as the more able and talented do not always reach the highest standards it would be reasonable to expect of them.
- In 2009 the proportion of learners attaining the expected level (Level 2) at seven years of age in English, mathematics and science was below the LA and national average as were the combined results. The proportion of learners reaching the higher level (Level 3) was also below in all three subjects. In these assessments girls out performed boys by a considerable margin.

Teacher

Denise is a mature teacher in her mid 40s and has worked as a teacher for less than five years. Originally a LTA (Teaching Assistant) in the school, Denise simultaneously completed her OU degree in Humanities and the GTP year during a prolonged period of study and specialist professional training spanning over six years. Denise was the School SENCO for two years before gaining full QTS in 2000. Denise's background in science and mathematics is up to general upper secondary education, although as part of initial teacher training she studied children's development and creativity and is identified as an inspirational leader of science education, although she is not the science coordinator for the school.

Over the last eighteen months, Denise has attended a number of science and mathematics conferences and courses and identified that the science conferences and courses had no impact on her teaching of science, but the mathematics courses and conferences had a large impact. Participation in networks of teachers for professional development in science also had no impact, but in mathematics had a moderate impact, whilst engaging in informal dialogue with colleagues on how to improve teaching in both mathematics and science had a large impact. In addition Denise considers that the Big Maths activities had impacted on her teaching and the children's learning in mathematics.

Science

Denise's spends more than four hours each week teaching both mathematics and science and recent science topics have been Light and Shade, Forces and Friction and Properties of Materials, covering all the main areas of the science curriculum. Her views on teaching science for children of

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compulsory school age indicate that she believes it is of great importance: To provide a foundational education for future scientists and engineers*.

g. To develop socially and environmentally aware and responsible citizens*.

h. To enrich the understanding and interaction with phenomena in nature and technology.

i. To develop more innovative thinkers *.

j. To develop positive attitudes to science.

k. To develop important attitudes and dispositions as a foundation for future learning.

* purposes were doubly emphasized by Denise.

Denise also identified in the teacher survey that for the age she teaches (7 and 8 year olds) she uses the following approaches in science very often:

- To understand that scientists describe the investigations in ways that enable others to repeat the investigations.
- To be able to ask a question about objects, organisms, and events in the environment.
- To know and understand important scientific processes.
- To be able to communicate investigations and explanations.
- To understand that scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- To have positive attitudes to science learning.
- To be interested in science.
- To be able to plan and conduct a simple investigation.
- To have positive attitudes to learning.
- To understand that scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).
- To be able to collaborate with other children

And the following quite often:

- To know and understand the important scientific ideas (facts, concepts, laws and theories).
- To be able to employ simple equipment and tools, such as magnifiers, thermometers, and rulers, to gather data and extend to the senses.

The following learning/teaching contexts ad approaches are also used in Denise's science teaching very often:

- Working in small groups

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- Physical exploration of materials
- Using outdoor learning activities
- Taking children on field trips and/or visits to science museums and industry
- Integrating science with other curricular areas
- Building on children's prior experiences
- Fostering collaboration
- Encouraging different ways of recording and expressing ideas – oral, visual, digital, practical
- Encouraging problem finding – e.g. children asking questions
- Encouraging problem solving – e.g. children solving practical tasks
- Encouraging children to try out their own ideas in investigations
- Fostering classroom discussion and evaluation of alternative ideas
- Fostering imagination
- Relating science to everyday life
- Using questioning as a tool in science teaching
- Using digital technologies with children for science teaching and learning
- Fostering autonomous learning

But, using history to teach science (e.g. transport, the work of scientists) quite often, open/unstructured play and teaching science from stories rarely and role/pretend play and drama almost never. Denise, further identifies that working in small groups, physical exploration of materials, taking children on field trips/ visits and integrating science with other curriculum areas, as being contexts most likely to contribute to the development of children's creativity. She goes on in the survey to identify that encouraging problem finding, encouraging problem solving and fostering autonomous learning as approached most likely to develop creativity as they have 'strong links to investigation and process as autonomous learning'.

In mathematics, Denise believes that more adult-led approaches are important; for example the use of games to promote logical thinking, especially in the more able, as they have strong links to emotional intelligence. However, these approaches should be non-competitive.

In her pedagogical practice, Denise very often encourages children to undertake the following activities in science:

- Observe natural phenomena such as the weather or a plant growing and describe what they see.
- Ask questions about objects, organisms, and events in the environment.

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- Design or plan simple investigations or projects.
- Conduct simple investigations or projects
- Employ simple equipment and tools to gather data and extend to the senses.

With the use of data to construct reasonable explanations used quite often, but identified as a future target and communicating the results of their investigations and explanations used quite often. Of these activities the three most likely to contribute to the development of creativity are asking questions about objects, organisms, and events in the environment, designing or planning simple investigations or projects and conducting simple investigations or projects. In her interview, Denise continues to explain that these activities help children to communicate their results and findings, discuss and compare findings and that the ability to communicate ideas orally is more important at this age (7 and 8 years of age) as written work is *often* (teacher emphasis) not a true reflection of thought processes.

The CLS survey also asks teachers to identify some essential features of INQUIRY learning in SCIENCE education and their possible variations in the classroom and Denise circled the following in her interview.

	A (Open)	**B (Guided)**	**C (Structured)**
a. **QUESTION:** Children investigate scientifically oriented question	Child poses a scientifically oriented question	Child selects from a range of, or refines, a scientifically oriented question provided by the teacher, materials or other source	Child is given a scientifically oriented question by the teacher, materials or other source
b. **EVIDENCE**: Children give priority to evidence	Child determines what constitutes evidence/data and collects it	Child selects from data/evidence provided by the teacher, materials or other source	Child is given evidence/data by the teacher, materials or other source
c. **ANALYSE**: Children analyse evidence	Child decides how to analyse evidence	Child selects from ways of analysing evidence provided by the teacher, materials or other source	Child is told how to analyse evidence provided by the teacher, materials or other source
d. **EXPLAIN**: Children formulate explanation based on evidence	Child decides how to formulate evidence based on evidence	Child selects from possible ways to formulate explanation given by the teacher, materials or other source	Child is given a way to formulate explanation based on evidence
e. **CONNECT**:	Child independently	Child is directed to	Child is given other

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Children connect explanations to scientific knowledge	finds and examines other resources and forms links to scientific knowledge	other resources and shown how to form links to scientific knowledge	resources and shown the links with scientific knowledge
f. **COMMUNICATE**: Children communicate and justify explanation	Child chooses how to communicate and justify explanations	Child is given broad guidelines on how to justify and communicate explanations	Child is given all the steps to justify and communicate explanations by the teacher, materials or other source
g. **REFLECT**: Children reflect on the inquiry process and their learning	Child decides independently how to structure reflection on the inquiry process and his/her learning	Child is given broad guidelines to structure reflection on the inquiry process and his/her learning by the teacher, materials or other source	Child is given a structured framework for reflection by the teacher, materials or other source

Denise's approach in the science classroom is to allow children to openly investigate scientifically oriented questions, analyse evidence, formulate explanations based on evidence, connect explanations to scientific knowledge and communicate and justify explanation and to provide guidance in giving children priority to evidence and when reflecting on the inquiry process and their learning. She strongly disagrees with an approach where teachers demonstrate the correct way to solve a problem, but strongly agrees that teachers should give children ample time to work out their own solutions to problems before showing them how they are solved, facilitate children's own inquiry and allow children to find solutions to problems on their own. She thinks it is important to regroup and discuss what has been found out and share ideas as some guidance is needed, although not in a 'dictatorial sense'. She continues that 'young children are still looking at the world in a way that makes sense to them. I love it when children will talk about scientific enquiry a couple of days later – "I've been thinking about…"'.

Assessment

Denise considers that for the children she teaches (7 and 8 year old children), that it is important that assessment should focus on positive attitudes and increase of interest in science and positive attitudes and increase of interest in learning science, with knowledge and understanding of scientific processes and competencies necessary to carry out scientific inquiry as the next important foci and with knowledge and understanding of scientific ideas (facts, concepts, laws and theories) as of lesser importance and understandings about scientific inquiry (e.g. how science and scientists work) as not important as an assessment focus.

Denise assesses her pupils most often by:

- Using checklists to record observations of children

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- During classroom interaction
- Evaluating children's relevant gestures or physical activity
- Marking their homework
- Using authentic problem-based tasks
- Asking each child to reflect on their own learning and progress
- Using open question tests
- Using questions in context.

Evaluating children's pictures, graphs etc which show their scientific reasoning is an assessment approach used quite often, using closed question tests and portfolios (collection of evidence of children's work and progress) rarely and children correcting each other's work and giving each other feedback never. She uses reward and praise very often when children use their sense of initiative, are motivated, come up with something new, show the ability to connect what they have learnt during your lessons with topics in other subjects, use their imagination, curiosity and show the ability to work together and thinking skills.

Assessments are used in science to identify areas for improvement in science teaching and to identify ways to improve child science learning very often and the following ways quite often (as they are identified as a school area of development):

- To identify aspects of the science curriculum that could be improved
- To monitor regularly individual children's or cohorts of children's progress towards a set of desirable science learning outcomes
- To inform parents of their child's progress in science

Other assessment approaches are never used in **Berrymede Primary School**. However, Denise identifies that the time teaching in mathematics and science affects the time assessing understanding and observing. Mathematics is assessed daily during each mathematics sessions and through marking independent work. Science is not taught daily and this does not allow for more regular assessment and observation of skills.

Resources in Science and Mathematics

Denise feels that the school is generally very well resourced in science, with instructional materials (e.g. textbooks), audio-visual resources, equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks), computers, ICT resources (e.g. computer applications), other digital technologies (e.g. interactive whiteboard, camera) and a budget for supplies (e.g. paper, drawing materials). Less well-resourced are relevant library materials (e.g. story books). Equipment and materials for hands-on exploration outside the classroom (e.g. sand box), teaching support personnel (e.g. classroom assistant) and other support personnel (e.g. technical support) are not available at all in her classroom, probably due to the age of her children and in common with

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many schools in the UK. The resourcing situation is much stronger in mathematics, with all the above resources being available.

Denise uses the following resources very often in her science and mathematics teaching:

- Teaching materials prepared by Denise
- Audio-visual resources
- Equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks, sorting activity games, rulers)
- Computers
- Digital technologies (e.g. interactive whiteboard)
- ICT resources (e.g. website, digital game)
- Relevant media materials (e.g. newspapers, magazines)

With student textbooks and resources downloaded from the Internet used quite often and teaching materials prepared by group of teachers in your school and relevant library materials (e.g. story books) used rarely. The school is hoping to purchase a bank of games in the near future. Denise uses the following resources to inform her planning in both mathematics and science:

- School curriculum
- National curriculum
- National teacher curriculum guide
- National education agency website
- Teacher professional association documentation or website
- School assessment guidelines
- National assessment guidelines

And student textbooks, teacher textbook guides and online textbook resources (include publishers' websites) less often.

Classroom

Denise's class consists of thirty Year 3 children, aged 7 and 8 years of age. There are two adults in the class, Denise who is the class teacher and one Classroom Assistant. The classroom is set up as a fairly typical classroom for this age of children, with working tables for four to six children, an interactive whiteboard, a book shelf and areas for creative work, mathematics, science (including a table for exploring materials with light sources) and four computers.

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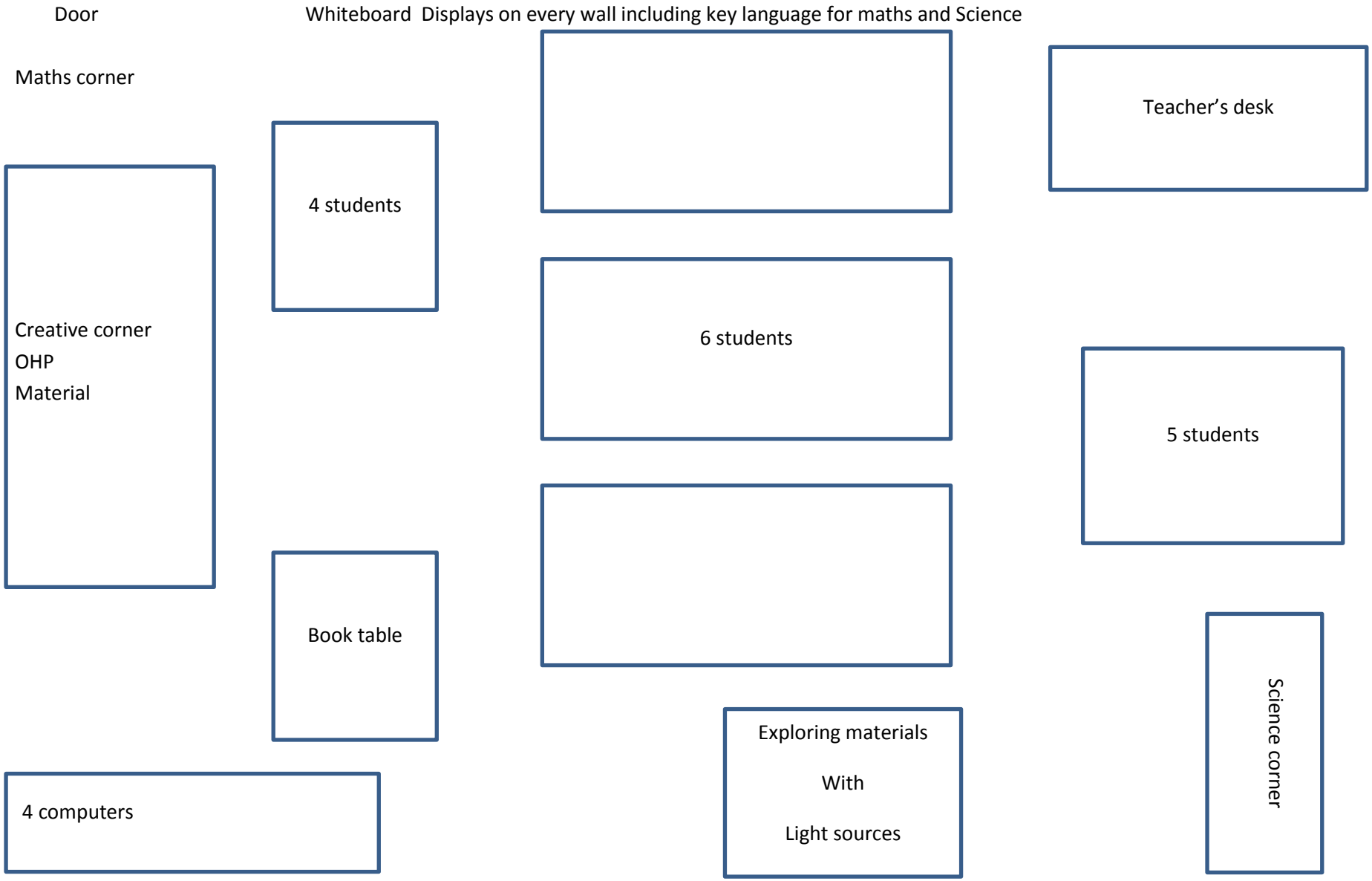
W1Denise_ Classroom plan



3.23.2 Episodes

Episodes were gathered during morning visits by two researchers working in parallel and observing different activities in the same classes, including some joint observations. The episodes in this case study illustrate a pedagogical approach of child exploration that was adult-initiated and often directed by the teacher.

Episode 1 – Puppets

This episode took place in Denise's class in the morning session, shortly after registration, with a whole class introduction (by Denise) to thirty 7 and 8 year old children.

Pedagogical framing

The aim of the lesson was to design, plan and make a shadow puppet. It was then followed up by group activities with the class divided into five groups.

Pedagogical interactions

Denise was working with a group of four children (two girls and two boys) to support scientific and mathematical learning. The Teaching Assistant was in the class and working with one specific child. The resources available were pens/ pencils and paper, plus materials for testing later.

Opportunities for science learning

Denise introduced the activity, explaining the different group tasks, which would be rotated and gave all the children a chance to ask questions, about the task. She encouraged the children to 'investigate' materials and to see which were 'translucent' or 'opaque'. She also encouraged them to cooperate with each other and 'explore' the materials.

In the small group of four (two girls and two boys), the children planned together to 'design' their puppets, linking the design to characters in Greek mythology, about which they were knowledgeable. There was lots of chatter and a very good discussion about the features of the characters and the group were well motivated and worked well together.

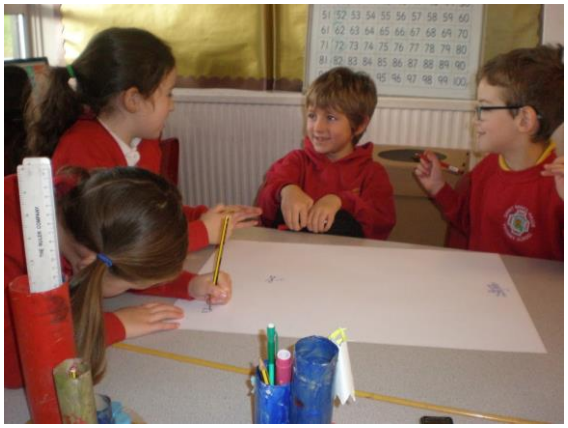


Image 1.1: Discussion

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The group 'independently' discussed the puppet 'characters' they wanted to make and 'negotiated' and agreed which puppet characters would be suitable. They then drew characters, with reference to wings.

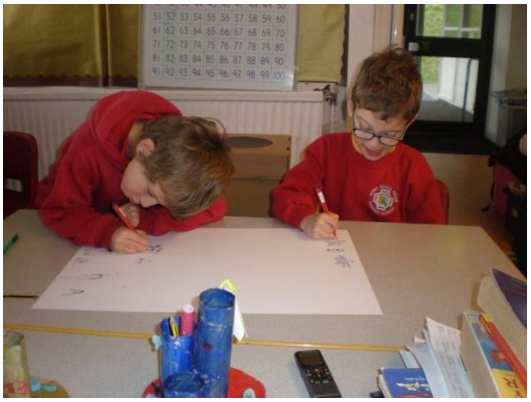

Image 1.2: Two boys drawing

Image 1.3: Discussing drawings

Boy 1: *"Swords"*
Boy 2: *"Flying… wings"*

As they 'designed' the puppets the children discussed their ideas and provided detail of what they were doing, as well as engaging in 'pretend play' as they draw:

Boy 1: *"Zeus"*

Two boys pretend play as Zeus as they draw and chat.

Boy 2: *"I can be the narrator and monster."*

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Image 1.4: Growling lion puppet

The two boys 'act out' parts of puppets as they work:

Boy 1:	*"Sword, shield or shoes? But you could have flying shoes."*
Boy2:	*"Or places where they live underneath them. [Relating back to reading of, listening to story of Myth, they are using.] I've done a Cave."*
Boy1:	*"I think he can't fit through it." [The boys act out being mythical characters, using the 'voice' of the character and attempting to 'fit' into a cave.]*

Denise then intervenes and asks the children about the puppets which are small and very intricate, with lots of detail.

Image 1.5: Detailed drawing

She refocuses them onto the properties of materials and the features that will make shadows saying, "*Remember you are only going to see the shadow*." One girl responds by saying, "*You couldn't see the smiley face*" (points to drawing) and Denise responds with, "y*ou would just see the shadow"* and *"are you going to be able to see the puppet?*" The children investigate the materials available, creating the shadow by using an outline to block the light. Denise asks "*How can we create that puppet with just an outline?"* and demonstrates with her hand not letting light through. One boy responds that they need to "*make the puppet bigger*", and there are lots of discussion about the outline.

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Denise leaves group and back on task the girls start to rub out some aspects of their drawings and start again. The group then discuss Denise's comments:

Girl 1:	*"Light behind me. Do a really good one with a stronger outline. Make it a bit darker so it comes out."*
Girl 2:	*"It needs to be bigger."*
Boy 1:	*"How can we make the face then? I want it smiley."*
Girl 2:	*"My mum did a silhouette of me I had to sit really still and my mum drew round my shadow'. 'This one looks better."*
Girl 1:	*"Features you won't be able to see it."*

Opportunities for creativity

The activity **motivated** the children and gave them a **sense of initiative** to **create** puppets for a specific purpose. They were using their **imagination** and **making connections** between the properties of materials, in order to make shadow puppets, and also characters from Greek mythology, through opportunities to discuss the features of their puppets amongst themselves. In this way **creative thinking skills** were a feature of the episode (see *D3.1 List of Mapping and Comparison Factors*).

Through the activity, the children were demonstrating the following synergies between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10).

- **Exploration** - was encouraged by Denise.
- **Motivation and affect** – was integral to the planning by encouraging children to use their imagination and make connections between the shadow puppets they were designing and characters from Greek mythology.
- **Dialogue and collaboration** - were encouraged to focus on the planned scientific concepts.
- **Problem solving and agency** – was evident through the small group exploration.
- **Questioning** – that helped children to refocus on the properties of materials.
- **Reflection and reasoning** – supported by **teacher scaffolding and involvement.**

Episode 2: Cooking courgette muffins

This episode took place in Denise's class in a morning session, initially with the whole class of thirty 7 and 8 year old children and then with one group of children, cooking courgette muffins as Mothering Sunday presents, while other children undertook tasks that include handwriting practice, cooking and card making. The additional evidence, in the form of photographs, for the episode are currently unavailable, due to technological difficulties but the teacher interview and survey have been used as support evidence.

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Pedagogical framing

The children were working with Denise and the learning objectives were weighing and measuring in mathematics and mixing of materials in science.

Pedagogical interactions

Denise's class started the lesson with the whole class of thirty 7 and 8 year old children and when children moved to work in small groups on a variety of tasks, she worked with one group of children, cooking courgette muffins as Mothering Sunday presents.

Opportunities for science learning

At the start of the session, Denise focused on the recipe for courgette muffins that was displayed on the interactive white board, asking children on a particular table to read out the ingredients for the muffins and praises them for their reading. She uses words like method and process (action words) which are repeated and emphasised, as well as 'good' food and 'bad' food discussing how they can limit the use of sugar and use healthy alternatives or quantities instead. In this part of the activity there are clear links between science, maths and literacy.

In the small group, the ingredients are weighed and the children are keen to establish 'fair' rules to ensure that everyone has access to the 'action' of weighing, mixing and measuring. Although different children read out the instructions, Denise becomes distracted (she is alone in the class with thirty children) and one child tends to monopolises the majority of the weighing, measuring and mixing, much to the indignation of the group who insist that he undertakes the task with meticulous attention to detail. The children ask Denise to enforce the rule and everyone has a turn in grating the courgette, but the final mixture seems hard and dry, so Denise asks 'which is the best surface on the grater?' and 'which side produces the best consistency of courgette if the cake mixture seems dry and hard?'. One child identifies the need ' make the courgette very sloppy and wet to keep the mixture creamy' and Denise asks if there is anything else they could do. The child responds that her mother ' puts a drop of milk in her cakes' and Denise says, 'shall we try that?'. Denise engages some children in the problem of what happens when instructions don't work and one child replies that they should experiment and 'try a bit of this and a bit of that and see what happens'. This discussion provides evidence of Denise's approach to teaching, encouraging curiosity and problem solving.

Finally the cake mixture is dolloped into paper cases within cake tins by individual children and there is great excitement about seeing if their experiment will produce 'fluffy muffins'. Denise says, 'I hope our experiment makes our muffins nice and fluffy'.

Opportunities for creativity

Motivation was evident in the children's enthusiasm for making muffins for a purpose; as gifts for their mothers. Throughout the episode, Denise's encouraged **curiosity** and **problem solving** and the children were able to **make connections** between the process of the making the muffins and the final product, with opportunities for **reasoning** (see *D3.1 List of Mapping and Comparison Factors*).

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Through the activity, the children were demonstrating the following synergies between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10).

- **Exploration** – by exploring the effect of the process of cooking on the final courgette muffins.
- **Motivation and affect** – by creating with a specific purpose.
- **Problem solving** – encouraged by **questioning** and **teacher scaffolding and involvement.**
- **Reflection and reasoning** – making the scientific and mathematical concepts explicit.

Episode 3: Discovering properties of materials

This episode took place in the late morning in Denise's class and involved all thirty children (aged 7 and 8 years of age) in a one hour session that started with a whole class introduction, followed by a carousel of activities and finished with a whole class plenary.

Pedagogical framing

The lesson was planned in three parts; firstly a whole class introduction, followed by a carousel of activities and finishing with a whole class plenary. The carousel of activities were:

1. Lighting booth: exploring the quality of materials by using a variety of light sources.
2. Creative Corner: exploring the properties of fabric and materials when placed on an OHP
3. Book Table: reading material on Astronomy and books on planets.
4. Greek Myths: revisiting books with Greek myths. Thinking about dark and light places in the stories and their potential for shaping children's puppet shows.
5. Recording sheets to provide written records of their discoveries about materials in relation to their puppet show.
6. Computer programmes with predictive activities regarding light and shadows.

Pedagogical interactions

Denise led the whole class introduction and plenary and moved between groups during the carousel of activities, supporting the children in using the resources (lamps, OHP ,fixed and movable screens and a variety of opaque, translucent and transparent materials), especially the use of lighting, whilst the Teaching Assistant was working with a group doing a paint mixing activity.

Opportunities for science learning

In the teacher- led class discussion at the start of the activity, Denise consolidated previous learning that had taken place and discussion 'science words' and knowledge connected to shadows and making their puppets. The children listened and responded well, with one child remembering that some of the materials were transparent. Denise praises the child and asks,' what made the material transparent?', to which the child replies, 'er ... you could see everything through it like it was a glass window'.

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Image 3.1: Denise discussing shadow properties

In the following discussion, the classroom rules about how to listen and talk together are exemplified in the behaviour of the children, showing mutual respect for each contribution.

Child: *"Yes and we made like … all coloured windows so everything looked purple and pink."*

Child: *"We made shapes so when the light was shining through the…like plastic paper and it was yellow or orange … it looked like the sun and there was blue transparent that made it look like the sea."*

Denise: *"Good Boy, when the paper is coloured the light shines through and makes yellow and blue shadows. You have made some useful discoveries to use in your puppet show. Can anyone remember other science words we used when we were exploring the materials this morning?"*

Child: *"Sometimes you couldn't see things good…it was light but it was like foggy shadow."*

Denise: *"Yes Good Girl, what science word tells us that we can see a bit of light but not clearly?"*

Child: *"Is it Opaque?"*

Denise: *"Good Girl. Yes sometimes the materials are Opaque or translucent and we cannot see clear shapes through the materials and they make soft shadows on the paper."*

Denise then shows an animated puppet show from Youtube, drawing attention to the characters being shown in the story and the background context. Complex ideas are being intersected within the teacher's narrative. She shows connections between light-effects and the characters in the story. Scientific language intersects with the notions of setting, character and the plot within the story and the children are engaged and volunteer technical analysis of shadows they see and the use of light to make different types of shadows. Denise constantly uses key vocabulary as she allocates various groups to new activities and authentic collaboration is evident in the way the children are co-operating with each other.

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Image 3.2: Exploring properties of light

The children then work in six groups on a carousel of activities:

1. Lighting booth: Children explore the quality of materials by using a variety of light sources
2. Creative Corner: Children explore the properties of fabric and materials when placed on an OHP with the Teaching Assistant encouraging them to consider the depiction of a character through translucent paper.
3. Book Table: Children read material on Astronomy and books on planets.
4. Greek Myths: The children revisit books with Greek myths, thinking about dark and light places in the stories and their potential for shaping children's puppet shows.
5. Recording: Children use sheets to provide written records of their discoveries about materials in relation to their puppet show.
6. Compute: Children use computer programmes with predictive activities regarding light and shadows.

During the activities, there is a palpable and genuine sense of systematic exploration as the children discover the properties of the materials often with surprise and delight, gaining new ideas about the way the stories might develop through the use of light and shade.

At the end of the session, there is a plenary, which begins with a clear purpose to consolidate the learning. Denise invites each group to give a progress report on the activities undertaken and children offer to share their work by reading extracts from books or demonstrating the properties of the materials. Examples of exemplary work were discussed and posters displayed with clear annotation and the children were encouraged to be co-teachers and support each other when there was hesitancy or the need for guidance:

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Child: *"I was very surprised by one thing today Denise. I discovered that Jupiter was shrinking every day at the rate of mm every day."*

Denise: *"Wow, that's amazing! Can you tell me your thinking about that?"*

Several children volunteered to develop the ideas. This included a ranking of Jupiter's position in relation to the sun to account for hot-spots or melt- down. Excitement grew as children postulated their theories about the shrinking planet. One boy was very excited and said… 'Oh [Mrs Name], my head is full of ideas and thinking about science- I must be a science-man.'

Opportunities for creativity

The episode provided opportunities to develop a number of creative dispositions, (*D3.1 List of Mapping and Comparison Factors*). **Motivation** and a **sense of initiative** were evident, especially in the small group activities, although the introduction encouraged **curiosity.** Both the whole class introduction and plenary activities encouraged children to **make connections** between past and current ideas and conceptual knowledge and to support **reasoning skills.**

Through the activity, the children were demonstrating the following synergies between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10).

- **Exploration** – in the small group carousel of activities.
- **Motivation and affect** – by encouraging children to **question** and be **curious.**
- **Dialogue** – in all parts of the lessons and **collaboration** in the small group activities and a reinforcement of concepts and vocabulary.
- **Problem solving and agency** – in the small group activities.
- **Teacher scaffolding and involvement** – throughout the lesson to encourage a focus on the scientific concepts.

3.23.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

In Denise's class, teacher-initiated exploration is used as the predominant pedagogical approach. These explorations usually involve small groups of children working collaborative and cooperative activities in which they explore physical materials, build on children's prior experiences and use questioning as a tool in science teaching.

What role if any does creativity play in these?

Creativity is evident in Denise's practice through experiences and teacher interaction that encourages children to make connections between prior and new conceptual understandings in science and creating ideas and artefacts, for example, courgette muffins and puppets. In the making

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of puppets the group of children observed felt confident enough to engage in free play with their puppets, even though Denise refocused their attention on the properties of the materials in order to make effective shadow puppets.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

Motivation and affective development are important aspects of Denise's practice and evident in all three episodes in this case study. Children are clearly free to express their ideas, negotiate boundaries and engage in free play and expression.

How do teachers perceive their role in doing so?

Denise facilitates learning and development through:

- Planning small group exploratory activities that stimulate interest and curiosity in the children.
- Providing support and scaffolding learning to ensure scientific and to a lesser extent (in the observed episodes) mathematical development.
- Making connections between previous and new ideas in all episodes, reinforcing and revisiting scientific concepts and experiences and drawing attention to connections between concepts.
- Developing scientific and mathematical vocabulary.

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3.24 Case: 'Brenda'

3.24.1 Context

Where?	Country	Wales			
	Setting name	W2 – South Parade Primary School			
	Location within setting	Pre-School			
Who? (children)	Year group/age of children	Reception; 4-5 years old			
	Number of children in class	28			
Who? (adults)	Number of adults	3			
	Role of adults	1 teacher and 2 teaching assistants			
	Case teacher role				
When?		1	2	3	4
	Dates of visits	31/01/13	01/3/13	08/3/13 2 researchers	08/3/13 2 researchers
	Times of visits		1000-1030	1330-1400	1400-1500

School/Setting

(See Joan case for school details.)

The last Inspection was in 2012 and identified that South Parade Primary School was a good school because:

- standards of attainment are good overall;
- pupils across the school are making good progress from their starting points;
- the quality of teaching is good;
- the school provides pupils with a wide range of learning experiences, which help them to broaden their understanding of the world and to develop new social and life skills; and
- the quality of care, guidance and support contributes significantly to pupils' wellbeing and has a positive impact on their behaviour, participation and learning.

Teacher

Brenda was not interviewed and has not returned the teacher survey.

Classroom

Brenda's class consists of twenty-eight 4 and 5 year old, Reception children, working with three adults (Brenda as class teacher and two Teaching Assistants.

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The classroom is set up as a fairly typical early years class with tables for working on and quiet and other areas, blocked off by screen or book shelves.

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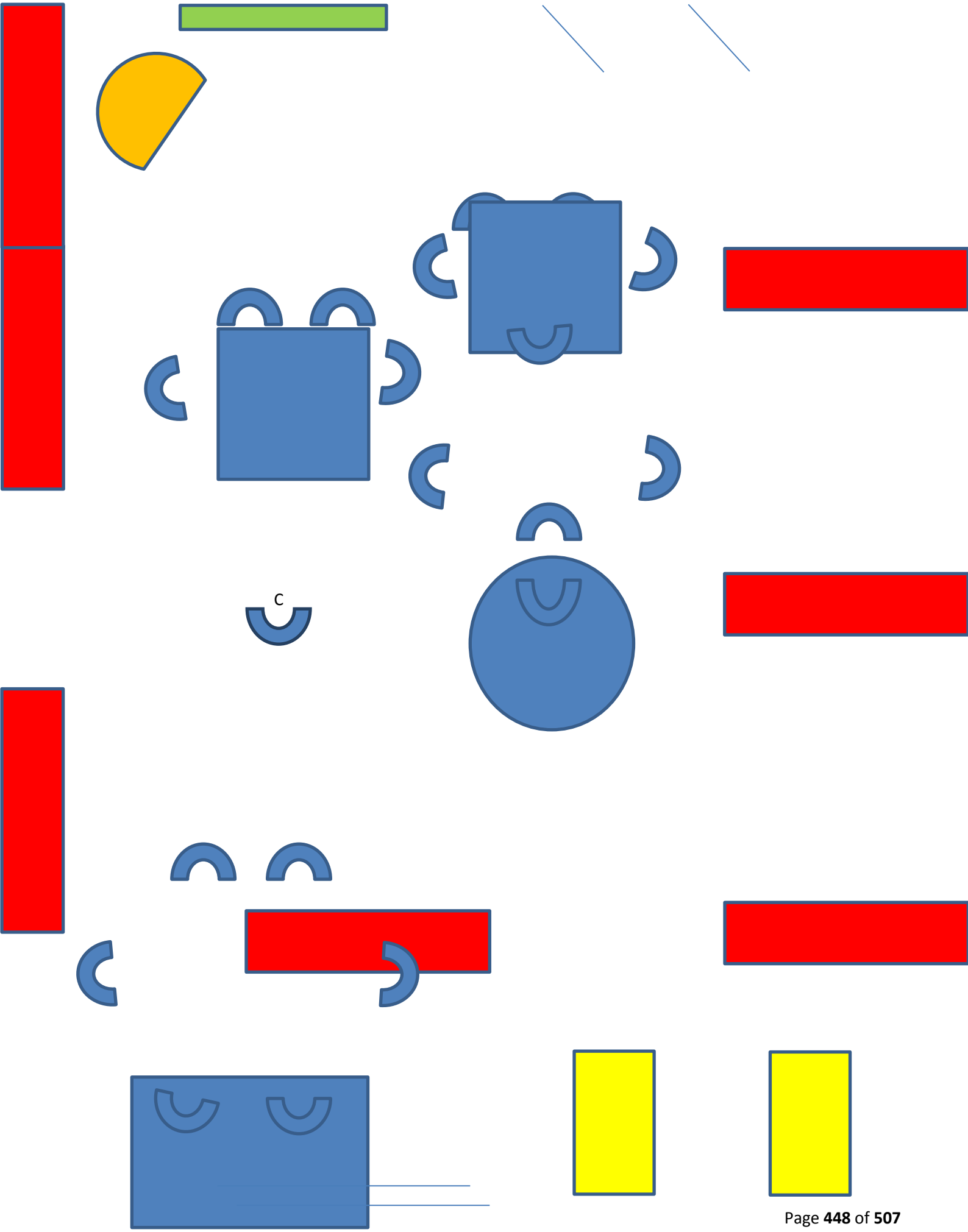
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3.24.2 Episodes

Episodes were gathered by two researchers and included some joint observations. The episodes in this case study illustrate the link between exploring and creating in mathematics and science.

Episode 1: Making musical instruments

This episode took place in an afternoon session in Brenda's class and the area outside her class, with twenty-eight children.

Pedagogical framing

The learning objectives were to make a musical instrument from a range of 'junk 'materials, such as, dried peas, elastic bands, cardboard tubes, margarine tubs with lids, small boxes, small plastic bottles with lids. Brenda appeared very confident to teach the science that was available that session and both teaching assistants seemed very capable and experienced and skilled in science teaching.

Pedagogical interactions

There were three adults in the class, Brenda, who was the class teacher and two Teaching Assistants. All 3 adults were 'floating' and assessing where the children needed the most help, although there was always 1 adult in the outside area, but this was flexible throughout the afternoon.

Opportunities for science learning

The activity starts with five children sitting at a table and they pick up items from the table and explore them.

Image 1.1: Group choosing and exploring materials

They appear fascinated with the dried peas, touching them rolling them around the big plastic bowl and making a noise with them rolling round. One child gains the attention of others and they join in, with the 'music making' with the dried peas. Another child takes some dried peas and puts them inside a tub, and then starts to shake the tub about. Other children begin to explore sounds in other ways by banging the empty plastic bottle on the table and another then bangs on top of a margarine tub using it like a drum. One child then puts elastic bands over his tub lid and 'strums' and shakes at the same time

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Image 1.2: Girls with shaker and guitar

One girl is not as involved with the others is calmly and carefully and in a very considered way putting dried peas one by one into her pot, every time she adds a pea she shakes it, considers the noise and adds one more. She is so absorbed in her activity that she continues even when the Teaching Assistant comes and asks the children what they have made and if they make a sound. Indeed, she spent 15-20 minutes engaged in making her instrument and did not engage by talking to anyone else and was totally absorbed on the task listening to the sounds and adding more peas until she was satisfied with the sound.

Image 1.3: Girl listening to sound of her shaker

Brenda comes over to the group and asks, 'Can anyone make a guitar like mine?' This motivates the children to make guitars, which are admired by one of the Teaching Assistants. She also helps one boy add an extra elastic band to his guitar.

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Image 1.4: Boy adding elastic bands

Image 1.5: Boy and girl adding elastic bands to guitar

Opportunities for creativity

Opportunities for creative dispositions (*D3.1 List of Mapping and Comparison Factors*) included:

- **sense of initiative** – children were encouraged to create their own musical instruments using the junk materials and their **imagination.**
- **motivation** – children were motivated by the act of creation and this encouraged **curiosity.**
- **connections making** and **problem solving** – the children were encouraged to make connections between the sound and the materials used and to use **reasoning.**

The activity in this episodes involved teacher initiated small group **play and exploration**, with the children working in groups, supported by the adult professionals. The episode involved **teacher scaffolding and involvement** in order to support **reflection and reasoning**. Teacher questioning reinforced ideas and children's **dialogue and collaboration** and **questioning and curiosity** were encouraged. There was some opportunity for **problem solving and agency.** The nature of the activities **motivated** the children and supported their scientific learning (*D2.2 Conceptual Framework*, pp. 9-10).

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Episode 2: Carpet musical instruments

This episode took place during the afternoon session in Brenda's class and involved all twenty-eight 4 and 5 year old children sitting on the carpet and working with three adults (Brenda and two Teaching Assistants), before they moved into groups for group explorations.

Pedagogical framing

The learning objectives were to introduce the idea of musical instruments and to explore how musical instruments make a sound, using a guitar and a flute.

Pedagogical interactions

There was a combination of teacher demonstration and questioning before the children had the opportunity to explore for themselves. Brenda began the activity by asking the children, "*How can we make a sound?*" She then gets out her flute and holds it up asking, "*How does this make a sound?*"

Image 2.1: Brenda with her flute

Opportunities for science learning

One child responds "*You can blow it"*, to which Brenda agrees and demonstrates, while all the children watch and listen. Brenda then asks the children to "*Find something to make me a sound with*." The children all look around them and one child spots the guitar in its case, saying "*There's a guitar*". Brenda takes guitar out of its case and holds it up, asking "*How does this make a sound?*"

Image 2.2: Brenda invites a child to show her how the guitar works

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A child identifies that it needs strings, at which Brenda invites the child to show her how. She then plucks at one string then strums across all the strings, asking the children to identify the difference between the sound of one string and the sound of all, saying, "*High… high… very high…"* and *"Low… very low…'.* Together the children say that the sound is "*different."*

Brenda then suggest that they all "*make some sounds together"* and the children start banging on the floor with their hands, hitting on their legs with their hands, tapping, banging, whistling and using their bodies to make sounds, clapping hands, clicking with their tongues, scratching with fingers and whistling. Brenda congratulated the children and said, "*Usually we're very quiet when we're working but this afternoon is a noisy afternoon and you are making lots of sounds. So you can make as much noise as you want.*"

Image 2.3: Tapping to make music

Image 2.4: Scraping fingers on a wooden ramp

Image 2.5: Banging

Opportunities for creativity

There were a number of opportunities for the development of creative dispositions, (*D3.1 List of Mapping and Comparison Factors*) such as:

- **motivation** – to make music in a variety of ways.

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- **connections making** and **reasoning** – by linking sounds and actions/ objects.
- **curiosity** – to explore the sounds made from different instruments and made in different ways.

Through the activity, the children were demonstrating synergies between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10). **Exploration** was evident in the activity as the children were encouraged to explore how sounds were made in a way that **motivated** the children and supported their scientific and mathematical learning. **Teacher scaffolding and involvement** supported **reflection and reasoning** and teacher questioning reinforced ideas.

Episode 3: 3Dshape

This episode took place in the classroom with a small group of four 4 and 5 year old children, working with a Brenda, whilst the rest of the class were in the school hall doing PE. It was an exploratory mathematics activity, using a selection of 3D shapes and with the learning objectives to develop the language of 3D shapes and use Maths language to talk about shapes, edge, side, face, 3D.

Pedagogical framing

This was an exploratory mathematics activity with the learning objectives to develop the language of 3D shapes and use Maths language to talk about shapes, edge, side, face, 3D.

Pedagogical interactions

Brenda worked with a small group of children whilst the other children in the class were in the school hall doing PE.

Opportunities for mathematics learning

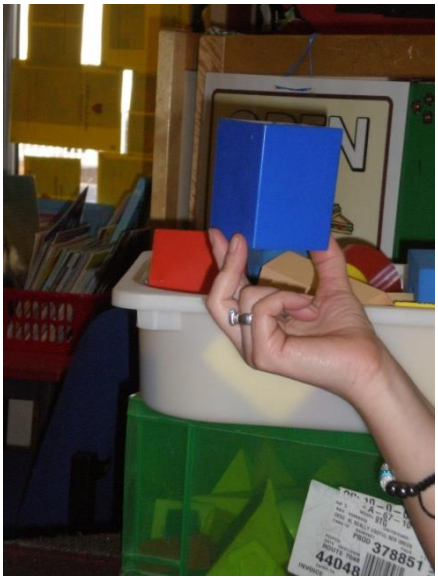

Image 3.1: Brenda holding up cube

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Brenda started with two children and asked them to observe features of the shapes, 'look' 'smooth' 'flat' and asking "*Does your shape have curved sides or flat edges?*"

Image 3.2: A collection of shapes to explore

The children were making structures with the shapes and Brenda constantly asked questions, motivating them and focused their attention on the shapes through positive reinforcement:

Brenda: *"Amazing castle"*
Brenda: *"The same?"*
Children: *"Circle"*
Brenda: *"Four sides?"*
Brenda: *"Can you find a square?"*
Brenda: *"A shape with square faces?"*

The children sorted the 3D shapes into piles.

Image 3.3: Sorting 3D shapes.

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One child pointed to a rectangle saying, 'see'. One child picked up a cone and said 'cone', using it to make a rocket.

Image 3.4: Making a rocket

Brenda reinforced 3D shapes by asking the children what they could tell her about the shapes and what was different about them and "*What does this shape have that this one doesn't?"* She then compares the 3D shapes and introduces a new shape, 'cuboid'. Each child makes a pile of cubes and cuboids, sorting the shapes. Brenda asks the children what the cuboid looks like and congratulates them; "*Well done, you've sorted into cubes and cuboids.*"

Image 3.5: Sorting cubes and cuboids

Brenda allows the children to play with the 3D shapes and one child builds a rocket and plays with it. '5,4,3,2,1 Blast Off!!'

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Opportunities for creativity

There were observed opportunities for creative dispositions, (*D3.1 List of Mapping and Comparison Factors*) such as:

- **sense of initiative** – children could use the 3D shapes to create objects, using their **imagination** and some **innovative** and **creative thinking.**
- **Motivation** – was evident throughout.
- **connections making** – between shapes and objects and vocabulary.

Through the activity, the children were demonstrating the following synergies between mathematics and creativity (*D2.2 Conceptual Framework*, pp. 9-10). The nature of the activity **motivated** the children and supported their mathematical learning. Teacher-directed **play and exploration** was evident as was **teacher scaffolding and involvement** in order to support **reflection and reasoning**. Teacher questioning reinforced ideas as did children's **dialogue and collaboration**.

3.24.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

In Brenda's class, teacher-initiated and directed play and exploration was the main observed pedagogical approach. Adult support and scaffolding of learning occurred throughout the episodes. The importance of language development and vocabulary are also evident in all episodes.

What role if any does creativity play in these?

Creativity is evident through the children's ability to make connections between ideas and concepts in both mathematics and science and create sounds, musical instruments and turning 3D shapes into structures that they could play with.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

The children are motivated by the choice of activities that stimulate, as well as by Brenda's encouragement and positive reinforcement. Explorations, even those that are teacher-led can support the development of mathematical and scientific understandings, alongside language development (including increasing vocabulary).

How do teachers perceive their role in doing so?

Brenda facilitates learning by:

- Planning activities that stimulate interest and curiosity in the children.

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- Reinforcing and revisiting ideas and concepts and experiences, drawing attention to connections between concepts and ideas and allowing children to explore and create their own musical instruments and structures from 3D shapes.
- Providing support and scaffolding learning throughout the activities, although occasionally it may have been beneficial to stand back and allow children some space to explore.

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3.25 Case: 'Joan'

3.25.1 Context

Where?	Country	Wales		
	Setting name	W2 – South Parade Primary School		
	Location within setting	Pre-School		
Who? (children)	Year group/age of children	Year 1; 5 & 6 years old		
	Number of children in class	28		
Who? (adults)	Number of adults	3		
	Role of adults	1 teacher and 2 teaching assistants		
	Case teacher role			
When?		1	2	3 &4
	Dates of visits	01/02/13	01/3/13	07/3/13 2 researchers
	Times of visits	100-1030	1115-1130	1345-1445

School/Setting

South Parade Primary School is a friendly close knit community school which has served the local community for over 100 years. They have a strong Christian ethos and this cascades throughout the school year. It's motto is 'Learning Together through Fun, Friendship and Faith' The school's vision is to set the fundamental purposes and values of South Parade Primary School in Wales as a fundamental cornerstone of its educational approach .In the school they aim to create within a Christian setting safe, secure and fun learning environment where every child feels happy and enjoys their learning. They strive to create an atmosphere where standards of teaching and learning are constantly in view and can be raised, and where all succeed to the best of their ability.

There are currently two hundred pupils, aged 4 to 11 years, on the school roll. Twenty-eight per cent of pupils are entitled to free school meals, which is above the national average. The school has identified 17% of pupils as having additional learning needs. One pupil has a statement of special educational needs. There is one looked after child in the school. Pupils come from a range of ethnic backgrounds. For 80% of pupils, English is the predominant language spoken at home. English is the main language of communication in the school and Welsh is taught as a second language. South Parade Primary School strives to make everyone feel valued as a member of the school/church community and that they have an important contribution to foster and develop good

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communication links within the school and its wider community. Children receive special awards each week for being kind, polite and respectful.

The last Inspection was in 2012 and identified that South Parade Primary School was a good school because:

- standards of attainment are good overall;
- pupils across the school are making good progress from their starting points;
- the quality of teaching is good;
- the school provides pupils with a wide range of learning experiences, which help them to broaden their understanding of the world and to develop new social and life skills; and
- the quality of care, guidance and support contributes significantly to pupils' wellbeing and has a positive impact on their behaviour, participation and learning.

The Inspection report recommended that South Parade Primary School work to raise boys' level of achievement, particularly in English, mathematics and science; the school's Science Curriculum is taught within a 'thinking skills' approach, reflecting changes to the Curriculum in 2008. They engage the children at the start of the session by using relevant and interesting activities. They then explore children's existing knowledge and understanding and present them with new challenges to move their understanding on. Children have the opportunity to participate in fieldwork, research enquiries, demonstrations and investigations. Once children have 'moved on' in their understanding of the scientific idea they are then given the opportunity to consolidate their learning by applying their ideas to a new situation. The school encourages children to review what they learn and the way they learnt it.

The content of the mathematics curriculum covers knowledge, skills and concepts in Number, Shape and Space, Measuring and Data Handling. Pattern and relationships in maths are explored through maths investigation and practice in mental agility is also included. The school uses the Abacus Scheme at Key Stage 2 and Abacus Evolve at Foundation level as a main scheme which offers progression through the school and a range of teaching methods including practical ideas and games to enhance the children's learning. The new skills curriculum in maths is covered through enhanced provision and the use of a data den in each KS2 classroom. Teachers use a range of teaching styles and materials to help children reach their potential in this curriculum area.

Teacher

Joan is the science coordinator for South Parade Primary School and has a BSc marine geology and geography and has a secure science background. She was influenced by her tutor at Cardiff University who advocated Forest schools philosophy. So this has inspired her to use this philosophy 'creatively' in her teaching and across the school, having undertaken forest school leader training course (Level 3, a pre-university level of qualification) and meeting in a cluster group for support the Forest School work in school.

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She obtained QTS (Qualified Teaching Status) and a PGCE (Postgraduate Certificate in Education) in 2010 and is currently in her third year of teaching, having always taught at W2 since qualifying. In these three years, Joan has taught Year 4 (8 and 9 year olds), Year 5 (9 and 10 year olds) and now Year1 (5 and 6 year olds).

She is working on the Inspection recommendation from 2012 that the school should strive to raise boys' level of achievement, particularly in English, mathematics and science and runs a science club. She acknowledges the importance of preparing children for national tests by activities such as Big Maths, beat that. She sees these activities as formative of assessment which does not pressurise the children and this is borne out by the children's learning walk when they identify the class display as helping them learn.

As part of National Science and Engineering (a week of science activities for schools and the general public, organised by the British Science Association, http://www.britishscienceassociation.org/national-science-engineering-week), which ran 15 to 24 March 2013, the whole curriculum and teaching and learning in Joan's class was through science. The planned activities, including, the hatching of chicks in the classroom, were highly motivating, but unfortunately did not coincide with the data collection period for the Creative Little Scientist project. In her interview Joan identified former creative science activities as:

- exploring what was alive, as it encouraged pupil observation,
- creative questioning about dinosaurs,
- activities that provide the children with opportunities to' transfer things independently', such as investigations,
- 'the Forest school approach, when we ask the children to look after an egg, decide what you need to protect an egg, so that it won't break and then they make it a home using all different materials. Then they get to test it, that's quite creative and explorative'. She goes on to identify that the Forest School approach adds an extra dimension to the school.

An example of the Forest School approach resulted in 'the display of bog babies. It's based on a story where the children take the baby away from the bog, and the Bog baby starts to die, and the children find out from their grandmother how to look after the bog baby and save it know after how to look after. And when they go back there's loads of bog babies'. Joan started this activity by reading the story of 'The Gruffalo' to a group of children in the outside play area and they followed this up by making homes for all the different animals in the story, collecting things from outside to make them. In another example, Joan describes how she blind folded the children and got them to walk round and explore the trees, by touching them and feeling them.

Joan identifies creativity as very important in learning and discusses in her interview both making creative artefacts (e.g. painting and drawing) but also creativity through speaking and using the imagination. She however, thinks that some children are unable to be creative and the activities and resources that the teacher provides can help develop creativity, so it 'comes in to every subject you

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teach being creative. Children are creatively interacting with the resources that I put out for them and then they always use them differently to how I thought they were going to but I think that is what's so exciting at foundation stage because it's how they choose to be creative with the equipment'.

Classroom

Joan's class consists of twenty-eight 5 and 6 year old, Year 1 children, working with three adults (Joan as class teacher and two Teaching Assistants).

The classroom is set up as a fairly typical early years class with tables for working on and quiet and other areas, blocked off by screen or book shelves.

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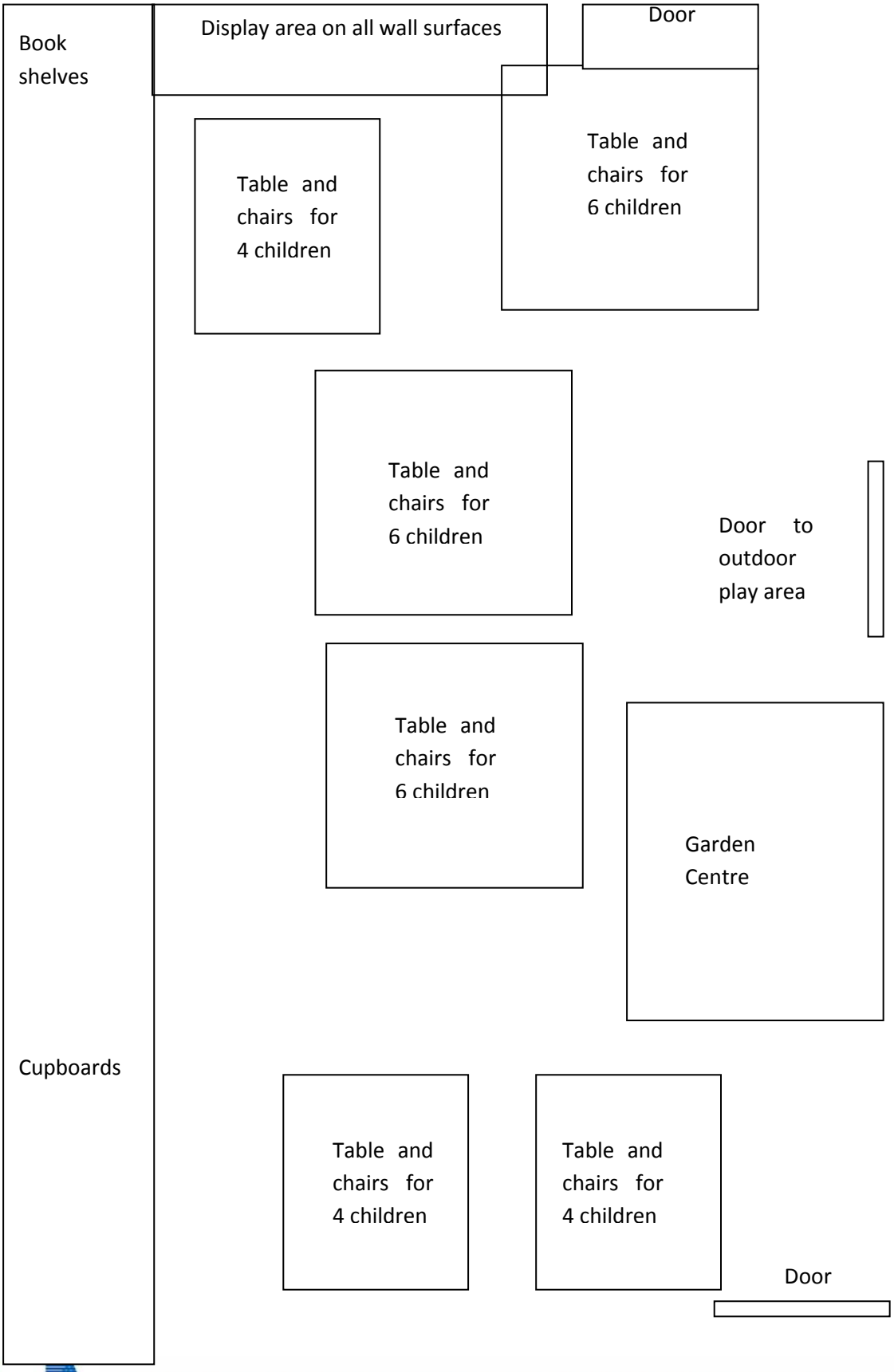

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3.25.2 Episodes

Episodes were gathered during visits by two researchers working in parallel and observing different activities in the same classes as well as some joint observations. The episodes in this case study illustrate the importance placed on the development of vocabulary in both science and mathematics.

Episode 1: Light and dark - torches

This episode took place in the morning session of Joan's class with twenty-eight 5 and 6 year old children (Year 1), sitting on the carpet and then moving to group work.

Pedagogical framing

The learning objectives were to explore light sources and the resources provided were the interactive white board, torches and light producing / reflecting objects.

Pedagogical interactions

The children started on the carpet, with a whole class introduction by Joan ,then moved to work in groups, supported by Joan and two Teaching Assistants (one of whom was working with a group at table and the other was with a group on a light walk around school).

Opportunities for science learning

Joan starts on the carpet and asks the class to keep their eyes open but put their hands over their eyes, as one of the children says 'like cups'. Joan demonstrates and slowly tells the children to 'slowly move your hands away from your eyes', but to 'open eyes but it's really dark'.

Image 1.1: Whole class introduction – 'Put your hands over your eyes'.

Joan then questions the children as to what they can see and the children answer, 'light through fingers', 'light' 'dark' and 'it makes it red. Joan continues with her questioning by asking how the light is getting in, although when children ask questions of their own, she replies that she will get back to them. Joan then writes WOW words on the interactive white board and makes links to literacy.

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Joan asks if hands are a good barrier to light and what a barrier is; she seems to ask and answer her own questions. She also asks where the light is coming from (there are different light sources in different places in the classroom, as well as the window) and identifies that if light is coming in from the window they don't need the light on. A further WOW word is written on the interactive white board; a screen a barrier, blocking it (light) out.

Joan then asks the children to identify what they know about light and what they would like to find out and lists light sources on the interactive white board. One child responds 'sun light bulb' and Joan suggests the addition of a describing word 'light is bright' and further suggests that 'it [light] might come from a lamp'. Other suggestions of light sources are the interactive white board and electricity (which is translated in Welsh), both suggested by Joan and a torch by a child. Joan then questions the children about the part light plays in our lives:

Joan:	*"Can we live without light?"*
Child 1:	*"We couldn't see without light"*
Child 2:	*"You could hurt yourself"*
Child 3:	*"Plants need light"*
Joan:	*"They need light to grow… If we had no plants to eat ... we need to eat to live"*

Joan then asks the children what they would like to know about light and encourages them to ask their own questions and Joan adds more words to the interactive white board. When the children go quiet, Joan suggests that they 'might think of some more questions as you're working' and explains the task for the rest of the session:

- a walk around school looking for light, accompanied by one Teaching Assistant,
- exploring a collection of objects, including torches and reflective jackets. In doing this Joan introduces words, such as 'reflective', 'shining', 'glow', 'torch', 'batteries' etc.

Image 1.2: Exploring reflective jackets

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Image 1.3: Exploring torches

- follow up worksheets

Image 1.4: Child working at table

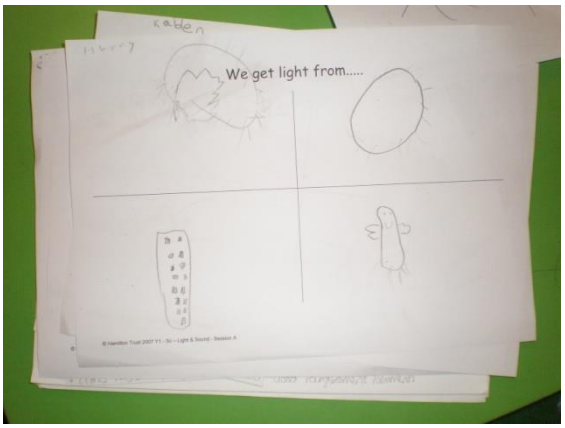

Image 1.5: Worksheet

Opportunities for creativity

There are a number of opportunities for creative dispositions, (*D3.1 List of Mapping and Comparison Factors*) in this episode. Children are **motivated** by being allowed to explore from their initial **curiosity** and develop **reasoning skills** through the development of scientific vocabulary and **connections** between the 'WOW' words and scientific understanding.

Through the activity, the children were demonstrating the following synergies between mathematics, science and creativity (*D2.2 Conceptual Framework*, pp. 9-10):

- Teacher-initiated **exploration,** that followed from teacher-led introduction.
- Opportunities for **dialogue and collaboration** and child **questioning** are more overt in the follow-up activities, where children can discuss what they are doing and ask questions.

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- There was potential for children to follow their own ideas and for child **agency and problem solving,** but these were not always capitalised upon.
- **Teacher scaffolding** was a characteristic of the episode and Joan asks questions and **scaffolds** learning.
- A feature of all the observed episode is the focus on reinforcement of key ideas and concepts, leading to **reflection and reasoning.**

Episode 2 - Life cycles

This episode took place in the afternoon session of Joan's class with twenty-eight 5 and 6 year old children (Year 1) with three adults (Joan, who is the class teacher and science coordinator and who is very knowledgeable in science) and two Classroom Assistants.

Pedagogical framing

Joan used a short film to highlights key words in a whole class introduction. This was followed by small-group activities.

- Graphics table: where children are drawing from a photograph.
- Scrapbook table: where children are creating a scrapbook by cutting and sticking words and pictures associated with the life cycle of the ladybird.
- Craft table: where children are making life-cycle mobile with 4 components, under the supervision of teacher and using observation and counting skills.
- Outside water tray to play with plastic tadpoles and plastic frogs that jump and squirt water.

Pedagogical interactions

The learning objectives were to develop knowledge of life cycles and published resources and photocopied work sheets were used to support the group activities that followed on from the whole class introduction to a new topic. The children started on the carpet with a whole class introduction to the topic by Joan and then moved to work in groups, supported by Joan and two Teaching Assistants.

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Image 2.1: Life cycle resources

Opportunities for science and mathematics learning

Joan started the introduction by asking the children what they understand by the term 'life cycle'. She quickly continues by repeating the question a different way and then asking, 'Where do we start in our Life?'. At this point one child replies 'in our mummies tummies', to which Joan asks two questions, 'Do we grow in our mummies tummies?' and 'When we come out of our mummies tummies do we keep growing?', to which all the children answer 'Yesss'. Joan follows this with:

Joan: *"Yes we keep growing when we are babies and we are toddlers and we got to nursery and we got to school…when do we stop growing?"*

Child: *"When we are 100years"*

Joan: *"No not really… we stop growing when we are 22 years old… we may grow outwards but we stop growing taller."*

Joan then repeats the life cycle of the children and then says that they are going to look at the Life cycle of animals. She asks, "*What might animals come out like?*" and one child answers "*Eggs*". Joan identifies that different animals come out in different ways and they live in different ways and gives the examples of a parrot who can live for 100 years and a butterfly who will only live for one summer.

This introduction is followed by a short film (2 minutes) about the life cycle of a ladybird (ladybug on the video), after which Joan reinforces the new vocabulary in the film; eggs, larva, pupa, adults and checks factual information with the children:

Joan: *"How many eggs, babies does the ladybird hatch, make?"*

Child: *"2000"*

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Joan: *"Good yes 2000…can you imagine having 2000 babies in your family? … How many insects does the lady bird eat?"*

Child: *"500"*

Joan: *"Yes that's a lot isn't it"*

Joan then replays the short film and highlights key words again. After this, the children are allocated an activity

- Graphics table: where children are drawing from a photograph.
- Scrapbook table: where children are creating a scrapbook by cutting and sticking words and pictures associated with the life cycle of the ladybird.

Image 2.2: Scrapbooking key concepts

Image 2.3: Making life cycle mobiles

- Craft table: where children are making life-cycle mobile with 4 components, under the supervision of teacher and using observation and counting skills.
- Outside water tray to play with plastic tadpoles and plastic frogs that jump and squirt water.

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Image 2.4: Outdoor play

On the craft table, the children were encouraged to count the legs of lady birds and count black pipe cleaners that were being used as legs. Joan asked them to identify how many pipe cleaners they would need if they were folded in half, to which one child identified three. Joan followed this us by asking why they needed three pipe cleaners if they have six legs, to which a child answered, "*Hey can have 3 legs on each end*" and Joan responded with 'yes we can double the number'. Later, Joan asked "*Because they are called lady birds are they all ladies?*" to which the children replied "*Noooo"* and one child said, "*We can call some of them man-birds [giggles]*".

Opportunities for creativity

Creative dispositions (*D3.1 List of Mapping and Comparison Factors*) that could be seen in this episode included **making connections** between past and present ideas, use of **imagination** and **innovative thinking** by asking children to identify with the life cycles being discussed and creating ladybirds on the craft table.

Exploration occurred in the follow-up activities and there was potential for children to follow their own ideas and for child ***agency and problem solving,*** but these were not always capitalised upon. Throughout all the episode, Joan asks questions and **scaffolds** learning, although she does not always allow space for the children to answer and to follow up their own ***questions***. Opportunities for ***dialogue and collaboration*** and child ***questioning*** are evident in the follow-up activities, where children can discuss what they are doing and ask questions.

A key feature the observed episodes are the focus on reinforcement of key ideas and concepts, leading to ***reflection and reasoning***. Joan uses shared (class) writing books for assessment purposes as she says that "*You can assess them at the same time (when you see what they've done)*". As

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children get older, Joan identifies that self-assessment becomes important and she uses three strategies:

1. Traffic lights (red green),
2. Thumbs up thumbs down
3. Two stars and a wish.

An example of this approach to assessment was a spontaneous activity for the children to participate in, where they each contributed to the shared book as and when they felt like it, filling in the blank pages on a theme, to produce a progressive class book. Marking involves using different colours for different adults in the class (e.g. teacher, Teaching Assistant), so 'you can see at a glance who has been working with each group, or maybe a group that you haven't seen a lot, sharing things that are significant. She also likes to takes quotes from the book and use it in the assessment, 'for example, a girl said she liked the north star best because it was the brightest star'.

Episode 3: Big Maths, Beat That

This was a mathematics session that took place in the morning session in Joan's class with all twenty-eight 5 and 6 year old children (Year1) sitting on the carpet for a whole class introduction, led by Joan, followed by small group activities, supported by Joan (as the class teacher) and two Teaching Assistants.

Pedagogical framing

The learning objectives were connected to Big maths- Beat That and used published resources and photocopied work sheets in the follow up work.

Image 3.1: Big Maths display

This activity was identified by Joan in her interview as regular activity that the children enjoyed and designed to get them ready for testing but not put pressure on them.

Pedagogical interactions

The activity was teacher-led and involved teacher questioning and children's structured responses.

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Opportunities for mathematics learning

The children begin by sitting in formal rows on the carpet and Joan reminds them of the activity and the need to work 'very quickly as quickly as we can'. The following revision conversation occurs:

Joan: *"Do you remember what we do to beat the Clock in 20 seconds?"*
Joan: *"We can do our double numbers very quickly. Do those first."*
Joan: *"Remember how to half a number. Do those next."*

Each child is given a clip board with two pieces of paper attached and they are reminded of the instructions, to sit still, face the front and not cheat, so that Joan can see what they can do and help them when they cannot. She also reminds them that their twenty seconds start when the music stops and then encourages them throughout the twenty seconds, reminding them of the instructions and that they can use their fingers and asking them to focus on what the question is asking them. The children do two sheet and then sitting on the carpet they begin Practice Maths by counting in tens checking 11X10and 12X10, drawing numbers in the air with finger pens and joining in the ten times table during multiplication songs played on tape recorder. In the latter Joan asks them to remember the whole number sentence is 2 times 10 equals 20

Following this activity, the researcher went on a learning walk with a child in which the child shows the researcher the Big Maths Wall (see Image 3.1: Big Maths display) as an example of what helps learning, by explaining to the researcher the rationale for Big Maths, by reading from wall, using the display to prompt her explanation of the tripartite approach to Big Maths.

Opportunities for creativity

Creative dispositions (D3.1 List of Mapping and Comparison Factors) observed were:

- **Motivation** – children clearly were motivated to learn in this way.
- **Reasoning and problem-solving skills**

Through the activity, the children were demonstrating a number of synergies between mathematics and creativity (*D2.2 Conceptual Framework*, pp. 9-10). ***Motivation and effect*** is evident in the activity and the learning walk. Throughout all the activity Joan asks questions and **scaffolds** learning and there is a focus on reinforcement of key ideas and concepts, leading to ***reflection and reasoning.***

Formative ***assessment*** was evident and Joan acknowledged in her interview the importance of preparing children for national tests by mathematical games and tests.

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3.25.3 Summary and conclusions

RQ2: Probing practice

What approaches are used in the teaching, learning and assessment of science and mathematics in early years?

The predominant teaching, learning and assessment approach in Joan's class is a teacher-led introduction, followed by adult-supported small group activities. Teacher questioning directs the children to the intended learning and language development (including vocabulary) is prized. Joan identifies in her interview that the children are not independent learners and they need adult guidance and prompting and so she would prefer to 'put an adult with that type of activity; investigating and exploring'. In the torch activity Joan used Year 5 and Year 6 pupils (aged 9 to 11 years of age) to support her class.

What role if any does creativity play in these? This would include the exploration of opportunities and challenges for development of skills and attitudes associated with creativity.

Creativity is evident through the focus on making connections to previous work, concepts and ideas. Some creativity is also evident in the follow up activities in exploring light sources. In her interview, Joan identifies the shared writing book as a form of creativity, saying 'it wasn't really creative, But now they take it into the garden centre and work in it by themselves, and until you look you don't know what they've done in them, it's sort of relaxed and creative'. Although these episodes do not focus on the Forest School approach this is clearly a creative aspect of Joan's practice.

RQ3: Probing practice

In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

Joan uses pace in the introduction to activities to motivate and foster interest. She also makes good connections to previous ideas and uses motivation and this also motivates children, such as linking life cycles to the children's own experiences first before moving onto the life cycles of animals. The competitive element of the Big Maths activity is also a motivating element in mathematics. The Forest School approach appears to motivate children to explore and investigate the world around them and Joan also identifies the use of a 'wow' word bank, where children can write new words, as a motivating factor in her teaching.

How do teachers perceive their role in doing so?

Joan perceives her role as:

- Planning activities that are well matched to the learning objectives for the age group.
- Reinforcing and revisiting scientific and mathematic concepts and experiences and drawing attention to connections between concepts
- Providing support and scaffolding learning through teacher questioning.

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- Preparing the children for national assessments.

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4. Discussion of findings

4.1 Enabling factors or barriers at the contextual level

4.1.1 School factors

As indicated in section 2.4, in selecting sites for fieldwork in the UK partners drew on official information about the quality of practice and findings from the teacher survey to choose a sample that suggested potential for observing examples of creativity in early science and mathematics. The selected schools for whom inspection evidence was available had all been judged as either good or outstanding with positive features identified in relation to mathematics, science and/or creativity.

Evidence from fieldwork processes, in particular from school documentation and interviews with staff, highlighted a range of factors at whole school level that can contribute to a climate that has the potential to foster creativity in early mathematics and science. These are outlined below.

Whole school approach to learning and teaching.

In a number of schools, practice was informed by explicit perspectives on learning and teaching, promoted by the school leadership and reflected in school practice. For example Country Nursery (NI1) indicated commitment to Reggio Emilia philosophy while Forrest School (SC2) based their teaching approaches on Froebelian principles and South Parade (W2) work within the Forest School philosophy. Braes (SC1) is a 'Rights Respecting' school with a strong emphasis on children's voice. Policy in St Denis (EN1) promoted 'problem solving and games'. Teacher planning and teacher interventions in Wayland (EN6) were informed by 'Sustained Shared Thinking' (based on the work of Siraj-Blatchford et al., 2002), Yardley (EN7) was involved in a project developing play-based approaches in primary classes and South Parade (W2) adopted a 'thinking skills' approach to learning and teaching. In many of the schools there was a strong commitment to teacher professional development. Seven of the fifteen schools were actively involved in initial teacher education offering on-going opportunities for discussion and evaluation of learning and teaching approaches.

Involvement in initiatives and events related to science and mathematics and promotion of creativity in learning and teaching

There was evidence in a number of the schools of ways in which **involvement in whole school initiatives and events had served to raise the profile and importance of science and mathematics and to promote creativity in learning and teaching**. Five of the fifteen schools had been involved in raising the profile of science and mathematics through working towards awards including Gold Quality Mark in Primary Science (EN1, St Denis), Eco School Status (EN1, St Denis; EN4, Ridgeway; NI2, Ashford; SC2, Forrest school) and Healthy Schools (EN1, St Denis; EN4, Ridgeway; EN8, Lindisfarne). Five of the schools regularly organised whole school activities focused on science and mathematics such as science or mathematics weeks or assemblies and participated in regional and national competitions. Two of the schools (EN4, Ridgeway; EN8, Lindisfarne) had been actively involved in research and initiatives related to creativity in learning and teaching.

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Team work

Teachers in several of the schools referred explicitly to the important role of team-working in enabling them to try out new ideas and reflect on practice. They had formal and regular opportunities for dialogue about planning, teaching and children's progress at different levels. For example:

- St Denis (EN1) has a science committee involving both staff and pupils that seeks to ensure science maintains a high profile and discusses how science should be taught across the school. This was reflected in the comments of Louise, one of the case study teachers in the school, who felt that the ethos in St Denis was that they were 'all in it together' and that the focus was on the child.
- In several of the nursery settings the staff in the nursery taught as a team. They met regularly to review activities and children's progress to inform planning (e.g. EN6, Wayland; SC1, Braes; SC2, Forrest). The value of this was highlighted by Martha (SC1), "*you can bounce ideas around – a lot of nursery planning needs to be in the moment*' [if it is to be responsive to children]."
- In some of the primary settings teachers worked with parallel class teachers in planning (e.g. EN3 Clover, EN7 Yardley). In the case of Emily (EN7) this provided both support and stimulus for developing play-based approaches in science and mathematics in Key Stage 1.

Differences between preschool and primary school

With the small number of sites in one country it is difficult to draw any clear conclusions about differences between preschool and primary school settings. Comments can only be suggestive of themes that might be explored further across the larger number of sites across the partnership.

Whole school approaches to learning and teaching were articulated and were influential in examples from both settings – based on child-centred perspectives and on generic strategies to promote children's inquiry and thinking. Both preschool and primary settings were also involved in initiatives and events related to science and mathematics. In terms of team working, staffing arrangements in preschool settings mean that team working tends to more common and is needed for staff to collaborate effectively not just in planning and in sharing information about children's progress but in day to day working alongside each other in the classroom. In nursery settings in England and Scotland for example, children are allocated key workers who need to communicate across the staff team to ensure progress of their key children is monitored closely across the wide range of provision both indoors and outdoors. In primary schools team-work was evident in schools where there were parallel classes in the same age group. This tended to focus on joint planning of activities to be carried out in separate classrooms rather than the sharing of teaching or assessment processes within the same classroom.

Differences between science and mathematics

Whole school initiatives related to science were reported more frequently than in mathematics. This may reflect the high priority given to mathematics in policy across the countries of the UK – so there appeared to be little need to 'promote' mathematics through particular initiatives. In contrast more active efforts are often needed to promote science education and to ensure it has a secure

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place within the curriculum. Furthermore science related initiatives are often linked to issues of concern in the wider community for example concerning the environment (Forest School approaches), sustainability (Eco School status) or health (Healthy Schools).

Opportunities and challenges for creative learning and teaching

The school factors highlighted above have the potential to contribute to an environment of mutual support and dialogue that can encourage creative teaching in a number of ways. Whole school perspectives and team working can provide important frameworks within which teachers feel able to discuss alternative ideas and take risks. All the examples of specific teaching approaches promoted at whole school level also all focused on factors identified in D3.1 as associated with creativity in learning in mathematics and science, such as problem solving, questioning or thinking skills.

4.1.2 Teacher factors

Teacher characteristics and education

All the UK 24 case study teachers were female. 13 worked in preschool settings and 11 in primary settings. There was a wide variation in age (between 20 and 60 years old) and in years of experience, with a number who had been teaching less than 5 years as well as several who had more than 20 years teaching experience. Almost all had BA degrees and teaching qualifications (one teacher was in the final stages of gaining qualifications). Only three had science or mathematics related degrees and many had not studied science extensively during their school education. Over half of the teachers had positions of responsibility in their schools ranging from head/deputy head to phase or curriculum coordinator and coordinator for science or mathematics. Nearly half the teachers referred to recent participation in courses, conferences or networks for teacher development. In a few cases teachers indicated the important support provided by these connections for example Emily (EN7) working with LEA network-related play-based approaches or Sarah (SC2) and Joan (W2), both involved in the Forest School network.

Teacher perspectives on learning and teaching in science and mathematics

Varied information was available from teacher interviews regarding teachers' perspectives on their roles in supporting creativity in science and mathematics. Common themes reflected many of the factors identified in D2.2 Conceptual Framework, for example the **importance of encouraging children's interests and curiosity, allowing space and time for play and exploration and providing opportunities for development of problem solving and inquiry skills.** Common roles for the teacher identified were the use of children's ideas as starting points, supporting inquiry through questioning and encouragement of dialogue and collaboration. In developing concepts teachers emphasised the need to provide a variety of experiences to allow learning in different ways and opportunities for revisiting and reinforcing key ideas. Here they referred to the role of the teacher in introducing scientific vocabulary and in helping children to make connections between experiences and ideas across contexts. **Very limited reference was made to factors associated with expressing or representing ideas, use of ICT or to assessment**. Assessment was also an area in which a number of teachers indicated they lacked confidence. This is explored further in section 4.2 Assessment below.

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Differences between preschool and primary school

No general differences were noted between the overall profiles and perspectives of teachers in preschool and primary school.

Differences between science and mathematics

No particular differences were evidence in teachers' overall views of learning and teaching in science and mathematics, although some differences were noted in practice as outlined in section 4.2 below.

Opportunities and challenges for creative learning and teaching

Teachers' perspectives indicated strong support for many of the features of creativity in learning and teaching identified in D2.2 Conceptual Framework. These represent important enabling factors in promoting creativity in mathematics and science. Some areas for development were however suggested in the lack of attention to varied ways of representing ideas, children's use of ICT or the reflection in learning and in common concerns expressed about assessment.

As discussed in 4.1.8 below, barriers to creativity associated with policy were volunteered by teachers in only a minority of cases. These challenges included, for example, concern about expectations of inspectors (Emily, EN7), coverage of the curriculum and the pressures of statutory assessment requirements in England, in particular related to testing in mathematics (Jenny, EN1). However these teachers also felt that they had strong support from their school and colleagues in interpreting policy requirements in the light of their own aims and values.

4.1.3 Materials

The list of factors (in *D3.1 List of Factors*) highlighted the importance of materials in fostering creativity in early science and mathematics. Important factors identified included the variety and use of physical resources, availability of space and human resources, the level of reliance on published commercial schemes, the use of ICT and the role of informal and outdoor resources. In this section we review the use of materials evidenced in the preschool and primary cases, reflecting on any differences between preschool and primary settings or between science and mathematics episodes.

The data collected across the United Kingdom revealed that a rich physical environment and **sufficient use of space** were to be more likely to be seen in preschool settings (e.g. 'Pulleys activity', Fleur 2, EN2; and the episodes from Alice and Maeve, NI1). Although primary classrooms tended to have more restricted environments, some were able to overcome this by using additional spaces (Louise, EN1).

A **variety of resources** was evident in both pre-school and primary *Creative Little Scientists* classrooms where children's creativity was being stimulated. Such resources were often used as a stimulus for a theme (e.g. Carnival of the Animals, Wendy, EN3), although their use was more pervasive in preschools, where use of varied resources was more informal (e.g. Cars and ramps, Jenny, EN1; Bubbles, Alice, NI1).

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The *Creative Little Scientists* classroom data revealed that across the United Kingdom countries, preschools were more likely to have additional **human resources** of one or two Teaching Assistants supporting activities, whereas primary schools usually had additional support on a one to one basis for specific children in the class. There were exceptions to this, with Louise (EN1) having a large number of additional adults, allowing her to organise many small group activities. There were no observed differences in human resources between mathematics and science activities although the quality of the support of additional adults (usually Teaching Assistants) appeared to be more important than the number of adults. That is to say, in episodes where the Teaching Assistant was well briefed by the teacher and was confident in their science and/or mathematics knowledge the children's learning was greatly facilitated.

The episodes across the UK revealed **little or no reliance on commercial schemes in either science or mathematics**. Even in the older years, where commercial schemes are stereotypically more prevalent (particularly in mathematics), there was little evidence of these, and any paper and pencil activities were based on self-devised worksheets (e.g. Caterpillar Boots, Caroline, EN4). This pattern was borne out by the *Creative Little Scientists* fieldwork in both pre-schools and primary schools. The wealth of data analysis from the United Kingdom episodes illustrates how these teachers engaged children in pre-school and school settings, to work with an investigative approach to build understanding and to make creative connections, through hands-on work.

This is illustrated for example through Ella's (EN8) development of block graphs work with 6-7 year olds, which involved some sorting, and on a similar theme Mary's (SC1) activity on sorting and counting with 5-6 year olds. Both teachers use the hands-on activity to encourage children to bring their own criteria for sorting, as the short excerpts below from episodes in each of these case studies reveal, starting with Ella (EN8) reflecting in her interview on the children's creative learning in mathematics:

Ella:	*"I think the real learning was about how adventurous they were, how creative they were in sorting their objects "*
Researcher:	"What sort of sorting would you see as adventurous?"
Ella:	*"The Prey/Predators – it's not numeracy linked but she (a child) linked in to science. So she linked it to previous learning." (Teacher interview)*

The open use of materials in Mary's classroom (SC1) was important in enabling two children, Gordon and Donald to make a creative leap beyond the task, to counting and then measuring:
Once they had both finished sorting objects by colour and size as well as counting them, Gordon took another initiative and proposed a creative way to 'measure' them by using the plastic chain links:

Gordon:	*"Now let's put them in green ones with green ones. Sort them out in colour now."*
Donald:	*"Let's see who has the biggest family [of bears]."*
Gordon:	*"Right, we have to count the families when we're done."*

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[…]

Gordon: "Hey I'm going to put them in a line and measure them with chains."

The fieldwork across the United Kingdom provided evidence of **how physical resources could be harnessed through children's exploration and play** to support their creativity, especially where children can explore the use of resources in creative and imaginative ways (e.g. 3D shapes, Brenda, W2; Shapes, Maeve, NI1). Small group exploration of resources was also observed, such as in the making musical instruments episode (Brenda, W2) and exploring properties of light (Denise, W1). In some episodes resources were used to create new drinks (Louise, EN1), puppets (Denise, W1) and cakes (Denise, W1). In other episodes resources were used enable children to observe the scientific phenomena in a creative way (e.g. Bubbles activity, Fleur2, EN2; Buttons activity, Fleur1, EN2; and Ice activities in Jenny EN1; Anita EN5; and Martha SC1). Having a variety of resources helped enable children to explore (e.g. Waterproof materials, Eloise, EN7; Push and pull, Lisa, EN8; Water play, Martha, SC1; Sorting, Mary, SC1). The resources chosen were often appealing to see, touch and use, increasing motivation for the activity (Bear box, Jenny EN1; Sorting Wendy EN3; Gloop, Shaving foam, Alice NI1; Ice, Maeve, NI1).

There were differences, however, between how resources were used in mathematics and science. Practical resources to explore number, calculations, shape, space and measures are more likely to be used in discrete mathematics activities, whereas role play mathematical activities (e.g. Joanne, W1) made use of play money and weighing scales etc. Baking activities were used in a number of case studies (Fleur2, EN2; Sarah, SC2; Denise, W1; Joanne W1) for weighing and measuring of ingredients. Linear measuring equipment was also used (Louise, EN1; Andrea NI2). Several episodes involved exploration of shape resources. In Caroline's class, (EN4) this resulted in imaginative play outside the set task, while in Maeve's class (NI1) the rich resources allowed independent exploration.

Science activities were more likely to take place in a **rich physical environment that fosters creativity** and to use books, stories and themes as a stimulus (e.g. Carnival of the Animals, Wendy, EN3; Gingerbread Man, Siobhan, NI2; Puppets, Denise, W1). Most science resources were everyday objects or materials. This may also promote the relevance of science to everyday life.

A further area highlighted in the List of Factors was **the use of ICT and digital technologies** and in particular, confident use of digital technology. The fieldwork revealed across the United Kingdom that ICT resources were being used in both preschool (e.g. Digi-Blu, Sally, EN2; BeeBots, Jenny, EN1; BeeBots, Jennie, EN6) and primary school (e.g. Sound and space, Louise, EN1; Habitats, Ella, EN8). However the use of ICT is not always in the hands of children; for example Joan (W2) uses the interactive white board to introduce the session on reflection of light and also the concept of the life cycle, but in each case the resource is used only as a stimulus and not by the children as part of their own explorations of the science involved. Similarly Mary (SC1) uses the interactive whiteboard for a mathematical sorting activity however although the children can interact with this activity in suggesting what happens and seeing it through this is done as a whole class group with the teacher remaining in control of the technology; the next part of the lesson is ICT-free with children working

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in pairs with physical resources to sort. Given the considerable potential of ICT to facilitate children's creativity, this remains an area where further research would be valuable.

Finally the List of Factors identified **informal resources, the use of outdoor resources** and **recognition of out of school learning** all as important in fostering creativity in mathematics and science. In terms of both science and mathematics, the fieldwork confirmed that across all four countries of the United Kingdom, many resources were indeed **informal** and related to play and exploration, motivation and were intended to stimulate children's curiosity and interest in science and mathematics.

The fieldwork revealed that **outdoor resources** were used far more extensively in pre-school settings, in part because in all four United Kingdom nations access to the outdoors, as an extension of the indoor classroom, is seen as a usual part of the curriculum. It is expected that pre-school children should be able to initiate enquiries and investigations, in a playful and imaginative way, following their curiosities and stimulated by provocations set in the outdoor as well as the indoor learning spaces. What this study revealed is how practitioners in early years settings harnessed children's scientific creativity in exploration, using outdoor resources. There was a spectrum of practice, at one end of which was Sarah (SC2) with 2-5 year olds experiencing 'Forest School' every week in cycle of eight weeks, which afforded opportunities for a range of scientific learning including changing of the seasons and life cycles, freezing and melting, fire-making and cooking. Somewhere in the middle was Jenny (EN6) whose 4-6 year olds had easy access to outdoor space and who regarded the science resources outdoors to be much richer than those within the classroom space. At the other end of the spectrum were teachers taking the opportunity to learn outdoors in a more structured and delimited way, for example Brenda (W2) who set one of her 5-6 year olds' episodes, making musical instruments, outdoors, or Linda (EN4), teaching 6-7 year olds, who, in line with her school's policy which foregrounds the practical investigation of living things and life processes, properties of materials and physical processes, undertakes delimited investigations outdoors as appropriate. The use of outdoor resources for mathematics however was much less evident in the data collected and is an area that could do with further investigation.

As to the **integration of children's out of school learning** with their science and mathematics learning in school, there were only two episodes across the whole data set (one in preschool, one in primary) that revealed explicit evidence of this. This absence points to an area that could benefit from further research,

4.1.4 Location

The list of factors for fostering creativity in early science and mathematics which the project generated prior to the intensive fieldwork period, highlighted the following to be key issues: access to **indoor and outdoor learning**, **recognition of out of school learning**, the different kinds of opportunities afforded by **formal and informal learning settings**, and by **small group settings**.
As indicated in the section about location within the 'materials' section, the data collected across the United Kingdom has revealed that pre-schools offered much more informal access to the outdoors. Whilst pre-schools and schools across all four countries made use of both indoor and outdoor

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learning contexts however much less use was made of the outdoors to learn mathematics. As indicated in the section on grouping, small group settings were used extensively across all four countries and both phases (pre-school and primary). However there was very little evidence of recognition of out of school learning.

4.1.5 Grouping

The list of factors generated by the *Creative Little Scientists* project prior to the in depth fieldwork, highlighted four modes of grouping as likely to be found in pre-schools and schools: multigrade teaching, ability grouping and small group settings. It also highlighted the number of children present in the class as an important factor.

The fieldwork across the United Kingdom revealed that pre-school class sizes could be as large as 60 (in one large pre-school setting in which children are grouped in distinct areas; where there were approximately 9 members of staff associated with this large group). The smallest group recorded was 20 children, in a Welsh pre-school class which had up to three staff involved with it. Staffing generally included one qualified teacher and other staff in preschool settings included qualified nursery staff and trained teaching assistants (some of whom were allocated to particular children with special educational needs). The highest pre-school adult-child ratio was found in Scotland where there were 6 adults working with a class of 33 children aged 3-5. The school class sizes were no larger than 30 across all four countries although some were as small as 25 (Northern Ireland).

In terms of how children were grouped for learning in both mathematics and science however, small group activities were found to be very common in all four countries, with pre-schools using **mixed ability friendship grouping** through free play. A difference was evident between preschool and primary school groupings. In preschool activities, located in free play, groupings changed through the play (e.g. Café role play, Jenny EN1; Ramps, Fleur1, EN2; Shop role play, Joanne, W1), or supported explorations (such as Buttons, Bubbles and Pulleys in Fleur1 and Fleur 2, EN1). The empirical work revealed how play enabled children to be **creative** and make decisions about **play partners** and which group to play and explore with. Where small groups were decided by the teacher, there were nevertheless opportunities for children to **share ideas, reason** together and **collaborate** in creating (e.g. Baking, Sally, EN2).

By contrast primary school activities tended to be **whole class** for the introduction in both mathematics and science, and plenary and **mixed ability, small group** activities in between. In schools, **ability grouping** was also used in mathematics and science in some episodes in England and Scotland; for example Ella (EN8) who grouped children into 'reinforcement', 'core' and 'extension' groups, with increasing degree of choice for the children in the extension group and Maria (SC3) who grouped children into ability groups denoted by colour with clearly differentiated activity in each. By contrast a mixture of ability and mixed small groups was used in two science episodes in one Welsh site (Joan, W2) where the teacher, a science specialist herself, is concerned to scaffold children's science learning closely. Interestingly Ella (EN8) comments in relation to one of the episodes from her practice, that although the higher ability children had more choice, it was the children in the lowest ability group who generated the most creative responses. For this activity, focused on

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camouflage, she judged that artistic creativity was as important as the scientific understanding and so resolved to group the children by their (artistic) creativity the following year although it was not clear how this was to be ascertained.

4.1.6 Time

The list of factors for fostering creativity in early science and mathematics which the project generated prior to the intensive fieldwork period, highlighted sufficient time for learning science and mathematics to be a key issue.

The data collected across the United Kingdom has revealed **differences between pre-school and primary classrooms in terms of time available for early mathematics and science.** Typical of pre-school classrooms was an approach to resourcing which encouraged children to be drawn to and return to resources and activities over time. This is perhaps summed up by Jennie (EN6) who emphasised, in her interview, the importance in pre-school settings of offering children time and the chance to revisit:

> *"Building on things and coming at it from several angles that can get missed out in later school number work or whatever – throwing bean bags, jumping along the logs - I think that is what is so wonderful about nursery and now reception provision - that children can explore through different methods and senses….variety of ways and never ending ..You cannot give them enough opportunities – say you have done shape or melting. You still need to come back again and again...It can take time."*

The re-visiting Jennie refers to is also discussed by Alice (NI1) who refers to children needing to be able to return to investigations over time, and was observed in Maeve's practice (NI1).

Staff in the pre-school settings across the United Kingdom foregrounded the need to be flexible with time, and to enable when appropriate children to lead the learning. For example in Lisa's class (EN8), her flexibility enabled children to revisit learning on pushes and pulls undertaken two weeks previously when, following rain, worms came out onto the grass. As she explains:

> *"...we stopped what we were doing and went outside, because that was they were more interested in, and they were talking about how the worm was pushing themselves along the ground... it was allowing them the opportunity and the time to just be able to use the resources practically ... to choose for themselves what they wanted to do in that particular lesson".*

In relation to fostering creativity in early science and mathematics, time was valued by primary school staff too, as Maria (SC3), teaching 6-7 year olds, reflected on which of her observed lessons had most fostered children's creativity, she selected one (the 'touch' lesson) which had, as she put it, *"…allowed them time … to independently think of … things from their own … life ….".* This is also evidenced in Caroline's classroom (EN4) also with 6-7 year olds, where time formed a vital dimension to mathematics exploration, encouraging children to make predictions and, perhaps, to be 'wrong'. Reflecting a school curriculum focused on the children's needs first and foremost, the practice of these two teachers facilitated children's creative thinking.

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However, more often, observations during the fieldwork in primary classrooms revealed rather more structured learning activities, with a whole-class plenary at either end of small group exploration, in which teachers very often left insufficient time between questions and expected answers. Primary teachers were more aware of time pressures and this could generate tension in determining how much children's own investigations and creative thinking could be accommodated, as noted in Andrea's class (NI2), where Ronan, aged 7, having finished measuring the items selected by practitioners, expressed a wish to measure the playground yet being aware of how long this could take, Deidre (the teaching assistant in charge of the activity) indicated she was not keen to allow him to explore this activity fully.

4.1.7 Content

The 75 episodes selected from the four countries represented a wide variety of contexts and content and covered a range of different areas of science and mathematics learning in both the primary and preschool settings. This was encouraging as it demonstrated that sites selected would provide a varied sample from which to draw examples. Common themes did emerge however. Looking past the subject content of the episodes, it was apparent that **mathematics was often identified as a discrete subject area, particularly in the primary school setting**.

In the preschool setting, mathematics episodes might come from role play activities (e.g. Cake shop, Martha, SC1; Role play shop, Joanne, W1) where interaction with practitioners was either minimal, or based around the role play environment. In this case then, mathematics was embedded within a variety of different developmental areas (and certainly not all focused on cognitive factors).

When looking to **science, there was a mixture of cross-curricular and subject-specific teaching and learning.** Examples of subject-specific teaching could be seen most readily in primary school settings, for example Andrea's (NI2) 'Flowers' investigation which examined the parts of a flower using the stems of a flower dipped in food dye, or Joan's (W2) 'Life cycles' lesson in which children were taught about the various stages of development in amphibians. There were however examples of cross-curricular contexts for teaching in science such as Ella's (EN8) egg carrier activity, which was set within the wider class topic on Transport and combined design technology and science and Sally's (EN1) soft play episode that combined science and PE.

Having said this, **subject links between science and mathematics were few and far between** – indeed, only one episode in the primary school setting (Courgette muffins, Denise, W2) and one episode in the preschool setting (Baking, Sally, EN2) explicitly identified science and mathematics as present in the same activity and only a further seven episodes showed links between the two.
Interestingly, both these episodes incorporate cooking. Whether this is purely coincidental, or a characteristic of food science may be something to further explore.

4.1.8 Influence of national policy and regulation

Educational policy across each of the four home nations, along with their similarities and differences, has been discussed extensively in a previous *Creative Little Scientists* document (D3.2, and D3.2

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Addenda 10-13). Discussed here are the empirical findings of the influence of policy on practice based on data collected during the observation period.

In England, discussion of the curriculum was far more frequent than in Northern Ireland, Scotland and Wales. The notion of 'covering the curriculum' is one that is frequently mentioned as a barrier to creative pedagogy in educational research, and often attributed to the pressures of national testing. This 'covering the curriculum' was indeed highlighted in a number of the English sites. In the first English site, EN1, Jenny was the author of the science policy, and while she included in the documentation permission for practitioners to use their professional judgement and not follow the framework to the letter if they felt this was appropriate, Jenny still felt there was a "tension" about moving away from the policy. This emphasis could also be seen in other sites, sometimes more implicitly from practice rather than from teacher interview evidence. It was possible to note that the content of Linda's observed science lessons (EN4) quoted the curriculum statements (the learning objective for episode 2 was written on the whiteboard; 'understand that sounds travel away from sources' is directly from policy documentation), showing the emphasis in her teaching on focusing on curricular objectives. Even with very young children, this emphasis on 'covering the curriculum' could be seen in practitioner's pedagogy. Anita (EN5) for example, based the content of her practitioner-led activities on the areas of learning and development that she had observed the children developing less frequently during their free play and choosing time. While this is of course an example of responsive and reflective pedagogy based on the children's needs, there is still the implicit acknowledgement that all areas of the curriculum must be addressed over the course of a term/year. This emphasis on 'covering the curriculum' in the early years could also be seen in Scotland, with Sarah (SC2, large city centre children's centre) expressing concern about the challenges of the current policy context in which practitioners and indeed children often felt pressures to address all of the prescribed areas.

However, **discussion of the curriculum did not always focus on its restrictive nature.** In contrast to Linda (EN4), Caroline (also at EN4) suggested that rather than policy, a greater external influence on practice was the attitudes and expectations of parents. The school (EN4) consistently scored highly in national assessments across all age groups and as such the school had taken steps to introduce a 'Creative Curriculum', and Caroline had implemented this 'Creative Curriculum' as a pilot three years previously. There was however parental expectation to maintain the existing high standards and there was some resistance to the new curriculum. Caroline was confident in the children's subject knowledge, which she attributed to the socioeconomic demographic of the area. As such, Caroline aimed in her teaching to focus more on developing children's learning skills, and therefore her teaching was based less around curricular content and more on the children's needs, and encouraging them to develop those skills in which they perhaps lacked confidence.

Particularly in Northern Ireland and Wales, there is little emphasis on external national assessment and thus is may appear that there would be less of an emphasis on 'covering the curriculum' and associated restrictions in pedagogy. In the main, this was the case in these countries with the case studies reporting very few practitioners discussing the influence of national policy, rather the

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influence of their respective sites' curricula – for example, the Reggio Emilia influence on policy and practice at Alice and Maeve's nursery (NI1).

It is of course hard to determine the balance between how the responses seen in the data set reflect national policy and how they reflect the individual cases given the small sample. The difference seen between Caroline and Linda in EN4 shows that even within the same site, the influence of policy can vary greatly. That none of the cases from Northern Ireland reflected on policy in any great detail may of course be due to the episodes observed.

4.2 Revisiting the Creative Little Scientists mapping and comparison factors: A summary of findings

4.2.1 Aims and objectives

The aims and objectives of teaching and learning in many of the cases observed were not made explicit, thus the evidence here is more limited than in the other areas of the list of factors discussed here. Where explicit evidence, such as planning notes, were not available it was necessary to draw inferences from the observations and from post-hoc discussions. This of course may differ

Across all the cases in the UK, both primary and preschool and in science and mathematics, developing **knowledge and understanding of science and/or mathematical content** could be observed in classroom activity. This factor was observed in around two thirds of the episodes (49 of 75 episodes) and in many of the cases it was present in all the episodes observed. In a number of cases, this development of knowledge and understanding of science took the form of **introducing and/or consolidating learning scientific/mathematical vocabulary.** Particular examples where this was the case were Joan's class (W2) where children were learning about the life cycle of animals and the relevant vocabulary (eggs, larvae, pupae, adults) or Anita's classroom (EN5) where in each of the episodes identified children were exploring states of matter, with the associated vocabulary (solid, liquid, melting and so on). In other cases, the emphasis on language was more implicit and tied in with an emphasis on the overall content – such as the language associated with using musical instruments (e.g. Straw flutes and Outdoor sounds, Linda, EN4; Carpet music and Making musical instruments, Brenda, W2) or using money (e.g. Shop role play, Joanne, W1; Cake shop, Martha, SC1; Money counting, Mary, SC1; Price prediction, Maria, SC3). Here we see explicit examples from both primary and preschool. Language was not, of course, the only focus of content teaching and learning in science and mathematics. For example in science episodes teachers also identified particular knowledge and understanding that they hoped children might develop such as '*water can be changed into ice'* (Melting and freezing, Martha, SC1) or '*some animals use camouflage to help them survive'* (Habitat, Ella, EN8). In mathematics examples of objectives included '*derive and recall addition facts and work out the corresponding subtraction facts*' (Café, Jenny, EN1) and '*I can count groups of two and three*.' (Alien Challenge, Maria, SC3).

One notable exception to the above was the two cases in one setting in Northern Ireland – NI1, County Park Nursery. None of the episodes here was identified as including knowledge or understanding of content as a notable feature of practice. This was explained by the practitioners as

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due to the Reggio Emilia ethos at the nursery, focusing on developing the abilities such as independence and responsibility rather than knowledge.

Most infrequently observed was practitioners encouraging or developing children's **understanding about science inquiry**, which seen in just over a quarter of the episodes (21 of 75 episodes). This was in contrast to practitioners planning for fostering children's **science process skills**, where over half of the episodes showed evidence of a focus on process skills. This contrast is interesting in that it appears to suggest that while practitioners are eager to engage children in investigative and problem solving activities, they are perhaps less concerned with ensuring that children are aware of how these processes relate to overall science method. Where there was an emphasis on understanding scientific enquiry, it was often to be found in primary education, in activities that were more practitioner-led or initiated rather than those that were more open-ended or exploratory. That is to say, science enquiry appeared to become an instructional activity for practitioners rather than an explorative one for the children.

In addition, it was difficult to identify explicitly instances in which **IBSE** had been **specifically planned** in the data set. There were 30 episodes in which this was noted, however in the vast majority of these, this was noted by the researcher implicitly from observation. This may account for why, in a number of episodes, creativity was seen in an almost incidental or accidental manner, particularly in mathematics activities. Indeed, in only two mathematics settings, Louise's 'Art' and 'Mother's day' episodes (EN1) and Lisa's 'Counting Minibugs' activity (EN8) was **creativity specifically planned for** to the extent that the teacher deliberately left open how the children should set about the task and record their finding. While this activity could be seen in a number of different episodes, creativity was frequently discussed at this school, hence the specific or particular coding for planned creativity.

In the other episodes then, since creativity was not planned for, we must conclude that **creativity was apparent as an unexpected outcome of the activity,** and this unexpected opportunity for creativity was on occasion one that was not always welcomed or fostered. An example of this might be the 'Outdoor measuring' episode (Andrea, NI2), where the opportunity for extending the activity was actively 'shut down' by the practitioner leading the activity with the children. A conclusion that is possible to suggest then is that practitioners are perhaps less aware of, or perhaps not prepared for the numerous opportunities for creativity that are inherent within different mathematics activities. This may be something to explore in further detail in future.

A factor that was common to many of the episodes was an emphasis on the **social factors of science learning**. This was particularly the case in the preschool settings, where many of the activities were designed so as to provoke excitement or sustained engagement. This might be through providing sensory-stimulating activities, such as the ice activities seen in Jenny, (EN1), Fleur, (EN2) and Maeve, (NI1) or outdoor activities such as those seen with Sarah ('Forest School', SC2). By providing these types of activities, practitioners also seemed to be paying particular attention to the **affective factors of science learning**. This could be seen in **efforts to enhance children's attitudes in science and mathematics,** again, through activities that were engaging (e.g. Day and night, Mary, SC1),

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motivating (e.g. Gingerbread Man Raft Siobhan, NI2) and provided children with opportunities for pretend play (e.g. Cake shop, Martha, SC1).

Lastly, and perhaps most importantly, was that almost uniformly across all episodes and cases was that **collaboration between children** appeared to be **highly valued**, and this appeared to play a central part of fostering motivation and affect in science and mathematics learning across many of the episodes.

Interestingly however these social and affective factors often featured in practitioners' overall planning or in general terms, rather than being the focus of specific learning objectives, especially in the preschool where social development aims form a major part of the curriculum (in all four home nations).

4.2.2 Learning activities

Mathematics

As noted in section 4.1.6, **mathematics was often seen as a more discrete area of teaching and learning,** whereas science was perceived as a more integrated or cross-curricular, reflecting the nature of the curricula in the respective countries (see Addenda 10-13 in *CLS* D3.3). A third of the episodes from across the four countries were focused on mathematics (24 of 75). Across these, there were few common themes among the learning activities, either in the various areas of pedagogical interactions or across age groups or countries. What was noticeable was the limited emphasis on **questioning** in the learning activities observed (in eight out of 24 episodes – three in preschool and five in school). While it was not explicitly highlighted in the learning activities list of factors, it may be important to note that one common feature across the mathematics episodes was that the observations did appear to suggest that many of the mathematics episodes were either practitioner-led or practitioner-initiated, certainly more so than the science episodes identified and particularly in the primary setting. This did appear to limit the opportunities for exploration in activities. This could be illustrated by the outdoor measuring episode seen in Northern Ireland (Andrea, NI2). This was a particularly practitioner-led activity, with a very focused and outcomes-driven lesson objective (measuring objects in the outdoor playground using different measuring instruments). The apparent desire to ensure that the children 'completed the task' meant that possible opportunities for creativity were missed.

The most common learning activities that were observed were **gathering evidence through observation** and **using equipment**, which were present in half of the mathematics episodes. If we examine the activities involved in these episodes, in nearly all of the episodes in which gathering evidence was observed in the primary school settings (Caroline, Ella and Emily in England, Andrea in Northern Ireland and Maria and Mary in Scotland), as previously noted the activities were structured and/or practitioner-initiated. This may reflect the findings that there was little opportunity for open-ended questioning, and that many of the episodes provided little space for mathematical questioning.

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Gathering evidence was frequently observed in the data set however the role of **explanation** in mathematics episodes in contrast was rarely emphasised. This is interesting to note given the comparatively high frequency of gathering evidence across the episodes. Evidence of children **designing or planning investigations** (particularly in primary – 5 from 14 episodes compared to 5 from 10 in preschool) was also limited in the data set. Designing an investigation, undertaking it and gathering evidence and looking to explain those observations could each be considered phases of the investigative process. That two stages of this investigative process are rarely apparent in the data set would suggest that, in mathematics teaching and learning, the focus is more on the closed mathematics tasks where the outcomes are predetermined by the teacher, and with little opportunity for open-ended problem solving. While it is of course important not to be overly emphatic in conclusions drawn from a *lack* of evidence, this would echo the discussion in section 4.2.1 above, which described how mathematics teaching and learning appeared to be largely focused on developing children's knowledge and understanding of mathematics content rather than, say, mathematical processes.

Learning activities (science)

Of the 75 episodes recorded 48 were focused on science with 3 further episodes in which science and mathematics were integrated. Of these 33 were preschool science episodes and 18 were set in primary school. The episodes provided varied examples of learning and teaching incorporating the different learning activities associated with inquiry in differing degrees.

In preschool the most common learning activities, included in the majority of episodes were **questioning** (21/33) **observing** (22/33) **using equipment** (25/33) and **making connections** (21/33). **Explaining evidence** and **communicating explanations** were only shown in about half the episodes. **Planning** was the learning activity least featured, shown only in about a third of the episodes. This pattern reflects teachers' perspectives and the emphasis in early years policy on curiosity and opportunities for exploration, rather than the more formal inquiry processes associated with planning, reviewing evidence or explaining. However the episodes did provide examples of young children's planning. Their planning was not necessarily made explicit but their actions suggested a clear sense of direction as shown for example in the episodes 'Cars and ramps' (Jennie, EN6) or 'Water play' (Martha, SC2). This was also reflected in interviews with the children subsequent to activities. The episodes also revealed examples of young children's capacities to explain evidence and communicate explanations, often when prompted by peers, teachers (Melting and freezing, Martha, SC1) or sometimes by the researcher (Forest School, Sarah, SC2).

In primary school opportunities for **questioning, observing** and **using equipment** were similar to those in preschool. It was notable that **making connections** was a feature of almost all of the primary episodes, possibly reflecting the greater emphasis in this phase on science knowledge and understanding and specific learning outcomes, as well as children's greater knowledge and experience. **Planning** and **communicating explanations** also received greater attention. Again this may reflect the more formal approaches and curriculum requirements associated with the primary phase. However **explaining evidence** was incorporated into less than half the primary episodes

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despite the key role of evidence in developing and reviewing explanations. This also reflects the neglect of the nature of science noted in the review of aims above.

Differences between preschool and primary

Opportunities for **questioning** were in evidence in both preschool and primary episodes but evidenced in different ways reflecting the different approaches to learning and teaching characteristics of these phases. In preschool settings questioning often emerged through space and time to explore (e.g. Water play, Martha, SC1; Scout camp, Sarah, SC2) and were often implicit in children's inquiries (e.g. Cars and ramps, Jennie, EN6). In primary settings where lessons were of more limited duration building in time to encourage and follow up children's questions was more challenging, although the older children often had wider experience to draw on in suggesting questions at the start of the project (e.g. Wendy, EN3; Day and night, Mary, SC1; Senses, Maria SC3). However opportunities were often missed to build on children's questions or to encourage further questions across the course of a project.

In terms of **planning** in preschool, this was fostered by access to a wide range of resources and time to for explorations to develop into more focused inquiries (e.g. Ice, Sarah, SC2). This was more evident in nursery schools and classes than in Reception classes.

In primary classes children were often given more restricted opportunities to develop their own investigations. They were often only able to plan and design some parts of an investigation, such choice of resources, procedures associated with fair testing, measuring or ways of recording, linked to the particular learning objectives for the session (Straw flutes, Linda EN4; Waterproof, Emily, EN7). However in both instances individuals took opportunities to develop their own directions for inquiry.

Making connections featured strongly in both settings in science. Teachers were keen to encourage children to make connections to everyday life and previous experiences (e.g. Ice and buttons, Fleur, EN2; Jelly, Joanne, W1; Carpet Musical Instruments, Brenda, W2. There were also examples of children making their own connections in both preschool and primary phases. In contrast **explaining evidence** was not strongly featured in either phase. There were often missed opportunities to review results and debate evidence. Having a purpose for this process is important for example answering your own question or having to agree on the best approach to solving a problem. For example in the 'Waterproof' episode (Emily, EN7), the children had to agree on advice for MAX about the best material to make an umbrella. The observations suggested that explaining evidence was generally only apparent when explicitly prompted by exchange with others either adults or (on occasion) peers. In some instances, explaining evidence only occurred in discussions with the researcher (e.g. 'Bubbles' and 'Foam', Alice, NI1)

In both phases **communicating explanations** was facilitated by varied forms of expression and representation. This provided the child with a starting point for explaining ideas and a child determined context for questioning by peers, teachers and researchers.

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Differences between science and mathematics

In both phases there were fewer opportunities in mathematics than in science episodes for the use and development of skills and processes associated with inquiry and problem solving listed as factors under learning activities. Notably questioning was coded in only a small minority of mathematics episodes. In both science and mathematics episodes explaining evidence featured very little in either phase.

Opportunities and challenges for creativity

The potential for creativity is indicated in the range of episodes featuring different learning activities. **The most productive contexts were associated in preschool with the provision of rich resources accessible to children and time and space for children to develop their own inquiries**. In the more restricted time for science available in primary school there are challenges in providing a purpose for children's inquiries. In some instances children's own questions, real problems or challenges provided motivating starting points and scope for children's creativity.

An important phase in inquiry (linked to its purpose) is the critical review of evidence, consideration of how it might be explained or what has been gained. This aspect of inquiry is frequently neglected. Further opportunities are needed for children to discuss and evaluate alternative ideas and evidence. This is a key feature of creativity in science highlighted in the *CLS* definition '*Generate alternative strategies and ideas as an individual and community and reason critically between these*' (D2.2 Conceptual Framework). There were often opportunities for generation of ideas and strategies in the episodes but more limited attention was given to evaluation and consideration of alternatives. Productive approaches identified in the episodes included encouraging different solutions and different forms of expression of ideas, generating a purpose for reviewing evidence and providing opportunities for peer and self-assessment.

4.2.3 Pedagogy

The factors under pedagogy (in *D3.1 List of Factors*) refer to the pedagogical commonalities (or synergies) identified earlier in the project between inquiry-based science education (IBSE) approaches and creative approaches (CA). These were detailed in the conceptual framework (*D2.1 Conceptual Framework*) and centred on themes such as the role of play and exploration, the role of motivation and affect, the role of dialogue and collaboration, the role of problem solving and agency, the role of fostering questioning and curiosity, the role of fostering reflection and reasoning and teachers' scaffolding and involvement

In this section we consider these synergies with regard to the pedagogical differences evidenced between the preschool and primary cases in the UK and between science and mathematics, considering finally the opportunities and challenges for creative teaching and learning.

Differences between preschool and primary school

The role of **play and child-initiated exploration** was more evident in preschool than primary school observations. Play additionally appears more valued as a pedagogical approach in nurseries and nursery classes (e.g. Fleur EN2; Alice NI1; Maeve, NI1), than in preschool Reception classes (e.g.

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Joanne, W2). Nevertheless, it did appear to be valued by some, such as Jenny (EN1) who taught a mixed Reception / Year 1 class and also Eloise (EN7). It was a surprising finding that across the set of UK cases play remained uncoded in nearly half the episodes. This may have been a consequence of what researchers selected as episodes, prompted by the irregular nature of visits, they were often unable to follow through the complex and fleeting examples of play that might have turned into a play based episode of creativity over several days. As a result opportunities offered by free flow play may be under-represented. This may also have been a product of the pressures at primary phase for teachers to lead and 'cover' curriculum content, though many of the primary teachers, such as EN 7 Emily sought to value play and recognised its importance. Nonetheless **teacher-initiated and teacher-led exploration** was more evident in primary school observations (e.g. Wendy, EN3; Andrea, NI2; Denise, W1) than in preschool contexts.

The importance of **motivation and effect** was evident in all episodes and further emphasised by teachers in interviews and the teacher questionnaires. In preschool, play and learning are often synonymous and children do not distinguish between the two (e.g. Fleur1, EN2; Maeve, NI1) and this approach to play and exploration capitalises on children's interests and encourages allows problem solving and agency. In some of the primary school episodes, children were motivated by being encouraged to express their ideas, negotiate boundaries and engage in free play and expression (e.g. Denise, W1). In others, such as the Shapes episode in Caroline's (EN4) primary classroom, the rather more tight framing of the activity and time constraints meant that the opportunities for creative engagement were not as fully utilised or developed as they might have been, and in such cases it was noted the children's creativity was often related to off task conversations or imaginative responses which did not further their understanding of mathematics or science (e.g. Shapes, Caroline, EN4). Motivation was fostered by many teachers through showing their own excitement and interest in the tasks, and again this was somewhat more marked in nursery and preschool contexts, (e.g. Alice, NI1; Maeve, NI1) in the case of Jennie (EN6) she showed her lack of certainty about what might happen on several occasions and this too interested and involved the young learners, prompting curiosity and questioning.

Dialogue and collaboration were evident in both preschool and primary school observations alike although the pace of some teacher-led primary school interaction did not always facilitate peer dialogue and collaboration that leads to problem solving and agency in older children. In some of the preschool contexts it was noticed that children did not engage in much dialogue and became focused, silent and engaged in their own thinking (e.g. Alice, NI1). But in the main across the UK episodes, prompted by their interest in the activities, by the teachers' questions which were used to foster sustained shared thinking and by the need to collaborate to achieve the tasks set /initiated there was considerable collaborative interaction between children. Some children were given the opportunities to discuss their ideas with their talk partners and learned from each other through identifying mathematical errors their partner had made and offering a strategy to solve those problems (e.g. Jennie, EN6). Such structured support for collaboration was understandably more common at the primary phase (e.g. Caroline EN4). Collaboration was valued by all practitioners,

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some of whom commented upon the need to hold back from 'overtalking' in order for the children to develop their thinking through conversation and collaboration (e.g. Lisa, EN8; Maeve, NI1).

In relation to **problem solving**, inquiries tended to be rather more teacher led and structured in the classes of the older children compared to those in nurseries. In both age phases resources and opportunities for exploration were offered by practitioners, but in the UK cases the primary teachers retained more control over the shape and form of the explorations. This may have been due to time pressures in relation to their ability to offer extended explorations which could develop in different directions over time. This is in contrast to the preschool where in depth explorations of key themes were often much extended (e.g. Alice, NI1; Maeve, NI1). In the nursery classes there was relatively rarely any explicit instruction given on how to use or experiment with resources (Lisa, EN8) and the children were allowed to take the initiative in finding and solving their own problems. Through taking the initiative, it was possible for them to follow their own interests and curiosity and develop their understanding. This fits with assessment guidance for the early years including observation of child-initiated activities. Even where preschool teachers set clear goals for an activity, they gave the children a strong sense of autonomy and volition in how they were going to solve the problem and share their findings (e.g. Martha, SC1; Sarah, SC2). This also happened in some older classes (e.g. Ella, EN8; Maria, SC3). In this way the children's problem solving skills and creative thinking skills were effectively fostered.

Teacher questioning was widely used to encourage children's observations and predictions, to make connections and to nurture curiosity. There was some evidence that on the basis of the children's own emergent questions, preschool teachers are more likely to stand back and allow them to follow their own avenues for inquiry based on their expressed curiosity (e.g. Anita, EN5; Alice, NI1; Sarah, SC2; Maeve, NI1).This links to issues of agency and the shaping of their own explorations, which in the primary school, as noted earlier were more likely to be shaped by the teacher. In the primary settings, teachers were more frequently asking questions to check on children's knowledge than in the preschool settings, in the former the teachers appeared to be seeking subject specific knowledge at these times and were inviting the learners to use their subject specific vocabulary, although as noted above during episodes in both settings, teachers did make use of questioning to prompt children's explorations and curiosity. It should also be noted some preschool teachers made extensive use of subject specific vocabulary in their questioning, particularly Anita (EN5), Jennie (EN6) and Martha (SC1).

The encouragement of children's diverse forms of expression was not as frequently noted as expected and was only recorded in a minority of episodes (e.g. Counting minibeasts, Lisa, EN8; Day and night, and Sorting and Counting, Mary, SC1). It is not clear whether this was because the UK teachers, whether primary or preschool did not perceive the young learners were capable of expressing and reflecting upon as well as recording their insights in various ways, though where this was witnessed it was evident the children of all ages were more than capable in this regard. Some preschool practitioners did value diverse forms of expression (e.g. Anita, EN5; Alice, NI1; Maeve, NI1), and it was also witnessed in some primary classes (e.g. Louise, EN1). There were also instances

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when the children's explorations, of the properties of light for example (e.g. Denise, W1), fostered curiosity and questioning with teacher support for reflection and reasoning. In other examples, the preschool children demonstrated considerable reasoning skills as they considered the different contexts of heating and cooling, melting and freezing (Martha, SC1) and child-initiated self-reflection was also noted on occasion such as in the Counting money episode (Mary, SC1). Some teachers were deliberately vague about their intentions with regard to recoding insights and this enabled the children to design their own form of communicating their findings which fostered variety and diversity (e.g. Lisa, EN8; Martha, SC1). In addition, the articulation of reflection and reasoning was often promoted by activities outside the episodes themselves – in interviews with researchers (e.g. Doubling, Emily, EN7; Counting money, Mary SC2), or in dialogue with teachers associated with assessment processes (e.g. Jennie EN6, Sarah SC2).

Teacher scaffolding in the UK case studies was characteristic of both preschool and primary school pedagogical approaches. Such scaffolding was apparent both **in the task/activity structure and in the teacher's on-going interactions** throughout the session. In the former, relatively open-ended problems were often offered as supportive scaffolds for learning, and in the latter teachers scaffolded the children's learning through intervening in the activities and talking to the class as a whole, reminding them for example about the emphasis of the work, the significance of exploration, the relevance of the learning objectives and/or the need to develop an appropriate problem solving/investigative approach. Scaffolded interactions directed at the whole class appeared to be more common at the primary phase, where the children were often engaged in the same activities (e.g. Caroline, EN4). In the preschool, children often undertook different activities and thus the practitioners' interactions were made manifest in small group or one to one conversations (e.g. Emily, EN7; Alice, NI1; Maeve, NI1).

There were some examples at this young age phase of activities which enabled problem solving and agency **without much teacher interaction**, such as the pulleys activity in the sand (e.g. Fleur, EN2) and the ice exploration (e.g. Maeve, NI1). There were also a few at primary phase too, such as the straw flutes episode (Linda, EN4) and the egg carrier episode (Ella, EN8). In these cases there was an emphasis on **standing back** once the activity had been initiated, the adults in the classroom played a relatively minimal role and the children were largely left to the task free from practitioner-intervention (e.g. Alice, EN1). This often appeared to prompt more open-ended questioning from the children, enabling them to scaffold each other's learning. There were other productive examples of teachers standing back and giving opportunities for children to improvise, such as in the water play episode (Martha, SC1) and the Alien Challenge episode (Maria, SC3), and also examples of scaffolding that introduced procedures in a way that fostered the children's subsequent independence such as in the Baking Episode (Sarah, SC2). In the robot Bee Bots episode (Jennie, EN6) there was evidence of adults joining in alongside children and thus scaffolding through modelling and sharing their enjoyment of the activity. In some observations with younger children, the teachers standing back meant that opportunities for problem solving and agency were not always facilitated (e.g. Role play activity, Joanne, W1).

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In the main however, teachers' scaffolded interactions involved them **guiding and instructing** the children (whether in whole class or small group contexts), and asking questions and prompting discussion and dialogue about experiences. In both preschool and primary, the UK teachers often modelled the language they wished the children to use and develop, (e.g. Anita, EN5; Jennie, EN6). In sum, teachers tended to act more as facilitators than instructors, particularly at preschool. Through the planned structure of the activities and their pedagogical interactions, they scaffolded the children's learning and fostered the learners' creative engagement, though this was not always explicitly planned for.

Differences between science and mathematics

There appeared to be fewer opportunities for **inquiry** and 'real life' **problem solving** in mathematics in the observed episodes, although it should be stressed that there were fewer mathematics than science episodes collected in the UK. Additionally, Mathematics was mainly taught, both at pre-school and at primary, as a discrete subject whilst science was taught as part of a topic or theme in a cross-curricular way. This integration of science activities – as seen in Egg Carrier, (Ella, EN8) or Melting and Freezing (Martha, SC1) – meant that more time was typically available for the children to immerse themselves in these activities, both in the sessions observed and in related activities over time, and this may have enabled them to engage in a more playful manner, moving from exploration to questioning and developing their curiosity and own lines of inquiry in the process. There was much greater evidence of teacher questioning to encourage children to express and share ideas in science, (this was a common feature of most science episodes (e.g. Mary, SC2; Emily, EN7), but it was only noted in a few mathematics episodes (Caroline, EN4).

Motivation and affect were important aspects of both mathematics and science episodes, often though not always evidenced through **play and exploration.** In contrast, in one observed primary school mathematics episode (Big Mathematics, Joan, W2) motivation took the form of competition, which motivated children to achieve in mathematics. Games were also used elsewhere in mathematics as motivational tools (Louise EN1; Lisa EN8) and helped to foster pupils' **positive attitudes** towards such work, though they were not observed in science activities.

Opportunities and challenges for creative learning and teaching

Opportunities for creative learning were seen through the pedagogical framing of activities in open ended ways that encouraged children to play and explore and in many instances to follow their own lines of **inquiry**, **solve problems.** The accompanying pedagogical interaction between teachers and children and children and children allowed learners to engage in peer **dialogue and collaboration** (e.g. Louise, EN1; Making shapes, Caroline EN4), and supported metacognition. This variously involved the teachers in standing back and allowing **free exploration** (e.g. Shapes, Maeve, NI1), or in **teacher questioning** that allowed for and valued **free expression** of ideas (e.g. Caterpillar boots, Caroline, EN4) and **reflection and reasoning** (e.g. Jenny, EN1)**.** In this way the children were enabled to *'generate alternative strategies and ideas as an individual and community and reason critically between these*' (D2.2 Conceptual Framework).

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Although across the UK, many of the open ended activities fostered creativity in science (and to a lesser extent mathematics), it should not be assumed that these were deliberately left open in order to foster creativity. **Some of the teachers did not have a clear idea of what is meant by creativity**, either as a concept in its own right or in relation to mathematics and science. In these cases, teachers referred to offering open ended activities in order to motivate and affectively engage the young learners, to foster play and exploration and develop positive curious attitudes.

In addition, a further challenge for the teachers in fostering creativity in mathematics and science related to matters of the pressure of time and for the primary teachers in particular, the **constraints of the school timetable**. Due in part to the set time period allocated to particular lessons at the primary phase, teachers were not always in a position to afford extended time for immersion and exploration, although Denise (W1) did achieve this in a number of examples. This meant that the children had less time to engage in free play with the available resources and on several occasions, opportunities for creative engagement were not fully realised. This was less of a concern in the preschool where time was more commonly stretched in response to children's interests and engagement. Furthermore, it was noted in some cases that teachers, busily supporting the large class of learners at the primary phase, often without the presence of additional adults in the room, **did not always see, hear or recognise the creative conversations and generative ideas which the children voiced or enacted**. Also in some cases children's creativity was related to off task conversations or imaginative responses which did not further their understanding of maths or science (e.g. Shapes, Caroline, EN4).

4.2.4 Assessment

Teachers indicated through discussion with researchers and their responses in the teacher survey that they used a variety of assessment approaches to inform their teaching. However these were visible to a limited extent in the episodes observed. In 28 of the 75 episodes factors related to assessment were not coded. Where assessment approaches were in evidence they tended to be unplanned and formative.

Formative assessment

In about half the episodes there was evidence of ways in which **formative** assessment was used to inform planning. For example Louise (EN1) regularly set targets in mathematics with children. The Bubbles activity (Fleur, EN2) was based on Fleur's previous observations of children's free play. In the Melting and Freezing episode (Martha, SC1), children's questions and responses were used to inform teacher interventions and future planning. Maria (SC3) used children's questions as a framework for planning the science topic on Senses.

Summative assessment

Summative assessment was only evident in three cases, all in the context of mathematics, such as Joan's (W2), Big Maths timed activities, Caroline's (EN4) paper, pencil arithmetic and multiplication tests as part of mathematics lesson 'warm ups' to track progress and Ella's (EN8) assessment of children's recording of block graphs Block Graphs. Summative mathematics tests were discussed in interviews associated with two cases as causing tension and restricting creative practice (Jenny, EN1;

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Louise, EN1). In the early years in the UK then, the data set, albeit from a small sample, would suggest that summative assessment does not play a large role in assessing young children or that summative assessment takes place at fixed times (but not during the period of fieldwork).

Assessment strategies

There was very **limited evidence of the assessment strategies employed in the episodes themselves.** Examples where assessment processes were evident included Cars and Ramps (Jennie, EN6), where teachers planned specific questions to elicit children's strategies and understanding; Melting and Freezing (Martha, SC1) where observations were recorded on post it notes or Day and Night (Mary, SC1) where children's prior knowledge and questions were recorded and displayed on the wall for future reference (these were also then included in Floor Books created for each science project to document learning across the class). However there were stronger indications of teachers' strategies in the forms of evidence collected and recorded in children's profiles and teachers' files as indicated below.

Forms of evidence

Again **the forms of evidence used and recorded to support assessment processes were indicated in only a few of the episodes** (10/75 episodes). They included for example:

- *Observations* made by teachers (often on post it notes) and photographs to provide evidence of both learning processes and outcomes. These were often further annotated with children's comments. This kind of approach to recording evidence was noted in a number of preschool settings (e.g. Anita, EN5; Jennie, EN6; Alice, NI1; Maeve, NI1; Sarah, SC1). Levels of staffing in preschool settings and the common practice of allocating a key worker responsible for tracking each child helped to facilitate these processes.
- In primary settings whole class approaches such as *brainstorming ideas and questions or children reporting back* on findings were used to provide evidence of learning, particularly in science (e.g. Wendy, EN3; Outdoor Sounds Linda, EN4; Waterproof, Emily, EN7).
- Across many of the episodes where factors associated with assessment were coded, *responses to teacher questioning* provided important evidence of children's current skills and understandings, both in talking with individuals (more common in preschool settings, with groups or the whole class (more common in primary settings).
- *Children's recording,* (sometimes with teachers' marking or annotations) was also regularly used to provide evidence of progress. Although often further commentary from children or the teacher would have helped to make explicit what the recording revealed about children's skills and understandings.

Peer and self-assessment

There were a few cases where peer or self-assessment was an integral and regular part of teaching and learning processes.

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In two preschool cases, Jennie (EN6) and Sarah (SC1), regular time was set aside each week for children to review their profiles with staff and to discuss learning from their recent experiences. They selected photographs and examples of recording of significance and teachers noted their comments. There were opportunities to look back on previous experiences and reflect on progress. In both these settings the profiles were accessible to both children and their parents and were used on a regular basis.

There were examples in some primary classes of the use of 'traffic lights' or 'thumbs up' for children to signal their understanding and achievement during a session (green/thumbs up to indicate understanding, red/thumbs down to indicate lack of understanding and amber/thumb wobbling in the middle to indicate unsure), such as in the cases of Louise (EN1), Mary (SC1) and Maria (SC3). In the Egg carriers and Habitat episodes (Ella, EN8), Ella built opportunities for both peer and self-assessment into different stages in the sessions to allow time for children to evaluate their own work, review the work of others and consider alternative ideas and strategies.

Differences between preschool and primary school

It is difficult to generalise from the small number of episodes where factors associated with assessment were recorded. However some general trends are suggested for further exploration. The systematic use of observation recorded in children's profiles and used to track progress and inform planning was noted only in preschool settings. Children's profiles of some kind were fairly common across the preschool settings but not noted necessarily in the episodes. They offer rich potential for involvement of children in reflection on their own learning, for revisiting experiences and for sharing with parents.

In primary school ongoing assessment of children's responses to experience relied more on teacher questioning, used during whole class sessions or group work and on review or marking of outcomes. Assessment records were often based on marking recorded in children's books alongside tracking grids indicating children's progress against curriculum requirements.

Differences between mathematics and science

Episodes did not show substantial differences in formative assessment approaches in mathematics and science. However there was a greater focus on summative assessment in mathematics.

Opportunities and challenges for creative learning and teaching

The episodes provided evidence of ways in which assessment processes can provide opportunities to support creativity in learning and teaching, through for example:

- *Eliciting children's interests, ideas and questions through group discussion*. This encouraged children's **reflection and reasoning**, provided exposure to **alternative ideas** and allowed teachers to build on and foster **children's ideas and interests**.
- *Observation* offered rich opportunities to gain insights into children's **developing strategies and thinking**.

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- *Dialogue and discussion* focused around recording and representations of experience (writing, photographs, models etc.) offered insights into individual **children's thinking** often not evident in classroom dialogue. This was also noted by researchers in their interviews with children about their learning (e.g. Art, Louise, EN1; Doubles, Emily, EN7; Maria, SC3; Jelly, Joanne W1).
- *Use of peer and self assessment* as an integral part of classroom processes has the potential to support children's **ownership and awareness of their own learning** in general terms. In addition the processes of **evaluation, reflection and reasoning** involved in peer and self-assessment also play key roles in problem solving and inquiry in science and mathematics.
- *Profiles and class floor books* to record experiences and learning allow revisiting of ideas (mentioned by a number of teachers as critical in learning) and can children to gain a **sense of their own learning and progress.**

However evidence from the range of episodes suggests that as yet these practices are not yet widely adopted as an integral part of classroom practice. This will be an important focus in developing materials for teacher education in Work Package 5.

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5. Implications

5.1 Implications for teacher training

Findings from the case studies highlight the potential for creativity in early science and mathematics education. They also suggest implications for the content of teacher education. Some key areas for teacher professional development are suggested below. They focus on factors identified through fieldwork processes and earlier stages of the project as of particular significance for fostering creativity through inquiry and problem solving in early science and mathematics. However, they do not focus on general issues such as teacher subject knowledge, confidence or skills in assessment that are also relevant. Examples from the case studies could play a very useful role in supporting teacher development in these areas.

Themes related to Teacher and School factors

Teachers' conceptions of the nature of inquiry, problem solving and creativity in early mathematics and science - approaches could include:

- *Opportunities for teachers to examine the aims of science and mathematics education and perspectives on learning – with a particular focus on the roles and nature of inquiry, problem solving and creativity in early science and mathematics and why they matter;*
- *Analysis of episodes from fieldwork in schools and the use of the fieldwork instruments to observe classroom practice to identify and discuss examples of creativity in learning and teaching.*

The case studies illustrate the strong influence of individual teachers on the opportunities provided for learning in their classrooms. While the perspectives of case study teachers were often in accord with factors identified in the Conceptual Framework D2.2, teachers were not necessarily familiar with features of inquiry or problem-based learning. Many valued the opportunities offered by the project for discussion of what might be meant by creativity in early science and mathematics. The approaches and activities above might support explicit planning for IBSE and creativity that was rarely seen in schools during fieldwork.

Development of whole school approaches - this could include:

- *Consideration of approaches to whole school curriculum planning for creative teaching and learning and inquiry based approaches in mathematics and science;*
- *Consideration of approaches to whole school planning and school infrastructure to support and maximise opportunities for such learning in the school grounds and wider environment;*
- *Approaches to timetabling and planning to offer time to incorporate extended inquiries building on children's ideas and questions;*
- *Awareness of organisations and networks within the science/mathematics/creativity communities that might provide support.*

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While the role of individual teachers is critical, findings also indicated that support at whole school level can be important in enabling teachers to take risks and try out new ideas. Whole school approaches to the curriculum, planning and timetabling as well as the encouragement of outside agencies can also help in creating much needed time and space for inquiry and in supporting learning outside the classroom.

Themes related to Pedagogical Framing

The roles of materials in fostering creativity in early mathematics and science – issues to be explored could include:

- *Ways in which the organisation and nature of resources can both constrain and extend children's explorations and inquiries;*
- *Recognising the potential in everyday materials;*
- *The importance of observing children's use of resources to gain insights into their developing explorations and thinking.*

The provision of rich resources was noted in many of the episodes, however children's use of resources was rarely the focus of teacher observation and discussion and in the case of digital technology this was rarely used by the children themselves as discussed below. The episodes provide useful examples of researcher observations of children's interactions with materials during free flow play or when the teacher was not present that could inform a more explicit approach to the provision and planning of resources including information and communications technology.

Grouping practices for different purposes – themes to be explored could include:

- *Varied forms of grouping for different purposes;*
- *Task design and resources to support collaboration;*
- *Ways of helping children to collaborate effectively.*

Varied forms of grouping were noted across preschool and primary settings. The episodes reported include examples of the potential contribution of collaboration to creativity in inquiry and problem solving, particularly in encouraging children to articulate, exchange and evaluate ideas.

Planning for extended engagement and progression over time - themes to be explored could include:

- *Consideration of time for immersion, play and exploration as the critical context;*
- *Consideration of motivating starting points and child initiation of inquiry;*
- *Flexible use of space and on-going access to resources to allow room for creativity;*
- *Building from children's interests and being flexible with the timetable to allow extended inquiry and follow through;*

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- *Ways of helping children make connections across experiences and links to everyday life.*

Strong motivation and affect were well represented in episodes but also an emphasis on depth through building seriously on children's ideas and interests. In many cases the adults too were affectively engaged

Themes related to Pedagogical Interactions

Teacher scaffolding to support creativity, inquiry and problem solving- this could include consideration of the following:

- *Ways in which teachers scaffold learning in mathematics and science that support the development of creativity;*
- *Establishing open ended learning activities;*
- *Recognising the moment to intervene and to stand back in order to observe, listen and build from the children's interests;*
- *Intervening with appropriate questioning to support inquiry.*

This relates to both designing learning activities and teacher questioning, see below, and was characteristic of both preschool and primary school pedagogical approaches observed. Teachers showed varied awareness of their roles in scaffolding children's curiosity and creativity.

Designing learning activities – features of inquiry-based approaches – themes to be explored could include:

- *Ways in which everyday learning activities can be opened up to allow greater opportunities for inquiry, problem solving and creativity;*
- *The key roles of children's questioning, planning and evaluating evidence in inquiry and the connections between them;*
- *Different kinds and purposes of inquiry;*
- *Connections between the development of understanding of concepts and procedures in science and mathematics and the processes of inquiry.*

The cases indicated widespread opportunities for processes of observing, communicating and making connections, associated with the generation of ideas However more limited attention was given to children's own questions, planning of investigations or the evaluation of evidence – aspects associated with the evaluation of ideas - although there were examples of episodes that illustrated children's capabilities to engage in such activities. This theme is linked to the nature of inquiry above, as it relates to conceptions of inquiry and creativity in science and mathematics.

Teacher questioning to support inquiry – this could include consideration of the following:

- *Different forms of questioning;*

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- *What forms of questioning are productive – when and why;*
- *Supporting children in raising scientific and mathematical questions;*
- *Ways of encouraging children's questions;*
- *Giving children the time to formulate their responses;*
- *Strategies for building on children's questions.*

The Conceptual Framework D2.2 highlighted the importance of teacher questioning in scaffolding children's inquiries, but also the complex issues of judgement in deciding when to intervene, when to stand back or the kinds of questions that might be productive in fostering children's independence and extending thinking. Fieldwork processes provided varied examples of both productive questioning and opportunities that were missed to extend learning.

The use of ICT to support children's investigations and problem solving – this could include for example the roles of ICT in:

- *Enhancing observations, making measurements, collecting data;*
- *Recording , presenting and analysing data;*
- *Modelling ideas;*
- *Searching for information;*
- *Controlling models;*
- *Communicating findings in a variety of ways;*
- *Alongside issues of management and support of ICT use in the classroom.*

There were very few examples of any of these uses of ICT across the UK case studies. While use of ICT was observed in classroom episodes, this was used mainly by the teacher or to support research using secondary sources. This has been identified throughout the project as an area for further development.

Forms of representation and expression – issues to be explored could include:

- *Purposes of recording, selecting approaches appropriate for purpose;*
- *Different ways of representing and expressing ideas;*
- *Recording as a process to support thinking , reflection and dialogue.*

The cases included episodes in both science and mathematics where children were able to represent and express their ideas in their own ways – however this practice was not widespread. Children's representations in these instances also offered valuable contexts for dialogue about their ideas and thinking. The focus in recording can often be on the product, rather than the process of recording, and the opportunity it can provide children to explore ideas and reflect on learning. It was evident

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that where teachers left open how ideas might be recorded this helped to free children's imaginative responses.

Assessment for learning – themes to be explored could include:

- *Different assessment strategies and forms of evidence in early science and mathematics;*
- *Using assessment information to inform planning and teaching;*
- *Integration of peer and self assessment into teaching and learning processes;*
- *Role of children's profiles and class floor books in encouraging revisiting and reflection on learning.*

Across all phases of the project assessment has emerged as a key area for development. While varied forms of assessment were employed across the cases to inform teachers' views of children's progress, it was less evident how assessment information was used to inform learning and teaching and there were few examples of children's involvement in peer and self-assessment.

The role of classroom research in developing practice

Teachers involved in this study valued the opportunity to reflect on and examine their own practices through being involved in the project. There may be implications for how teacher education can integrate such professional enquiry as a mode of learning. Themes that might be explored could include those outlined above.

5.2 Implications for policy development

The case study findings have implications for policy across the United Kingdom, policy that would help enable teachers to foster creativity in early science and mathematics. The key policy implications are outlined below.

Importance of entitlement to CPD

The case studies reveal how challenging teachers found both identifying opportunities for creativity in early science and mathematics, and recognising when children were demonstrating this. There is a clear need for continuing professional development (CPD) which addresses the fostering of creativity in early science and mathematics for example through developing:

- Teachers recognition of the value of developing creativity in and through mathematics and science and the mutual benefits afforded;
- Teachers' capacities to recognise opportunities for promoting creativity through science and mathematics, by considering the curriculum potential, and
- Teachers' sensitivity to expressions of creative engagement by children in these aspects of learning, so as to recognise, engage with and extend these.

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Need for training for science and mathematics co-ordinators

Science and mathematics coordinators can play key roles in the development of whole-school approaches to science and mathematics. However they need specialist training and support for the development of school level policy and practice in this area. School wide approaches can help to ensure greater consistency and progression in children's experiences. They can provide a framework for professional reflection on provision that seeks to develop children's creativity in early science and mathematics, building on this over time.

Potential of projects and initiatives to raise the profile of science

The case studies illustrated the potential of recent national initiatives and award schemes to support schools in raising the profile of science and mathematics in the curriculum. The value of such initiatives and projects related to science and mathematics could be more widely recognised in policy. For example, working towards gaining awards such as Gold Quality Mark or Eco School Status or using the Healthy Schools toolkit provided opportunities and incentives for schools to develop aspects of policy and practice and to gain recognition of their work. Wider dissemination and sharing of such examples can help generate enthusiasm and provide encouragement to other schools seeking to enhance learning and teaching in science and mathematics.

Coherence in policy

An important implication for policy from both the case studies and earlier phases of research in the CLS project is the need for coherence across policy and associated guidelines related to curriculum, pedagogy and assessment. While the importance of inquiry and creativity is often recognised in the rationale and aims of the curriculum, these dimensions are reflected to varying degrees in curriculum or assessment requirements or in guidance in relation to pedagogy. Examples of key implications for the curriculum and for assessment are outlined below.

Time and space in the curriculum

The case study analysis revealed much there was greater space and time for children in pre-school settings to generate child-initiated enquiries and to follow these through, in comparison with the more often teacher-initiated and teacher-choreographed activities bounded by time and space in primary settings. The greater flexibility and holistic approaches characteristic of the early years curriculum, compared with the more subject-bound early primary years curriculum, with mathematics and science identified as distinct areas of knowledge and skill, together with pressure on children in evidencing these, was apparent in each of the four countries of the United Kingdom. Early primary teachers found it more challenging (due to a crowded curriculum and performative pressures), to find the time and space for children to pose and respond to their own questions, and to investigate and generate creative responses. Policy frameworks for science and mathematics need to allow sufficient flexibility in space and time by ensuring the curriculum itself is not overcrowded, and that the breadth of inherent possibility in any aspect of the curriculum is not so narrow as to stifle creative engagement by children.

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Valuing formative assessment

The case studies provide illustrations of the key roles of formative assessment in fostering creativity in learning and teaching in early science and mathematics. For example sensitive observation and questioning by teachers enabled them to recognise and extend children's inquiries. Children's engagement in peer and self-assessment offered opportunities for considering alternative ideas and strategies. The employment of varied approaches to representation and expression allowed both children and teachers to reflect on learning. However across the case studies as a whole, formative assessment was often implicit in practice rather than employed in strategic ways to support and evaluate learning and teaching. Assessment was also an area in which a number of case study teachers indicated they were less confident. There is need for greater recognition of the importance of formative assessment in policy and the development of associated guidance for teachers.

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