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

D4.3 Country Reports

Report 5 of 9: Country Report on in-depth field work in Greece

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D4.3 Country Reports

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Table of Contents

The project CREATIVE LITTLE SCIENTISTS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 289081.

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1. Aims of this Report

The *Country Report on in-depth field work in Greece* 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 Greece.

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 six cases (each case comprises one teacher and the children they work with), based in four 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*

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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 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 Greece 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

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purpose.

- **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
	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.

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	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.

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.

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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 in fieldwork in Greece 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. 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.

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).

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- Geographical accessibility for researchers.

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).

Informed, voluntary participation was a key ethical consideration. Headteachers, teachers and parents were all provided with written information about the project and were given the opportunity to discuss this further with CLS researchers. Written consent was obtained from headteachers, teachers and parents before the fieldwork was undertaken. 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.

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.

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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

The characteristics of the final sample of fieldwork sites are given in the table below.

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Fieldwork Sites		GR1	GR2	GR3	GR4
General Selection Criteria					
Phase	Preschool	X			X
	School		X	X	
Governance	Non-fee paying		X	X	X
	Fee paying	X			
Age(s) of children	3				
	4	X			
	5	X			
	6	X	X	X	
	7		X	X	
	8		X		
Mixed age groups					
Special school					
High Diversity	SEN				
	Non-native speakers			(2 out of 16) 12.5%	(1 out of 17) 5.9%
	Socio-economic disadvantage		X	X	
Location	Urban	X			
	Suburban			X	X
	Rural		X		

The episodes described in the following sections are summarised in the table below.

Site code	***Teacher***	***Year group(s)***	***Science episodes***	***Mathematics episodes***
GR1	Mina	Kindergarten	• Paintings	• Measuring Tables • Shape Trees
GR1	Katia	Pre-Kindergarten	• Pansies • Branches, Leaves and Pine cones	• Yellow Colour Tones
GR2	Gianna	Second Grade	• Playing with the microscope	• Baking cheese pies • The baking sheet problem and dough shapes
GR2	Stavros	First Grade	• What are clouds made of? • Plants	• Bee-bot
GR3	Sotiris	First Grade	• Little Prince travels to the solar system • Moving pictures and cartoons • Magic flute	
GR4	Sonia	Kindergarten	• Ice balloons • Building Mr. Zip	• Game of Swallows

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2.4.3 Limitations

The fieldwork was undertaken during a three month period of time between January and March 2013. The limited timeframe to carry out all the required classroom observations only allowed researchers to gather data from a specific window of the school year. According to the participating teachers this particular period of the school year limits their activities, especially for science. A large part of the *"more creative and exploratory"* activities are planned during the final two months, in April and May. This meant that the episodes analysed in this report lacked the majority of outdoor activities in both preschools and primary schools.

A further limitation to this report is that it is not certain that the lessons observed were part of teachers' standard practice and not an attempt to carry out activities that teachers felt that would provide data for the purposes of the *Creative Little Scientists* project. Few of the teachers (e.g. Gianna, Mina) stated that their involvement in the project led them to try out activities for the first time. On the other hand, children's attitudes and their feedback to these activities highlight that important elements of these activities were part of teachers' standard practice.

An additional limitation is the fact that most of the observations were conducted with limited recording apparatus, largely due to the prohibition of video recording in all Greek schools. The majority of observations were carried out with two researchers present which improved reliability and allowed a form of data triangulation. During each of the observations researchers had two audio recorders and two digital cameras to record audio and capture images. Although researchers were allowed to move freely in the classroom, it was observed that their presence caused severe disruptions to the lesson. As a result, audio recorders were not in constant movement in order to be able to capture all children interactions and focused on teacher-child interactions. With all the rich activity going on inside the preschool and primary classrooms it was difficult for researchers to keep fieldnotes, take photographs and move the audio recorder around the classroom simultaneously (and without disrupting the flow of the lesson).

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3. Case Studies

3.1 Case 1 – 'Mina'

3.1.1 Context

Where?	Country	Greece			
	Setting name	GR1			
	Location within setting	Pre school			
Who? (children)	Year group/age of children	5-6 years old			
	Number of children in class	23			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher + 1 German teacher			
	Case teacher role	Preschool teacher			
When?		1	2	3	4
	Dates of visits	17/1/13	13/2/13	14/2/13	28/3/13
	Times of visits	09:30-11:00	09:20 – 09:55	09:20 – 10:50	09:30 – 10:30

a) School/setting

The school is situated in a suburb of Athens approximately 17 kilometres from the city centre. It is one of the largest private schools in Greece providing education from pre-kindergarten (4 year old children) to secondary education (18 year old children). The main aims of the school for kindergarten are:

- Emotional maturity, familiarization with the new social environment and compliance to behavioural rules both on an individual and group scale
- The development of the pre-schoolers' intellectual skills
- Physique development

All the learning material has been written by a group of experienced Greek and German kindergarten teachers and is based on the following principle method: playing and daily experimentation help the children expand their experience and mental abilities.

The aims for primary school are:

- The individualization of teaching and the support of the pupil according to his/her character, aptitudes, possible special needs and, above all, with respect to his/her personality.
- The application of modern teaching methods.

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- The enhancement of the syllabus.

The school has a philosophy that focuses on science education. According to its philosophy, familiarization with figures and natural laws is the first step which leads to the development of more complex skills, like the ability to analyse and synthesise. Experimentation, coming in touch with simple but interesting natural phenomena as well as comprehension through research and questioning are the key points of the lesson. The school also promotes outdoor learning and according to the vision of the school learning does not take place only in the classroom but also in the Physics' and Computer science's lab, in the music and art room, in the video room and in the library. The school's special editions for the teaching of Greek and foreign languages are of great help to the pupils of all grades in primary school.

b) Teacher (using the interview and survey)

Mina is in her fourties, and holds a BA in Preschool Education from the University of Athens. She has 11-20 years of teaching experience and she has taught in kindergarten (5-year olds) for the last four years. Mina studied science and mathematics last as part of her BA degree, although neither was a subject of emphasis during the course. Based on the responses she gave to the survey, Mina can be considered as confident across all the categories. All her responses were consistent with high confidence except her general pedagogical knowledge, where she feels very confident. She also reported having received CPD training during the last 18 months, citing workshops on Science/Mathematics subject matter or methods, individual or collaborative research on a Science/Mathematics topic of personal interest and engaging in informal dialogue with colleagues on how to improve science teaching as the ones having a large impact. The only category where Mina did not receive training was mentoring and peer observation and coaching of Science/Mathematics teaching, as part of a formal school arrangement.

c) Classroom (including the age of the children)

There are 23 pupils in the class, with 14 boys and 9 girls. In terms of the classroom setting, the classroom is housed in a spacious open-planned space, with a large area being occupied by tables situated in the centre of the classroom. On one side of the classroom large benches are placed against the wall providing enough space for all the children to sit. This space is called the Circle. Around the classroom there are several areas dedicated to specific themes, known as “corners”. These areas are used by the children looking for resources to assist them in their learning during the lessons and during the half-hour free playing portion at the beginning of each day. The classroom is well resourced with rich mathematics artefacts, puzzles and games, a reading corner and an interactive table. A garden which is looked after by the students is one of the main activities carried out by children during the spring and gives them a chance for hands-on exploration.

Same as all the other schools in the sample, this kindergarten class follows the 2003 curriculum for preschool education. There are however additional teaching materials written by experienced science educators employed by the school especially for this purpose. Teachers across the different kindergarten classes coordinate their lessons by teaching the same themes

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and topics during the school year but, at the same time, having the necessary autonomy to modify teaching activities and material according to the needs of their pupils and their learning pace.

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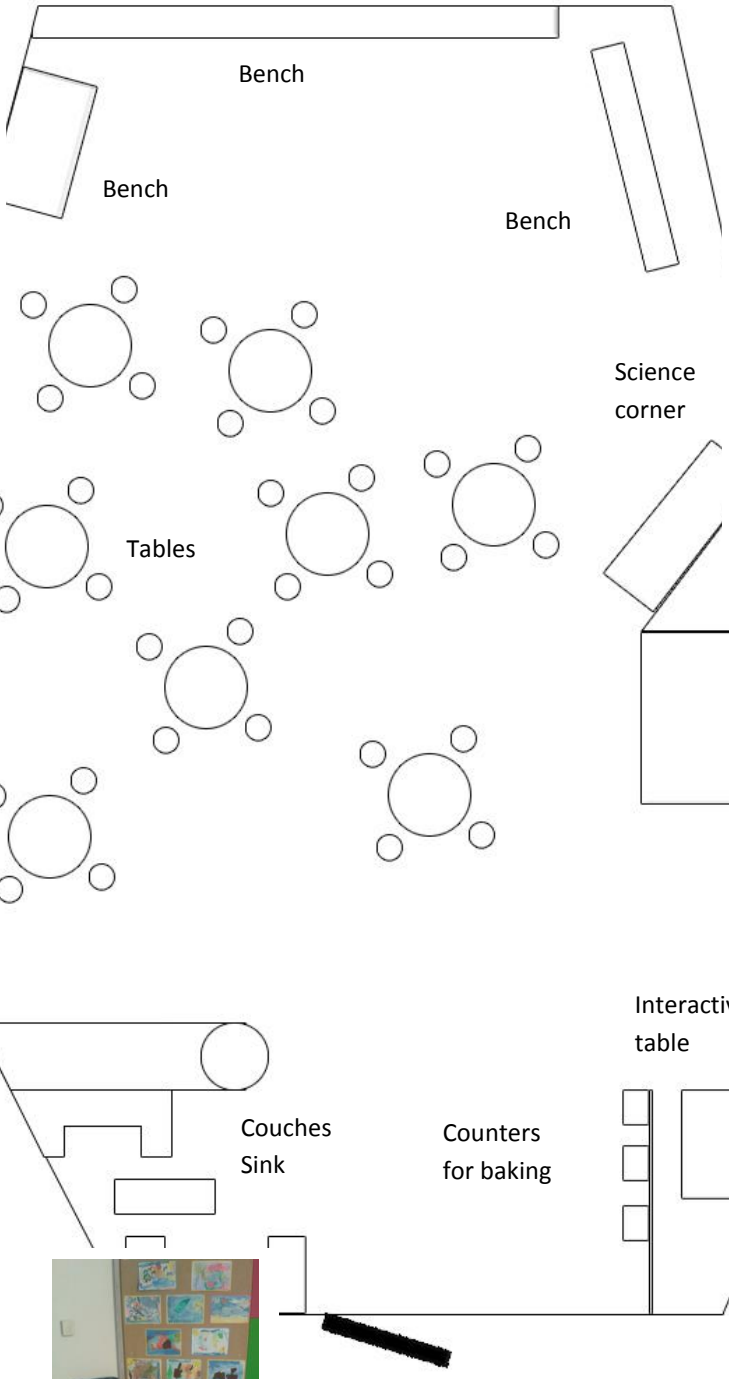

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3.1.2 Episodes

Episode 1: Shape trees

The first episode presented here is a lesson with children playing with geometrical shapes. Children had to bring objects from the classroom ("The shape hunt"), discuss their shape with the teacher, comment on specific shapes' mathematical properties and finally make "shape trees" using paper and a variety of other material. This episode relates to both activities and illustrates ways in which the teacher sought first to support children in becoming familiar with shapes and their properties using everyday objects and get them to construct a depiction of a tree.

Pedagogical Framing

Mina's planning indicated a number of key aims for this session including that children should be able to:

- name the different shapes and categorise them
- recognise shapes in their environment
- collaborate in groups and create a group project in the topic of shapes
- develop early argumantation skills to justify their ideas

The "shape hunt" activity is linked to the first aim, while the second activity that involved children categorising different objects and presenting their results to the classroom is tied to the second and third aims. Finally, the shape tree activity aims to promote and facilitate dialogue and collaboration. Children were divided into 3 groups of 6 and 1 of 7 and Mina had prepared all the activities using materials that were already in the classroom.

Pedagogical Interactions

The lesson started as children seemed very excited from the beginning when Mina let them know they would be working in groups and playing with shapes and objects. After splitting up the 4 teams Mina told the children: "I will tell you what I would like from you and you can then go about it your own way. Do whatever you want." Each team was assigned a colour and the only instruction provided by Mina was for children to find objects that are the same colour as their team's and bring them back to her. The children were given 3 minutes to do so and at the end a variety of shapes was brought back to the tables.

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Mina asked the children to share their findings with the rest of their classmates. The children had to raise their hand to speak and after that they had to name their shape. Mina then asked them questions to assess their knowledge of shapes. The children did have one previous lesson devoted to the names and properties of geometrical shapes, but Mina felt that this was knowledge they had acquired outside of school premises. Mina used questions to motivate children to present their shapes. She asked children to name their shape, explain their process to distinguish between the different shapes and point specific geometrical properties, such as angles.

The questions used by Mina during this activity were almost identical for each of the children. She started off by asking "what is this?" and continued by asking "how do you know?" Her final question was "How did you reach this conclusion?" and was aimed at children using both their language skills and their bodies to show what they were talking about. An example of one team of children presenting their shapes follows.

> *Mina: Let us now hear from the yellow team. Were you good investigators?*
>
> *All: Yes we were.*
>
> *Mina: Let us see what you are here to present to the rest of us. Tell what you found or you think you found. N?*
>
> *N: This is a circle.*

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Mina: How do you know?

N: It is round.

Mina: What does everybody else think? Do you agree with N? Is that the name of this shape?

All: Yes.

Mina: Do we see shapes like that around us?

Ni: It is the shape of the planet Earth.

Mina: Oh is that right?

A: I have two more shapes. Circle and square.

Mina: A has two shapes in her hands. Lift them up so everybody can see. A, what makes you say that these are a circle and a square?

A: One shape does not have any...

Mina: What does one shape not have?

A: The circle does not have any sides while the square has four.

Mina: Did everybody hear A?

All: Yes.

A: Four identical sides.

Mina: Oh that is a nice observation. Can all of you see that?

All: Yes we can.

Mina: D, you also have two shapes.

D: Yes they are a circle and a triangle.

Mina: How did you reach to the conclusion that they are a circle and a triangle?

D: Because the triangle has three angles while the circle does not have any.

M: I also have a triangle.

Mina: How can you be sure?

M: It has three sides and three angles.

The discussion continued until all the children had presented the shapes they brought. During all this they had successfully identified that 90 degree angles are called “right angles” and that is why the equiangular rectangle gets its name (in Greek, both words come from the word ‘orthos’ meaning proper or correct).

When talking about the rectangle (presented by V), D mention that it has 4 right angles.

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D: There are 4 four right angles.

Mina: How did you come to this conclusion?

D: The angles are "longer" than the other angles (forming a right angle with his hands)

Mina: What is the shape called?

D: Its called rectangle (orthogonio in Greek). Right (ortho in Greek) and angles (gonies in Greek).

Mina: So we have a word that is made up from two other words, right?

D: Yes. Ortho and gonio

Mina: Very good.

D: and if you change it you can make it into a square. If you go like this (showing that the longer two parallel sides should be shortened to equal the remaining two sides).

Children also noticed equal sides on rectangles and triangles, but did not mention comparisons between angles.

For the next playful activity, Mina asked the 4 teams to find objects in the classroom to bring to the class assigning a specific shape to each team (square, triangle, circle and rectangle). An hourglass was used to count down the time available to bring back the objects as Mina stood aside and let the children choose their objects. Children then came back to their tables with a variety of objects and were ready for another discussion. The discussion that followed was conducted in a similar tone and allowed the children to articulate their observations and reveal their previous knowledge of shapes.

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During this discussion Mina asked children to compare and find similarities and differences between the objects they found and various shapes. At the end of the discussion Mina commented children on being very good researchers asking them if they would like to play one more game. The children excitedly agreed and Mina brought out the material for the final game.

> *Mina: I know how beautiful things you have made here and I want you to make something now using all these materials I have brought. I would like you made "shape trees". You can use any of the material here to make them and each team will have a specific shape so we don't get mixed up. Let's start.*

The activity lasted for 15 minutes with children working both individually (e.g. cut the shapes in their preferred size) and collaboratively (e.g. to decide where/if shapes could/should be put on the shape tree). Children were very excited during the activity and Mina moved around the room, offering assistance and providing encouragement. The activity concluded with the 4 teams standing up in front of their classmates to present their shape tree.

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After the 4 presentations were done, Mina started a discussion about the nature of the activities that proceeded, mostly trying to bring out what the children felt about working in groups and collaborating.

> *Mina: Take a look around to see your friends' work and compare it to your team's work. How did you feel working within the team? What did you like? What didn't you like? What made you feel happy? I want you to think for a bit.*

Children said that they enjoyed making the shape trees together. F said that he enjoyed working with shapes, measuring the rectangles to cut and glue them to the trees. Measuring shapes was what L mentioned as particularly enjoyable, while Li said that she enjoyed seeing what the other teams had done, especially the team working the triangles. Mina, after allowing every child to assess the day's activities, concluded the lesson by letting the children know what she felt about their work.

> *Mina: Let me tell you what I really liked. The way you worked together, collaborated. You worked very well as a team and any disagreements and conflicts were kept to a minimum. You did everything very well and managed to complete all your tasks within the time provided. Let's give ourselves a big round of applause. Well done, you were great!*

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Opportunities for Creativity

Features of creative teaching were shown in the use of questioning to foster dialogue and collaboration as children presented their observations and explanations. The use of questioning is also characteristic of Mina's sensitivity to stand back or guide and her approach to teacher scaffolding. The use of questions addressed to children was characteristic of the teaching approach chosen by Mina to conduct a children-driven lesson which would allow children ample space and time for children to articulate their thoughts and encourage them to explain their ideas. The concluding activity involving children making shape trees evidences the value of play in Mina's teaching approach and, to a lesser extent, her sensitivity to include diverse forms of assessment as part of her lesson. Children were given minimal instruction and guidance to carry out the activity and they were allowed to cut and glue different sizes and materials to the shape tree. The only restriction was that they had to work with only one shape per team. The shape tree activity even though used to provide data for assessment, did so less for the cognitive development of the children and more to evaluate group work as evident by the concluding classroom discussion aiming to reveal children's feelings towards collaborative work.

Opportunities for development and demonstration of creative dispositions were dominantly linked to children's motivation and curiosity. The first two activities (shape hunting and bringing objects to the group) successfully motivated children, as they seemed genuinely excited to learn about shapes. The object hunting activity, where children had to bring objects and identify their shape allowed them to make connections between the two dimensional and three dimensional representations of shapes. Children went from examining a shape on paper (2D) to playing with simple 3D representations in the first activity (the third dimension in these objects could be easily disregarded) and then to connecting these representations to actual everyday objects.

Episode 2: Measuring tables

As the children are starting to familiarise themselves with the concept of numbers as well as their symbols a variety of different activities are used in the kindergarten. As the overall philosophy of the preschool directs teachers provide opportunities for exploration, handling and organising physical materials through solving problems that arise either from the teacher or the children inside the classroom. This particular episode focuses on children taking measurements of their work tables using any of the measuring tools provided or a measure the dimensions of the table using a tool of their own conception.

Pedagogical Framing

The teacher's planning documents provide rich data for the lesson's pedagogical framing but also the overall teaching strategy regarding mathematics. According to Mina a mathematics curriculum for these ages (4-6 year-olds) should start with three main thematic areas ("Numbers and operations", "Geometrical and spatial properties" and "Measurements"), in order to build solid mathematical foundations. It does however have to link to children's previous experiences and to their needs and interests.

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The main pedagogical points for this lesson which are highlighted are:

- enable children to foster their interest and motivation in mathematics using everyday situations and their experiences
- encourage children to keep "mathematical notes" as they are working in the classroom using symbols
- encourage children to count in their everyday activities
- encourage children to make estimations and predictions
- children to be able to form and check hypotheses
- children to be able to solve problems (process information, take decisions, find a result, confirm results)

Pedagogical Interactions

Mina started the activity off by reminding children that they have been talking about getting new tables for the classroom. The children would be divided into 8 teams (6 made of 4 children and 2 more with 3 children) to help Mina with a problem she had. Mina went on to inform children that she spoke to the carpenter to place an order for new tables, but when he asked her to tell him exactly what tables she wanted, she did not know how to respond. She concluded by asking the children if they wanted to help her measure the tables so that she can alert the carpenter. The introduction to the activity that followed is consistent with Mina's teaching strategy evident from her statements made during her interview. Mina feels that it is every important to connect mathematics to the children's everyday life using appropriate activities and making sure that the children are motivated.

> *Mina: I want you to help me send the instructions to the carpenter. I will give you notebooks so you can write down what you measure. I will provide some instructions. Each team will decide how they are going to take their measurements. We need to provide three measurements to the carpenter. Height, length and width. Each team will deliberate and decide on the measuring tool they are going to use. You can use anything you like. Either from the materials here or anything else you can think of. Do you remember for example using our palms to measure [indistinct] earlier in the school year?*
>
> *Children: Yes we do.*
>
> *Mina: So now go into your teams and decide all together what each team is going to use.*

Children went and sat on their tables and after 3 minutes Mina started asking them what their decision was. The children chose to work with a tape measure and a ribbon. The next step to the process was the notebook. Mina asked children to record their measurements and observations to the notebook in writing. The children immediately started playing with the material provided and as their yelling was getting louder, Mina stopped them to give the final instruction. Mina said, *"To make it easier you need to collaborate. If every one of you wants to keep the tool for himself/herself, the team will not succeed in the task".*

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The children started working together, with one child holding the tool, one in charge of the recording to the note book and two more assisting the child that was taking the measurement. Some teams kept these roles throughout the activity, while others rotated to take all the roles possible. After 15 minutes Mina invited all the teams to present and discuss their findings.

Each team had the opportunity to present their measurements and findings as Mina wanted to know what they had noted in their notebook. Mina was asking them to provide their measurements for shape, measurement tool used, length, width and height of the table. She began by commenting on whether the team managed to use the notebook to record their measurements. Then she asked them what tool they used and how, what is the shape of the table and finally the actual numbers for the measurements. The first four teams either used a tape measure or a wooden meter to take their measurements so their reporting involved only

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numbers and very little extra information. Team 5 however chose to use the ribbons to measure the table.

Mina: Team 5 used the ribbons. What did you measure?

M: Everything. We even measured the legs.

Mina: Let's see how you managed to do all this. Could I have your attention here please? This is important. Let's see how they managed to measure the table with something different as the ribbon. Team 5, how did you measure the table's height for example? I have never measured before in my life. You have to tell me how. Make me understand.

M: We start here [places the end of the ribbon to the ground] and go.

Mina: Wait, where do you stop? Where does the table end? [children looking] Isn't it shorter this way? Or longer? Which is which?

M: Longer.

Mina: The table or the ribbon?

M: The table.

Mina: So the ribbon then is ...

M: …shorter.

Mina: You needed a little more, didn't you?

All: Yes we did/

Mina: Is this a correct measurement then for the height?

All: No.

Mina: We have to try again.

[Children seem disappointed].

Mina: Do not worry. This is just an unsuccessful attempt, as long as we understand what we have to do now. After everything is done we have to check our results. If we find something that is not done well, we try again. [Mina grabs the ribbon] The example of team 5 shows us that we have to try again. You will try again right? We realise from the checks we have done that this ribbon... Would you please tell us what you found out M? You know this better than me.

M: The ribbon is shorter than the table.

Mina [to all]: What does this mean? Will we give the carpenter the correct measurements? What table are we going to get? Bigger or smaller?

All: Smaller.

Mina: When we realize this we have to get the ribbon again. Then we try again then to

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make sure that we have gotten the correct measurements. If we send the measurements to the carpenter as they are, he probably won't be able to make the table. He might get confused. We need to reach to a final result to send to the carpenter. In order to do that we have to do what? [No answer] What did we just do? I will tell you a new word now for what we did. It's called verification. What does this mean? We will check if the measurements we took are "real".

The lesson concluded with the children gathered together as one group discussing the lesson. Mina asked children to tell her what and if they enjoyed the lesson, if anything amazed them during any of the activities and what could be done to enjoy lessons such as this more, carried out similarly to the conclusion of the first episode above. During the discussion children mentioned overcoming problems in collaboration (D: We argued at first but we discussed it and then we agreed), understandings (A: I understood that if I don't have a ruler on me, I can use other things to measure like a ribbon) and enjoyment (V: I really liked what we did measuring the tables. It was very fun).

Opportunities for Creativity

Features of creative teaching were observed during this lesson in the efforts made to enhance children's attitudes in mathematics by connecting mathematical knowledge with everyday life. As recorded in her teacher interview, Mina believes that it is very important to provide children with stimuli to establish a strong link between mathematics and their use in everyday life. It her strong belief that the mathematical concepts although taught in preschool are not the first priority for the teacher. That is why it is very important to provide children with meaningful and exciting activities to motivate children through all forms of play.

Opportunities for development and demonstration of creative dispositions are present in this setting in the form of collaborative work and children developing early understandings about inquiry. Collaboration between children plays an important role in this lesson, as the children had to work together in order to reach to a result (the measurements in this case). It is unclear however if the children felt that collaborative work assists them in developing understandings. Mina allowed children to plan and design their measuring strategy. She offered minimal directions before letting the children to measure the table, most of which had to do with what they were looking to measure and very little on how they would be going about to do it. An additional element contributing to creative learning in mathematics and science observed is the conscious effort on the part of Mina to promote basic understandings about inquiry. This is particularly relevant to the part of the lesson where Mina is trying to talk to them about the process of verifying the measurements. This part would have been longer, based on Mina's planning, but was unfortunately cut short due to time constraints. Mina however told the children that they would be working together on verifying their results the following day.

Episode 3: Paintings

The final episode presented involves an activity that was carried out at the conclusion of the

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most popular theme in Greek preschools, the cycle of water. Over the course of 3 weeks, Mina and the children were working with water and especially trying to understand the processes that take water on a cycle beginning and ending in the sea.

Pedagogical Framing

The cycle of water theme is commonly used in Greek preschools, offering a multitude of topics and physical processes that are considered suitable for early years education. The significance of the cycle of water to preschool science education can be seen by the multitude of aims and teaching objectives mentioned in the overall planning as provided by Mina (lesson plans and interview). The aims and objectives for the cycle of water include elements of knowledge/understanding of science content, learning about science process skills, social factors of science learning and affective factors of science learning. The activities carried out during this period included children conducting simple experiments with water, a visit to an "experiment museum" where they observed a variety of experiments with water, outdoor learning. This episode focuses on the concluding activity of the cycle of water series of lessons that involved Mina initiating a group discussion of two famous paintings. The activity served a dual purpose for Mina, it contributed to assessing the series of lessons concerning the cycle of water on one hand and integrated a scientific topic with other curricular areas, such as the arts, in order to facilitate positive attitudes and increase children's interest in science.

Pedagogical Interactions

The activity started with Mina presenting the two paintings by Rene Magritte and Kostas Paniaras, a Greek painter. She asked children to look at both paintings and think of a story. Their stories could be about anything and about either painting. Children took turns presenting their stories with Mina asking questions which were either about the cycle of water or about how the paintings made the children feel. Two incidents are particularly interesting one for each painting, as children managed to see the connections between the paintings and the cycle of water and provide Mina with data to assess the children's learning.

The first incident revolved around a discussion of Mina with a single child about the Paniaras painting, while the second one involved a group of children contributing and adding to the story about the Magritte painting. The first story about the Paniaras painting was presented by S who

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said that the painting of the Greek painter reminded him the mathematics CD he hears when he goes to bed.

S: Arithmetics fits here. It reminds of my CD that I listen to when I go to bed.

Mina: What do you mean?

S: The sky when I put on the CD. The sky full of clouds, looking dark.

Mina: How did that happen?

S: The weather made it like this, cloudy.

Mina: How?

S: The water came to the clouds. By the sun.

Mina: What did the dun do?

S: Water vapour. It heats it.

Mina: and where does it go?

S: Up. To the clouds.

Mina: Do you see it?

S: Here [points at the painting]

In contrast to the stories about the Paniaras painting, where each child presented a different story, the Magritte painting was a "work in progress" with children expressing their thoughts during the discussion or starting their stories based on the ones previously presented by their classmates.

The first story about Magritte's painting by K was. K said that the wind is lifting the people upwards. They are judges being swept off their feet in the courtyard of a courtroom. Mina asked K about his feelings when he looked at the painting. K said that it made him happy because they were flying. The next child who commented on the Magritte painting said that he imagines the judges going down towards the earth. "They are coming down. Maybe a helicopter dropped them off and they are going to the courtroom" he said. When Mina asked him what are the judges doing falling off helicopters, G said that they are going to work this way. Mina asked children whether this could happen in real life and Ia said that if she used her imagination it could happen. The next child Ch said that the judges are like meteorites and that they are falling to the Earth. Her contribution was praised by Mina as "very different and special". Il then added that they must be wearing parachutes to go down and when Mina asked if she could see the parachutes drawn by Magritte or imagined them she responded by saying that she imagined them because parachutes slow the judges down when they fall. Mina asked what else can fall from the sky and M immediately said the rain. Mina instead of using this first mention of rainfall to direct the focus towards the cycle of water chose to ask Il about why she thought the painter chose to draw humans falling from the sky. Il responded that they were coming from outer space to go to work and that as soon as they got in the building the "proper" rain started to fall.

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M then added that it was about to rain so we could say that before there was a “human rain”.

The lesson continued with Mina asking children to compare the two paintings and think about whether there was any reason that these paintings were side by side. Children made various observations on similarities between the paintings such as having grey on them and that the weather is just about to rain. Also a number of children said that they could not see any connection between the two paintings. M was the last one to speak:

> *M: In the left one it getting ready to rain and in the second it already rains but people*
>
> *Mina: Very nice. I am very glad. M took all your ideas and got them a step further. That is the way. I say something, someone else says something else, then another one and another one and we get a lot of ideas. When this happens and we have a lot of different ideas we can reach to a conclusion.*

The lesson ended with Mina closing all the window drapes, asking then to close their eyes and listen to a CD she had brought for them to hear. Mina said, “When we listen to something with our eyes closed, our imagination runs away” and V responded “It does not run away, it comes closer. To us and quickly.”

Opportunities for Creativity

The lesson described above presented various opportunities for creativity on the part of both the teacher and the children. In terms of creative teaching, Mina designed and carried out a cross curricular activity to assess the children’s learning on the cycle of water, bring children closer to the arts and kelp the children see that science can be present even in a seemingly unrelated discipline. The questions asked to the children were used to allow them to articulate their thoughts and feelings on the two paintings, rather than try and direct children towards the cycle of water. The ability to stand back during the majority of the lesson and allow children to express themselves freely succeeded in assisting the children to fulfil the aims set by Mina for this particular lesson.

By using the two paintings as the only resources, the teacher was able to make the links between science and real life activities very explicit. Dialogue and collaboration were encouraged in the lesson, especially when children were feeding off each other to further the story about the Magritte painting, which ultimately led to the conclusion of people falling like rain. Mina modelled possibility thinking with her “I wonder” and “I want you to imagine” questions. Motivation and affect were also creative factors in this lesson largely due to the nature of engaging with paintings and the arts in general. This is evident by the inclusion of questions that required children to express what they felt when looking at either of the two paintings.

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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?

Mina uses a combination of small group and whole class activities in her lessons. The group activities are dominant in Mina's teaching practice, with whole class activities either involving children interacting with her to complete a simple task or during the beginning and conclusion of lessons to introduce a topic for the former and to assess children's learning and enjoyment for the latter. Assessment information collected during the conclusion of lessons is used to inform planning and encourage children to reflect on their own learning through discussions that allow children to reveal what are the experiences they consider significant. A particular emphasis is evident on collaboration and dialogue for all the activities observed during the four visits to Mina's classroom as the majority of tasks involve the children talking and working together. Encouraging play and exploration, in both teacher-led and child-initiated activities is another approach used regularly by Mina in her lessons to facilitate children's natural curiosity about the world around them, the scientific phenomena that they experience and make connections between their everyday life and science.

Opportunities for processes such as predicting, selecting materials, representing ideas or reasoning are offered by Mina with 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. Questioning was used throughout the lessons to promote sustained shared thinking with questions such as "*What do you think will happen if …? What do you see? How could we do that? What do you think we should do next? Why do you think that happened?"* The provision of a rich and supportive physical and emotional environment is very important to Mina in order to promote positive attitudes and interests. Physical hands-on resources that lead to children's explorations were used as the main learning activity, in every lesson observed.

What role if any does creativity play in these?

Teacher creativity was evident in the imaginative activities, the interesting resources and Mina's ability to provide the necessary environment that promote children's creative dispositions by giving both time and space for children to work on their own pace. The use of questioning to foster dialogue and collaboration as children presented their observations and explanations was evident during the lessons observed allowed Mina to be sensitive to the children's interests in order to conduct a children-driven lesson which would allow children ample space and time to articulate their thoughts and encourage them to explain their ideas.

In terms of teaching for creativity, Mina encouraged the children to make connections (Paintings) and to design their own investigations (Measuring tables). A positive atmosphere

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where all children's ideas were valued and given ample attention was evident in all the lessons with Mina taking the time to discuss them all either with one child or, if she believed it was interesting enough, with the entire classroom. Children were required to make predictions through play and exploration, simple constructions and questions, but rarely these predictions were revisited after the conclusion of the activity.

RQ3: *Probing practice*

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

The carefully planned activities and rich resources used by the children managed to motivate learning and promote a positive attitude towards science and mathematics. An important element of Mina's teaching practice was the conscious effort to link both subjects to everyday life and children were given the opportunity to apply their learning, which assisted them in making their learning relevant and meaningful. Motivation and affective development is a very important aspect of Mina's practice, *"the start of it all"* as Mina said in her interview. Conscious efforts were made on the part of Mina for children to understand that play and learning are not separated and that playful explorations can lead to both learning and excitement. This approach to play and exploration capitalises on children's interests and strengthens children's agency in the classroom and contributes to creating scientific understandings.

Dialogue between children and Mina encouraged explanations and reflection on learning. During the teacher children interactions children raised and answered questions and made observations which revealed children's connections between experiences and events.

How do teachers perceive their role in doing so?

Mina stated that it is very important to make learning meaningful to the children by encouraging children agency and providing them with a rich physical environment for exploration. The best way to do that according to Mina is build a meaningful context that allows children to recognise the impact of science and mathematics on everyday life. She stated that teachers should *"create the appropriate learning environment and provide the appropriate material for children to be able to make their own connections, especially between mathematics/science and their everyday life"*. Mina also believes that a key aspect of teaching practice in kindergarten is that one should realise that *"children come to the school with knowledge that shouldn't be underrated, as a teacher it is your responsibility to take this under consideration. You have to modify your teaching according to that, the children do not come here as tabula rasa, they come to the classroom bringing their experiences and knowledge. That is why you have to work with the children to construct their knowledge and stay away from the opinion that you should give them the final product and expect them to learn."* As Mina said, she tends to introduce topics using a very open-ended activity or brainstorming session to get a good overall picture of the previous knowledge and experience brought by the children. This knowledge allows her to plan her strategy and model the teaching activities to the needs of the specific children.

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In terms of organising the actual activities Mina mentioned that her teaching experience dictates that the teacher should refrain from overloading lessons with many activities and resources. With limited time to cover the curriculum and time management being a very important issue to most of the teachers Mina believes that "*if you free yourself from the pressure of time management once in a while, an activity could pleasantly surprise you by taking the children a step further than you had originally planned and truly witness the children's potential. You have to forget the other activities you have planned and run with the one."*

Mina also referred to the tension between process versus outcome in teaching science and mathematics. The school's direction according to Mina dictates that process is more important than the outcome in this particular age. Her personal view can be summed up by the following quote taken from her interview: "*You have to provide closure for the activities. When an activity is left without children reaching to a conclusion or result it leaves them hanging. They want to have something of an outcome to show for their work. Ultimately, process and outcome should not be used with or between them. In my opinion it more appropriate to use the "and" and retain a balance between the two. In my view, children experience the process and feel glad about the result."* Her opinion reveals an issue that had not been referenced by any of the other teachers, the children's need for closure when it comes to the activities carried out in the classroom.

According to Mina her role in promoting children's interest, learning and motivation involves supporting children's affective development in science and mathematics by planning cross curricular activities *("I felt particularly proud when children still come to me after two months and tell me their thoughts and feelings on the Magritte painting"),* valuing diverse forms of expression *("I like for children to use a variety of different ways of expressing themselves")* and sensitivity to stand back and let children take responsibility of their learning *("I tried to listen, not speak too much and refrain from showing them that I liked the direction the discussion was taking. It is difficult because you get excited").*

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3.2 Case 2 – 'Gianna'

3.2.1 Context

Where?	Country	Greece			
	Setting name	GR2			
	Location within setting	Primary school			
Who? (children)	Year group/age of children	6-12 years old			
	Number of children in class	8			
Who? (adults)	Number of adults	1			
	Role of adults	1 teacher			
	Case teacher role				
When?		1	2	3	4
	Dates of visits	17/1/13	13/2/13	14/2/13	28/3/13
	Times of visits	10:40 – 11:45	10:40 – 11:40	10:40 – 11:40	09:00 – 10:00

a) School/setting

The school is situated in a village approximately 45 kilometres from the city of Rethymno in Crete. It is a four-teacher school that a little less than 50 children attend and gathers students from the 6 nearby villages of the Municipality of Amari. The six grades of primary are grouped in 4 classrooms, one for each of the first and second grade and two others that group, one the third and fourth grade and the other fifth and sixth grade. The school is separated into two separate buildings, on for the first two grades and the newly built kitchen, and a bigger and older one for the final 4 grades and the teacher/principal's office. The school, fuelled by the principal (and fifth and sixth grade teacher), has made several changes to its operation, resources, setting and most importantly its curriculum. All changes started with the layout of the classrooms. Cupboards were removed and large sofas were brought in the classrooms. The principal commented that changes to the school were made gradually first inside the classrooms, decorating and making space but considered turning the school's vision to nature as the biggest change making the biggest difference.

b) Teacher (using the interview and survey)

Gianna is in her mid-twenties, and holds a BA in Primary Education from the University of Thessaloniki. She has 6 years of teaching experience and she has taught in the first two classes of primary school during the last 4 years. From 2009 until 2012 Gianna taught the first two classes of primary education concurrently (children aged 6 to 8 years old), while the current academic year she is only teaching in the first grade (6-year olds). Gianna studied science and mathematics last at secondary education, since during her BA degree neither topic was emphasised with only an overview offered. Based on the responses she gave to the survey,

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Gianna can be considered as confident in her general pedagogical knowledge, in assessing children in both mathematics and science. Gianna is also confident in her knowledge of the didactics of mathematics and her mathematics teaching, but less confident in the relevant categories for science. That said, she self-reported her confidence level in her science teaching as low while her confidence in her mathematics teaching as high.

c) Classroom (including the age of the children)

There are 8 pupils in the class, with 5 boys and 3 girls. In terms of the classroom setting, the classroom is housed in a spacious open-planned space, with a large area being occupied by desks situated as a half-circle facing the blackboard and other smaller areas, known as "corners". These areas are used by the children looking for resources to assist them in their learning during the lessons. The classroom is well resourced with rich maths artefacts, puzzles and games, a reading corner and an interactive whiteboard at the centre of the large wall opposite the entrance.

Classes are regularly taught outdoors with a growing number of activities can be found in the yard of the school. A garden which is looked after by the students and a recently constructed chicken coop offer many opportunities for children's explorations away from the classroom. Digital technologies are used very often by the teachers in the form of videos and interactive teaching material on the whiteboard, but it also part of the planned activities organised by the school with students producing material for a web television station run by the students.

Same as all the other schools, this classroom follows the 2003 curriculum for primary education. What is interesting about this particular school is that its remote, rural location allows the teaching staff a rather unique level of autonomy to operating the school. Always within the provisions of the curriculum, the teachers can modify their teaching schedule according to the children's needs as they are expressed by their interest in the various activities. What was observed during the visits to this school was that the teachers there were not afraid to carry out activities where they were not sure they would work in their classroom. Compared to the other schools observed during the fieldwork, this particular one allowed teachers they opportunity to take risks and challenge themselves regularly.

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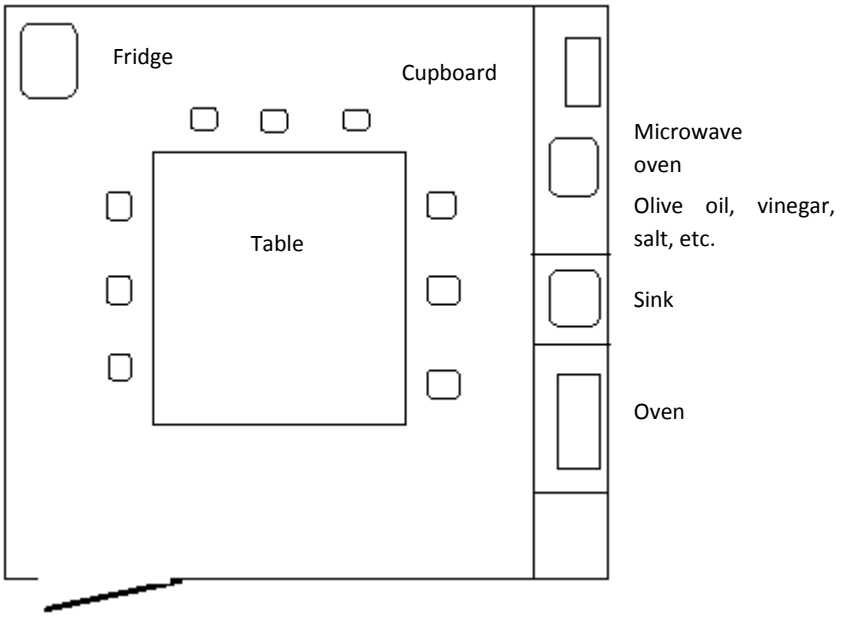

3.2.2 Episodes

Episode 1: Baking cheese pies

The first episode analysed here presents an activity held outside of the classroom. The children along with Gianna moved to the school kitchen, a small square room that had a big wooden table at the centre with chairs for the children to sit and included all the necessary kitchen appliances. Gianna did not link this activity to any previous work done in mathematics, she just informed the children that they would be making cheese pies in the kitchen. The children were very excited and were anxious to start. The ingredients were placed on the kitchen counter so that children would not be able to see them at the beginning of the lesson and the only material left on the table at the beginning of the lesson was a big empty bowl. After the children sat down Gianna began to go through the instructions with the children.

Pedagogical Framing

The aim of this lesson was for the children to learn about measurements and understand the concepts of measuring with different containers in this case which would allow them to grasp the concepts of bigger/smaller, volume and mass. Gianna wanted to involve children in an activity that was closely linked to children's everyday life so she chose to make cheese pies. The tools used in measurements were spoons, cups, bottles and other everyday appliances used in the kitchen. Children, after carrying out this activity, would understand the differences between each measuring tool as well as their proper use. An additional aim set by Gianna was for children to play using the dough they had made to make simple shapes (square, triangle, etc.) to remember and familiarise themselves further with early geometrical concepts. An intention of Gianna which she later described in her interview was for children to solve possible problems that might arise during the activity. Baking cheese pies was a whole class activity that allowed

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children to work both individually and collaborate with their classmates in order to complete the task given. The activity lasted a little over an hour in total.

Pedagogical Interactions

The lesson started with Gianna asking children to tell her what are the ingredients used to make cheese pies. She then let children know that she needed someone to write the recipe on the blackboard for everyone to see. Each child would then measure an ingredient and add it to the bowl.

After giving out the instructions Gianna asked for the main ingredients. Flour was the first ingredient brought up by Z. Gianna said that the recipe requires 2 cups of flour. The filling of the cups with flour immediately posed a challenge for the children.

G: How can you fill up the cup? What is the best way to do it without making a mess.

A: He can use his hands.

G: Are they clean?

K: No they are not.

G: Even if they were completely clean, wouldn't you have more problems with filling the cup?

Z: Some will fall out.

G: How can we fill the cup then?

M: Turn it upside down and it will fall into the cup.

G: Let's see what happens then.

A: Let's put the cup here and turn the bag to drop the flour.

G: What do you think would happen if we tried that?

T, K: It will fall out.

G: It will, won't it?

Z: With the spoon. The spoon, Do we have any spoons here?

G: That is a great idea. Let's see.

K reached for a spoon and proceeded to fill up the cup. After the first spoons of flour went in the cup Gianna asked "Are you counting the number of spoonfuls?" K replied that he did not, as was everyone else in the classroom.

Gianna: Shouldn't we know how many spoons are needed to fill one cup?

K immediately emptied the cup and said that he was going to start over. He then proceeded to count each spoonful he added to the cup.

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K: 1, 2, 3…

Whenever necessary the other children provided assistance to K with counting. It took 40 spoonfuls for K to fill the cup.

In order to fill the second cup T took over and started counting spoonfuls. By the end she had reached 28 spoons to fill the cup. A discussion started immediately on what caused the difference between filling the two cups.

Gianna asked G: how this can be possible since both used the same spoon and cup?

Z: How can one do 28 and the other 40?

A: T got more flour in the cup. I mean that K poured less flour in each spoon than T did

G: What else do we need for the cheese pies?

Z, A, T: vinegar.

G: One tablespoon of vinegar is what we need according to the recipe.

A went to the board to write it down. After adding the rest of the ingredients in the bowl Gianna told that they would now start to mix them up with their hands in order to make the dough.

Opportunities for Creativity

By using an activity that was very close to the children's life at home and allowing them to eat the results of their work (children ate and handed out their cheese pies in the school a day later) provided motivation to the children and gave the activity a sense of purpose. Children were drawing from their previous experiences to carry out the activity, something that is evident by

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their knowledge of most of the ingredients as well as the time they needed to stay in the oven. Whilst the children's contributions were not always accurate, Gianna used questioning to allow children to elaborate on their thoughts and correct their misconceptions. Based on her interview, Gianna felt that the activity allowed opportunities for creativity. In terms of creative teaching, because the children were very motivated and excited throughout the lesson and also were able "to see for themselves and not just be passive receivers of a theoretical lesson" and in terms of the children being creative because the activity allowed them to experiment and children felt more closer to playing than learning which according to Gianna made them to act more creatively. She added that the activity allowed children to take a step further and think about additional things they could do with the materials at hand.

Episode 2: The baking sheet problem and dough shapes

The second episode was observed during the cheese pie baking activity as well. A problem presented itself when the children had to use the surface of the table to mold the dough. Since they thought that the table was dirty, Gianna asked what they could use to solve this problem. Z said they could clean it up while G said to use what he has brought. Gianna introduced the baking sheet and G said that is what he meant. Gianna gave the roll of baking sheet to the children and instructed them to cut just enough to do their job.

Pedagogical Framing

The cheese pie activity was not part of a larger theme or series of lessons. Gianna used the

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activity to allow children to play doing and apply their previous knowledge in mathematics within a familiar activity they have observed in their family life. The activity allowed children to observe and actively participate in the cheese pie making and processes such as mixing (although they were not explored due to time constraints on that particular day). Opportunities arose for mathematics understanding by way of getting immersed in measuring.

Pedagogical Interactions

The entire activity was predominantly teacher led, as Gianna was giving instructions that children had to follow and directing them throughout the lesson. Gianna used questioning to probe deeper into opportunities for mathematics that arose during the lesson. The incident described below is an example of a problem that arose during the making of the cheese pies and the teaching strategy used by Gianna to promote learning and understanding. The use of questioning was helpful in keeping children's interest and in formatively assessing their understanding during the activity.

The children proceeded to use the scissors to cut the pieces of baking sheet needed to cover the table. Z did not place the sheet on the table to measure the correct length to cover the entire surface and a small part of the table was left uncovered. Gianna asked them to think about what they could do to solve this and cover the entire table. Z then measured the rest of the sheet needed to cover the table correctly with the help of A. The children encountered an additional problem when trying to get the baking sheet to set on the table. After removing the sheet from its packaging, it had gotten a circular shape which made it harder to sit properly on the surface of the table. Gianna instructed them to try without any scotch tape as it would ruin the dough if it came into contact with the scotch tape. The difficulty the children faced was because they tried to place the sheet with its hollow side facing upwards.

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After trying unsuccessfully to straighten the sheet with their hands, they realised that it would be impossible to succeed and they stopped to think what they could do. Gianna intervened to remind them not to use any scotch tape and to alert the rest of the class to contribute their ideas. An tried to solve the problem on his own and Gianna asked from A, Z and N to help An to find a solution. “Z, what can you do to place the sheet correctly so it will stay on the table?” was what Gianna asked. Children briefly argued about what they could do until A stood up and went “Oh, I know what we should do. Let’s put it this way. Let’s reverse it and put this side [the hollow side) looking down.” He then proceeded to place the sheet correctly. Gianna agreed with A and congratulated him on his idea.

G: Now that we have made our dough we will play before making the cheese pies.

An: What are we doing?

G: First of all, I want you to get a piece of dough and make a small ball.

N: Do we squash it now?

An: Yes, do we squash it? [Children are referring to the next step in making cheese pies].

G: No we will not be making cheese pies straight away, let’s play with the dough for a bit. Make a small ball with the dough.

Children start making their dough balls.

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K: Is that small enough?

G: That is perfectly fine, but try to make it rounder. Everybody leave their ball in front of them. Now get a little piece of dough and make another ball that is twice in size from the original one.

T: Bigger.

G: Not just bigger. When someone says twice what do the mean? How much bigger?

N: Two times.

G: Z, is this two times bigger? Which one is the biggest?

Z: Yes.

G: Show me which one is the biggest.

Z: This one.

G: Everybody, take a look at the two, do you think this is twice as big?

All the children: No.

G: Which one is two times bigger?

T: This one [points to another pair of dough balls].

G: Which one is bigger?

T: This one.

G: Is it two times bigger?

T: Yes.

K: Look at mine.

G: This is ...

N: Tenfold (wrong word).

G: What is it called?

A: Tenfold.

G: What do you call something three times bigger?

N: (correct answer).

Gianna went on for numbers 4 to 10 as well asking children to tell her the correct word used. She then asked the children to make a “snake” with the dough. Once the children made the first “snake”, Gianna asked them to make another one, but this time longer.

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Gianna then asked children to identify which one of the two "snakes" was longer. The children easily chose the correct one and then Gianna asked them to observe any other differences between the two "snakes" apart from the length. The children's first response was to say that the one is larger. Gianna insisted and asked again for anything else that is different between the two. A remarked that the longer one is thinner while N pointed to the other one and said that it was thicker.

Opportunities for Creativity

The opportunities for creativity which are evident in this lesson are linked to providing children with opportunities to learn within a meaningful context closely connected to their everyday life and previous experiences. Although the focus of the lesson was not on the use of material, the few materials used (ingredients, baking sheet, dough) caused a number of problematic situations in the classroom. According to Gianna's interview, these problematic situations, such as the baking sheet issue, allowed children to think for themselves and evidence their creative potential. Gianna used questioning to assist the children in finding their solution while encouraging dialogue and stood back or interfered according to the amount of direction she felt the children needed in a given problem. Gianna said, *"there would be no point in interfering and offering a ready solution to the children. They would be happier if they solved the problem and I felt very confident that they would ultimately find a solution. Not just for this particular problem, but for every problem they face. […] they just need time. If you allow them to express their ideas, they will ultimately find a solution. If they contribute they can solve the problem."* Gianna also

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took advantage of all the problematic situations to promote mathematical understanding (bigger/smaller, thinner/thicker). Features of creative teaching in this episode consist of providing children with exciting experiences that spark children's interest.

Episode 3: Playing with the microscope

The activity observed was not part of a wider thematic area but rather a standalone lesson for children to get a chance to learn about the microscope. Children did not know anything beforehand so even the introduction to the microscope intrigued and excited them from the beginning. The activity was introduced in order to prompt children's interest and enthusiasm in science through play and exploration.

Pedagogical Framing

This session focused on children understanding the use of the microscope. No materials were prepared beforehand as Gianna wanted the children to choose the material used based on their own preference. The aims for the lesson was for the children to familiarise themselves with a scientific tool that the children had never seen before, such as the microscope. Additional aims for the lesson included children raising questions, making comparisons, causing wonderment and creating opportunities for problem solving. As Gianna said in her interview, "I had planned something in terms of learning activities for today but it did not happen. I wanted the children to direct the activity."

Pedagogical Interactions

The teacher began the lesson by introducing a new friend that is really small, smaller than everybody. She then brought out the microscope which introduced itself as Mr. Microscope. The children asked what does Mr. Microscope do and Gianna responded that people use him to look at very small things. "*The microscope has a better eye than humans so it allows us to see things we have trouble seeing clearly" was the phrase Gianna used to describe the microscope. "Even an ant?"* asked K. Gianna then asked K if he is able to see an ant and K responded that he can see the ant but not its parts like the legs. N then added that you have to get very close to the ant if you want to see its members.

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In order for the children to understand the use of the microscope, Mr. Microscope would help them by using an easy example. Gianna went to the blackboard and asked the children to stand on the other side of the room by the door. She then proceeded to ask the children if they could see a little dot she had drawn on the blackboard. The children replied that they could not and moved a step closer to the blackboard. This went on until all the children could see the dot. Ar then asked Gianna if she could try it for herself and went on to draw a dot on the blackboard. Ar did not succeed at drawing the dot small enough for her classmates to be unable to see it from the other side of the room so Gianna asked what she had to do. Ar replied she had to draw it smaller and tried again. Gianna then asked all the children to sit close to Mr. Microscope to start playing with it.

> *G: Try to imagine that the dot we drew on the board would seem larger through Mr. Microscope. Mr Microscope would make the dot larger and larger until …*
>
> *All: we would be able to see it.*
>
> *Ad: Imagine how big it would look if it was this [makes a large circle with both his hands] big, Mr Microscope would make it look even bigger.*

Gianna then took a sheet of paper which is used during the language lesson and showed it to the children:

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G: What colour is this [egg holder]?

All: Yellow.

G: And?

All: Blue.

G: Do you see any other colours?

All: No.

G: Is there anything inside the blue?

All: No.

G: Now we put our eye here in the hole of Mr Microscope and see.

K: Miss are we going to see it from here? [points to the screen of the projector].

G: Yes one will look through the microscope and the rest will look at the screen.

Gianna puts the paper under the microscope.

K: Oh there are many small dots here.

Other children excitedly observe the dots (indistinct in audio recording).

G: Are there any dots here? (lifts up the paper)

Ad, N, Z, Ar: No there are not.

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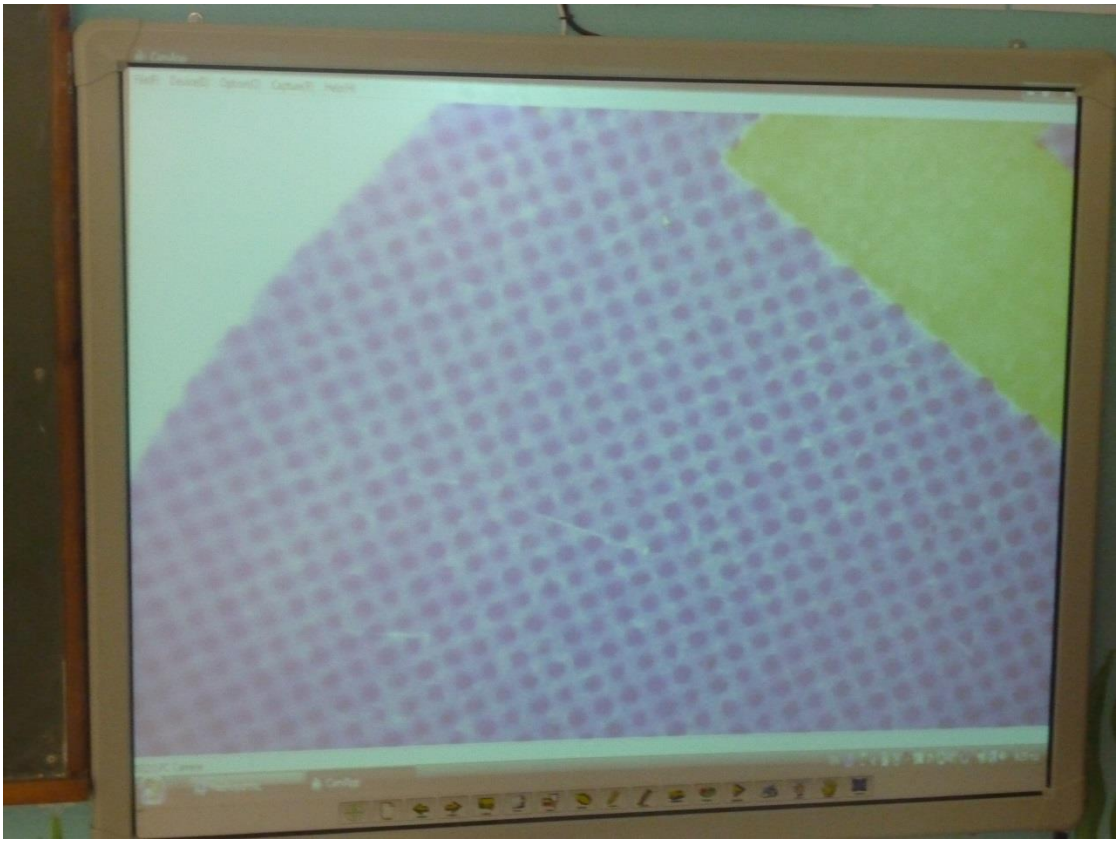
G: How can there be dots here then?

Children do not respond.

G: Let's try something else then.



Gianna then told the children that they could put their hands under the microscope to see if they can understand what is going on. An put his hand first and said that it looks like bread. What made a big impression to all the children was how dirty was An's hand. "*If we have even a little dirt in our hands, the microscope makes it seem a lot more"* said Gianna. Children then procceded to place their hands under the microscope and focused on what seemed interesting to them (K's broken fingernail, Ar's nail polish) and yelled out their observations. The most commonly phrase used by the children during their observations was "*This looks like…".* After the first two children put their hands under the microscope, the rest started to yell out different things or parts of their body they wanted to see. Ad put the microscope to see the inside of his nose, An wanted to look inside his ear and T wanted to see her hair. The children were captivated by the activity and seemed particularly excited during the entire time. Ar pointed out that this was not a lesson and asked whether they were going to have a lesson during the day. Gianna although she did not interfere a lot with children's observations did try to direct children towards identifying different shapes that they could see through the microscope.

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The children were very interested in looking at the different things placed under the microscope and particularly enjoyed finding out what the picture the saw resembled with. Gianna after observing the excitement of the children asked them to think about what part of their body they wanted to put under the microscope. Gianna took advantage of the time the children were putting various parts of their body under the microscope to start asking questions about the human body. Children responded with high levels of excitement for one more time.

At some point children started to bring different items they found inside the classroom and kept asking Gianna to allow them put them under the microscope. Gianna responded by proposing that each child would bring an item to the microscope that would be hidden from everybody else. *"This will be a fun game of guessing",* Gianna said. Children brought forward a variety of items (book, eraser, sponge, chalk) and the rest of the children had to guess what the item under the microscope was.

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Gianna seemed just as excited during this as the children, something she commented in her interview. Gianna said that she enjoyed the lesson very much and was pleased with the children's interest to the activity. She added that when she realised how enthusiastic the children were during the activity, she decided to allow them to completely direct the direction of the lesson. Children were so excited that even after Gianna told them that the lesson was over, they went outside and started bringing even more items to put under the microscope.

Opportunities for Creativity

The microscope and the related activities carried out caused great interest and enthusiasm throughout the learning in both the teacher and the children. Motivation, curiosity and sense of initiative were evident in children's commitment to the activity. Children actively participated in all the activities and shared their observations and thoughts. Gianna said that she did not fell that the activity was very creative because it involved her handling the microscope which limited what children could do for themselves. The most creative part of the lesson happened after its conclusion when children went outside for recess and came back in the classroom holding various items from the school yard (bees, ants, flowers, etc.). At that point they handled everything themselves and made interesting observations without any interference from the teacher. It was an excellent opportunity of self-motivated children inquiry and observation fuelled by children's interests and motivation.

Particular features of creative teaching evident in this episode include the provision of exciting

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experiences to foster children's curiosity and interest. The provision of meaningful 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. According to the teacher interview, Gianna saw the brief activity with the dot on the board as creative because it allowed children to think and problematize.

3.2.3 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 common pedagogical approach observed across the episodes is the use of physical exploration. What is also a consistent and significant observation is the playful context which facilitated learning and stimulated the children's motivation and interest during the lessons. The children as evident by a statement made in the microscope episode did not feel that this type of learning activity is a traditional/typical lesson, but rather a playful activity with set rules and teacher supervision. Such an enjoyable learning environment has potential to enable children to develop and sustain positive attitudes towards maths and science learning, and creative dispositions. An additional element which contributes to the above is the inclusion of activities that are relevant to learners' everyday experiences such as the cheese pie episode

In brief, all of these pedagogical approaches and learning activities helped creating a learning environment where learners feel safe to develop their creative dispositions, such as taking risks and initiatives in coming up with different imaginative ideas and solutions; and being constantly curious and motivated to explore new concepts or phenomena around them.

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?

Gianna believes that these approaches observed allowed children to take a step further in their learning, allowed them to take risks and try out additional things they could do with the materials at hand. Gianna remarked that "*it is often challenging for a teacher to plan activities with children of this age group (younger than 8 years old) because unfortunately in our minds there are a lot of deep seeded experiences left from when we were students. Children should behave and not talk inside the classroom; they should always raise their hands before they speak and other stuff like that. The biggest challenge for a teacher is to overcome all this and move forward. For example, a child could say something that seems dumb and a teacher could build an entire lesson around it while most teachers just dismiss it and move on.*" This reveals the importance of children's agency to the teacher but also the meaning of a teacher listening carefully to children's ideas and a sense of potential for conceptual development.

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3.3 Case 3 – 'Sotiris'

3.3.1 Context

Where?	Country	Greece			
	Setting name	GR3			
	Location within setting	Primary school			
Who? (children)	Year group/age of children	6-12 years old			
	Number of children in class	16			
Who? (adults)	Number of adults	1			
	Role of adults	1 teacher			
	Case teacher role				
When?		1	2	3	4
	Dates of visits	18/1/13	13/2/13	14/2/13	28/3/13
	Times of visits	10:10 – 11:30	10:00 - 11:30	10:00 – 11:30	10:00 – 11:30

a) School/setting

Located on the city of Rethymno in the island of Crete, the 9th Primary School is a state-funded primary school, serving over 200 children from age 6 to 12 years. While the official ethnicity breakdown across the school is not available, it is noted for its predominantly Greek demographic.

The school follows the 2003 National Curriculum for Primary Education, a national framework which promoted cross curricular work across themes, subjects and education levels. Under this framework, each school gets to design their own curriculum to reflect their particular needs and circumstances. The school and the nursery are housed in a fairly modern building with a large number of teaching areas for the six grades and additional spaces such as the computer room and the science laboratory.

b) Teacher (using the interview and survey)

Sotiris is in his late twenties, and holds a BA in Primary Education from the University of Crete in Rethymno. He has 6 years of teaching experience and this academic year (2012-2013) is his first with children younger than 8 years old. Sotiris studied science and mathematics last as part of his BA degree, with both subjects being areas of emphasis during the course. Based on the responses he gave to the survey, Sotiris can be considered as very confident across almost all areas, except his knowledge and understanding of important scientific processes, competencies necessary to carry out scientific inquiry and understanding about scientific inquiry where he considers himself as less confident. Sotiris considers all the items linked to the vision of science education as important emphasising on providing a foundational education for future scientists and engineers, enriching the understanding and interaction with phenomena in nature and

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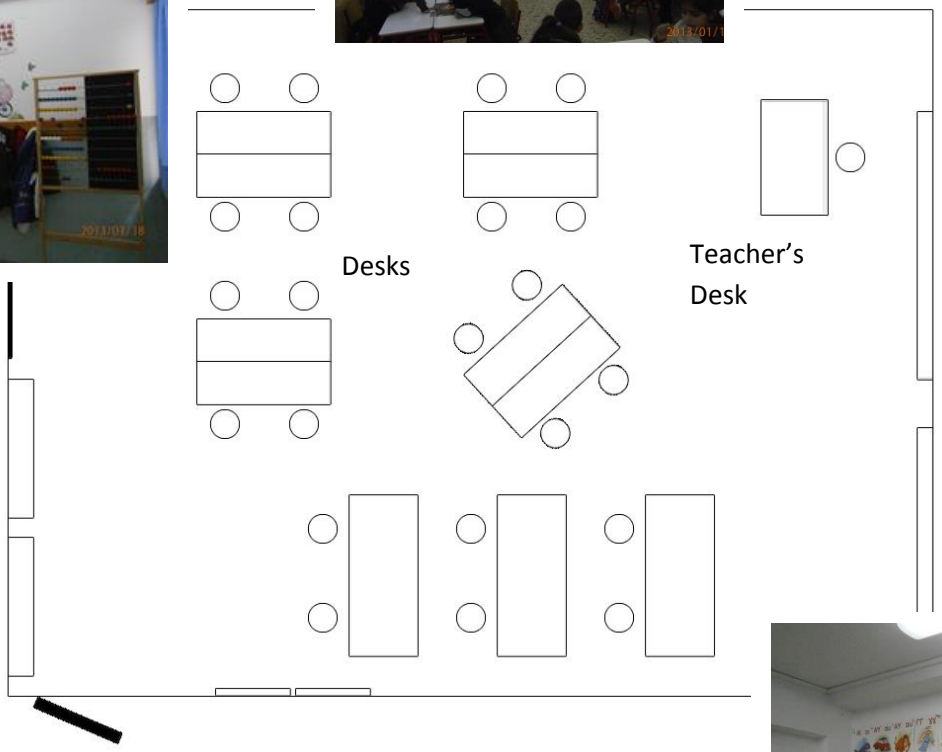
technology and developing positive attitudes to science and dispositions as a foundation for future learning.

c) Classroom

There are 16 pupils in the class, with 10 boys and 6 girls. In terms of the classroom setting, the classroom is adequately spaced for 17 persons with a limited number of materials available for children to play and explore. The majority of the material in the classroom included children's work, some classroom rules and writing supplies.

The classroom is equipped with an interactive whiteboard at the front of the classroom, next to the teacher's computer, and a traditional blackboard on the other side. The children are sitting in desks grouped together to divide them into teams of 2, 4 or 6. Children rarely move away from their seats during the lessons and teams stay the same for the duration of the day. A garden which the children tend to regularly is situated right outside of the school.



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3.3.2 Episodes

Episode 1: Little Prince travels to the Solar system

The content of this episode focuses on an activity where the children were learning about the solar system for the first time in primary school. One week before the first visit the entire first grade of the school watched an episode from the animated series "The Little Prince". After a brief discussion on that day, children started asking questions to Sotiris about planets and wanted to know more information. As Sotiris said just before the lesson started, *"they were very excited about both the Little Prince and the planets that the travelled. I wasn't expecting such enthusiasm, so I had to do something. I organised a series of lessons and activities for the solar system. What you see today is the introduction, the first one."*

Pedagogical Framing

The lesson started off with Sotiris asking the children if they wanted to hear a fairy tale. It was the story of the Little Prince and his latest adventure. The story was accompanied by pictures and brief videos to provide a visual representation of the story to aid the children. Sotiris in his brief informal pre-interview presented the aims for the entire series of lessons on the solar system, which included a series of activities. This first introductory lesson was focused on taking advantage of the children's enthusiasm with the Little Prince story and the solar system. The third element which Sotiris had planned to include in this lesson was Greek mythology where the names of all the planets of the solar system come from.

The aims for the session shown in the teacher's planning were for children to be able to name the planets and compare them in terms of size and distance from the sun.

Pedagogical Interactions

The children responded with enthusiasm as Sotiris started telling his story. The story was about the Little Prince finishing all his choirs and being left with nothing interesting to do. As the Little Prince was feeling bored, he decided to look at the stars which seemed magical and interesting. He then remembered a gift he got from his friend from Earth, the aviator. The gift was a telescope which made the faraway stars and planets seem closer. However, when the Little Prince tried to look at the Earth where his friend the aviator was he realised that he did not know where the Earth was on the sky. That made the Little Prince very sad. The solution was given by another friend of the Little Prince, the crow, who would help the Little Prince to learn about the Earth and the rest of the planets of the solar system.

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Sotiris then began to speak about the planets, taking the role of the crow as the children took the role of the Little Prince. Sotiris encouraged children to comment and ask questions during the entire time the crow presented the solar system. The approach to present the planets was consistent throughout this part of the lesson. Sotiris began by introducing the name of the planet. He then provided a few basic pieces of information (size, distance from the sun, surface) about the planet inviting questions or observations from the children. A brief connection to the myth of the relevant god followed with children mentioning what they had heard before and asking more questions.

Following the presentation of all the planets (and Pluto) Sotiris told the children that they were going to play a game. Children had to work in groups of 4 and collaborate to stick small stickers with the names of the planets to a picture of the solar system. The game involved Sotiris asking

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questions on both the planet characteristics and the relevant mythology, with children were answering them and sticking planets' name tags on the laminated picture of the solar system. The activity went on for 15 minutes.

Sotiris (as the Little Prince): Now I know the names of all planets.

A: So now we are going to play.

Sotiris: We are going to help the Little Prince to name all the planets.

All: Yeah!

D: I remember them too.

G: We will help him.

An: and play.

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Sotiris: We will play a game with points for right answers.

As Sotiris was giving out the pictures to the groups a discussion among one team began.

M: What is this?

A: This is the Earth

M: Are you sure? How?

A: It is blue for the sea and brown.

M: I have Poseidon.

A: I don't know where it goes, do you?

M: No, I cannot remember, but we'll find out soon.

The discussion stopped for a moment as Sotiris was ready to start the game by asking questions for points. A, clearly knew more than the rest of his group and took the lead in the discussion within the group by answering his classmates' questions. Discussions within the group were interrupted by the game that was continuing in the classroom. Children in this particular group were using the time needed for Sotiris to correct of discuss with other groups to continue their discussion without losing touch with the game.

The next activity involved children colouring the planets using colouring pencils. Sotiris showed them pictures of the planets and children had to represent them on paper. A classroom discussion went on during the activity with Sotiris offering additional information and reminding previously mentioned information and the children yelling observations about the planets. An example follows below.

Sotiris: Now we are going to the biggest planet. What is this one?

J: Jupiter. It is brown.

Sotiris: Yes, very good. Have you drawn already?

J: Yes.

Sotiris: Children, J here has painted some horizontal lines on Jupiter's surface. That is an excellent observation.

J. Well done.

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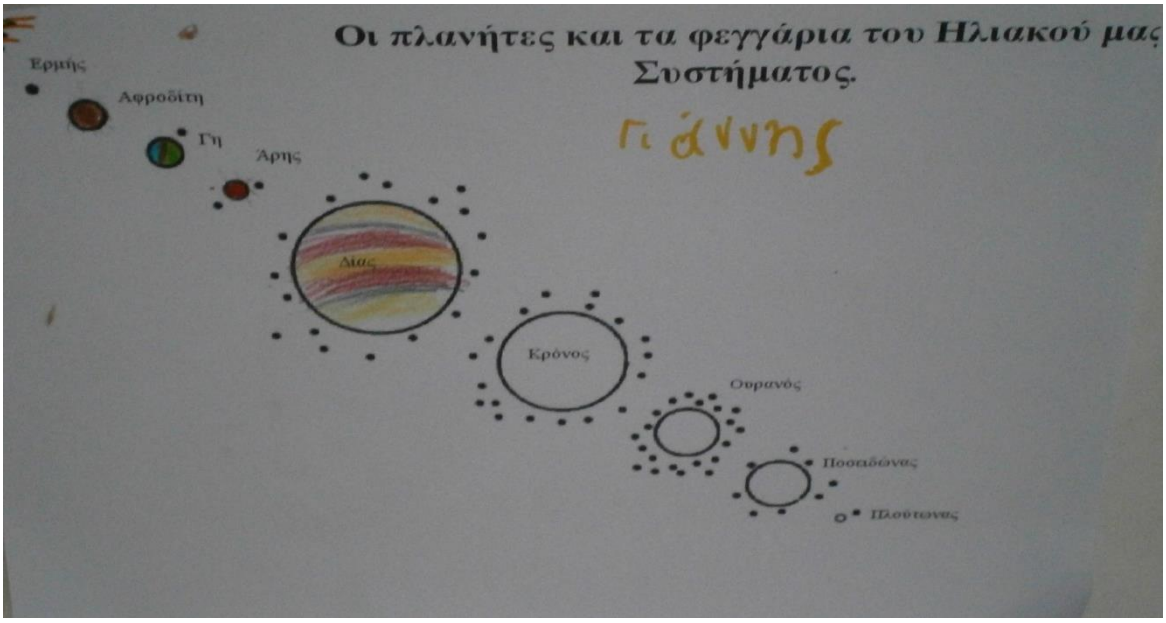

After the colouring activity Sotiris showed the children a video of the Little Prince flying around the solar system and asked them to check and see if they remembered the planets' names. Finally, the entire class went outside to the school entrance to observe the model of the solar system which had been on display.

Opportunities for Creativity

Features of creative teaching were reflected in the opportunities for learning offer by Sotiris carefully organising and preparing of materials to support children's explorations. The role of materials in this particular episode is key, especially due to the fact that each of the materials used are offering different stimuli to the children, valuing the importance of diverse forms of expression in the classroom.

Another aspect of this episode was the cross-curriculum approach chosen by Sotiris to introduce the solar system. Sotiris used two different sources to link the topic of the solar system to other subject areas, the tale of the Little Prince and Greek mythology. The first was, according to Sotiris' interview, by chance as he did not intend to use the Little Prince in any capacity to teach the solar system. As he said, "I did not expect them to enjoy the Little Prince story so much. They immediately started asking questions about space and the planets. I never really liked the Little Prince so I did not think it would be of much use to me, but I was wrong". On the other hand, Greek mythology and especially the tales of the gods was a choice made from previous experience as Sotiris found that the ancient myths cause enthusiasm and interest to the children.

Even though not planned specifically by Sotiris the activities offered time for children to conduct brief discussions away from the teacher. Something that was not evident in the field notes taken by either researcher was the interactions between children when the teacher was away talking to the other teams, which were largely children disagreeing on the topic at hand or assisting

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those that did not know what to answer.

Episode 2: Moving pictures and cartoons

The second episode presented here focuses on a teaching of optics through cartoons. Sotiris driven by children's interest in cartoons planned a lesson specifically aimed at teaching the basic principles of animation. The lesson observed was part of a two-day topic that involved children learning about animation and constructing simple devices that display a rapid sequence of images to create an illusion of movement. The episode that follows is taken from the first day where children construct a device that is comprised of two pictures that rotate on a straw to give the illusion of two pictures being seen as one.

Pedagogical Framing

The topic taught in this series of lessons was brought up by the children. As part of their daily routine children constantly watch animated videos that either introduce (the episode above) or provide explanation to the topic being taught. As Sotiris explained in his interview, children were curious about cartoons and how they were made. In an effort to satisfy their curiosity and enhance children's attitudes in science and mathematics, Sotiris planned a series of activities to show them the basic principles of animation. When Sotiris referred to this lesson in his interviewed he said, *"I like to connect what I want to teach with something that the children enjoy. It is a random process. It depends on what the children say or ask me".*

Pedagogical Interactions

The lesson began with Sotiris asking children if they remembered how cartoons work. He reminded them that he had told them the last time they asked him. Children said that they remembered and Sotiris told them one more time that cartons are made when a lot of pictures move quickly so that they seem as one moving picture. Children seemed to remember this and N added "*They are lots of drawings moving quickly, they are fooling our eyes so that we see a moving thing"*. Sotiris agreed that this device *"fools our eyes and our minds"* and allows us to see moving objects that form short stories.

Sotiris started off by going over the history of cartoons using a video of a zoetrope. He explained that this device was made a very long time ago, in ancient times and referred to it as a very early form of entertainment. Using the video Sotiris explained how the zoetrope was made and how it worked *("A circular box painted black except for a series of drawings on the inside. They then spinned it round very quickly to see cartoons").* Sotiris also explained that in order to see the story properly, one has to "*change their viewing angle and put his eye close to the little hole"* in order to see the cartoon. "*You have to be at eye level",* Sotiris added.

After the video, Sotiris began to explain what they were going to do next. Each child would choose a paper with two pictures on it. Then, they were going to fold the paper in half and insert a straw in the middle and staple it on the paper. Children started choosing drawings, using scissors to cut the frame of the drawings and folding the paper in half. Sotiris was walking around the tables asking and answering questions while helping children staple the straws onto

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the piece of paper.

The questions that were asked by children during this preparation phase were mostly about colouring the drawings and less about how this would make a cartoon. Sotiris was also making a spinning drawing of his own while doing this and by the time the children were starting to staple the straws he had made one for himself. He demonstrated how the children could see the story once they were done and left those who had completed making it to play and experiment with what they had made.

Similar to the previous episode, the focus of this episode is on an interaction between two children collaborating to assist each other in this task. The two children involved, A and N, were finishing up building the devices. A was nearly finished while G was finishing up colouring the drawings. The discussion that followed:

G: Did you make it?

A: Yes.

G: Does it work?

A: Yes, I can see the man lifting the weight.

G: I am finishing now, can you help?

A: Sure.

G asks Sotiris to staple the straw. After Sotiris leaves the discussion continues:

A: Oh I can see it. It is cool.

G (trying to see his one): I can't see it. Have I done something wrong?

A: No it's the same as mine.

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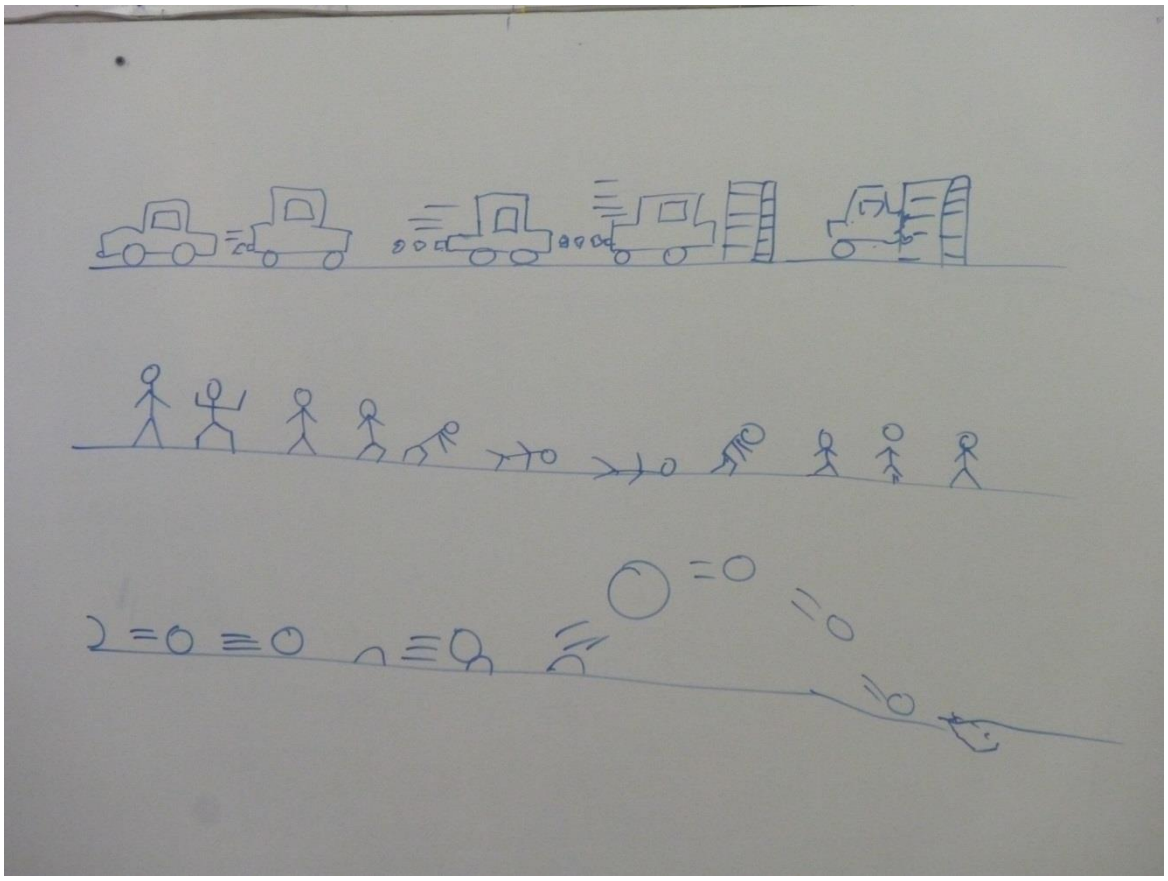
G: Why can't I see it then?

A: You are not lifting it high enough. How can you see it if you hold it down there? Lift it up to here. Your eyes, they have to be straight to the cartoon to see it properly.

G lifts the device to eye level and seems happy to see his cartoon. Both children continue to play with their cartoon straws.

After 15 minutes of children fixing their devices with the help of Sotiris and playing with the straws, Sotiris moved on to the next activity. He told the children that they would be drawing to make the inside of a zoetrope. At this point Sotiris went to the whiteboard and drew 3 examples for children to get ideas for their drawing.



Children were free to draw whatever they wished, but most of the boys chose to draw a similar picture to the one with the car crashing on the wall. The limited time remaining did not allow Sotiris to devote the same amount of time to this activity, which judging from the children's drawings posed significant difficulties to them. Sotiris tried to explain the correct way to draw for the zoetrope but as the lesson ended he did not succeed to tackle any of the children's misconceptions. He did however plan to finish the activity on the following day.

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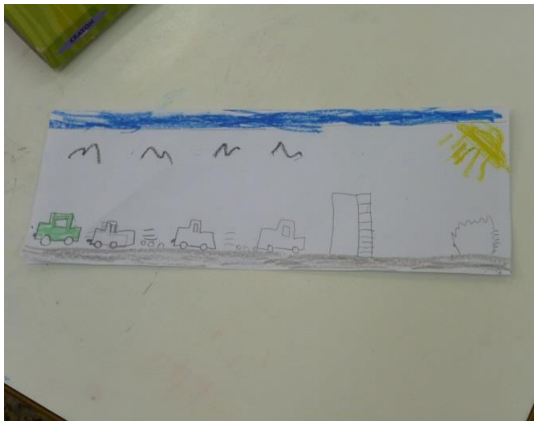
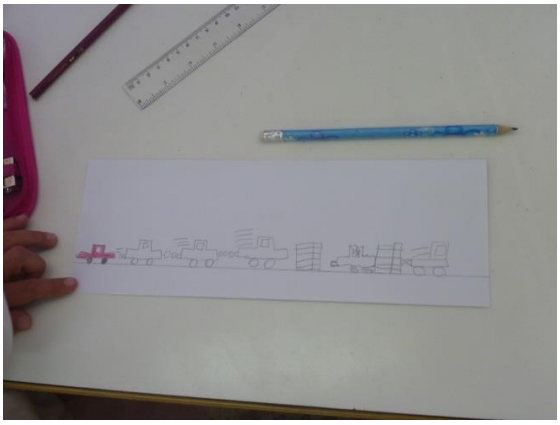
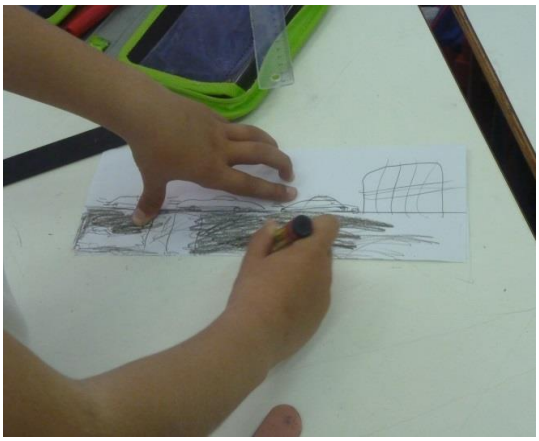
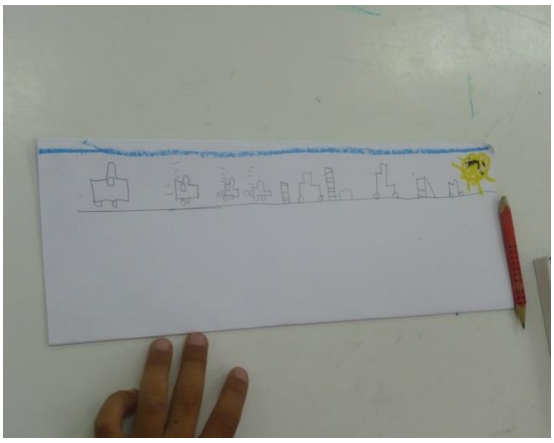

Opportunities for Creativity

Features of creative teaching, similar to the previous episode, were evident in the opportunities for learning offer by Sotiris carefully organising and preparing of materials to support children's explorations. The activity generated great interest and enthusiasm throughout the day in children and attracted growing attention. Children watched with rapt attention and were keen to share their experiences.

The materials provided by Sotiris managed to provide shared and meaningful experiences to children as evident by the interaction between A and G presented above. The important element here is that the interaction between children took place away from the teacher's eyes, not allowing Sotiris the opportunity to build on these types of classroom interactions.

Episode 3: The magic flute

Pedagogical Framing

The final episode presented here is based on the very popular legend of the Pied Piper. The legend was used by the teacher as an introduction to a hands-on activity where children had to construct their own pan flute. The pan flute is referred by the teacher as "magic flute". Similar to the second episode, this activity was the beginning of a two-day lesson on sound that began by using a topic initially irrelevant to science which was connected to a specific scientific topic using targeted activities which sustain the children's initial excitement and interest. The

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materials provided were a series of drinking straws to make the flute, scotch tape and scissors. The activity would be concluded with a work sheet to assess their learning by asking children to draw themselves with the magic flute and write their answer to the question "What would happen if my flute was magic?"

Pedagogical Interactions

Sotiris began by reading the legend of the Pied Piper to the class. Halfway into the story the teacher paused and asked a series of questions to the children to assess their early understandings. After the children responded, Sotiris continued reading the story. Immediately after the story, a video of the same legend was shown to the children. During the video several children remarked that they had seen this particular video before, in a different classroom with another teacher.

Sotiris then announced that the children would be making their own magic flutes right there in the classroom. Children reacted very excitedly, yelling and waving their hands. Children were divided into 4 groups of 4 and each group had a pair of scissors on their table. Sotiris provided one straw for every child and asked them to cut them on the dotted line using the scissors. Children had to compare the length of each of the straws that they had cut within the team and announce their results to Sotiris. Children were then asked to cut a longer straw and compare all over again. This was repeated until each child had cut 7 straws. Sotiris then asked the children to sort the 7 straws from shorter to longer.

After comparing the straws children were asked to build an "inverse ladder" which Sotiris would assist them in gluing them all together. A strip of scotch tape was provided by Sotiris for each of the children to start aligning the straws. Children were facing difficulties in this particular task and the teacher asked them to collaborate and help each other in order to succeed. The children that finished making the flute were asked to think about how it is possible for the straws to produce music. Children with their finished flutes started blowing into the flutes and examined their instruments to try and answer Sotiris' question. After all the children completed making the magic flute, Sotiris initiated a classroom discussion.

> *Sotiris: Now that we're done playing with our flutes, I want you to explain to me something. How is it possible to go from just having drinking straws to being able to do this? [plays the flute] How can placing straws one next to the other produce sound?*
>
> *J: Because we blow.*
>
> *Sotiris: Where?*
>
> *J: Into the straw.*
>
> *Sotiris: and where did we find the air to blow?*
>
> *J: In our mouths.*
>
> *Sotiris: Do you mean that our mouth has the air?*
>
> *D: Yes.*

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Sotiris: Oh I get it now. So if I get a straw and hold it close to somewhere that air is blowing I will get this sound?

All: Yes.

Sotiris: What if I put it in front of a small fan? What you think would happen then?

All: Yes, yes.

Sotiris: so now that I don't have such a fan, what do I do?

All: You blow with your mouth.

S: because they have colours. That is why they make sounds.

Sotiris: Do you think so?

S: Yes.

Sotiris: So if I get this black tape and wrap it around the straw it will stop making this sound?

S: Yes.

Sotiris: Do you want to try it?

S (and several other children): Yes [there are a few children nodding that it will stop making sounds].

Sotiris: I don't think colour has anything to do with it but I am not really sure so we'll see it now. It might be about the colour you never know. Should I cut it a bit? I don't want to spend the rest of the tape.

Some: OK.

[Sotiris blows and children hear a slightly louder sound. Those that thought it would start to cheer].

Sotiris: So we see that the black straw can produce sounds. Because I made it thicker it might even produce louder sounds.

[Sotiris takes a regular straw with the same length and shows it to the children]

Sotiris: M are they the same?

M: Yes they are equal.

[Sotiris starts to blow into the two straws].

Sotiris: The two sounds are?

All: The same.

Sotiris: What does that help us understand? It means that if I have two straws of equal length then?

D, A, M: the same sound.

Sotiris: Same length means same sound. Now what if I get a shorter straw?

??: different.

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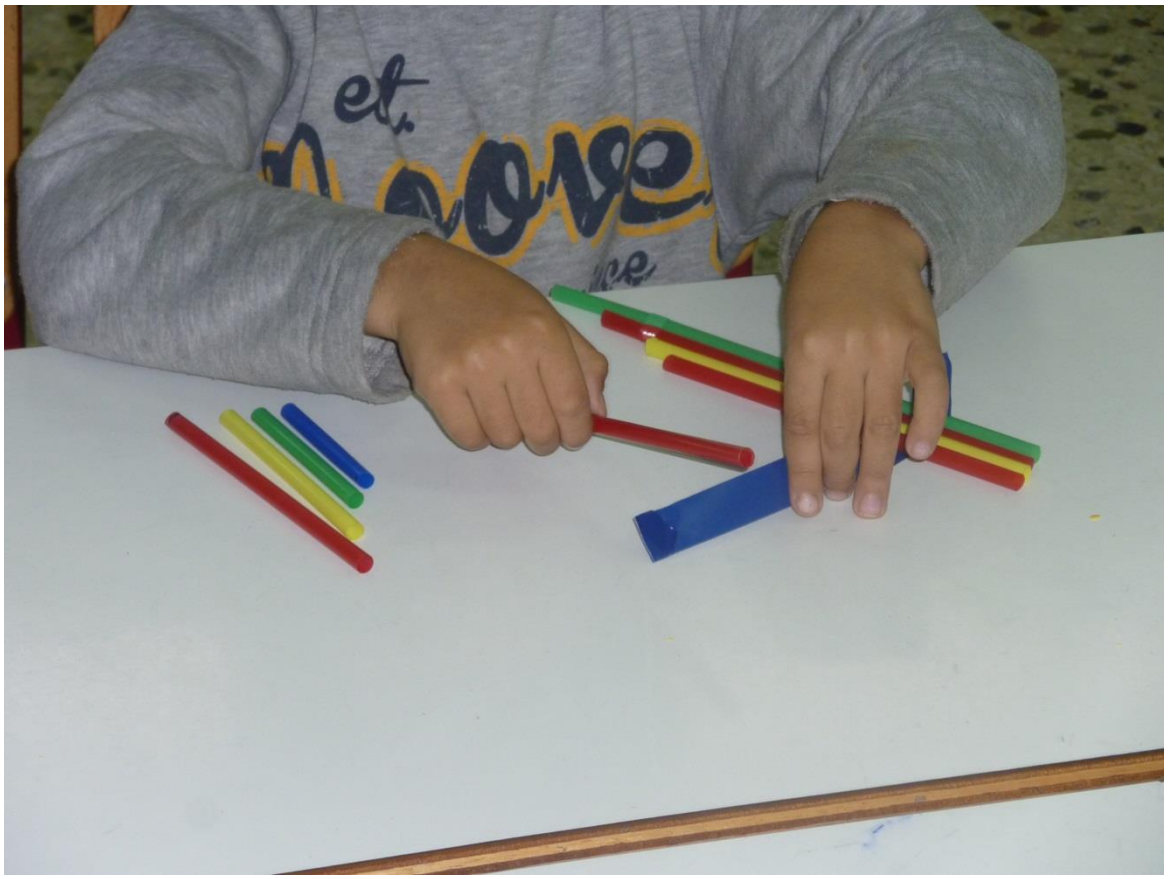
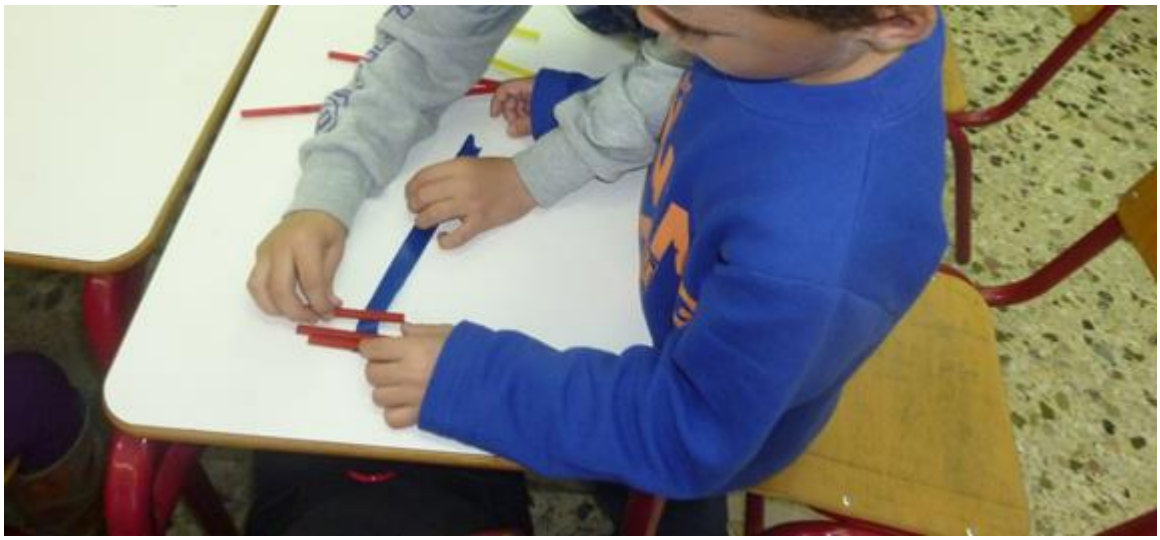
Sotiris: Let's hear [starts blowing into the straws].

??: It's like the piano, left right.

Sotiris: It's like they are the big and the small.

The lesson concluded with Sotiris handing out the work sheets he mentioned previously. "What if" is constantly mentioned in Sotiris' instructions to children about drawing the worksheets.





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Opportunities for Creativity

There was clear evidence of collaboration between the teacher and children and the children themselves, where those who had built their magic flute shared their expertise with those who had problems making the flute to work. Sotiris 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. The introduction to the activity using storytelling demonstrated a creative approach to planning the activity, recognising that the children would be motivated and engaged in an activity which was connected to a story that they enjoyed and stimulated their curiosity. The children themselves showed an eagerness to participate as they were eager to play with the flute and retained that level of engagement all the way through the conclusion of the lesson actively participating in the final portion of the lesson that involved comparing, hypothesising and predicting whether colour, thickness and length were had any influence on the sound coming out of the flute.

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?

Sotiris uses a combination of whole class, small group work. Teacher questioning is used to scaffold the children's thinking and help them make connections. He values collaboration and dialogue so sets tasks that involve the children talking and working together. In Sotiris' class, the pedagogical approach for the three observed episodes was dominantly teacher-led, with all the activities planned by the teacher beforehand. Open play and exploration were common in this classroom although rarely initiated by the teacher. Time for children to play and freely explore the materials was provided by Sotiris during the 3 episodes, mostly during the group activities as he went around the groups asking questions and directing the children. Even though activities were teacher-led, there were few opportunities for children to choose direction of learning. Cross-curricular opportunities and science were capitalised on, so that children felt that science was also part of play activities, rather than repetitive mechanical activities. Teaching science from stories was a very common teaching approach that highlights the importance of engaging children affectively and emotionally in order to make learning relevant by engaging children and enabling them to see science content in context.

What role if any does creativity play in these?

Sotiris demonstrated teacher creativity in the imaginative lessons and materials he used, utilising a range of approaches, including stories and games. In terms of teaching for creativity, Sotiris provided both thought-provoking resources and adult support. The stimuli and support provided by Sotiris led children to make connections between science and literature (Little Prince) and science and history (Cartoons, Planets). The role of narrative as a playful imaginative context in which young children's creativity can be nurtured is an area for potential exploration in mathematics and science is particularly evident here as it connects to children's affective

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engagement and is evidenced as a context in which possibility thinking may be fostered.

Creativity is evident in the approach to formative assessment, eliciting children's ideas at both the start of a topic, as well as during the lesson with brief assessment activities. Sotiris encouraged the development of scientific ideas by getting the children to articulate their thinking orally and by representing their work in different ways (Magic Flute, Cartoons, Planets). These activities showed creativity by encouraging the children to make connections between previous ideas and activities and cross-curricular concepts and ideas. On the other hand, it appears to be a tendency to follow previously planned activities, rather than follow children's lines of inquiry.

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 the lessons observed. The children were very motivated in all of the lessons observed by providing an engaging and meaningful context for the activities carried out in the classroom. Using playful activities was also highly motivating to the children. Sotiris said he liked using stories of history to introduce a topic as he felt very strongly that children respond positively to their use. The emphasis on collaboration and dialogue during the small group activities seemed to motivate the children as well.

Dialogue between children and Sotiris encouraged explanations and reflection on learning. During the teacher children interactions children raised and answered questions and made observations which revealed children's connections between experiences and events. Additionally, as a result of Sotiris going around and focusing on one group of children at a time during the activities, allowed pupils in other groups to get on with the activities themselves. This resulted in him standing back and allowing pupils outside his group to take initiative in their own learning.

How do teachers perceive their role in doing so?

Sotiris said that it is very important to him to build on the children's interests when teaching a topic. The children's interests can lead him anywhere in terms of activities and stimuli he wants to offer the children. Sotiris mentioned that such an example was the Little Prince activity. Sotiris said that he never liked the Little Prince stories and felt that his pupils would feel the same. However, he was mistaken and as soon as he realised the children's excitement over the Little Prince, he planned an entire lesson around the story. According to Sotiris, the Little Prince episode allowed him to present certain pre-mathematical concepts which are usually difficult for children to grasp in such a way that the children found to be easier and more exciting. "*I like to step on children's interests and move further than what the curriculum dictates"* was what Sotiris said. He strongly believes that by building on children's interests allows him to teach more difficult topics as children's attention remains focused and it is easier for him to direct them

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towards learning aims linked to cognitive aspects of learning. Reflection is also mentioned by Sotiris as an important part of his practice, *"I think about what were my shortcomings as a student in certain topics or subjects and I try to bring in my knowledge as a teacher to improve the experience of the students.[…] My goal is for the students to surpass the teacher",* were his words. Cognitive development was not the only aspect of children's learning that concerned Sotiris. *"I want my students to remember what they learned here, especially not just the knowledge they acquired. […] I like to give as much as I can to my students."* This statement was connected to developing important attitudes and dispositions as a foundation for future learning.

His role in planning was focused on providing additional resources to textbooks and distancing himself from the traditional lesson where textbooks are the dominant, and often times only resource. Sotiris stated, "*I don't like to stand over a textbook during the lessons. I get bored. I have observed that lots of times the material presented in the textbooks are irrelevant to children's previous and everyday experiences"* and he continued by *saying "No matter what is written in the textbook, children will lose interest if they keep depending on it. If you don't provide them with additional activities and stimuli, you'll lose them. They live in a time that offers a multitude of audio-visual stimuli, if you don't keep up you become irrelevant".* Providing additional material and imaginative activities are particularly useful when teaching abstract concepts in science and mathematics.

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3.4 Case 4 – 'Sonia'

3.4.1 Context

Where?	Country	Greece			
	Setting name	GR4			
	Location within setting	Pre-school			
Who? (children)	Year group/age of children	5 years old			
	Number of children in class	14			
Who? (adults)	Number of adults	1			
	Role of adults	1 teacher			
	Case teacher role	Lead teacher			
When?		1	2	3	4
	Dates of visits	18/1/13	13/2/13	15/2/13	27/3/13
	Times of visits	12:30 – 14:00	12:30 – 14:00	12:30 – 14:00	12:30 – 14:00

a) School/setting

The 23rd Preschool of Rethymno is a public preschool in the city of Rethymno, Crete. It caters to children between the ages of 4 to 6, divided into two age groups (4-year olds/5-olds). The preschool is situated very close to the city centre in a two floor building with limited outdoor space for the children. Each age group is working with one teacher during the entire school day. There is one computer in each of the classrooms of the school that the teachers can use, mostly for playing music to the children.

b) Teacher (using the interview and survey)

Sonia is in her mid-thirties, and holds a BA in Primary Education and has participated in a 2-year CPD course in early years teaching. Of her over 10 years of teaching experience, she had taught both 4 and 5 year old classes, and the current academic year she is teaching kindergarteners (5 year-olds). Sonia's highest formal education level in which she studied science and mathematics was during her BA degree with both subjects being taught at an introductory level. In the survey, she self-reported her confidence level for her knowledge and understanding of important scientific ideas, processes and scientific inquiry, as well as her competencies to carry out scientific inquiry and her knowledge of mathematics pedagogy to be low (2 in the 4-point scale ranging from very low to very high). That said, she self-reported her confidence level in both her science and mathematics teaching to be high.

Over the last 18 months, she took part in a professional development workshops and informal conversations with other members of staff all of which had a substantial impact and studied relevant literature on science and mathematics to average impact.

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c) Classroom

Within the classroom itself, which is semi-carpeted, there are 3 small low round tables which facilitate group work and 4 small benches where children sit in a circle named "Our gang" whenever Sonia is addressing the children as a group. A range of resources are scattered all around the classroom, mostly in shelves on the walls. The classroom is equipped with a book corner and a computer that Sonia used for playing music to the children. On the walls are many colourful displays of children's work as well as learning resources such as vocabulary, the rules of the classroom and material relevant to the topic currently examined in the classroom (e.g. outcomes of a brainstorming session with children's ideas). There are 11 children in Sonia's class, each having their own drawer which contains the artefacts and drawings children have created but are not displayed on the wall. Usually, the largest part of the work done by the children in a theme is displayed in the classroom until the theme is concluded. In each of the 4 lessons observed, children started working in one group (sitting around the teacher in "Our gang") and then moved on to limited individual activities and mostly group work. Children were generally divided into three groups which were the same throughout the activity and the theme at hand (e.g. Winter). At the end of every lesson children returned to "Our gang" to comment on the day's work and discuss emerging issues.

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Building blocks

Counter

Bench

"Our gang"

Tables

Bench

Computer

Pencils, markers

Mattresses

Toys

Display of children's work

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3.4.2 Episodes

Episode 1: Ice balloons

The activity observed was part of a series of lessons entitled "Winter". A part of the Winter lessons was dedicated to ice and snow. The activity observed was decided after a brainstorming session where children tried to decide what they wanted to find out about ice. The teacher used brainstorming to allow the kids to control their learning path but also to assess previous knowledge and any major misconceptions before any activities were planned. The following day children participated in a second brainstorming activity aimed at bringing out specific activities and material which would allow them to study ice properties. In first activity picked by the children pieces of fruit were placed in a bowl of water which were then placed in the freezer. Pieces of fruit were also left in the classroom to facilitate comparisons (children wanted to see which ones would go bad first). The second activity which children chose was to fill balloons with water and place them in the freezer to see what happens. The teacher then added one balloon that had red dye in the water before being placed in the freezer without children knowing. The activity involving the ice balloons was the one observed and analysed below. Before the beginning of the activity the teacher commented on not knowing exactly what the children are going to do. As Sonia commented, "They will start guiding me now and we will see where it goes".

Pedagogical Framing

A variety of materials were placed on the floor of the classroom in the centre of the spot where all the children gather. The materials included syringes, paintbrushes, watercolours, dyes, bottle of vinegar and magnifying lenses. Children were free to add to the material chosen by the teacher.

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The activity began with the teacher asking the children to think about the materials on the floor and what their purpose is. K replied that they are going to be doing experiments with colours. The teacher, after seeing that the children were more interested in the materials themselves (used for the first time in the classroom based on the pre-interview with teacher) than the topic of ice, asked children if they wanted to just play with the materials instead of looking at the ice cubes they made yesterday. Children brought up the two activities they had done during the previous day (fruit and balloons) and they decided to vote the most popular to carry out during the lesson. After counting the votes, it was decided that the children were going to play with the ice balloons. The teacher then asked if they remembered what they had done the day before and if they remembered how they made ice.

A brief discussion began with the teacher asking children where they think it is suitable to work and E replying that they should sit at the tables and work in their groups. After allowing a couple of minutes for the children to settle in the tables and start playing with the ice, the teacher started going around and chatting with the children. For example, D observed that there was water on his table, Sonia asked him what he did to cause this and allowed D to explain that he had rubbed the ice cube. Sonia allowed children space and time to follow their questions and interests (e.g. P: Could we paint them after we are done? T: Let's try and see what happens). This was consistent throughout the lesson and her comments before the lesson began. The teacher would only address the whole class during this activity to alert the children of a classmate's idea.

Pedagogical Interactions

Early (5 minutes in) during the activity one team made various observations regarding ice which allowed the teacher to ask whether a tool could help them observe the inside of the ice better and bring this to the other children's attention. The interaction between K and Stella is provided below.

> *K: Miss, I see something here. It's like the prickles of a hedgehog.*
>
> *T (to all): What is the tool that can assist K in seeing the inside of the ice?*
>
> *??: The magnifying lens.*
>
> *T: Do you want to go and get the tool that you think will assist you in seeing inside the ice?*
>
> *[more kids comment on the hedgehog inside the ice. D throws the ice on the table to see if it breaks "D: Let's see if we can break it"].*
>
> *T: What does the inside of the ice reminds you of?*
>
> *E: It's like shivers.*
>
> *T: Oh how interesting. What a nice word to say.*
>
> *[Children take turns in looking through the magnifying lens commenting on what they*

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see].

E: Guys can we look at the juice on the table now? [proceeds to look at the water through the magnifying lens]

T: Try and put your finger through the hole there.

D: It stings.

K: When it breaks it stings.

The mention of the magnifying lens led to all three teams picking up the lenses to see for themselves.

When the ice started to melt and more water started to gather in the bowl the teacher asked the children if a different material could help them in seeing the ice better. E said that colours could do that and proceeded to pick colours to paint the ice. The teacher allowed children to use whatever they wished (vinegar, newspaper, tin foil), constantly encouraging them to try out their ideas (*"Just get what you want and play with the ice", "Of course you can do what you like").*

After enough liquid was gathered in the bowls the teacher asked children where the water in their bowls came from. When E responded that it was the added colours that made the water, the teacher asked if she was certain. She received a negative response from E and moved along to the next team.

After the short break for children to clean up, all the children sat together in what is called "The Group". A child suggested that Frosty (a doll which was commonly used during the "Winter lessons") should come out to hear what they had done. The teacher said that each team will get the chance to present their findings.

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The focus of this part of the lesson was for the children to present and communicate their observations and explanations *("Each team will tell everybody what they did, how they worked, what they saw, what made an impression, what made them go wow!!!")* and for the teacher to be able to discuss any major issues that came up during the activity ("*Where did we get the water?"*).

The question was brought up by the teacher. The children's first response was that the colours were responsible for the water in the bowls. After a second teacher question 2 children disagreed (E, N). E said that after the ice melted the colours were added to make the water. Similar to before any disagreement was settled by children voting. 6 children believe it is from the ice and 9 believe it just from the colours. The teacher asked children if they were sure of their answer and then used Frosty to express uncertainty and confusion regarding this particular issue. After the comment made by Frosty M said that the ice is melting because of heat. Sonia then summed up the disagreement adding the comment made by M and asked children if there is heat in the classroom. When the children said yes Sonia asked them what they thought would happen if it was cold in the classroom. 3 children responded that the ice wouldn't melt. D suggested that if the ice was outside it wouldn't melt because it would not get hot. D said that the cold outside would make the ice break. When asked by the teacher why he thought that was going to happen, D responded that they should go outside and experiment to find out. Since that was not possible on the same day Sonia asked the children if they wanted to try it out on the following day.

The ice balloons activity was concluded with the children using a worksheet prepared by Sonia to assess the work done by children. The picture below shows an example of one of the children's work. The page on the left has "*What would happen if I were an ice cube for a day"* typed at the upper left corner and blank space for the children to paint. The middle page has

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"*What would happen if we place fruit and water in the freezer"* and finally the one on the right *"What did eventually happen".* It is evident that the worksheet uses questions which, although not done on purpose by Sonia, was in agreement with the central question linked to possibility thinking (what if?). The example below is a typical example of a completed worksheet for the two pages on the right. Most children managed to depict what would happen if fruit and water are placed in the freezer sufficiently, drawing the fruit inside the block of ice. The same can be said for the third page that asked what did eventually happen. The drawings show the fruit scattered, with water instead of ice. The drawings done by the children in the first page (What would happen if I were an ice cube for a day?) depicted a variety of different points of focus. 4 children drew the ice cube melting and turning into water with two offering the sun as the one responsible, 4 children chose to draw a static picture of the ice without any indication of what would happen, 2 children drew the ice inside the freezer and commented on the fact that it would not melt there and finally, one child drew an ice cube inside a house and commented on the house being cold due to the ice cube. The drawings show that children seem to grasp the fact that the ice melts when not in the freezer, but it is unclear, apart from the children that offered a reason to why the ice melts, if they understand that heat leads to the ice melting.

Opportunities for Creativity

The activity observed (Ice Balloons) is a common activity in Greek kindergartens which teachers use to get children familiarised with ice and try to present basic ice properties and melting. Sonia during the previous day brought ice into the classroom and a limited number of other material (salt, water colours) and let the children play freely with all of them.

A number of factors that have been identified as important to nurturing creativity can be found in the lesson observed. Sonia facilitated learning by valuing the role of open play as she allowed the children to carry out a learning activity in a playful environment. Children's motivation and active interest towards the task was facilitated, as the teacher made sure that each activity was

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coming from their interests or questions. Curiosity, one of the creative dispositions, was promoted during the lesson and is evident by the children's observations and questions, as well as their active engagement with the activity. Children seemed comfortable to collaborating throughout the lesson in handling the tools and materials provided, as well as in distributing roles among team members for more complex tasks. Explaining and communicating observations was also a point of focus in the pedagogy of Sonia as well as attention to the value and potential of physical materials in the classroom. Sonia's sensitivity to stand back, provide limited guidance to what the children were doing was evident throughout the lesson as she allowed the children to work at their own pace rarely attempted to guide the children to both materials and explanations to the phenomena observed. Children's learning is formatively assessed by the teacher both throughout the lesson using her brief interactions with each child as well as during the final portion of the lesson when the children gathered in one group to revisit what they had experienced and discuss some important issues that came up during the lesson which are linked to the learning aims and objectives set by the teacher.

According to the brief informal conversations with Sonia, she believes that all activities in the classroom should be led by children's interests by taking advantage of situations that arise during the lesson. It is important for Sonia to promote the learning objectives set but always incorporated in an environment that provides space for the interests of children.

Episode 2: Building Mr Zip

The second episode presented here was part of a theme titled "Feelings". Children had spent time discussing about feelings (names, facial expressions of feelings) in previous lessons, so Sonia decided that this would be a great opportunity to let the children experiment with balloons in the context of anger. The content of this episode focuses on the process of getting to experiment with balloons starting from a short story related to a Mr Zip, a fictional character who serves as the manifestation of anger for the children. The activity provided children with a chance to choose their material to "build Mr Zip" providing sufficient justification for their choice.

Pedagogical Framing

At the start of the lesson Sonia referenced an incident from earlier in the day when two children had an argument. She asked the two children to tell her how they felt, to which both responded they felt angry. This prompted Sonia to start telling the children the story of Mr Zip, a man who is always angry. The angrier he gets, the more his head gets bigger. The story of Mr Zip served as an opportunity to get the children to pick the best representation of Mr Zip from the material available in the classroom. Sonia asked the children to choose one item in the classroom to build Mr Zip and provide an explanation for their choice. Sonia specifically told children to use their imagination when picking their item for Mr Zip. A variety of material was suggested by the children to build Mr Zip, with most of the suggested items ending up being rejected by the children themselves when the teacher asked them why they thought this particular item could

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represent Mr Zip.

Pedagogical Interactions

After all of the material found in the classroom was deemed unfit, the teacher introduced a big bag of additional items for children to pick. After all the children chose their item, Sonia started to ask each child why they thought their item was suitable to build Mr Zip. Children provided their explanation and the rest of the class voted on whether they believed the explanation was sufficient. After the first two attempts, two children brought forward a small ball and a balloon to represent Mr Zip. The teacher used this as an excellent opportunity to let the children present, explain and support their opinion in front of the entire class.

L: It's the balloon.

T: Please tell me why do you think it's the balloon.

L: (inflating) because it is getting bigger.

T: How is it getting bigger?

L: I inflate it. I blow into it, with air.

T: (to the rest of the class) Do you think this resembles Mr Zip?

Children to L: Make it bigger. Make it bigger.

N: It is the ball. The ball is the one.

T: I am hearing different ideas here. Let N and L come up here in the middle to try and persuade us about what should be used for Mr Zip. After they have explained we will get to vote and decide which one is the best to use. So let's begin with L.

L starts to inflate the balloon while children yell for her to continue and make it bigger. Then she carefully lets the air out of the balloon to deflate it. She does not say anything during her presentation.

T: Who wants to tell what is L doing?

P: She is inflating the balloon.

T: Does this remind you of Mr Zip?

Children yell (indistinct).

T: Why? Provide an explanation. Why yes and why no? Those who said no should go first. J why do you think it is not the balloon?

J: It does not have a body, a mouth or eyes.

D: If we draw on it then it will have.

T: Ahh, should we draw on it then?

M: No it will burst if we try. We should vote. Anyone who believes that Mr Zip is the

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balloon should sit on the bench and anyone who thinks that N has it correct should stand up.

T: Let's see how many are sitting down. Let's count. […] So the result is 8 for the balloon and 3 for the ball. Now they will get the chance to prove to us what they believe. L is inflating and deflating the balloon. N why do you think the ball is Mr Zip?

N: It has a big head. It starts of smaller and then it gets bigger?

T: How does the ball get bigger?

N: This bigger and this is smaller (pointing to the balloon) and then the ball gets bigger.

T: How?

N: Like this (hitting the ball with his hand)

T: Is it getting bigger? Do it.

N keeps hitting the ball harder.

M: You are making it smaller this way, not bigger.

T: Has it gotten bigger?

N: Yes… (trails off, no explanation).

T: So, what do you think which one managed to make his/her Mr Zip bigger?

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Children yell L's name.

T: Does anyone think it is N's? (No response) How did L manage to make the balloon bigger? Should I go and get more balloons to test L's idea and see for ourselves if Mr Zip can be made using the balloons.

Children yell excited that they will get to play with the balloons.

Opportunities for Creativity

The main focus of the lesson was for children to start playing and experimenting with balloons. The approach followed by Sonia was truly interdisciplinary as she chose to place the balloon activity within the overall theme of feelings, particularly anger with inflating a balloon. This explicit connection between science and children everyday life was not aimed solely on achieving cognitive goals alone, but largely relied on the social and affective dimensions of learning as they are presented in detail in the Creative Little Scientists' Conceptual Framework (D2.2). Sonia facilitated children's learning by motivating children when she suggested that each child had to choose an item to represent Mr Zip. Apart from observation this particular task allowed children to use the items in order to check if the item they chose was appropriate for the task at hand. Following the individual work carried out by the children, they were asked to present and explain their idea in front of the classroom clearly showing the value placed by Sonia on the social dimension of learning by encouraging children to communicate their explanations in front of the entire class. An additional element evidencing the focus on social factors of learning is the voting process, a common activity in Sonia's classroom, which allows children to actively participate in activities they did not initiate themselves and provides space and time to express alternative ideas.

Similar to the other lessons observed and Sonia's interview the role of play is particularly valued here. All activities were carried out in a playful environment and presented as a game or a mission to children. Questioning was used to elicit ideas and encourage reasoning, probing the ideas and comments made by the children further towards the learning objectives set by Sonia. Children also seemed highly motivated to carry out the activity set by Sonia, while her limited involvement in the decision making process strengthened children's developing agency as learners.

Episode 3: Game of swallows

In the days prior to the lesson observed Sonia had started to work topics related to Spring with the children. At the beginning of the lesson Sonia reminded children of a story they heard the previous day involving swallows and commented on the good work done by children. What followed was Sonia showing children cards with numbers from 1 to 10 for children to recognise. Children easily recognised all the numbers and seemed to enjoy the task. Sonia then showed children cards with the equals and less than/greater than symbols and asked children whether they remembered their use *("Do you remember what does this help us understand?").* Children yelled the word equal, but only P added that "*it shows that they are the same*". Children seemed

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to also understand the greater than/less than symbol using a story about more ghosts wanting to go in the *"open side"* of the symbol.

Pedagogical Framing

The materials for the activity that would follow were presented by Sonia, while A proposed to play with ice instead. More children supported A's suggestion evidencing than children had an continuing interest with ice more than two months after their ice balloons activity (Episode 1). Sonia brought the children's attention to the materials at hand asking children whether there was any water they could turn into ice. Children answered there was no water they could turn into ice and seemed to understand that turning water into ice requires time due to the fact that they did not persist in suggesting using ice in this lesson.

Sonia informed children that they should think about what they wanted to do with the materials in front of them. The materials provided by Sonia were 5 plastic yogurt containers, 5 pudding containers, a large wooden dice and a regular dice and , cutouts of swallows, pieces of paper with numbers 1 to 10 and symbols, strips of shredded paper, an empty paper tissue box and a large box of white hard candy.

She said "*Your mission today is to find out what you can do with all these materials. How can you play with these?"* Sonia allowed time for all the children to think about what they wanted to do

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(*"We need to think now. We need your ideas").* Children started to ask questions about what they could/should do and what they couldn't/shouldn't and Sonia responded that it is completely up to them and that they could create anything they wished.

Pedagogical Interactions

M was the first to try out and present her idea. She started to build a nest for the swallows using the material provided. It was evident that M would use the given material to construct the nest and not try to make a game for the children to play. This was also apparent in the children's ideas that followed and could be attributed to the limited instructions provided by Sonia, as well as the fact that the Greek word for both play and game is the same. It is possible that children understood that they had to construct something to play with and not establish the rules of a game. Sonia throughout the length of the ideas presented by children did not make any attempt to correct or divert the children's focus to her intended type of activity, but rather facilitated their ideas while trying to bring out mathematical concepts and processes linked to the presented ideas by consistently asking the children questions (mostly to count or recognise which of two numbers is bigger/smaller).

An example of the role of the teacher in this particular activity is evident during the presentation of the first idea by M. When M managed to build the nest, she placed a number of hard candies in the centre as swallow eggs.

> *T: A problem presents itself now. How did you know how many eggs you had to place inside the nest? Why not put more or less in there?*
>
> *M: That's how many eggs are made by the swallow.*
>
> *T: How many is that?*
>
> *M: Should I count? (She starts counting without removing the "eggs" from the nest) Seven. They are seven.*
>
> *J: No it is not seven.*
>
> *T: M, are you sure?*
>
> *M: Yes.*
>
> *J: No she is not. She did not count the rest at the bottom.*
>
> *T: So J please come here to verify the result since you do not agree with M.*
>
> *J starts to remove the eggs one by one from the nest to count them.*
>
> *N: Do not take them out.*
>
> *J: They are ten.*
>
> *Children want to move forward with their own ideas but Sonia stops them.*
>
> *T: Since I am being Ms Grumpy today, I want to ask difficult questions. Which one of the*

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two managed to find the best way to count the eggs correctly?

All children yell for J.

T: What was different about what J did?

N: He took them out.

T: What was different about M's attempt?

E: She counted one by one inside the nest.

Although Sonia didn't instruct children to contribute their ideas to the one presented, she did not interfere when the children started to offer ideas but rather brought the ideas she thought needed to be explored further in front of the entire classroom *("Oh N, what a very good idea. Please share it with the rest of the classroom").* This allowed the children to feel actively involved in the activity with limited occurrences of children being impatient about trying out their idea.

When P got up to share her idea she started building a nest similar to the one before. When she was ready to start placing eggs inside the nest Sonia asked how she would decide how many she would put in there.

When P replied she did not know, Sonia asked again if there was something that could assist her in making that decision. After a small pause P pulled a piece of paper with the number ten ("I got this"). Sonia then asked of is a piece of paper helpful to which P replied that it helps her to put ten eggs inside the nest. Again Sonia brought this up to the entire group. "*Look everybody, P*

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had a very different idea. P, could you share it with us please?" P did not respond to the final question of Sonia but started adding eggs to the nest. Sonia tried to get her to describe her process but she declined. Sonia after remarking the different and new idea of P, turned to M for an answer *("M, what did P do? Did you observe?").* M replied that the number helped her to count the eggs she would put in the nest.

At this point several of the children told Sonia that they were tired, bored and that it was time for them to eat. Sonia replied that if they have no interest in continuing they should stop, but asked the children if they would like to make one final attempt. Only after the children agreed, Sonia allowed E to start playing with the material.

Opportunities for Creativity

The initial task was set up for children to produce original and imaginative outcomes in a problem solving activity that required them to construct a game with a variety of materials provided. Similar to the other activities identified, where one appropriate snapshot could not be isolated and explored for analysis, within this activity a number of shorter instances of children's creativity, facilitated through the teacher's pedagogy, can be identified. In this example, Sonia provided the children with a problem solving exercise that had a wide range of possible solutions. The role of play in this particular activity is seemed to be valued by Sonia, something which is common across all the observed lessons and interviews. This is particularly evident at the start of the task where Sonia says, "How can we make a game? How can we play?" Even though the task is clearly linked to problem solving, Sonia deliberately sets the entire problematic situation within a game. It has to be noted that Sonia, even though she observed that children were tackling the problem from a totally different perspective she had planned from the beginning of the lesson, she did not try to guide children to her planned direction but rather chose to welcome the wide range of responses that had been generated by the children and encouraged children to come up with their own strategies in order to solve the problem and finally to present their findings. The emphasis of the lesson itself was not so much on the children's answer per se, but on developing early mathematical concepts and problem solving strategies.

As has been discussed previously, Sonia plans activities that value the social dimension of learning in science and mathematics while specifically positioning collaboration as this is one of the attitudes that she feels the children need to develop. This can also be observed in this activity. There are examples during the lesson where children ask for their classmates' assistance and take their contributions under serious consideration. Sonia, by welcoming every response and solution offered by the children during the task, provided children with an environment in which they are allowed to make mistakes and recognise that there is not always a 'right answer'. Even though the activity does not place children to work together explicitly, the safe environment created by Sonia for the children to operate, facilitated collaboration and dialogue.

Creative approaches to teaching are reflected in particular in building an appealing and

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meaningful setting for the activities described in this episode that nurture connections between experiences and allow opportunities for physical exploration, and, making links to children's prior learning and everyday life. Questioning was the main tool employed by the teacher consistently throughout the lesson to elicit children's ideas and encourage reasoning. This is particularly evident in the transcript extract presented above where Sonia only uses questions to solve the disagreement between the two children and promote understanding of a basic mathematical skill, such as counting.

The use of problems that have more than one answer and valuing all different forms used by children to present their own idea was an explicit attempt on Sonia's part to attempt to enhance children's attitudes towards mathematics, particularly towards problem-based learning. The focus on the social dimension of learning (mostly through collaboration) together with the playful and exploratory 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.

3.4.3 Summary and conclusions

RQ2: *Probing practice*

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

In the four lessons observed a number of interesting findings and themes have emerged in terms of teaching and learning approaches used by Sonia in science and mathematics. All the tasks observed were placed in a wider context, such as ice balloons in the theme of Winter or the swallow game in the Spring theme, making it very easy for children to relate science and mathematics to everyday life and strengthen the social relevance of science and mathematics from such an early age. An overarching approach used by Sonia in every lesson observed was her constant encouragement for children to try out their own ideas in investigations. Sonia facilitated children to carry out all the tasks using their own strategy allowing them both ample time and creating a classroom environment which welcomes different ideas. Children's ideas were always presented in front of the entire classroom either at the end of the lesson (in "the group") or during the task when Sonia prompted the children to hear what one of their classmates had thought of. Sonia took advantage of these new ideas in order to foster classroom discussion and ultimately evaluate alternative ideas. Fostering collaboration between children was another approach observed in the lessons, as Sonia used group work in the majority of activities and supported children whenever she thought they needed encouragement to collaborate. The value of collaboration was particularly evident in children asking their classmates for assistance if they felt it was necessary even in individual work.

What role if any does creativity play in these?

The activities observed provided evidence to support that Sonia is teaching creatively. The resources she provided contributed in motivating children, even though she repeatedly

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expressed her disappointment in the school's resources. Sonia's flexibility in the direction of the activities observed, as evidenced by a number of her statements in the interview and informal discussions before or after the lessons (*e.g. we'll start off here and see where they will take me),* is another example of her teaching creatively. One of the stronger features of her teaching was the ease with which she was able to adapt the lesson to the developing interests of the children as the lesson progressed. As stated in her interview, during her preparation for the lesson, she uses the internet to search for examples of relevant activities so she would be ready facilitate the emerging children interests. In terms of teaching for creativity, Sonia encouraged the children to make connections, to manage their own investigations, to reflect and provide explanations through inquiry. Time and available resources were provided for the children to explore and there was a supporting atmosphere where ideas were valued.

RQ3: *Probing practice*

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

Sonia's teaching in both mathematics and science was characterised by approaches that linked to everyday life which allowed children to make their learning relevant to their settings and interests. Eliciting children's motivation and providing a playful supportive environment are the two most central aspects of Sonia's practice, allowing the children to simulate play and learning. This approach to play and exploration builds on the interests of children and provides space for the children to follow their path to forming understandings in science and mathematics. The teacher's use of storytelling was common in the lessons observed with children showing enthusiasm while being eager to participate and contribute to the activities that would follow. Collaboration and dialogue were also evidently valued by children with examples of children inviting others to assist or contribute, as well as the use of the voting system for any decisions made by the entire class.

How do teachers perceive their role in doing so?

Sonia described her role in fostering children's learning by dividing the lessons in those that are aimed at teaching concepts (mostly in Mathematics) and those that do not aim specifically at teaching a concept, such as the ones observed and presented here. The first set of lessons were described as "*lacking spontaneity and freedom"* by Sonia during her interview. Sonia described this type of lesson as more closed-ended and restrictive to children. On the other hand, the lessons observed fall in the second category and Sonia spoke in length about the method she uses during these lessons. Sonia described the introduction to most of the lessons remarking that "it really helps if you just present them [material, symbols] at the beginning and then just let them play with them. This allows children to start forming understandings and realise how or why something happens". She continued by highlighting that children have to be properly motivated by activities that are linked to their interests. If that is the case, Sonia believes that children use play to gather "snapshots" of knowledge which can be transformed into knowledge by everyday contact with stimuli offered in their everyday life. The initial ideas "emerge

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effortlessly and spontaneously without being routed in understanding, but after repetition and revision they will get there [to understand]". The duality of her role is also evident in assessment, where Sonia assigns more closed-ended worksheets to evaluate the understanding of concepts, in contrast to open-ended worksheets aimed at portraying what children felt was important, letting them free to express their "knowledge" as they feel fit. In terms of assessment, Sonia stated that peer assessment is constantly going on informally among children during group work when they are collaborating to reach a common goal. Her goal is for the children to reach a point where they will not always turn to her to let her know who did what, but settle any similar situation within the group.

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3.5 Case 5 – 'Stavros'

3.5.1 Context

Where?	Country	Greece			
	Setting name	GR2			
	Location within setting	Primary school			
Who? (children)	Year group/age of children	6-12 years old			
	Number of children in class	8			
Who? (adults)	Number of adults	1			
	Role of adults	1 teacher			
	Case teacher role				
When?		1	2	3	4
	Dates of visits	17/1/13	13/2/13	14/2/13	28/3/13
	Times of visits	08:50 – 10:30	08:50 – 10:30	10:40 – 11:50	08:50 – 10:30

a) School/setting

The school is situated in a village approximately 45 kilometres from the city of Rethymno in Crete. It is a four-teacher school that a little less than 50 children attend and gathers students from the 6 nearby villages of the Municipality of Amari. The six grades of primary are grouped in 4 classrooms, one for each of the first and second grade and two others that group, one the third and fourth grade and the other fifth and sixth grade. The school is separated into two separate buildings, on for the first two grades and the newly built kitchen, and a bigger and older one for the final 4 grades and the teacher/principal's office. The school, fuelled by the principal (and fifth and sixth grade teacher), has made several changes to its operation, resources, setting and most importantly its curriculum. All changes started with the layout of the classrooms. Cupboards were removed and large sofas were brought in the classrooms. The principal commented that changes to the school were made gradually first inside the classrooms, decorating and making space but considered turning the school's vision to nature as the biggest change making the biggest difference.

b) Teacher (using the interview and survey)

Stavros is in his late-twenties, and holds a BA in Primary Education from the University of Thessaloniki. He has 5 years of teaching experience and from 2009 until 2012 he has taught in the two final classes of primary school during the last 4 years (children older than 8 years old). This is his first time he is teaching the first grade. It is also his first year in this school as he was recently transferred. Stavros studied science in Post-Secondary Non-Tertiary Education (General) and mathematics at secondary education, since during her BA degree neither topic was emphasised with only an overview offered. Based on the responses he gave to the survey, Stavros cannot be considered as confident in his general pedagogical knowledge, in assessing

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children in both mathematics and science, in his knowledge of the didactics of mathematics and science and his mathematics and science teaching. Stavros self-reported that he is only confident in his ICT skills.

c) Classroom

There are 8 pupils in the class, with 6 girls and 2 boys. In terms of the classroom setting, the classroom is housed in a spacious open-planned space, with a large area being occupied by desks in a pi-shared formation facing the blackboard and other smaller areas, known as "corners". These areas are used by the children looking for resources to assist them in their learning during the lessons. The classroom is well resourced with rich maths artefacts, puzzles and games, a reading corner and an interactive whiteboard at the centre of the large wall opposite the entrance.

Classes are regularly taught outdoors with a growing number of activities can be found in the yard of the school. A garden which is looked after by the students and a recently constructed chicken coop offer many opportunities for children's explorations away from the classroom. Digital technologies are used very often by the teachers in the form of videos and interactive teaching material on the whiteboard, but it also part of the planned activities organised by the school with students producing material for a web television station run by the students.

Same as all the other schools, this classroom follows the 2003 curriculum for primary education. What is interesting about this particular school is that its remote, rural location allows the teaching staff a rather unique level of autonomy to operating the school. Always within the provisions of the curriculum, the teachers can modify their teaching schedule according to the children's needs as they are expressed by their interest in the various activities. What was observed during the visits to this school was that the teachers there were not afraid to carry out activities where they were not sure they would work in their classroom. Compared to the other schools observed during the fieldwork, this particular one allowed teachers they opportunity to take risks and challenge themselves regularly.

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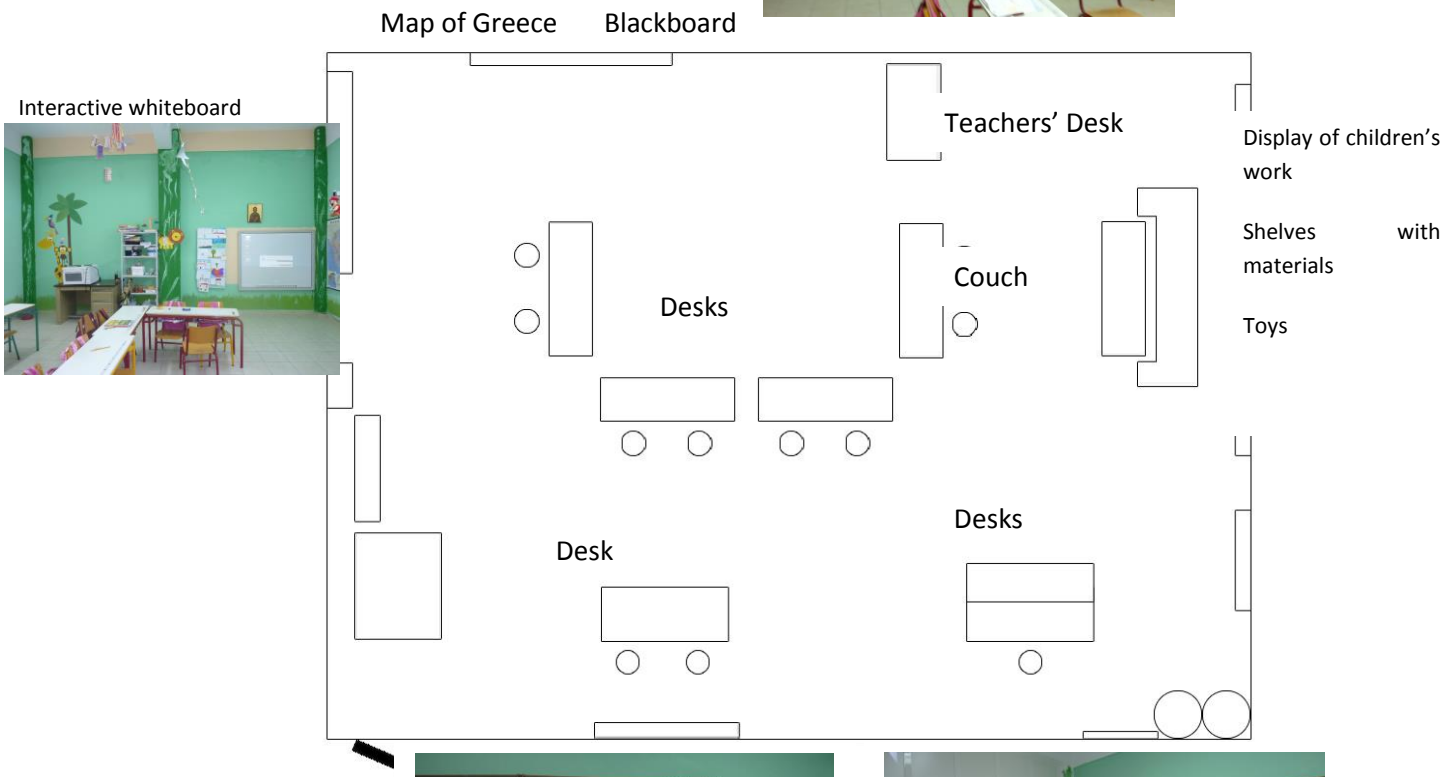

3.5.2 Episodes

Episode 1: Bee-bot

The first episode analysed here presents an activity using the Bee-bot robot a floor robot commonly used to teach orientation in pre-primary and early primary children. The children had played with the Bee-bot before and seemed excited as soon as Stavros told them that they were going to use the Bee-bot (called Voula the little bee) in this lesson.

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They began the lesson by revising what they had heard about orientation in the previous lessons using a nearby church as their point of reference since all churches are oriented a certain way. Then, Stavros announced that they were going to play a treasure hunt game using the bee-bot, similar to a game they had played in a previous lesson. Stavros went over the rules of the game they were going to play. There would be two teams (dolphins and lions) from 4 children each competing for a treasure chest which when opened would reveal a puzzle that they children of the winning team had to solve.

Pedagogical Framing

The aim of the bee-bot activity according to the interview given by Stavros was for children to be able to solve simple problems using a step by step approach and acquire basic knowledge about orientation (4 cardinal points). An additional aim was for children to understand how the bee-bot rotates and the change in perspective necessary to direct it when it rotates. In order to tackle any problems during this Stavros had made a cut-out version of the bee-bot that children could use to model its movements and check for mistakes during the input stage. It is his intention to move the bee-bot activity further to teach more topics which are most related to mathematics (e.g. multiplying small numbers in order to move the bee-bot).

Pedagogical Interactions

An important part of the lesson was right at the start when Stavros went over the process that children had to follow in order to win the challenge and collect the prize. These were presented as general rules, with the specific game's instructions were presented immediately after. The general rules were:

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- Read the instructions carefully because they will lead us to the prize.
- Have patience with the go button – the teacher has to be informed before the beginning of an attempt.
- Collaboration always helps in reaching the goal.

Each team then chose their instructions at random in a small piece of paper. An addition to the game compared to the last time children played it was that this time they had to record their attempts and when successful they had to present the correct solution in writing. After receiving their instructions both teams were left to discuss their strategy. Stavros again reminded them of the rules and children started to discuss how they were going to win the treasure. After 5 minutes the first team was ready to begin their first attempt for the treasure.

The first attempt was unsuccessful and Stavros commented that he could see that the bee-bot was disoriented. He advised the children to go to their table and discuss what they thought went wrong and try to come up with an alternative solution. He asked the children to also think about what went wrong. “Was it poor collaboration? Was it not paying attention to the instructions? Please think and come back.” Was what Stavros said.

The first team (dolphins) went back to their table and started discussing their mistake.

A: If you did not press the right button then…

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Z: But I was the captain of the team, I had to handle the bee.

A: Yes, but you need to listen to all of us.

E: We need to decide what to do together, we made a mistake and now if they are correct they will win.

A: He is doing everything in a hurry.

E: No he just wants to press the buttons on the bee.

K: It doesn't matter who presses the buttons, it only matters if we win.

Z: Let's start again then.

The children then began to plan the path of the bee-bot but Stavros arrives.

Stavros: Where do you think you got it mixed up?

A: K pushed the button to go right, and then E said that we should press forward but K pushed right again.

Stavros: Did this [the bee cut-out] help you?

All 4 children: Yes it did a little.

Z: But we need to fold it so it won't get wrinkles. In order to use it we have to fold it like

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this.

Stavros: Oh right, now I see. Now what do you have to do to reach the goal?

K: We need to work together.

Stavros: You need to listen to what the others are saying. For example A and K might have to different ideas. You need to discuss both ideas first before making up our minds.

A: But Z does not hear us and he pushes the buttons himself.

Stavros: Z is the captain of team but he needs to listen to everybody. Best way is for all of you to take turns pushing the buttons. Discuss what you should do now.

Stavros leaves to go to the other team and children discuss who will push the buttons the next time. The second team (Lions) managed to get the bee-bot one square away from the target. They then went to their side of the table to discuss what went wrong.

After their second failed attempt the dolphins went back to their and argued about who was to blame for their failure. Stavros then approached them and asked them what was wrong. E complained that they kept yelling instructions and she did the best to follow them but couldn't. A said that this was not the case and K was doing whatever she liked. Stavros told the children that this was a dispute that needed to be settled and said that who is pushing the buttons is not important. After that he asked the team to have specific roles in order to succeed. He gave out the roles and let the children to decide who is doing what.

After one more failed attempt Stavros told the children that he had observed that they kept having issues with distinguishing right and left. He then asked children to think about their writing hands and see which is right and which is left. He reminded them that he is left-handed. The children then lifted their right hands to show Stavros which one was right. He continued on to say that he had observed that instead of saying left and right when moving the bee-bot, children keep saying this way of that way. Stavros then asked the children to move the bee-bot while saying right or left depending on where it goes and see if that helps them.

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Stavros: Right and left do not change for Voula. You have to check where she is looking to figure out if she needs to go right or left. If she is turned backward then what happens? Be careful when that happens.

Stavros then told D to face him and asked D to tell him which is his [Stavros'] right hand. When D answered wrong, Stavros explained that when two people are facing each other their right hands are on the opposite side. He then turned around to show that his right hand was on the same side as D's when both are facing the same direction.

After the instructions provided the next team managed to find the treasure chest and win. One more chance was given for the other team to reach the chest for a tie between the two teams. After one more unsuccessful attempt, which Stavros took the time to explain what went wrong to the losing team, the game was over and Stavros announced the winner. He commented that each team could have reached the treasure with fewer attempts if they said "turn right" or "turn left" instead of just "turn".

Stavros: Without saying left and right it was easier for you to get confused and pushed the wrong button, that is why I think took you this many attempts to reach the treasure.

Opportunities for Creativity

Arguably, this lesson fostered pupils' creative dispositions in a number of ways. Given the hands-on nature of the activity pupils were seen to be excited and motivated to carry out their tasks.

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An important aspect of the activity that contributed to children's enthusiasm is the competition element and the reward offered to the first team that reached the treasure chest. As Stavros commented in his interview "*Children especially enjoy similar activities. Whenever we have competition their excitement and interest is sustained throughout the lesson.*" Stavros uses questioning during his brief discussions after a failed attempt to encourage children to explain what they are doing and to foster dialogue and collaboration. The treasure hunt activity was focused on developing problem solving and reasoning skills, aiming to establish connections between the Bee bot buttons and the actual movement of the robot, design the route to the target and understand the change in perspective and direction as the robot moves on the board.

Creative approaches to teaching are reflected in particular in setting a motivating and meaningful context for the activities described that allow opportunities for physical exploration, and problem solving opportunities. Stavros was actively interest in children's explorations and shared their own excitement during the entire lesson, using questioning as the main method of eliciting ideas and encouraging reasoning.

Episode 2: Plants

The episode presented here was the final activity observed of a two-day lesson on plants. During the two days children got the opportunity to gather plants, observe them, discuss what they found interesting, learned the different parts of each plant as well as the 3 different categories of plants. The two lessons included a number of different teaching approaches and activities, from children going outside of the classroom to take photographs of plants to teacher giving a lecture-style lesson to present the different parts of the plant. The focus of this episode is the activity right at the end of the two lessons with children representing different kinds of plants with their bodies.

Pedagogical Framing

From the beginning it was apparent that the main learning objective of the session was to use this investigation as an opportunity for children to learn particular areas of knowledge about plants, particularly the main parts of plants. Children were learning through the use of inquiry based approaches within a series of planned and scaffolded activities. The lesson took place both indoors and outdoors and included both formal, teacher-led aspects and informal, child-initiated aspects. Even though certain parts of this session involved lecture style teaching on the part of Stavros, the activities that involved child-led exploration, collaboration and valued child agency were dominant. The groupings ranged from whole class, to small group, to individual work with children working individually on the provided worksheets.

Pedagogical Interactions

At the outset of the lesson the children were asked to form two teams (red and yellow) of four, go out to the yard for 5 minutes, gather plants and bring one per child back to the classroom.

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Each child would then present his/her plant to the rest of the class and highlight what impressed them about it. Children took turns to present the plants they brought in (olive branch, lettuce, turnip, rose). When presenting the plants, children included any information they knew about the plants with Stavros asking them questions.

Stavros then asked the children to compare the different plants they had brought and spot similarities and differences. Children were asked to observe the different plants and guided Stavros to draw the different parts of a plant on the blackboard. Children described the parts as Stavros provided the scientific terminology. The entire classroom discussion ended with Stavros announcing that in the days that would follow the children were going to plant lentils and provided children with general instructions.

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The lesson concluded with Stavros splitting the children into two groups of four and giving each of them a digital camera. Children had to go outside and take photographs of various plants they could find in the school premises. The photographs would then be collected by him and children along with Stavros would discuss them the next day.

During the second day, the lesson began with a revision of the activities of the day before and a brief evaluation of the parts of plants. The typical phrase used during this part of the lesson was *"What did we say about...yesterday?"*. For the next forty minutes children looked at the photographs they had taken the day before and tried to find and name the different parts of each plant.

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Stavros supported children with the proper terms to use for previously mentioned characteristics and introduced new terms (e.g. stamens) when children observed and commented that specific characteristic of the plant. Stavros insisted on children observing the photos and describing the different parts of the plant or the shape of its flower. He used questioning to allow children to elaborate on their thoughts and correct their misconceptions. Children were also required to make comparisons, predict on the evolution of different plants and provide explanations.

The concluding activity of this two-day lesson, which is the focus of this episode, was a role playing exercise.

> *Stavros: We are already divided into two teams. I will remind you the basic characteristics of herbs, bushes and trees (the three categories that characterise plants) and I want you to form a living statue.*
>
> *K: Ahhh, this is very nice.*
>
> *Stavros: The first team will show me what a herb looks like, the second team will show me a bush and so on.*
>
> *Z: How are we going to do that?*
>
> *Stavros: Using your body.*

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D: With our hands?

Stavros: You can use your whole body; you can do whatever you like. First off the herb. This means soft sprout for example. Then you will do the bush and finally the tree. I want you to think about the herb. You can discuss and rehearse for five minutes and then you will come back here to show me.

Children start discussing what to do, trying to agree on an idea. The first idea is pictured in the image below with four children standing up with their hands over their heads.

Stavros: What are you supposed to be?

An: We are a pine.

Stavros: Why do you have your arms up?

All four: It's the branches.

Ar: and the hands are the leaves.

Stavros: That is very good. You can try to move your hands to show that there is wind blowing. Try to do a bush now.

The other team yells for Stavros to come and see what they have done.

Stavros: Let's see. What are you doing here? Why are you on the floor?

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E: You are looking at us from above.

Stavros: I understand now. What are you then?

All: A herb.

Stavros: So what is E supposed to be then?

E: The sprout.

Stavros: What about the others?

K, Z, ??: Leaves.

Stavros (as he is standing above them): So what am I supposed to be now that I am standing here.

K: The roots?

Stavros: Now I could be the roots as I am under the trunk.

By the time that Stavros was done with the second team, the first team was trying to do a herb. Stavros reminded them the basic characteristics of herbs.

Stavros: What about you then?

All four: We are a poppy.

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Stavros: Oh that is very nice. What are you doing now?

Children all yelling, inaudible in the recording.

Stavros: So you three are the leaves and D is the flower. I get it now, well done.

Stavros: That was very good. Let's see what the others have done. What are you supposed to be?

All four children: A tree

E: A tree with three branches.

Stavros: That is very good.

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The lesson ended with one more revision of the basic characteristics of the three categories of plants by Stavros and a brief presentation of the lentil panting activity that would follow the next day.

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 with activities such as choosing plants to present in the classroom, using the digital camera to photograph plants for observation and role playing. The focus of this episode to the role playing activity showcased children's imagination while making connections to the knowledge provided by Stavros during the two lessons. The role playing activity was an excellent opportunity in both creative teaching and promoting children's creativity. On one hand, Stavros used it as a formative assessment activity right before the conclusion of the lesson, entirely different from all other assessment activities observed and allowed Stavros to gather diverse forms of evidence to evaluate children's understanding. On the other hand, this activity was an excellent example of children being creative with the two teams presenting two very different depictions of plants based on their perception of the three dimensions, a physical attribute based on based on their spatial attributes; or their dimensions and the position of the eye relative to the objects. The role playing exercise is an example of broadening the assessment and evaluation of science and mathematics through employing a creativity lens.

Features of creative teaching were reflected in the opportunities for learning in the outdoor

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environment involving children gathering plants in both the physical and digital worlds. Children's interactions with Stavros fostered their interests and questioning was used to encourage children to extend observations and articulate explanations.

Episode 3: What are clouds made of?

The final episode analysed here is part of a very common topic in the Greek science curriculum for preschool and early primary education.

Pedagogical Framing

The third episode took place during a lesson on the cycle of water. Even though children had briefly heard of the cycle in a previous lesson, this particular session had to do with a specific question that the children had some days before. The children wanted to know what are clouds made of, so Stavros fuelled from their interest organised an activity to remind them about the cycle of water, to provide them with more information and ultimately lead the to the answer to their question. The session started with Stavros telling children a story about "Noulis the little water drop", a character they had seen when they first heard of the cycle of water. The materials used in this lesson included a teacher demonstration with a pot of boiling water, a video from the internet and work sheets (both paper copies and on the interactive whiteboard).

Pedagogical Interactions

Stavros introduced Noulis to the children and told children that today they were going to be able to answer a question they had; how are clouds made? Children watched a YouTube video about the cycle of water. The video was a slide show of pictures (both real life and figures) showing the different stages of the cycle. A work sheet which showed the cycle of water was given to the children to complete at the end of the lesson. Stavros said that the work sheet depicts the story of Noulis' life and after the lesson and the experiment they are going to see they should be able to complete it. Children commented on what they thought was interesting about the video, as Stavros used questioning to encourage children to articulate observations. He continued to use questions when he asked children to compare the 4 pictures of the work sheet to the images of the video they saw in order to support children's reflection and reasoning.

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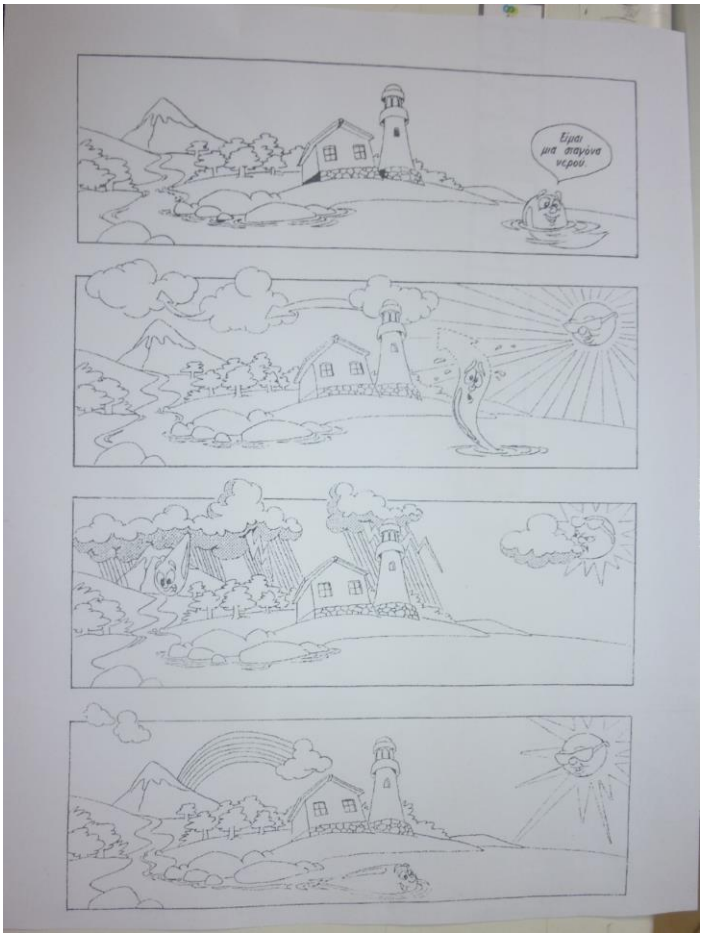

Children recognised the first and third strips of the work sheet (water drop in the sea and water drop falling from the cloud when it rains) easily and were able to describe what happens correctly. When discussing about the second strip (water drop rising to the sky), the children had problems describing how Noulis goes up from the sea to the sky. Stavros insisted on whether children could see the process that “lifts” Noulis to the sky. Two children were able to provide an explanation. K said “He grows and goes up the sky”, An said “the sun warms Noulis and he gets hotter and hotter and he becomes steam”, while E said “He goes up for rain to fall”. Stavros commented that it is an invisible process we cannot see but you what follows might help them to understand.

Stavros then proceeded to carry out a demonstration to show the evaporation phenomenon. He used a gas canister, a coffee pot filled halfway with water and a tray. Immediately after presenting the materials and lighting up the gas canister An said that this will make the tray to sweat.

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D: Why does the bathroom mirror get steamed up when we are taking a hot shower?

Stavros: With what does it steam up?

D: With water.

Stavros: Where does this water come from then? Can we see where it comes from?

All: No.

Stavros: So when water is very very hot (either by us here now or by the sun outside) a phenomenon called evaporation happens. What is evaporation? When I heat up a liquid, the liquid starts to "worry', it does not feel good and wants to escape.

An: Even gasoline?

Stavros: Of course gasoline as well. That is something that we cannot try here and you cannot try yourselves. Imagine now that you are kept inside a closed space, like an elevator. The elevator is built for 3 but there are 8 people in there and on top of that someone turns up the heat. That will make you want to get out of there. The same thing pretty much happens to Noulis and his friends in the coffee pot. What do you see now that the water starts to get hot?

All: Steam comes up.

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Stavros: The steam is created because the water is very hot and the water drops inside…

An, Z: Are very hot.

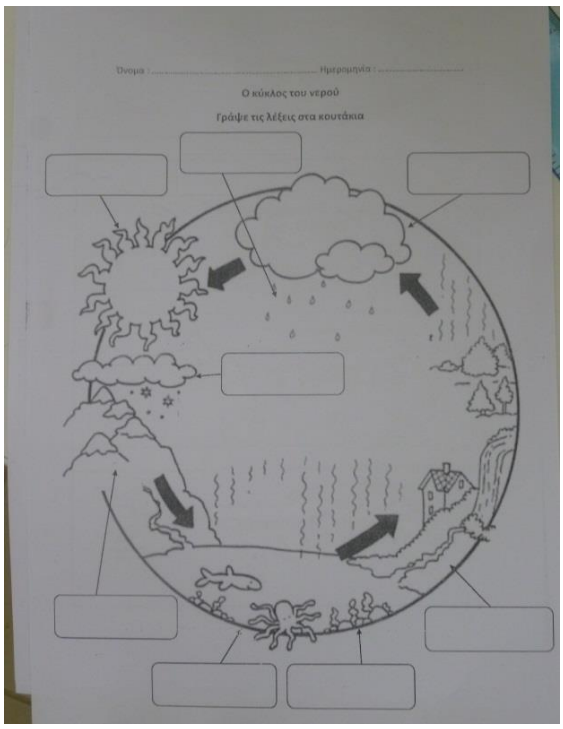
Stavros: and they want to get away like we said before.

Ar: Will there be rain?

Stavros: We will see.

Stavros then asked children to stand up and come closer to the coffee pot. He asked them to imagine that the water in the pot is the sea, the gas canister is the sun that heats up the sea and the tray is the sky. Let's see now what happens when Noulis reaches the sky.

Stavros brought the children's attention to the tray and asked them to see what happens there. All the children gasped with wonderment and pointed to the tray which now had water drops dripping on its side. Stavros reminded them that there was no water anywhere near the tray before the demonstration and noted that the more he holds the tray on top of the pot the more water they will see dripping. Ar said that the tray is crying and Z said that the drops are falling down. Stavros then went back to the second strip of the work sheet and asked E to explain what happens to Noulis. E said that the sun heats up Noulis and he cannot take it anymore and he leaves.



Stavros: What did we say that we call this phenomenon?

All: Evaporation.

Stavros: Remember that this can happen to any liquid, not just water.

Ar: Even in our eyes?

Stavros: If we keep our eyes open for a long time they will get dry. That is why we blink, to keep our eyes lubricated. That was a great question Ar. Now let's go back to what happens to Noulis when he reaches the sky. There he meets up with other water drops.

Z: His friends.

Stavros: That is right. All the water drops get together and they form… Look at the third strip.

E: Clouds.

Stavros: Now if somebody asks you what are clouds made of, what are you going to answer them?

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[pause]

Stavros: An, if somebody asks you, your brother that goes to the first grade for example, what are clouds made of what are you going to answer them?

An: The sun warms up the water and then water goes up to the sky and turns into clouds.

Stavros: So what are they made of then?

An: Water. I mean steam.

Stavros: That is right.

Ar: Yes but when the clouds come up from the sea, don't people see them?

Stavros: Remember Noulis in the coffee pot before? Did you see him go up to the trey?

Ar: No.

Stavros: That is what happens when the clouds form. You cannot see water drops come up to the sky.

After going over the final part of the cycle, rain, which the children seem to understand, Stavros recapped the 4 stages of the cycle of water. He chose to use a picture on the interactive whiteboard which contained all stages of the cycle. Stavros then handed out another worksheet for children to complete on their own which asked them to complete text boxes on a picture of the cycle of water. No assistance was provided to the children as Stavros specifically told them to answer whatever they wished. After the children were done, Stavros asked the children to tell him what they wrote on each of the blanks.

The conclusion of the lesson included a role playing activity, similar to the one observed in the previous episode. Stavros told children that they would be Noulis' friends, water drops, and designated specific parts of the classroom as the sea, a river, a mountain and a prairie. Stavros was the sun and asked children to move wherever they felt they had to go.

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6 children went to the “mountain” and 2 went to the “prairie” and Stavros asked them where they would go next. All the children headed for the sea, while none went to the river. Stavros congratulate them and briefly went over the stages of the cycle of water one final time.

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. They made connections for example between the height of the ramp and the movement of the vehicles and offered explanations for actions and ideas.

Particular features of creative teaching evident in this episode include the provision of exciting experiences to foster children’s curiosity and interest. Teacher questioning encouraged dialogue about experiences. Children were invited to record observations and reflect on their experiences through drawing.

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?

The observations carried out by the researchers in Stavros’ classroom revealed specific approaches used by the teacher as part of an established teaching strategy. Stavros using a mixture of storytelling, digital technologies and exciting teaching materials focuses strongly on eliciting children’s curiosity in the topics he is required to teach. The learning activities apart from feeding off children’s excitement also highlight a sensitivity on the part of the teacher to support children’s interests and build his teaching around their experiences and previous knowledge. Teacher questioning is also used to motivate and to encourage children to express their ideas during the lessons. Stavros using leading questions tends to focus on fostering children’s reflection and reasoning while allowing them time and space to develop their thinking and express their thoughts. Stavros plans learning activities that present problem solving opportunities while highlighting the value of collaborative work and children working together towards a common goal.

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In terms of assessing students, Stavros tries to use a variety of different assessment strategies which value diverse forms of learning. This is particularly relevant to the role playing activities used at the conclusions of two out of the three episodes presented in this report.

What role if any does creativity play in these?

Rich opportunities were offered by Stavros for the promotion of children's creative dispositions, in particular motivation, curiosity and sense of initiative in pursuing their own interests. The focus of this episode to the role playing activity showcased children's imagination while making connections to the knowledge provided by Stavros during the three episodes. The role playing activities in two of the episodes were excellent opportunities for children to display their creative potential using truly diverse forms of expression. The two similar activities were also characteristic of Stavros' teaching practice which according to him relies on fostering children's interests and allowing them space and time to express themselves.

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?

Collaboration and dialogue were evidently valued by Stavros in his practice. As part of his interview he mentioned that effective collaboration takes time and effort, but for his class "*collaboration is easy now. The children are at ease with collaborative work. They were working in small groups from last year, so now they have no problem working together."* This was observed during the 4 visits with children being able to work together without arguments and welcoming suggestions and ideas from others. The combination of group work, collaboration and approaches that linked to everyday life facilitated children in making their learning relevant.

Questioning is also a central teaching approach observed during the classroom observations. Stavros described his use of questioning in his interview:

> *"I use questions to allow them space and time to understand where they did not succeed. If they don't succeed I still won't provide the right answer, just tell them to give it a think for next time. Next time they will get the chance to tackle the problem again and go a step further. It just needs more time."*

The above quote also highlights the approach for teacher scaffolding and Stavros' willingness to stand back and follow the learning pace of the children. An exception to this was the teacher-led portion of the plants lessons where Stavros "tried to lead them to understand the different parts of plants". Motivation and sense of initiative were observed in children's sustained engagement to the learning activities. Stavros considers motivation as the driving force.

> *"Their motivation to reach the treasure "lent" them the knowledge necessary to achieve their goal."*

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The use of the outdoor environment, a common fixture in Stavros' teaching, and the importance of making links with children's everyday lives to engage interest and foster curiosity succeed in providing opportunities for exploration in the early years. Stavros said in his interview that he particularly enjoys outdoor activities as they allow him to both enjoy them and give him the opportunity *to "do things differently".*

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3.6 Case 6 – 'Katia'

3.6.1 Context

Where?	Country	Greece			
	Setting name	GR1			
	Location within setting	Pre school			
Who? (children)	Year group/age of children	5-6 years old			
	Number of children in class	28			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher + 1 German teacher			
	Case teacher role				
When?		1	2	3	4
	Dates of visits	17/1/13	13/2/13	14/2/13	28/3/13
	Times of visits	10:50 – 11:40	10:30 – 12:30	12:00 – 12:40	09:25 – 10:30

a) School/setting

The school is situated in a suburb of Athens approximately 17 kilometres from the city centre. It is one of the largest private schools in Greece providing education from pre-kindergarten (4 year old children) to secondary education (18 year old children). The main aims of the school for kindergarten are:

- Emotional maturity, familiarization with the new social environment and compliance to behavioural rules both on an individual and group scale.
- The development of the pre-schoolers' intellectual skills.
- Physical development.

All the learning material has been written by a group of experienced Greek and German kindergarten teachers and is based on the following principle method: playing and daily experimentation help the children expand their experience and mental abilities.

The aims for primary school are:

- The individualization of teaching and the support of the pupil according to his/her character, aptitudes, possible special needs and, above all, with respect to his/her personality.
- The application of modern teaching methods.
- The enhancement of the syllabus.

The school has a philosophy that focuses on science education. According to its philosophy, familiarization with figures and natural laws is the first step which leads to the development of

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more complex skills, like the ability to analyse and synthesise. Experimentation, coming in touch with simple but interesting natural phenomena as well as comprehension through research and questioning are the key points of the lesson. The school also promotes outdoor learning and according to the vision of the school learning does not take place only in the classroom but also in the Physics' and Computer science's lab, in the music and art room, in the video room and in the library. The school's special editions for the teaching of Greek and foreign languages are of great help to the pupils of all grades in primary school.

b) Teacher (using the interview and survey)

Katia is in her thirties, and holds a BA in Preschool Education. She has 11-20 years of teaching experience and she has taught in kindergarten (5-year olds) for the last three years. During this school year Katia is teaching the pre-kindergarten (4-year-olds) class in the school. Katia studied science and mathematics last as part of her BA degree, with both subjects being points of emphasis during the course. Based on the responses she gave to the survey, Mina can be considered as confident across all the categories. All her responses were consistent with high confidence except her general pedagogical knowledge, where she feels very confident. She also reported having received CPD training during the last 18 months, citing science education conferences or seminars, reading Science professional literature, individual or collaborative research on a Science topic of interest and engaging in informal dialogue with colleagues on how to improve science/mathematics teaching as the ones having a large impact. The only category that Katia does not believe had any impact on her teaching was science/mathematics teaching observations in other schools.

c) Classroom

There are 26 pupils in the class, with 16 boys and 10 girls. In terms of the classroom setting, the classroom is housed in a spacious open-planned space, with a large area being occupied by tables situated in the centre of the classroom. On one side of the classroom large benches are placed against the wall providing enough space for all the children to sit. This space is called the Circle. Around the classroom there are several areas dedicated to specific themes, known as “corners”. These areas are used by the children looking for resources to assist them in their learning during the lessons and during the half-hour free playing portion at the beginning of each day. The classroom is well resourced with rich maths artefacts, puzzles and games, a reading corner and an interactive table. A garden which is looked after by the students is one of the main activities carried out by children during the spring and gives them a chance for hands-on exploration.

Same as all the other schools, this classroom follows the 2003 curriculum for primary education. There are however additional teaching materials written by experienced science and mathematics educators for science and mathematics. Teachers across the different kindergarten classes coordinate their lessons by teaching the same themes and topics but having the necessary autonomy to modify teaching activities and material according to the needs of their pupils.

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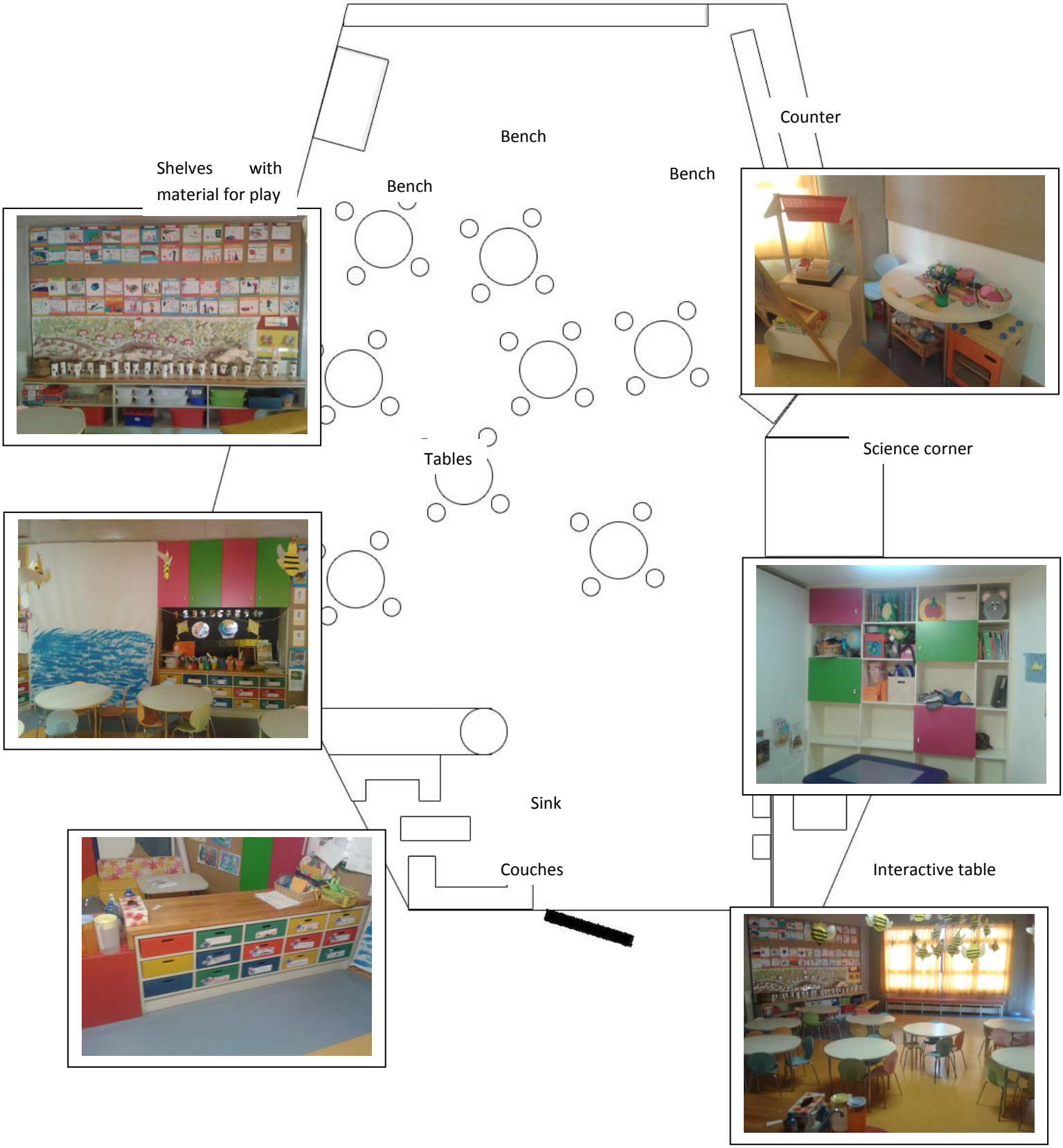

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3.6.2 Episodes

Episode 1: Pansies

The first episode of Katia presented here was taken from lesson which used the recurring topic of plants to teach about scientific inquiry. The teacher had searched for activities to promote children's problem solving, comparison and observation skills. The particular topic chosen by the teacher as the context of this activity was plant growth. This episode focuses on day one of the two-day lesson that involved the experiment with the pansies.

Pedagogical Framing

The aims for this two-day lesson, according to Katia's planning documents, were for children to:

- recognise the factors that influence the growth of plants;
- tackle a problem;
- find ways of isolating one factor of plant growth to study;
- recognise the factors that are constant.

The skills that Katia was aiming for children to develop with this activity were for children to recognise the different factors as variables and study the variation of the different factors on plant growth. Katia planned the activity across two days. During the first day, children would make predictions about the growth of the pansies and make an "observation folder" to record their predictions and observations. On the second day, 5 days later, the children would observe the pansies and record their findings in regard to teacher growth and come to conclusions on the influence of each of the factors. The teaching assistant was responsible for watering the pansies between the two days. Similar to a number of other episodes a story was used as an introduction to the lesson in order to excite and motivate the children.

Pedagogical Interactions

The lesson began with Katia asking the children if they remembered Mr. Planty, an agriculturist who loves all plants. In the story Mr. Planty had to leave his greenhouse to tend to a lettuce garden that was threatened by snails. That meant that he was forced to leave his 5 newly planted pansies to be tended by his five assistants. Each of the five assistants chose to keep his/her pansy during Mr. Planty's absence. Katia then explained how each assistant tended to the pansies.

What did each assistant do?

- Assistant 1: put the pansy in a box
- Assistant 2: covered the pansy with a plastic bag
- Assistant 3: stored the pansy in the refrigerator
- Assistant 4: placed it right next to the other flowers on the greenhouse

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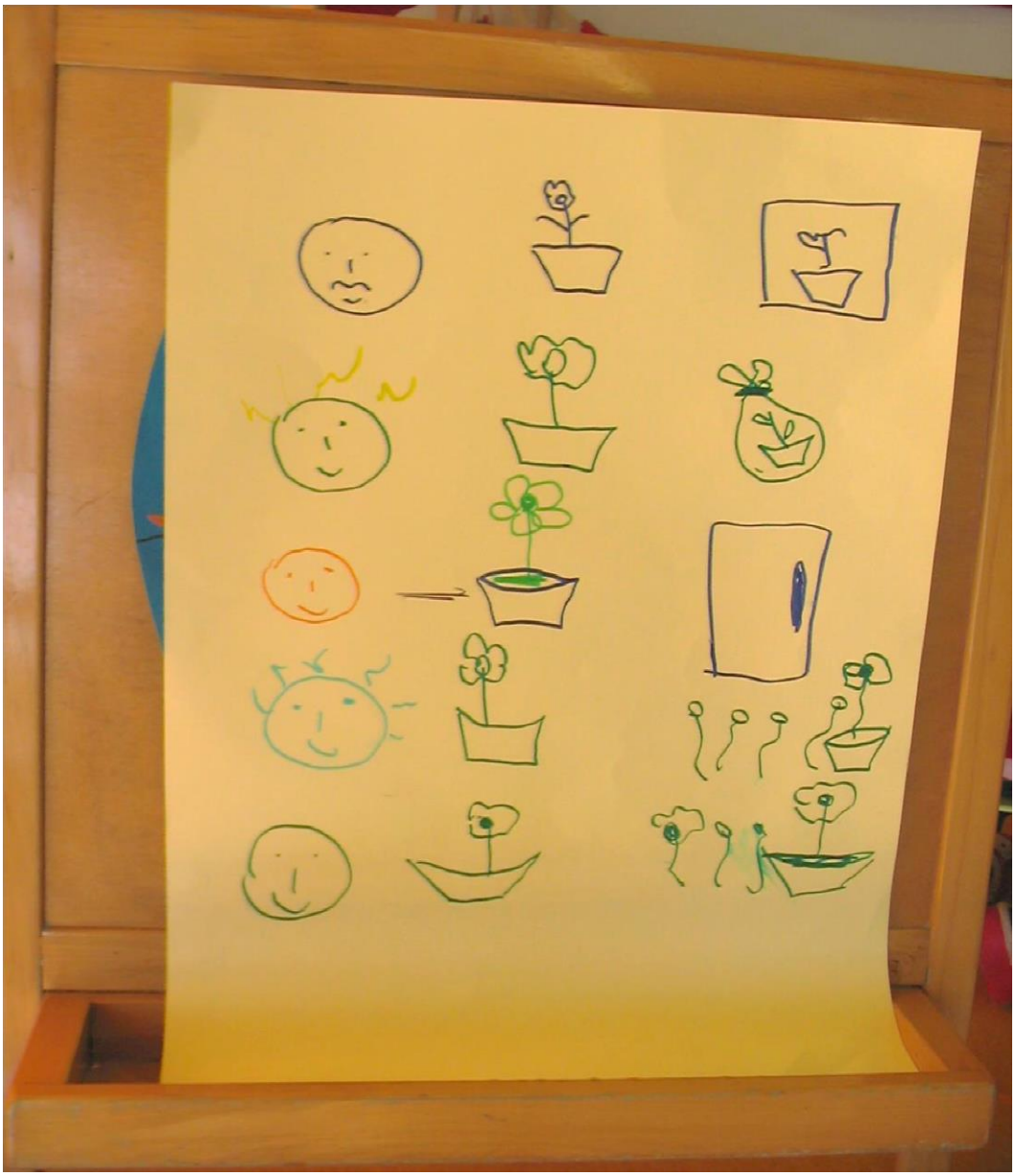
- Assistant 5: similarly placed the pansy in the greenhouse but forgot to water it

As Katia was telling the children what the different assistants did, the children were yelling out their comments and objections.



Katia: […] the third assistant remembered that his grandmother told him that lettuce should be stored in the fridge in order to stay fresh for longer, so he stored his pansy in the fridge.

B: but it will be cold in the fridge [two more children agree].

S: If the pansy gets too cold, nothing bad will happen to it.

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Katia: So cold is not bad for the plants, is it?

G: No it is not bad. The fridge makes ice. If the plant is in the fridge, the ice will fall onto the soil and water will fill the flower pot. So the plant would not need as much water as normally.

During the story of the five assistants and their pansies Katia asked the children numerous times to predict what would happen and used "What if" questions on three occasions. Even though the children were eager to contribute to the discussion and share their thoughts, Katia insisted on them waiting to record their early observations and predictions. Katia concluded the story by saying that the person who told her this story did not know what happened with the 5 pansies, "*do you want to experiment and see what happens?"* was her concluding phrase.

Children were then divided into 5 teams and a brief discussion between Katia and each team followed. The teacher briefly explained what each team would do as she brought out the pansies and asked them to think about what they thought would happen. Katia also explained that before doing any observing the children had to become scientists, which meant that each team would have to make and use an observation folder.

Katia: Every team would have an observation folder which you will use to record and store all your thoughts.

A: and all the evidence we find.

Katia: Very good, you are right, that as well.

S: and all the leaves we find?

Katia: Everything. Everything we observe while we study the pansies.

A: Will we start playing this right away, right?

Katia: Yes, we will start now.

Then, each team sat in front of Katia who presented them with their pansy and an empty folder and began to ask them questions about the pansies. There were two types of questions asked by the teacher during this part of the lesson. The first type Involved questions about planning the investigation in terms of methodology and resources ("*How would you go about doing …?" "What could you use to be able to do …?*"), while the second required students to use their imagination to predict what would happen after the 5-day observation period *("I want you to imagine, to think, what would happen if the assistant … what might happen to the pansy during these 5 days?"*

Children seemed particularly engaged during these discussions with the majority of them providing ideas and predictions all of which were recorded by Katia in each team's observation folder. The line of questioning used by Katia during the discussions served an additional purpose which is very important for the teacher (as stated in Katia's interview) and that is to elicit

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children's previous knowledge and modify her teaching accordingly.

One of the five discussions carried out is presented below:

Katia: I want you to imagine, if the assistant placed the pansy in a box what might happen to the pansy during the next few days?

O: It will wither [two more children agree].

J: It will get hot.

Katia: I am writing everything down in your observation notebook. Does anyone else from this team have anything to add? An, what do you think?

An: It will wither.

V*: but they [the assistants] watered it every day. All except this one [shows the 5th pansy].*

Katia: I agree, but is water the only thing a plant needs?

All: No.

O, V, J: The sun.

F: And food.

Katia: So it needs the sun and food. What is the food for plants?

F: Fertiliser.

Katia: What is fertiliser? Is it liquid?

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F: No it's something soft.

Katia: Like what?

F: Like dirt.

Katia: And it contains nutritional elements right?

F: Yes to feed the plant

Katia: What else does a plant need?

O: Soil.

Al: Rain. And water without the rain.

Katia: That's right. If the weather does not rain for a while we need to water the plant ourselves. What if now we placed the plant inside the box, what will be missing?

Al: The sun.

Katia: OK so what symbol would you use to describe your team then? Do you think that it should be the sun?

All: Yes.

Katia: One of you should come here and draw the sun on your observation notebook.

An: I can use the orange marker as well.

Katia: Yes you can.

An: Sometimes the sun is orange so I can use this one.

Katia: That is right.

O: there is also a red sun.

Katia: Yes.

O: When it rises in the morning.

Katia: Very nice. Now do you want to write all your names on the observation notebook?

The rest of the five teams participated in similar discussions for the next 15 minutes with Katia asking questions that ultimately revealed both children's previous knowledge and their predictions on what would happen to the pansies. The lesson ended with Katia telling the children that they would be checking up on the pansies and comparing what they had written today with what they see then.

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Opportunities for Creativity

The episode presented above revealed opportunities for creativity in terms of both creative teaching and children learning creatively. Katia, throughout the lesson used "What if" questioning, mostly aiming at encouraging children to make predictions and provide explanations. Children's autonomy in this activity was limited due to the controlled nature of the experiment. Although children were motivated by the story they heard and by Katia asking them several questions on what they would like to do to find out what happened to the pansies, the actual planning of the investigation was carried out entirely by Katia. On the other hand, the playful nature of the activity allowed children the freedom to express themselves freely and offer their ideas and thoughts. One more characteristic that allowed children opportunities to learn creatively was the importance of collaboration stressed by Katia during the lesson. Katia encouraged children to work within the groups and not separate the tasks between them. She also told children that *"Real scientists collaborate all the time and share their thoughts to generate more ideas"*. These opportunities for dialogue and collaboration that fostered thinking and reasoning skills associated with creativity. Children were very motivated and showed considerable curiosity about the 5 pansies.

Episode 2: Branches, leaves and pine cones

The second episode presented here for Katia involved an activity that involved children collecting leaves, branches, and pine cones in order to compare them regarding size, length and

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width.

Pedagogical Framing

The lesson began with a story, a familiar introduction to many of the lessons observed. The story's protagonist was Vagia the owl, a common character in Katia's lessons, used in several lessons to introduce topics, problems and bring children work sheets to work on. This particular story was taken from a children's book titled "Ouch" (Scammell and Terry, 2006) and involved the problems of a hedgehog trying to get into his nest to sleep for the winter (hibernation). A series of activities which had their roots in the hedgehog story were planned by Katia, from outdoor learning opportunities that allowed children to collect evidence to the dramatization of the story enacted in such a way as to encourage problem solving.

This lesson was described in Katia's planning documents as an excellent opportunity to integrate mathematics and one more subject of the curriculum, creation and expression (linked to the arts). As a result there are separate aims for mathematics and expression set by Katia. The aims set for mathematics are:

Children should be provided with a multitude of opportunities to apply their mathematical knoweldge in their daily activities through stimulating situations and appropriate teaching interventions so that they:

- Get immersed in problems and explore a variety of situations, build on previous knowledge and reach to conclusions.
- Understand simple properties of time and space (big-small/wide-narrow/short-long/before-after).
- Organise and expand their knowledge of numbers (promote the use of mathematical language).

While the aims for Creation and Expression are:

- Children should express themselves freely through dramatization, develop their creativity, know themselves and the world around them.
- Children should handle objects and assign them with new meanings.
- Children should collaboratively create.

Comparing both sets of aims can reveal a significant difference, the focus on cognitive aspects for mathematics and the focus on affective aspects for Creation and expression. The interesting observation here is not the difference between the two sets itself, but rather the lack of any recognition of the affective aspects of learning in mathematics. This is consistent with the direction provided by the curriculum were the large majority of aims in the mathematics section of the curriculum is focused on cognitive aspects of learning.

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Pedagogical Interactions

This activity involved children observing and exploring leaves, branches and pine cones they had collected on a previous day to build a nest similar to the hedgehog in the story. Children would compare and sort the material they had gathered outdoors while having a discussion with Katia as she supported them using questions and her observations.

The discussion began with Katia reminding children the premise of the story with the hedgehog and asking them to remember what they had gathered on the previous lesson. Each of the material gathered was connected to one pre-mathematical property as the pine cones were either big or small, the branches were long and short and the leaves were wide or narrow. After a brief discussion that reminded children of what they had done in the previous lesson, children were divided into the same groups and were asked to start sorting the material gathered according to the specific property assigned to them. In order to assist and guide children in sorting the material, Katia provided them with large sheets of paper with designated spaces to place their material. Children were encouraged to share their thoughts among the team before starting to sort their material. Each child had to explain what he/she wanted to do and if the other children agreed only then a branch or a pine cone would be placed on the presentation sheet. This instruction led the children to have discussions and arguments over where each branch was placed and revealed children's thinking, especially in those instances where Katia was participating as well. As Katia mentioned in her interview, in retrospect, she wouldn't not draw boxes and lines in the paper sheets for children to place their branches and leaves if she had to do the activity all over again. She believes that this posed additional problems to the children, as they had more objects to place than spaces on the sheet. It was exactly this situation that posed a significant problem to the teams and revealed opportunities for children to solve a problem. It was the lack of specific instruction on the part of Katia that forced the children to find a way to carry out the activity and reach to a conclusion. As Katia commented in her interview, "*I did not expect then to gather so many leaves and branches so I had drawn fewer boxes than they had objects".* This oversight from Katia forced children to do more than just sorting their objects, they had to group the objects as well in order to be able to fit the designated spaces in the paper sheets. This was particularly relevant to the teams that worked with the pine cones.

One of the discussions between children (and Katia) on how to measure two branches is the focus of this episode.

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Two children O and G were disagreeing on which of the two branches was shorter by placing them side by side. G turned to Katia for assistance.

G: Miss this does not stay down (the branch was bent in the middle).

O: Of course it doesn't. It is not like these ones (already placed on the sheet). It is like this one [a branch similarly bent].

K: I understand but I want you to try and measure which is the longer one. Try to think of a way you could do that.

O: This goes here then.

G: No this is taller that the other.

O: Yes but it is also thicker.

O: Let's measure them to see then [puts his finger on the branch and moves it while counting] 1, 2, 3, 4, ... , 15.

[Another boy, K, tries to count as well imitating O] 1, 2, 3, ... , 36.

At the same time O is measuring the other branch.

O: 1, 2, 3, ... , 7.

K: 1, 2, 3, ... , 10. Miss I am counting 10 and 36. This is the longer one, I counted it.

Katia: Very good. You think this is longer. Where will you place it?

K: Here.

Katia: Are you sure? Why don't you measure it.

K: 1, 2, 3, ...

Katia: How do you measure the branch? With your hand?

K: Yes, like this [starts counting].

Katia: You can do it like that but you have to remember that you have to be consistent while you count. Always repeat the same thing. You can use other "types of finger", like your palm for example.

K: Like this?

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Katia: Exactly, now try it for yourself [Katia leaves the team].

After Katia's departure all the children in the group tried to measure the branches using different parts of their arms (finger, palm, forearm).

O: This is difficult to do.

G: It is very nice though.

O: I am tired of this.

G: I am not.

This part of the lesson lasted for 15 minutes and after all the children had managed to place at least some of the branches and leaves on the sheets, Katia brought them back altogether to the Circle for a classroom discussion and evaluation. During the discussion and presentation of children's work in front of the entire classroom, a number of important issues came out. One of these issues was a revisit of the measuring problem presented above within one group. The issue was brought up during the presentation of findings of the second team that had to sort branches. This discussion although presented similar problems that the children faced when trying to measure length revealed elements of problem solving by one girl, A, who explained how she was able to measure the different branches and be certain that she was correct.

A*: I do it like this [places one end of each branch on the edge of the sheet].*

Katia: So I put them here? Like this?

A: No you push them up with your hand. They have to be on the same place. Can I show you?

Katia: Of course. [...] That is very good. Did you all see what A did there? All branches should start from the same place.

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Opportunities for Creativity

Motivation was evident in the children's enthusiasm to compare the pine cones, leaves and branches and display them on the large paper sheets. Throughout the episode, Katia encouraged curiosity and children were able to make connections between the pre-mathematical properties (length, width, size) she planned. The outdoor part of the lesson that allowed children to gather materials for their investigations facilitated observation and raised a number of questions concerning the natural world. It was this part of the lesson that Katia identified as the most creativity-enabling due to the volume of observations and questions that children raised which in turn fuelled a number of subsequent activities in the classroom.

Features of creative teaching were shown in particular in the provision of rich resources, exploration and problem solving and the use of questioning to support children's reflection and reasoning. The materials provided afforded opportunities for children to explore what happened as cars went down the ramps.

Episode 3: Yellow colour tones

The third episode presented here involved children in Katia's classroom mixing colours to learn about different tones of yellow and grey. During the year a number of lessons are devoted to presenting children with works of art, mostly in the form of paintings. As observed in another lesson it is common for teachers of this particular school to build lessons around famous paintings.

Pedagogical Framing

Katia said in her interview that children had not dealt with colour tones before but have been playing with mixing two different colours to produce a third one and know which are the basic colours. She also said that the children's ideas would lead the teaching process. The aims for this lesson were:

- children to understand the difference between colour tones through different observations, comparisons, trials and errors;
- to be able to sort based on colour tone.

The idea was for children to work in 7 groups of 4 on the different tones of yellow by adding white (3 teams) and black (4 teams) to produce lighter tones for the former and darker tones for the latter. The different outcomes would be put on display in front of the entire class to sort

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them all out. Children were encouraged to make predictions on the outcome and present arguments to support their side.

Pedagogical Interactions

Children were divided into groups and sat on separate tables to start work on mixing the colours to produce the different tones. Katia provided them with specific instructions to mix the two colours in front of them. Each team would mix an amount of yellow paint with white or black paint. In order to produce different tones each team has to add a specific amount of either white or black measured in spoonfuls. The mixing portion of the lesson lasted for less than 10 minutes and by then end each team had produced 12 different tones (6 lighter and 6 darker than the original yellow). A classroom discussion followed in order to sort all the different tones into one sequence going from black to white in one large sheet of paper.

Katia asked children to compare the colours and explain what they were doing so that the rest of the class could comment and either agree or disagree. Katia used a variety of different questions to allow children to articulate their thoughts and succeeded in making the final sheet of paper with all the tones in the right sequence without her interfering in the children's decisions.

As soon as the large sheet was finished, Katia started writing numbers on the back of the sheet, one for each of the tones. Children were counting out loud as Katia was writing the numbers, reaching a total of 14 different tones. She then cut the sheet into 14 different squares and told the children that they would start playing a game with all the colours. 8 of the children were then divided into two groups, one that would study the darker tones and the other that would study the lighter tones. The rest of the children would look at pictures of famous paintings and comment on the colours and different tones they observed in each of them.

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One of the two teams immediately started sorting the different tones using the numbers on the back of each piece of paper. As a result they finished their task very quickly, while the other team that chose not to use the numbers on the back took longer as they had to decide on the sequence of the tones. During this part of the lesson, Katia was moving around the classroom from group to group asking children questions. As soon as she realised that the first team had used the numbers instead of the tones to sort the cards, she asked children to do it the "*proper way without cheating".*

When all the groups had finished their task, all the children returned to the Circle to discuss what they did and evaluate their findings.

> *Katia: Rabbits [second team], please explain what you did and how. You had to sort the colours from darker to lighter tones.*
>
> *F: We took all the colours and started putting them side by side. When we saw one that was darker we put it to the right.*

Then F, J and S placed the cards on the floor and started turning them to reveal the numbers. With each card being flipped children would count using the numbers they saw.

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Katia: Let's see what the whales did.

The first team then put the cards on the floor and started looking at the numbers on the back to sort the cards with the different tones quicker. P a student from a different group yelled "They are doing it wrong, they are looking at the numbers". Katia did not address this fact to the team directly, but rather asked them "What did you do? Did you mostly use the numbers on the back or look at the different tones?" The children said that they used both at some point but they looked at the colours for a longer time.

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The lesson came to an end with a brief discussion between Katia and the children that looked at the paintings. Katia asked the children about the colour tones in the painting (which are lighter and which are darker) and children provided examples of different tones on the painting. The discussion went on for 5 minutes and was used by Katia to assess the understanding of the different tones in the children that did not get to play with the numbered cards.

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Opportunities for Creativity

Creative approaches to teaching are reflected in this particular episode by Katia planning an activity that set a motivating and meaningful context for the children that allowed them with opportunities for physical exploration, and fostered connections between experiences, children's prior learning and everyday life. Questioning was used to elicit ideas and encourage reasoning. The assessment activity chosen by Katia at the conclusion of the lesson played an important role in enabling her to utilize children's responses and emerging ideas in the following lessons and assess her own teaching practice. The introduction to the activity using storytelling demonstrated a creative approach to planning the activity, recognising that the children would be motivated and engaged in an activity which was connected to a story that they enjoyed and stimulated their curiosity

On the other hand, the guided approach followed by Katia throughout the lesson limited children's opportunities to display their creativity. There were opportunities for children to share their ideas within their group when Katia was not present and argue over the direction each team would follow, but these were very rare due to time constraints.

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?

Katia follows a consistent approach to all the lessons observed. She uses stories to introduce topics and themes in order to motivate and excite children from the beginning of each lesson. After the introduction, Katia divides children into groups where she encourages dialogue and collaboration by reminding children to share thoughts and interact with each other. Group work is clearly the preferred learning context in Katia's classroom taking up the majority of the time with whole class activities being used either when introducing a topic or in assessing children. All the activities observed are carried out in a playful context, but due to the dominance of a guided approach they cannot be considered as open play. The playful nature of these activities does however succeed in facilitating children's natural curiosity, their immersion in the activities and their sustained interest in science learning and learning in general. 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 the way that hypothesising and predicting were valued and encouraged, as was observation, describing and recording.

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. Questioning was used throughout the lessons to promote sustained shared thinking while a rich and supportive physical and emotional environment can be considered as necessary in order to promote positive attitudes and interests in science and mathematics learning.

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What role if any does creativity play in these?

Creativity is evident in Katia's approach to formative assessment, eliciting children's ideas at the start of a topic and evaluating their learning at the conclusion. However, the information gathered on children's previous knowledge does not seem to influence planning, as Katia tends to follow previously planned activities, making an effort to touch on the subjects mentioned by the children during formative assessment, but always within the confines of the planned activity.

Providing rich experiences that motivate and encourage problem-solving and highlight children's agency also reveal opportunities for creativity. As Katia noted in her interview she wants children to face problematic situations in the classroom and considers this as particularly creative. The children, with Katia's guidance and assistance, are given the opportunities to express themselves and to develop their listening skills as they spend half the time in the classroom working on in small groups where dialogue is expected. As mentioned above, Katia wants the children to work collaboratively, share thoughts and co-operate in the teaching activities and is particularly sensitive to supporting meaningful collaboration instead of children working separately within the groups.

RQ3: *Probing practice*

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

Children seemed to enjoy the rich range of activities planned by Katia which tend to focus on making observations, predictions, connecting ideas and communicating them for the whole class. 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. Children demonstrated high levels of engagement and interest which was reflected in their enthusiasm and enjoyment during the lessons observed. Dialogue and collaboration is the main approach that is used by Katia to foster young children's learning, interest and motivation in science and mathematics. Katia was supporting collaborative work by participating in children's discussions to remind them the rules of collaboration and dialogue. This was a conscious effort on Katia's part to support collaborative work. Katia said during her interview that *"sometimes you have to intervene during their conversations to remind them to really listen to one another and contribute to the discussion".*

How do teachers perceive their role in doing so?

Katia stressed a number of aspects of teaching and learning that she feels are very important for a teacher to foster young children's learning, interest and motivation in science and mathematics. She focused on hands-on activities that provide children with rich stimuli which build on their inherent curiosity and create opportunities for learning. She commented on how many activities were planned based on children's observations and questions after they went outside to gather pine cones, branches and leaves (Episode 2). She feels that the teacher has to

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listen to the children and modify planning according to the children's interests.

The most important aspect of her role according to Katia was supporting collaboration and dialogue as she spent a large part of her interview talking about the process of children working together. Katia believes that small group work is essential in kindergarten because all the children can participate, something that is not possible in the whole group activities. "*Different groups reach to different conclusions and outcomes. You get to hear more opinions from all of them"* was what Katia noted. Small group work is also considered creative by Katia, largely due to the fact that it motivates children to participate in every activity. In contrast the "Circle" and the whole group discussions limit children's motivation as some of them, the ones that feel anxious about speaking in front of the whole classroom, tend to stay silent. She also revealed an interesting aspect to the whole group activities which, by her words, take half of the time in the classroom; she explained that "*we do this in order to prepare children for primary school where things are different".* Katia also said that collaborative work is very difficult for both the teacher and the children in the beginning *("It takes practice and time. Children have to come into constant contact with the "rules of collaboration. They have to learn to listen and respect the opinions of others").* Finally, Katia noted that one of the aspects of collaborative work that is challenging for teachers is that it often slows down the lesson and in terms of time management it is much easier to turn to whole group activities or children working individually. However, it is easier for a kindergarten teacher to promote collaborative work than a primary teacher. According to Katia "*We can be flexible with our activities. We have enough time to focus on collaboration. It is much more difficult to do this in primary".*

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4. Discussion of findings

4.1 Enabling Factors or Barriers at Contextual Level

In selecting sites for fieldwork in Greece information about the quality of practice was drawn from the findings of the teacher survey. 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.

4.1.1 School factors

Evidence from the in-field research presented in this report gathered mostly from interviews with staff, highlighted a range of factors at whole school level that can contribute or pose significant barriers to a climate that has the potential to foster creativity in early mathematics and science.

An important factor is the presence or absence of a whole school approach to learning and teaching. In the GR2 primary school, teachers fuelled by the principal (and fifth and sixth grade teacher), have made several changes to its operation, resources, setting and most importantly its curriculum. Teachers were collaborating in planning learning activities, having discussions about their lessons and working together to solve any problems they might have. This promotion of the school vision is rarely found in Greek schools due to the absence of collaboration and direction from school leadership. In most Greek schools (including the remaining three schools of the sample) teacher collaboration and a shared school vision is limited to teachers coordinating to cover the same topics throughout the year, so that different classes for the same age group of children are moving with the same pace through the curriculum topics that have to be covered.

On the other hand, significant barriers to creative teaching and learning are posed by school contextual factors, some of which were observed during the in-field work and others already mentioned in the previous stages of the Creative Little Scientists project.

The most significant barrier to creative teaching and learning according to teachers in the school visited is the lack of resources due to the poor school finances that prevent teachers from being able to renew old classroom materials or invest in getting new ones to carry out learning activities.

4.1.2 Teacher factors

Teachers' responses to the survey and their interviews provided rich data on their education and training, their teaching experience and their confidence.

The primary school sample can be considered as experienced with having over 10 years of teaching experience, while the primary sample is less experienced with 5 or 6 years fg teaching experience for each of the 3 teachers (Gianna, Stavros and Sotiris). This is consistent with the

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overall sample of preschool and primary teachers in Greece, which was also found in the results of the teacher survey. Primary teacher population in Greece is significantly younger and less experienced compared to the preschool teacher sample, a fact which can be attributed to aggressive governmental recruitment policy in primary education and immediate work placement offered to teacher trainees after they were awarded their Bachelor's degree during the last decade. All teachers possessed BA degrees and teaching qualifications. No teachers were found with science or mathematics related degrees and 2 of them, both in primary education, had not studied science or mathematics during their BA degree. Nearly half the teachers referred to recent participation in CPD courses, conferences or networks for teacher development. In terms of teacher networks or collaboration between colleagues in the same school, teachers rarely work together apart from coordinating time management within an age group to cover the same content during the same period. This can be considered as a barrier to creative teaching and learning, as there were teachers who reported that they were forced to modify their teaching significantly to catch up to what other teachers have been doing or slow their pace down to allow other teachers to catch up with them.

Teachers' interviews and data from the classroom observations indicated that features of creativity in learning and teaching identified in D2.2 Conceptual Framework were valued in both preschool and primary education. This was particularly relevant for certain creative dispositions such as motivation, imagination and curiosity. Promoting these creative dispositions was deemed as essential to teachers both for their teaching as well as for children's learning. However, other creative dispositions identified in the Creative Little Scientists project were either not considered as important to teachers for this age group, or not associated explicitly with creativity (e.g. making connections).

Differences between preschool and primary school

No significant differences were noted between the overall profiles and perspectives of teachers in preschool and primary school. The differences in practice that were observed during the in-field work are discussed in detail in section 4.2 below. The one difference that was evident in the teachers questionnaire responses and their interviews was that preschool teachers received science and mathematics instruction during their teacher education, while primary teachers presented a varied picture with only a portion saying that they were taught during their BA degree and others. The variation in primary teachers could be attributed to the different curriculums taught in the various Pedagogical Departments in different Greek universities.

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 observed during the classroom observations. These differences are discussed in detail in the section that follows.

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4.2 Revisiting the CLS Mapping and Comparison Factors: A summary of findings

4.2.1 Aims and Objectives

The teaching and learning aims and objectives were not made explicit by half of the teachers whose lessons were observed as part of their planning documents. In the 3 cases that specific aims or objectives were not provided by the teachers before the observations, an effort was made to collect evidence from the teacher interviews that followed. This is characteristic of the varied level of detail in teachers' planning their lessons, with some setting specific aims and objectives as part of their planning and others setting aims and learning objectives in more general terms. It is unclear however why some practitioners do not consider setting specific aims and objectives as an important part of their practice.

In terms of aims and objectives that focus on knowledge or understanding of science content, the majority of episodes show that teachers tend to include such aims or objectives in their planning (in 13 of 18 episodes). In all the episodes presented above there was at least one aim, no matter how undervalued or implicit it was, that focus on science content and children acquiring knowledge. Even in the episodes were the focus was on children developing skills on scientific inquiry through observations or simple investigations, there was always a scientific concept or principle that children had to understand.

Another factor that was common in the majority of episodes was the importance of social factors of science learning. Teachers tend to include objectives that aim to promote collaborative and communal engagement, as well as facilitate communication (in 14 out of 18 episodes). The vast majority of aims linked to social factors of science learning focus on collaboration and children being able to work together. The important role of social factors in the aims and objectives set by teacher across both preschool and primary is consistent with the relevant findings of the curriculum analysis conducted in WP3.

Similarly, aims and objectives that focused on affective factors of science learning and efforts to enhance children's attitudes in science and mathematics were part of teachers' planning in both preschool and primary education (in 10 out of 18 episodes). Interestingly however affective factors of science learning were limited on a more general level and did not commonly focus on specific learning activities planned (e.g. to enable children to foster their interest and motivation in mathematics using everyday situations and their experiences – Mina/Episode 2). Another set of aims that was commonly found in the episodes observed was the inclusion of aims and objectives linked to science process skills and more particularly to predicting, observing and describing for science and measuring, describing and classifying for mathematics. Teachers tend to set aims and objectives that intend to bring children into contact with process skills that can be realised in the classroom with the hands on activities or simple investigations carried out by children in the classroom.

On the other end of the spectrum, aims and learning objectives linked to understanding about

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scientific inquiry were included in 7 out of the 18 episodes observed. Teachers seemed to restrict their planning and aim setting to children participating in activities that involve them in meaningful experiences linked to the development of process skills. Although observed in the actual lessons, the aims and objectives set by the teachers do not seem to value the development of children's understandings about the scientific methodology (in 4 out of 18 episodes).

Finally, in terms of setting aims to promote creativity, teachers planning documents and the data gathered from their interviews show that teachers are not including creativity explicitly as part of their aims and objectives (the word creative was not mentioned at all in any of the data on aims and objective for any of the 6 cases). Creativity, however, was included implicitly through the inclusion of some of the creative dispositions identified by the Creative Little Scientists project. These were motivation, imagination, curiosity, problem solving skills and reasoning skills (in 8 out of 18 episodes). It also has to be noted that no teachers provided any specific links between the creative dispositions mentioned above and creativity. Motivation and curiosity were more linked to affective factors of learning and problem solving and reasoning skills were connected to children's cognitive development.

Differences between preschool and primary school

The distinct difference in the aims and objectives set in teachers' planning between preschool and primary education. Setting aims that focus on knowledge or understanding of science content is particularly more common in primary schools, as all the episodes presented above had at least one aim or objective linked to knowledge of science content. This factor was dominant among the aims and objectives set for the lessons in primary education and undervalued in preschool as kindergarten teachers tend to focus more on the social and affective aims and objectives. This is consistent with the analysis of the curriculum in Greece which was carried out in a previous stage of the project (D3.2), where "knowing and understanding concepts has a dominant role among the various intended learning outcomes. Verbs like learn, recognize and know (all used extensively in the cognitive domain of Bloom's taxonomy) are used very often when presenting the learning outcomes" (CLS 2012).

Differences between science and mathematics

One difference was observed between aims and objectives set between science and mathematics which is consistent with the direction provided in the curriculum. As mentioned in the analysis of the Greek curriculum, there are a number of learning objectives for mathematics which, due to the nature of numeracy, follow a rather close-ended approach linked to cognitive aspects of learning. A similar situation was observed during the field research especially for primary teachers. The aims and objectives set for science included both affective and social aspects of learning apart from focusing on children's cognitive development. The same was not the case for mathematics where aims and objectives were restricted to cognitive and social aspects and developing process skills. This has to be said that was relevant for primary

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education rather than preschool where there was a balance between cognitive, social and affective aims and objectives.

4.2.2 Learning Activities

In science the most common learning activities, included in the majority of episodes were explaining evidence and communicating explanations (in 13 out of 18 episodes), gathering evidence, both in terms of observing (in 15 out of 18 episodes) and making connections (in 17 out of 18 episodes). Planning and designing investigations was the learning activity least featured (in 4 out of the 18 episodes). This pattern reflects teachers' perspectives and the emphasis in policy on providing children with opportunities for exploration, which are translated in practice with children observing, gathering evidence and presenting their outcomes. There were instances in specific episodes that contain examples of children planning their investigations.

In both science and mathematics episodes explaining evidence featured very often in either phase (in 13 out of 18 episodes). What has to be noted is that almost all the teachers considered children explaining evidence and communicating their explanations more as part of assessing knowledge, rather than a part of the methodology of the learning activities. This is evident by the data gathered from teacher interviews and the common teaching methodology that brought together the different small groups to present their findings at the conclusion of every lesson in front of the entire class. The emphasis and frequency of both factors (explaining and communicating) is characteristic of the important role of the social dimension of education for teachers.

In terms of questioning, although both preschool and primary teachers took advantage of children's questioning to promote understanding, they did not explicitly encourage the children to ask questions (in 5 out of 18 episodes). Most questions were directed by the teachers to the children in order to reveal their previous knowledge, any problems they might be facing and their understanding. However, opportunities were often missed to build on children's questions or to encourage further questions across the course of a project, if the teacher did not feel that the question did not serve the purposes of this particular activity.

Making connections was also a learning activity that was prominently in science for both preschool and primary teachers. As observed in almost all the episodes presented, teachers planned activities that started off by eliciting children's previous knowledge and used observation and gathering evidence to connect previous knowledge to the topic or scientific concept taught. An important connection that all teachers strived for children to make was the one between the topic being taught and children's everyday life which is evident by their choice of context they provided to the children. Teachers in their interviews noted that they chose specific activities that have meaning to the children in their classroom, while they might not choose the same if they taught in a different school.

Learning activities observed in the 18 episodes commonly included children gathering evidence.

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This part of lessons focused more on children observing (the teacher demonstrating a part of the cycle of water (Stavros – Episode 3), themselves observing a natural process such as ice melting (Sonia – Episode 1), comparing through observation (Katia – Episode 1)). On the other hand there were fewer opportunities for children to use equipment to gather evidence and in the episodes where children were doing so, children were using everyday materials they have used before to carry out simple explorations. In only one instance the children got to use "scientific equipment" to gather evidence (Gianna –Episode 3). Learning activities that include observation and using simple equipment are also promoted in the curricula for both preschool and primary education. In the relevant section of the national report on policy (D3.2) it is commented that, "Teachers plan learning activities that encourage children to observe and describe natural phenomena, use simple tools to gather data and communicate their results or explanations at the end of the activity".

Differences between preschool and primary school

As mentioned in D3.2, there are no significant differences found between preschool and primary in the Greek curriculum, as learning activities suggested are focused on promoting children's explorations though gathering evidence by observing and using equipment. Differences in learning activities between preschool and primary in the 6 cases were evident, although they will be thoroughly analysed under the factors in the pedagogy section of this report that follows. That being said, there were instances of learning activities in preschool and primary that significantly differ due to the difference in the nature of the activities. In primary schools teachers tend to plan learning activities that are dominantly teacher-led. These are commonly a series of specific tasks that children have to complete without the opportunity of changing their learning path according to their interests. In preschool on the other hand, even though most episodes contain learning activities that are set by the teachers but are led by the children both in terms of pace and focus. In one case however, Sonia, provided children with a context and materials for exploration and left the learning activities to be set by the children.

Limited flexibility in the learning activities observed in primary schools was credited to time management issues by the teachers. The closed-ended nature of the learning activities in primary schools ensured that each activity would not exceed its designated time. Teachers in primary schools commonly rushed children to finish tasks or moved quickly from one task to the next in order to cover as many of the planned activities as possible. In preschools however, the lack of a rigid timetable allowed teachers to extend the duration of learning activities that they considered important or children seemed to enjoy. This particular finding will be expanded in the relevant time section of this report.

Differences between science and mathematics

Comparing the learning activities in mathematics with those carried out in science revealed significant differences. Learning activities in mathematics tend to include ... more than those in science. This is consistent with the curriculum analysis in D3.2 where learning activities in

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mathematics tend to be less open-ended than science, "designed to lead to an expected or 'correct' result".

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 one of mathematics episodes.

Opportunities and challenges for creative learning and teaching

The opportunities for creativity identified in the episodes analysed are indicated in the variety of different learning activities observed. Children allowed access to rich resources provided by teachers to carry out simple explorations and inquiries. Another opportunity was providing children with time and space to reflect on their own inquiries and consider alternative ideas and solutions to problems. In primary education, where time is limited and puts significant pressure on teachers, challenges to creative teaching and learning can be identified. In some episodes, activities were cut short in order to avoid delays in the planned schedule and children's questions were not answered. Further opportunities are needed for children to discuss and evaluate alternative ideas and evidence in both primary and preschool in order to promote creative learning as both dialogue and reflection on children's own inquiries have been identified as two of the important synergies between IBSE and creative approaches and particularly valuable according to the definition given to creativity for the purposes of the Creative Little Scientists project which is to "Generate alternative strategies and ideas as an individual and community and reason critically between these" (D2.2 Conceptual Framework).

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) 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 these synergies are presented with regard to the pedagogical differences evidenced between the preschool and primary cases and between science and mathematics, considering finally the opportunities and challenges for creative teaching and learning.

The role of **play and exploration** according to the Creative Little Scientists' Conceptual Framework includes the significance of open and role play, physical exploration, outdoor activities and use of digital technologies during the lessons in preschool and primary education. All forms of play were particularly valued by preschool teachers based on the data gathered during the lessons (in 7 out of 9 preschool episodes) and the teacher interviews (all three preschool teachers). Similar to the preschool curriculum that heavily promotes the use of play as

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the main pillar of pedagogy, teachers in preschool tend to plan the large majority of their lessons on playful exploration. On the other hand, in primary schools, playful learning activities were observed in only 3 of the 9 episodes (one from each teacher). It is interesting to note that in only one of the 3 instances where playful exploration was observed were open-ended activities that allowed children to freely play with materials or equipment. In 2 out of the 3 episodes teachers set up activities that relied on a strong element of completion (Stavros – Bee-bot, Sotiris – Little Prince) and only in the third (Gianna – Microscope), children were allowed to play with a piece of scientific equipment that they had never seen before and really motivated and excited both the children and the teacher. The result was for the teacher (Gianna) to postpone the planned activities and let children's excitement lead the way. No significant difference was observed between science and mathematics lessons in terms of play and exploration, although the mathematics lessons that included play were not focused on numeracy but rather on mathematical processes, such as measuring (Mina – Measuring tables) or orientation (Stavros – Bee-bot) or on children realizing the use of mathematics in their everyday life (Mina – Shape trees). In science, play was used to both promote understanding of scientific knowledge (Sotiris – Little Prince) and processes (Sonia – Ice balloons, Katia – Branches, leaves and pine cones).

The second part of this synergy, exploration, was dominant in both preschool and primary as teachers felt that it provides the essential context for children to learn in science. Physical exploration, although observed in all mathematics episodes presented here, is not the norm. In other mathematics lessons observed but not included in this report, children were not left in contact with any physical materials to explore, but rather worked with just their pen and paper.

The two remaining factors, outdoor learning and use of digital technologies, were heavily dependent on the school's location (GR2 site) for the former or the individual teacher's fluency with ICT (Sotiris, Stavros).

The importance of **motivation and affect** was evident in all episodes and further emphasised by teachers in interviews. All the teachers as part of their interviews highlighted the importance of motivating children and providing with rich stimuli through exciting learning activities. Similar to the previous synergy, the role of motivation and effect is one of the most important aspects of the pedagogy promoted. The national curriculum states under the title Teacher Role that the teacher has to create the necessary conditions so that in an environment which is attractive, safe, friendly and rich in stimulation, all children can be motivated to learn. The teacher has to organise appealing, meaningful and interesting teaching experiences in the spirit of collaboration, encouragement, acceptance, love and sharing. The teacher also seeks the "effortless participation" of every child in the daily activities at their own pace and takes advantage of children's previous knowledge and experiences as a starting point (GPI, 2003). The episodes observed and the teacher interviews mirror the direction of the curriculum, as teachers strive to motivate children and enhance their attitudes in science and mathematics.

Teachers In both preschool and primary tended to follow a common approach to the synergy of

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motivation and affect, as they all tend to use teaching approaches that are linked to this synergy at the beginning of lessons, usually to introduce a topic or an activity/exploration. This is particularly the case with the use of stories that teachers very often use to start a lesson. Similarly, other factors identified as part of this synergy, such as incorporating children's prior experiences in their planning and learning activities, relating science to everyday life and providing cross-disciplinary context were also observed in the majority of episodes regardless of education level or subject. All three factors are included in teachers' practice due to the promotion of the constructivist, cross-curricular approach in the current curriculum (D3.2 National Report).

Dialogue and collaboration were evident in both preschool and primary school observations alike. Small group settings and collaborative approaches were observed more often in preschool (in 6 out of 9 episodes) than primary (in 3 out of 9 episodes) with preschool teachers preferring group work to individual or whole class activities during children's explorations. Primary teachers on the other hand tend to stay away from group work, with children forming groups either in competitive tasks (Stavros – Bee-bot) or when resources were limited (Stavros – Plants, Sotiris – Little Prince). Classroom discussion is one more learning approach that was frequently observed in the episodes for both preschool and primary. Similar to the use of stories to introduce topics, classroom discussion was very often used as a concluding activity. Teachers gathered children and started (and led) a discussion as a form of formatively assessing children's knowledge. Classroom discussion was also used by all preschool teachers to evaluate affective aspects of learning at the conclusion of lessons, with teachers asking children to express their feelings about the lesson.

In relation to **problem solving and children agency**, inquiries tended to be rather more teacher led and structured in primary classes compared to those in nurseries. In regard to the frequency of use of the three types of inquiry (open/guided/structured) in preschool and primary lessons, a guided approach is the choice of the majority of episodes observed for the former, while a structured approach is the preference for the latter. They were instances of an open approach to inquiry in preschool (Sonia – all episodes), as they were for a guided instead of a structured approach in primary (Gianna – all episodes). Opportunities for children to solve problems were not allowed very frequently by teachers in the 18 episodes observed. In 8 (4 for preschool and 4 for primary) of the episodes teachers allowed children the opportunity to tackle a problem. In most cases teachers had planned to introduce a particular problem or anticipated its rise. In other cases however, the teacher allowed children space and time to explore which inadvertently led to children discovering problems (Sonia – all episodes) or totally unexpected situations arose which posed problems to children that the teacher had no preparation for (Gianna - baking sheet problem). No difference was observed for this synergy between science and mathematics.

Fostering **questioning and curiosity** in their pupils is considered as very important by teachers in both preschool and primary schools. Teachers however tend to focus more on eliciting children's

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curiosity than encouraging their questions. In only 4 episodes teachers explicitly invited questions from children, telling them to think of questions to ask. On the other hand, teacher questioning was the most frequently used teacher-pupil interaction in the episodes observed, in order to encourage children's observations and predictions and allow them to make connections. A teacher trying to elicit children's curiosity was also frequently observed in the 18 episodes presented, although in reality curiosity was not observed in the context of this synergy which supports that teachers often employ open ended questions, and promote speculation by modelling their own curiosity (D2.2). Curiosity in this context is seen more as complimentary to motivation, one more driver for children to keep children interested in learning. Since teachers seem to be very focused on keeping children interested in learning, it is worthwhile to note the failure to acknowledge multimodal expression in a lot of the episodes presented. This is particularly relevant for mathematics episodes, where only in one episode (Mina – Shape trees) multimodal expression and experience was recognised.

The teacher has a key role to play in promoting a supportive climate for debate, questioning, feedback and critical reflection which is the essence of the next synergy identified in the conceptual framework which is fostering **reflection and reasoning.** In less than half of the episodes (8 out of 18 episodes) observed teachers were supporting children's reflections and encouraged children to consider alternative ideas. Children evaluating of alternative ideas was more commonly found in science than in mathematics. This can be attributed to the more closed ended nature of mathematics tasks observed as mentioned above, where the task ended as soon as children found the one correct answer. The episodes that teachers encouraged children to consider alternative ideas, particularly in mathematics, were devoted to teaching process skills rather than specific content (measuring, handling the microscope). Out of all the activities that required children to learn specific content in science or mathematics, only one, the Bee-bot activity, was planned to specifically allow children to consider alternatives and evaluate from them to choose the correct one. Although reflection and reasoning is highlighted in every teacher interview as an important aspect of children learning, was not evident in the majority of lessons due to the fact that teachers did not allow children time to reflect on the activities carried out. In these episodes, when children come to a conclusion or result, the teacher congratulates them and moves on to the next planned task. Reflection is only promoted as part of the classroom discussion (done for assessment purposes) after the completion of all planned activities.

Teacher scaffolding was characteristic of both preschool and primary school pedagogical approaches. Scaffolding was particularly obvious in the teacher's on-going interactions throughout the session and less so in the structure of the learning activities. Teachers in both preschool and primary classrooms preferred to intervene during the activities, almost exclusively through the use of questioning, to remind children about the importance of exploration, observation and certain scientific processes and keep them focused to conquer the learning objectives set. The few episodes were the activities were structured to allow scaffolding involved open-ended problems were often offered as supportive scaffolds for learning. The

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difference between preschool and primary regarding teacher scaffolding is that primary teachers used explicit instruction more often than delaying instruction until the learner has had a chance to investigate and inquire on their own or with others. In preschool the situation is reversed, as teachers tend to allow time and space for children to investigate more often that getting involved immediately and offering specific instructions to lead children to the desired/correct outcome. The preschool teachers can be considered as facilitators of learning, with Sonia being an exemplary case of a teacher being highly attentive to children's observations and ideas and facilitated children in taking up positions both as decision-makers and agentic learners, utilising the time and space made available for them to explore and experiment.

Opportunities and challenges for creative learning and teaching

Opportunities for creative learning were seen (and mentioned above) through the pedagogical framing of activities and the learning aims and objectives set by the teachers during the planning stage and involved pedagogical approaches that encourage children to play and explore, take the lead during their inquiries and choose their strategy to solve problems. The pedagogical interactions observed between teachers and children or among children that possess the potential to promote creative learning, allowed learners to engage in dialogue and collaborate, and supported metacognition. This involved teachers standing back to allow children time and space to explore freely, which strengthened their agency as learners or teachers asking questions to facilitate reflection and reasoning. The most dominant aspect of teachers' views on their practice though was motivating children and sustaining their excitement in learning for both science and mathematics. Motivation, along with curiosity, takes a dominant place in both pedagogical framing of lessons and the interactions during the lessons. This is not the case however with imagination, as it was used in a rather limited capacity in both preschool and primary schools. In most case, imagination was used to encourage children to think about the abstract concepts in science and mathematics, usually when teachers said "Now I want you to use your imagination to…".

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 (e.g. Sotiris – Moving pictures and cartoons). Finally, it is worth to mention that the majority of the teachers who took part in the in-field research do not seem to have a clear idea of what is creativity, either as a concept in its own right or in relation to mathematics and science. Creativity is an intriguing, but vague concept for teachers, who seem to have many challenges in planning their lessons to promote it. It is thus, more commonly associated with the arts (e.g. children being creative through their drawings) than science and mathematics. In practice creativity is intertwined in children's free expression, as opposed to children being able to generate alternative strategies and ideas and reason critically between them. It might be this nebulous conceptual understanding of creativity that limits teachers' pedagogy in promoting creative dispositions to motivating, engaging and developing positive

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curious attitudes in children, instead of including children developing a sense of initiative, problem solving, connections making and reasoning skills as well.

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. In only 2 of the 18 episodes factors related to assessment were not coded. Where assessment approaches were in evidence they tended to be planned and formative. Teachers in both preschool and primary schools devoted time during the lessons to evaluate children's knowledge through teacher questioning. Similar to the use of storytelling at the beginning of lessons for introductory purposes, classroom discussion was used for assessment purposes at their conclusion. However, formative assessment questions were also used during lessons for the teacher to review children's understanding before moving on to a different activity that had different learning aims.

In preschool, teachers brought the children back from their work tables to sit as a group usually in a circular shape in front of the teacher. This setting had a special name for each of the cases observed and when children were sitting there they had to follow certain rules. According to the teachers in preschools, this is done for classroom management purposes to decrease children shouting and arguing. Children who wished to speak had to raise their hand and get permission from the teacher. This was totally different during the learning activities that were carried out in small groups where children were free to discuss and speak freely. In primary classrooms, where children rarely worked in groups rules applied during the entire lesson.

Another difference between preschool and primary assessment strategies was the inclusion of affective aspects of science and mathematics learning apart from cognitive. In 2 out of the 3 preschool cases, teachers asked children how they felt during lessons, whether they enjoyed themselves, if they would have done anything differently. The answers they received were used to inform their planning of subsequent lessons. Both Mina and Sonia stated that some of the lessons observed were fueled by comments and suggestions from children. Apart from being sensitive to children's attitudes towards learning, preschool teachers were also more open to multimodal assessment. Apart from children's answers in oral and written form, children's drawings were used very often in both preschool and primary schools. Children were either asked to draw what they felt in regard to certain learning activities or use their imagination to answer a hypothetical question. One preschool teacher also evaluated children using their stories (Mina – Paintings), while one primary teacher used role playing to assess children's understandings (Stavros – Plants).

Although not evident in the episodes presented in this report, in primary mathematics lessons summative assessment strategies were commonly observed. Teachers handed out work sheets for children to complete in a given time frame to assess their understanding of previous topics. It was also observed for entire lessons that lasted up to 90 minutes to be devoted to children solving arithmetical problems. These were called revision lessons and were held when an

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important part of content was covered (e.g. subtraction). Another approach to summative assessment that was observed in Sotiris' classroom were a half-hour mathematics competition were children had to solve a number of exercises. If they got every answer correctly they were crowned kings and queens, if they had one mistake princes and princesses and so on. In contrast to other summative assessment activities, children in Sotiris' classroom were very excited to solve numeracy problems. Similar lessons were absent in science. The inclusion of such activities to assessment in mathematics shows the increased focus on cognitive aspects of mathematical learning compared to science where children are usually asked to present their work and explain their choices and thoughts. This is caused by the lack of any assessment strategy to evaluate children's understanding about scientific inquiry or science processes.

Opportunities and challenges for creative learning and teaching

Opportunities for creativity in teaching and learning in assessment processes observed are mostly linked to the creative dispositions that have been part of the pedagogy of the teachers such as motivation, imagination and curiosity. Classroom discussions revealed children's thinking and their understandings on very specific topics which allow opportunities for the teacher to modify his/her planning and teaching practice. This can be considered as a significant opportunity for creative teaching due to the role of assessment in planning more interesting and meaningful learning activities.

An important barrier however is the large class size in most Greek schools. As mentioned by Katia, it is very difficult to include every child in the discussion when there are more than 20 children in the classroom. It is very challenging for a teacher to assess the children that do not feel comfortable in front of the entire class in these settings. As a result, only a portion of the class actively participates in these classroom discussions, even though all children are given the opportunity to speak through teacher questioning.

4.2.5 Materials and Resources

There is great variation in terms of materials and resources used in the 6 cases observed. Classrooms lacking materials and proper resources was a common complaint of many of the teachers who participated in the in-field research. Sonia said in her teacher interview that lack of materials is the biggest barrier she has to face in her planning.

Even though teachers felt their schools were underresourced, the materials used in the classroom facilitated children's explorations and managed to get children immersed in the tasks. In 7 out of 18 episodes analysed the resources provided managed to create a learning environment that fostered creativity. Everyday materials were used in both preschool and primary to facilitate links with children's previous knowledge and everyday life and promote the relevance of science to everyday life. Examples of everyday material used include cooking supplies, drinking straws, balloons, ribbons and dice among others. Science activities were more likely to take place in a rich physical environment that fosters creativity.

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Human resources on the other hand proved to be more challenging as in most cases teachers did not have any assistance and even in the private preschool where a German teacher was present during the lessons, she was not able to contribute anything other than trying to control children's behaviour.

The list of mapping and comparison factors highlighted the thoughtful use of physical resources, together with valuing the potential of physical materials, and the way in which the classroom environment fosters creativity in science and mathematics, as under-researched. The fieldwork 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. The fieldwork revealed that the use of outdoor resources depended heavily on the school setting and philosophy rather than individual teachers' beliefs. In 2 out of the 4 schools visited outdoor activities were not mentioned as possible to be carried out due to physical constraints. Limited outdoor space which was covered in concrete did not allow teachers to plan outdoor activities in these 2 schools. On the other hand, in the two schools where the location and infrastructure allowed outdoor exploration motivated teachers to plan outdoor activities.

A further area highlighted as under-researched was the use of ICT and digital technologies and in particular confident use of digital technology. The fieldwork revealed that ICT resources were being used in primary classrooms (e.g. Gianna – Playing with the microscope, Stavros – Plants, What are clouds made of?, Bee-bot, Stavros – Little Prince, Moving pictures and cartoons). However the use of ICT is almost always away from the hands of children or used to carry out simple assessment tasks (e.g. children filling in a table that reviews the parts of a plant). Given the considerable potential of ICT to facilitate children's creativity, this remains an area that is under-researched.

Also identified in previous Creative Little Scientists work (D2.2) as under-researched is the use of informal resources for nurturing creativity in early science and mathematics. In terms of both science and mathematics, the fieldwork confirmed that across all cases many resources provided in the classroom were informal and related to play and exploration, motivation and were intended to stimulate children's curiosity and interest in science and mathematics.

4.2.6 Grouping

The analysis of the grouping of children during science and mathematics will be carried out in contrast to 3 different factors: multigrade teaching, ability grouping and small group settings.

Even though multigrade teaching is common in Greece, especially for schools situated in remote and rural, none of the cases observed included more than one age group being present in the same classroom. Ability grouping on the other hand is not an established practice in Greece, as there is no provision to divide children according to their ability. There were 3 teachers that, as part of their interview, referred to their approach in grouping children. The deciding factors according to those teachers were based largely on behaviour rather than ability. As Katia

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mentioned in her interview, she tends to place only one strong character in each team. However, *"When this child starts to be disruptive to the rest of the group, I put another such child in the same team to let them taste their own medicine and understand how difficult it is to collaborate".*

Small group settings on the other hand were used in 7 out of 9 episodes in preschool compared to only 3 of the episodes in primary school. Primary school teachers tend to use more whole group activities than preschool teachers where whole class activities are strictly used to introduce a topic and motivate children or as an assessment activity to conclude lessons. The importance of small group work to both preschool and primary school is analysed in detail in the pedagogy section (4.2.3) of this report.

The most significant barrier in using small groups comes from primary teachers who believe that there is not enough time for collaborative work in primary schools. Teachers have to cover a multitude of curriculum topics, particularly in mathematics, the open-ended nature of group work along with the added responsibility of managing children's behaviour make activities that require group work seem costly in terms of time management.

4.2.7 Location

The list of mapping and comparison factors established by the project during the work of WP3, highlighted 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.

The observations across the 6 cases showed that location, in terms of the factors presented above, is heavily dependent on individual teacher's teaching philosophy, the school philosophy, but more importantly the school location and building. Even though no differences were found between preschool and primary school, outdoor learning was observed more during science than mathematics lessons. A significant barrier which is common across all cases is the limited use of outdoor learning as a popular teaching practice in Greece. Even though the current curriculum includes opportunities for outdoor learning in the guidance it provides, this does not seem to be the case in Greek schools as teachers use outdoor activities considerably less often.

4.2.8 Time

In terms of time management, the list of mapping and comparison factors for fostering creativity in early science and mathematics highlighted sufficient time for learning science and mathematics to be a key issue. In 8 out of 9 preschool episodes, sufficient time was provided for all the learning activities and rarely children were rushed to complete a task so that the entire class could move on to the next planned activity. Preschool teachers preferred to devote additional time to the activities carried out and cancel other activities that were included in their planning. On the other hand, in half of the episodes for primary, activities were concluded with teachers postponing parts of the activity for a later date. Primary teachers preferred to go through as many of the activities planned in the time available. This can be attributed to the

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overloaded curriculum in primary as reported in both the national report in policy (D3.2) and teacher interviews.

An important difference between science and mathematics in terms of time available to teachers was the significantly more time devoted to mathematics compared to science, particularly in primary schools. The fixed timetable in primary schools contains more than 4 hours per week for mathematics and only 2 for science in most schools. Teachers mentioned in their interviews that they often take up the time allocated to the Flexible Zone (D3.2 National Report on Policy in Greece) in order to carry out learning activities in science. In general significantly more time is devoted to mathematics teaching than science for both preschool and primary.

4.2.9 Content

In terms of content in the episodes observed and the data gathered from teacher interviews, it was apparent that mathematics was often identified as a discrete subject area, particularly in the primary school setting.

The majority of mathematics episodes presented in this report present a mixture of cross-curricular and subject-specific teaching and learning. Cross-curricular activities were used by teachers to promote process skills (Mina –Measuring tables, Gianna – Baking cheese pies, Sonia – Game of swallows) in both preschool and primary in mathematics, but it has to be noted that the episodes observed are not representative of the majority of mathematics lessons. Other mathematics lessons that were observed and not presented here as episodes tended to focus on developing children's numeracy skills and limit learning activities to repetitive tasks were children had to solve simple problems or follow the teacher's lead in learning new mathematical concepts. This difference in pedagogy can be attributed to the overloaded curriculum in primary mathematics which contains a large amount of learning aims and objectives that teachers have to help the children achieve. This is identified as the largest barrier to creative teaching and learning in regard to content in primary education mathematics.

When looking to science, cross-curricular approaches to teaching and learning were very common. Examples of cross-curricular contexts for teaching in science such as Mina's 'Paintings' or Stavros' 'Little Prince' evidence links between science and the arts for the former and language and literature for the latter. Having said this, subject links between science and mathematics were commonly observed in science lessons with teachers trying to incorporate simple and brief numeracy tasks (e.g. children counting the people falling in one of the two paintings in Mina's "Paintings episode). In other lessons, such as Gianna's cooking lesson, science and mathematics are integrated that they include mathematics learning aims apart from aims and objectives linked to science. Another finding for science highlights the similar themes visited in both preschool and primary for science. Themes like the cycle of water or plants are a significant part of the science curriculum in both age groups and children continue to work on them after they leave preschool and continue to primary. There is however a difference between preschool and primary education, as similar topics in science are more process-

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oriented at preschool (e.g. observation highlighted) and fact-oriented (e.g. children able to name parts of the plant) at primary.

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5. Implications

5.1 Implications for teacher training

The narrative episodes from the in-field research presented in this report have revealed a number of findings that have the potential to promote for creativity in early science and mathematics education. These important findings contribute to the previous work carried out in the project, aimed at revealing teachers' conceptualisations and probing classroom practice and suggest implications for teacher education and professional development.

In terms of teachers' conceptualisations, teacher education should provide instruction on setting aims in science and mathematics which highlight opportunities for fostering inquiry and problem solving, the nature of science and creativity. The majority of teachers observed in the in-field research tend to include elements of the factors identified in the Conceptual Framework (D2.2). This however cannot be attributed to their education or participation in professional development, but rather to their experience in the classroom and their personal beliefs. There is a need of teacher training to provide specific instruction in order to provide teachers with a solid conceptual understanding about scientific inquiry, problem solving and creativity. This is particularly relevant for creativity which, similarly to its portrayal in the current curriculum, is rather vaguely defined by teachers both in terms of conceptualisations as well as in practice. The need for practical instruction in teacher training in regard to creativity is also evident. Teachers need to be provided with opportunities to experience and study exemplary lessons that will allow them to clarify the concept of creativity early in their careers. Additional attention should be given to providing opportunities for primary teachers to include aims that value the role of play and collaborative work which have been found to be underrepresented in primary schools.

Teacher education should also provide teachers with more opportunities connected to planning and carrying out learning activities that foster scientific inquiry and creativity. The opportunities provided would allow teachers to feel more comfortable in planning and realising open-ended activities where children's questioning, heavily underrepresented in the episodes is encouraged and viewed as a driver to promote both cognitive and affective development. In order to succeed in empowering teachers towards using more open-ended activities in their lessons, teacher education should also focus on methodically promoting teacher scaffolding and their ability to stand back or intervene in ways that do not stifle, but facilitate children's agency. Teacher education should help teachers recognise the value of encouraging children's questioning in promoting cognitive development by providing specific examples of learning activities linked to scientific inquiry that highlight the role children's questioning, planning and evaluating evidence. Teacher education should also provide opportunities for primary teachers to include more learning activities that highlight the role of collaboration and playful exploration. The findings reported here highlight the limited role of both elements in primary education, as teachers tend to prefer whole group activities to small group settings and severely limiting the amount of playful activities during lessons. Teachers should feel confident in encouraging children to express, share and evaluate their ideas and explanations. In order for

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teachers to be successful in allowing that kind of space and time for children's expression, teacher education should also provide them with examples that show a variety of different ways that teachers can encourage children to expressing ideas. This could convince teachers on the potential of communication to facilitate children's reflection and reasoning.

Another aspect of teaching practice that teacher education should provide additional instruction is materials and resources used in the classrooms. The findings of this report highlight the provision of rich resources in science and mathematics learning activities in order to facilitate both scientific inquiry and creativity. Teacher education should provide teachers with opportunities that highlight the role of materials in strengthening children's explorations and their sense of agency in learning. Apart from allowing teachers to understand the potential of rich resources, teacher education should also encourage them to search for materials and resources to enrich their practice on one hand and empower them to be able to plan learning activities around everyday materials by taking advantage of opportunities that stem from children's own interests.

The final aspect of teaching and learning which teacher education should contribute in order to promote creativity in early science and mathematics education is assessment. Assessment is the one curriculum component that has been identified as underdeveloped in all previous stages of the project (Conceptual Framework, curriculum analysis, teacher survey). Teacher education should provide teachers with a framework that will allow them to evaluate children using a variety of strategies, both formative and summative, valuing diverse forms of assessment and involving children in peer/self assessment.

5.2 Implications for policy development

The episode analysis reveals that preschool teachers allowed significantly more space and time to their planned activities in science and mathematics than primary teachers. Learning activities in primary schools tended to follow a strict timetable that allowed limited flexibility for the teacher to extend the duration of an activity during lessons. Primary teachers attribute this to the overloaded curriculum in mathematics and language in the first grades of primary school that leaves very limited time and space for child-driven explorations in mathematics and severely limits the teaching hours available for science (the wider curricular subject entitled Study of the Environment) in primary schools. The findings from the case studies presented in this report strengthen the tensions and criticisms mentioned in the policy report of WP3 (D3.2) where the quantity of content to be covered was not in line with children given time and space to guide their inquiries and control their learning. Policy for science and mathematics should allow sufficient time and space for both children to be able to lead their explorations and for teachers to be flexible in terms of time management to allow that kind of freedom to their pupils.

The findings presented in this report also highlight the need for providing a more concrete framework for creativity to practitioners. Teachers did not seem to have a concrete and working

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definition of creativity or any of the creative dispositions identified in the Creative Little Scientists' Conceptual Framework. Although some of these dispositions (e.g. motivation, curiosity) are valued by teacher, they are not closely associated with creativity, especially in terms of learning objectives and activities. Policy should provide ample guidance for practitioners to be able to foster creativity in science and mathematics in both preschool and primary education in Greece.

However, based on the analysis of the case studies, there is a clear need for official policy to offer meaningful and targeted continuing professional development (CPD) initiatives to provide teachers with a coherent view of teaching practice within the framework of the National Curriculum. A large scale CPD initiative is being carried out in Greece at the moment but, as mentioned in the national report on policy (D3.2), recent change in government has left the programme to be implemented in a much more limited scale than initially announced. The lack of CPD opportunities and official guidance offered to practitioners in Greece has led to teachers developing a curriculum based more on their personal interpretation, professional experience and beliefs rather than on the guidance of the official curriculum documents.

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