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

D4.3 Country Reports

Report 2 of 9:

Country Report on the in-depth field work in Finland

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D4.3 Country Reports

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1. Aims of the report

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

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 six sites of pre-primary and early primary education. Each case contains episodes, documenting examples of science and mathematics through the lens of creativity.

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Finally, this report is one of the working documents that will provide input to the *Report on Practices and their Implications* (Deliverable D4.4), which is the final outcome of Work Package 4. The latter will give a detailed account of the analysis of the evidence gathered through the field work in all partner countries, as well as identify a set of exemplary Case Studies illustrating the variety of approaches observed and the possibilities identified.

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 Finland 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

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of primary education in the partner countries. As such, this report has to focus on research questions RQ2, RQ3 and provide input towards RQ4.

Sub-questions running across all research questions probe:

- **Aims/purpose/priorities**, including teachers' explicit and implicit perspectives and identities as scientists and mathematicians, and in relation for example to: aims and purposes of creativity in science and mathematics education; how science and mathematics are taught and learned in relation to other domains of knowledge; how these shift from pre-school to primary across the consortium; how these relate to inquiry-based science education (IBSE); views of creativity in relation to perceived purpose.
- **Teaching, learning and assessment**, including learning activities, pedagogy and resourcing, and in relation for example to: multimodal expression and experience; learning activity types; resources used; dynamics between adults and children; exploration; questioning and argument; also how teachers assess creativity in early science and mathematics education.
- **Contextual factors**, including ethos, teacher characteristics and teacher general education and knowledge, skills and confidence, curriculum, institutional factors, home-school links and the wider cultural background, location, grouping, time.

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

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

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Table 1: Dimensions, Sub Questions and Factors

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

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	Materials and Resources ***Framing and Interaction***	With what are children learning?	• rich physical environment for exploration; Use of physical resources thoughtful; Valuing potential of physical materials; Environment fosters creativity in sci/ma • sufficient space • outdoor resources; recognition of out of school learning • informal learning resources • ICT and digital technologies; confident use of digital technology • variety of resources • sufficient human resources • policy documents; NO reliance on commercial schemes	• M:Explor. • M: Cr • M:Space • M:Outd. • M:Inf. • M:ICT • M:Variet. • M:Human • M: Pol.
	Dimensions	**Sub questions**	**Factors important to nurturing creativity in science and mathematics in the early years**	**Coding**
PEDAGOGICAL FRAMING	Aims and Objectives ***Framing and Interaction***	Toward which goals are the children learning?	• knowledge/understanding of science content • understanding about scientific inquiry • science process skills; IBSE specifically planned • capabilities to carry out scientific inquiry or problem-based activities; use of IBE/PBL • social factors of science learning; collaboration between children valued • affective factors of science learning;efforts to enhance children's attitudes in science and maths • creative dispositions; creativity specifically planned	• AO: Kn.Sc • AO: Und. SI • AO: Sc Proc Skills • AO: IBSE/PBL • AO: Social • AO: Affect • AO: Creative
	Location ***Framing and Interaction***	Where are they learning?	• outdoors/indoors Recognition of out of school learning • formal/informal learning settings/ • small group settings	• L. Out/ • Indoors. • L.Formal/ Informal • L.grp
	Grouping ***Framing and Interaction***	With whom are they learning?	• multigrade teaching • ability grouping • small group settings • number of children in class	• G:MG • G:Abil. • G:SmallG • G:No.

2.2 Research Instruments and materials

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.

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

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

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

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

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

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

The research instruments chosen by the *Creative Little Scientists* consortium were also applied in this study. Eight core instruments were used: a map of the classroom or learning area, some field notes, videotapes, digital photos, teacher interviews, children's group interviews and children's artefacts. In addition to these, there were repertoire instruments such as a planning sheet, local curricula, evaluation sheets and learning material which teachers have created and/or published themselves.

All site visits were *videorecorded* to capture as authentic a description as possible about the learning situations. Videotaping provides very rich first hand data, gives access to other partners to see and evaluate the episodes and enables researchers to later reflect on the situations. Mostly only one video camera was used but in some cases two cameras were available. In addition to the video camera, when necessary, a photo camera was also used for videorecording (e.g. if the battery needed recharging). Because videotapes provide detailed insights for discussions and interactions during the activities, field notes and sequential digital photos were not taken systematically, only used as supplemental material.

Researchers always made their video recordings from the back of the learning situation. The camera was mostly in one place and was positioned to cover the learning area; sometimes the researcher walked around with it during observation to gain a more

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multidimensional overview of the children's and teacher's work or to capture more detailed insights into individual activities.

Alongside the videotaping, digital photos were taken to capture some additional material and to focus on some specific detail. Photos provide good insight into some particular situation (e.g. grouping, relationships etc.) or object (materials, tools, artefacts etc.). A total of 635 photos were taken and stored on local servers.

There were two interview instruments, one for the teacher (see appendix 19) and one for the children's group interview (see appendix 20). The project template protocol was used for the interview and translated into Finnish. Interviews were always conducted after the observation period, during the second visit. All the interviews were recorded and conducted in quiet, comfortable environments; the teacher interview and children's group interview were parallel or sequential.

Data on the children's artefacts was mainly collected through digital photos; electronic material created on an interactive whiteboard, was saved and uploaded into the databases; when available, examples of learning activity sheets were captured.

As a supplemental research instrument, official material was also collected. Teachers were asked to provide planning and evaluation sheets, local school curricula and evaluation sheets intended for summative evaluation. In addition, Internet pages were used to gain site information on the school.

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.

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

Data for this study was collected on 6 experienced classroom teachers with the aim of focusing on their teaching, learning and assessment, reflecting on good practices (see D4.1). Firstly, there was particular focus on their experience in science or/and mathematics education as well as in early years education. Secondly, voluntary teachers from those who had participated in the teachers' survey during the earlier phase of this project had to be found and thirdly, teachers were to be selected from different parts of Finland to confirm the geographical representation.

Based on these criteria, researchers started to clarify the potential teachers suitable for participation on the study. Some recommendations were received from policy makers on the Finnish National Board of Education; researchers used their collegial contacts and studied teacher journals to seek for suitable participants. Based on the process described and this background work, in total, 8 teachers were contacted. Two refused participation, so 6 teachers were selected for the study (see table 2).

The teachers and their schools were located in different parts of Finland (see figure 1). Researchers contacted the schools in December 2012 to decide on the potential dates for visiting during the data collection period which had been agreed on the *Creative Little Scientist* –project. With the exception of Joensuu in Eastern Finland which had two participants, each municipality had only one.

Table 2. Sampling information

Fieldwork Sites		**1**	**2**	**3**	**4**	**5**	**6**
General Selection Criteria	-Participation in survey - National awards -Published school materials	Mary	Kirsten	Rita	Rachel	Helen	Tina
Phase	Preschool	X	X	X	-	-	-
	School	-	-	-	X	X	X
Governance	Non-fee paying				x	x	x
	Fee paying	x	x	x			
Age(s) of children	3	-	-	-	-	-	-
	4	-	8	15	-	-	-
	5	-			-	-	-
	6	14	13	3	1	3	-

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	7	-	-	-	6	9	-
	8	-	-	-	12	10	-
	8-9	-	-	-	-	-	13
Mixed age groups		-	X	X	X	X	-
Special school							
High Diversity	SEN	X	X	X	X	X	X
	Non-native speakers	-	-	-	X	-	-
	Socio-economic disadvantage	X	X	X	X	X	X
Location	Urban						
	Suburban	x	x		x	x	
	Rural			x			X

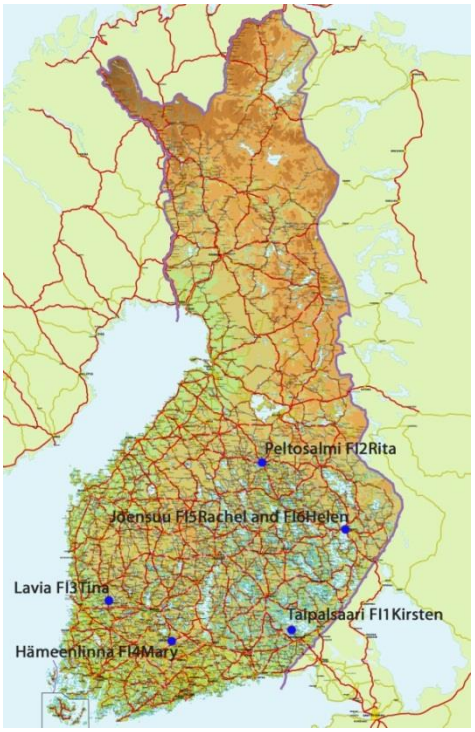

Figure 1. Geographical location of schools involved in the study

2.3.2 Site visits

The researchers personally visited each site themselves. Due to the long distances, two visits were combined and longer observation time was spent during the same visit. However, researchers confirmed that during these visits they had been able to collect all the information intended for the project. Teachers from Joensuu were involved in another research project at the same time, so their first data collection period was conducted before the actual data collection period of WP4 in the consortium.

The task and timetables of the visits are presented in the following table (table 3).

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The teachers were not asked to specifically plan anything out of the ordinary for research purposes, rather to work with materials and activities which are appropriate and inherent for the teacher and children. The researchers wanted to observe normal everyday activities in natural circumstances.

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Table 3. Data collection process: dates, sites and aims of visits.

Visit	Dates	Site	Aims of visit
1st – 4th Visit	20.9.2012 8.11.2012 11.2.2013 4.2.2013	Joensuu / FI6Helen	to observe daily, learning activities with recordings to create a map to make field notes to talk with children to talk with teacher(informally) to collect material available
1st – 4th Visit	27.9.2012 15.11.2012 1.2.2013 15.2.2013	Joensuu / FI5Rachel	
1st Visit	22.1.2013	Taipalsaari/ FI1Kirsten	
1st Visit	24.1.2013	Peltosalmi/ FI2Rita	
1st Visit	28.1.2013	Lavia/ FI3Tina	
1st Visit	29.1.2013	Hämeenlinna/ FI4Mary	
Interviews	26.2.2013 (teacher) 27.2.2013 (children)	Joensuu / FI5Rachel	to observe daily, learning activities with recordings to talk with children to interview and photograph teacher and children to collect more material such as curricula, teachers' working plans etc.
Interviews	27.2.2013	Joensuu / FI6Helen	
2nd Visit	7.2.2013	Peltosalmi / FI2Rita	
2nd Visit	8.3.2013	Taipalsaari / FI1Kirsten	
2nd Visit	21.2.2013	Lavia / FI3Tina	
2nd Visit	20.2.2013	Hämeenlinna / FI4Mary	

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2.3.3 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.
- 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).

The key elements of ethical research are voluntariness and trust (Ryen 2004). All participants on this research were entirely voluntary. Before the onset of the study, researchers contacted the teachers several times through e-mails and telephone conversations in order to explain the aims of this study. The teachers' voluntary participation in observations and interviews was highlighted and their confidence to work with the researchers was confirmed through informal discussion about the needs and aims of the research.

Current with the preparation for the teachers' participation, permission to undergo this research was requested from the school or kindergarten in question. A letter informing about the research and request for permission to conduct it, was sent to the Head of each kindergarten or school. All sites reacted positively to the researchers' visits and granted research permission. In addition, in one case, a representative of the municipality signed the document granting permission to conduct the research.

The teachers worked with the children, thus confirming the children's voluntary participation. Via the teachers, researchers sent a letter to parents in which the aims of the study as well as all the research instruments and use of the data were explained (see appendix 21). Based on this, parents gave permission for the child to participate on the study, as well as their permission to use videos, photos and children's artefacts as a part of

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the study and in the project's internal communication. All the children were given permission to participate on the study.

The children were interviewed as a group. Beforehand, the researcher had discussed the idea of the interview with the children and had asked who would like to participate, thus confirming the children's awareness and voluntary participation. In some instances, more children wanted to be interviewed than was actually required, so several interviews were organised to give all the children this opportunity.

The research produced rich, detailed data, consisting of material which is not anonymised and which makes individual identification possible. This raw, research data has been securely stored by the researchers and only short episodes from it can be provided for consortium access. The video material used for narratives is intended for internal discussion only and cannot be publicly presented. The parents allowed the material photos to be published in this report.

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.

Analysis of the Finnish data

Firstly, the videotapes were reduced and potential episodes were created. The focus was placed on the following criteria in material selection:

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1) existence of creative dispositions in teaching/learning activity
2) existence of inquiry approach in teaching/learning activity
3) existence of teacher or /and child centreness

The final sample consists of episodes of all participating (n= 6) teachers.

After selection of the episodes from the total data, the narrative descriptions were produced according to methodological guidelines of WP4 (see D 4.1). The main discussions in the video recording were translated, explained or summarised in narrative descriptions, and the narratives were coded using the shared coding system. The translated narratives were stored within Moodle to enable the other partners' access to these; the rest of the material was stored in UEF databases.

In order to be able to find synergies between science, maths and creativity, the episodes were analysed using the coding schema provided in D4.1. Based on three episodes from one case, the case descriptions were produced through summarising and synthesising the analysis done in separate episodes, focusing on a) Pedagogical Framing b) Pedagogical Interaction c) Opportunities for mathematics and science learning and d) Opportunities for Creativity.

2.4.2 Limitations

This study provides only very limited insights within a particular time frame, thus the observations are only examples of the learning activities that are generally conducted at sites. Because of time limits on the project regarding the collecting and analysing of data, no generalisation can be driven. In addition, the provided implications may be limited.

All the episodes could not meet the level of excellence. The teachers who were observed were selected, based on several criteria, therefore a level of excellence could not be confirmed in advance. The teachers selected their teaching content and methods themselves and in order to ensure confidence in the teachers' participation during the pre-phase of the study, this factor was not highlighted.

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3. Case studies

The case studies consist of three episodes created from the collected data. The episode narratives are enclosed as appendices (see appendices 1-18) in this report. In this section the specific context, general description and the summary of findings from each case is presented in terms of research questions (D 2.4), factors created on the project (D 3.1) and suggestions based on the earlier phases of the project research (see for example D 3.4).

3.1 Case 1 Mary – Learning science and maths in an outdoor environment

3.1.1 Context and teacher's background

Where?	Country	Finland	
	Setting name	FI4	
	Location within setting	Pre-school	
Who? (children)	Year group/age of children	6 years	
	Number of children in class	14	
Who? (adults)	Number of adults	2	
	Role of adults	Teacher and assistant teacher	
	Case teacher role	Learning science and maths in natural environment	
When?		1 & 2	3 & 4
	Dates of visits	29/1/13	20/2/13
	Times of visits	8.30-13	8.30-14

a) School/setting

The kindergarten is located in Hämeenlinna (South-west Finland, population of 67 506) and is run by the Local Education Authority. In the beginning of 2012, the kindergarten started the international programme 'Eco-Schools' which aims to raise children's awareness of environmental and related sustainable issues. Activities at the kindergarten are determined by the surroundings and the children's interests. Values held in esteem at the kindergarten are: the child and childhood, parenthood and partnership in care and education, safety, nature and surroundings. (Kindergarten Hirsimäki 2013a; Statistical Centre 2013a.)

When the kindergarten was founded in 2001 it was surrounded by forest; focusing on nature and the environment seemed to be a natural choice. Although the kindergarten is nowadays surrounded by a residential area the focus still remains. The kindergarten has

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one preschool group in which nature and environmental activities are emphasized more than in the other groups. The original idea of forming this group came from the Head of the kindergarten; the group was developed, using as an example another group, Luhtaröllit, from the Pirkkala municipality. This preschool option has been available from 2005. (Kindergarten Hirsimäki 2013a; FI4Mary_Pre_Int_200213.)

There are 6 groups in the kindergarten, totalling 101-150 children: three preschool groups, two groups for 3-5 year olds and one group for 1-3 year olds. The first and second class of primary school is also under the same roof and there is active collaboration between the kindergarten and these classes. (Kindergarten Hirsimäki 2013b; Teacher survey questionnaire.)

b) Teacher (FI4Mary_Pre_Int_200213)

The teacher is a female, less than 50 years of age. She has a Bachelor's degree in Education and she has worked for almost 20 years as a kindergarten teacher. During her Bachelor studies, there was no emphasis on science and mathematics but she has postgraduate studies related to these subject areas. She has 7,5 credit units mathematical and science studies, these are still to be completed, and she has also finished a pedagogical programme called Metsämörri (*The troll of the forest*). (Teacher survey questionnaire; FI4Mary_Pre_Int_200213.) In this programme children learn to enjoy nature through their own experiences and senses; the programme includes plays, stories and songs. (Suomen latu 2013.) This Metsämörri-programme has been a good starting point for the teacher's nature and environment education but she hopes to develop these methods still further. She considers that the main reason for her enthusiasm towards nature and environment education is in her own relationship to nature. She has enjoyed walking and exploring in nature since she was a child and she has also been a girl guide. (FI4Mary_Pre_Int_200213.)

For the last eight years, this teacher has run the preschool group that focuses on environment and nature. During the present school year she has addressed the following topics in her teaching: Different ecosystems (e.g. swamp, forest, lakes), plants, seasons (autumn foliage), sustainable development, animals' overwintering and winterfeeding. (Teacher survey questionnaire; FI4Mary_Pre_Int_200213.)

She emphasizes scientific inquiry and problem based learning within the group, placing importance on working with the children to look for information in answer to the questions which arise from the children or which are based on their observations. She sees the teacher's role as one who emotionally accompanies the child, providing new experiences and helping the child to understand the surrounding world. (FI4Mary_Pre_Int_200213.)

c) Classroom and children

One of the kindergarten's preschool groups focuses on nature and environment education. This group has its own place near the kindergarten (about 300m) in a forest area where

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their learning activities take place. Most of the activities are held outside but there is also a hut and a toilet in the close vicinity. Activities are held between 8.30 am and 12.30 pm and after that, preschoolers return to the main area of the kindergarten. Every day, this pre-school group also eats outside in the forest. There are 14 children in the group, all 6 years of age; they will go to primary school in the autumn of 2013. (FI4Mary_Pre_Int_200213; Kindergarten Hirsimäki 2013c.)

The kindergarten has six operational content areas. These content areas are part of a larger set which teachers can apply in their work.

- Mathematical reasoning: Mathematical learning starts from everyday situations and play. The surroundings awaken children's mathematical thinking.
- First language and interaction: Children have the opportunity to read or look at books at all times. Children have learned different rhymes which have been used as a part of activities.
- Art and culture: The Kindergarten environment encourages children's imagination. Children are encouraged to express themselves in a way natural to themselves; this way they find tools for dealing with their emotions, actions, thinking and social behaviour. In addition, the Kindergarten uses drama, arts (hand crafts) and music in versatile ways and emphasises the importance of offering children experiences in which they feel they have been successful.
- Nature and environment: Nature offers many opportunities for exploration and wondering. When a close relationship is built with nature in the early years, it can continue through the whole of one's life. All of the staff demonstrate a positive attitude towards nature and environment education and this helps children to notice the wonders of nature. Children use a lot natural materials in their play and in their artefacts.
- Physical education and health: This factor has been taken into consideration at lunchtime and when the children are resting; they are encouraged towards self-directed activities and are free to move around in their surroundings.
- Religion and ethics: Religious education focuses on the Lutheran holidays and how they are celebrated, although the kindergarten does take into account other religious views of life. The main aim is to develop the child's positive self-image and attitude towards life. (Kindergarten Hirsimäki 2013b.)

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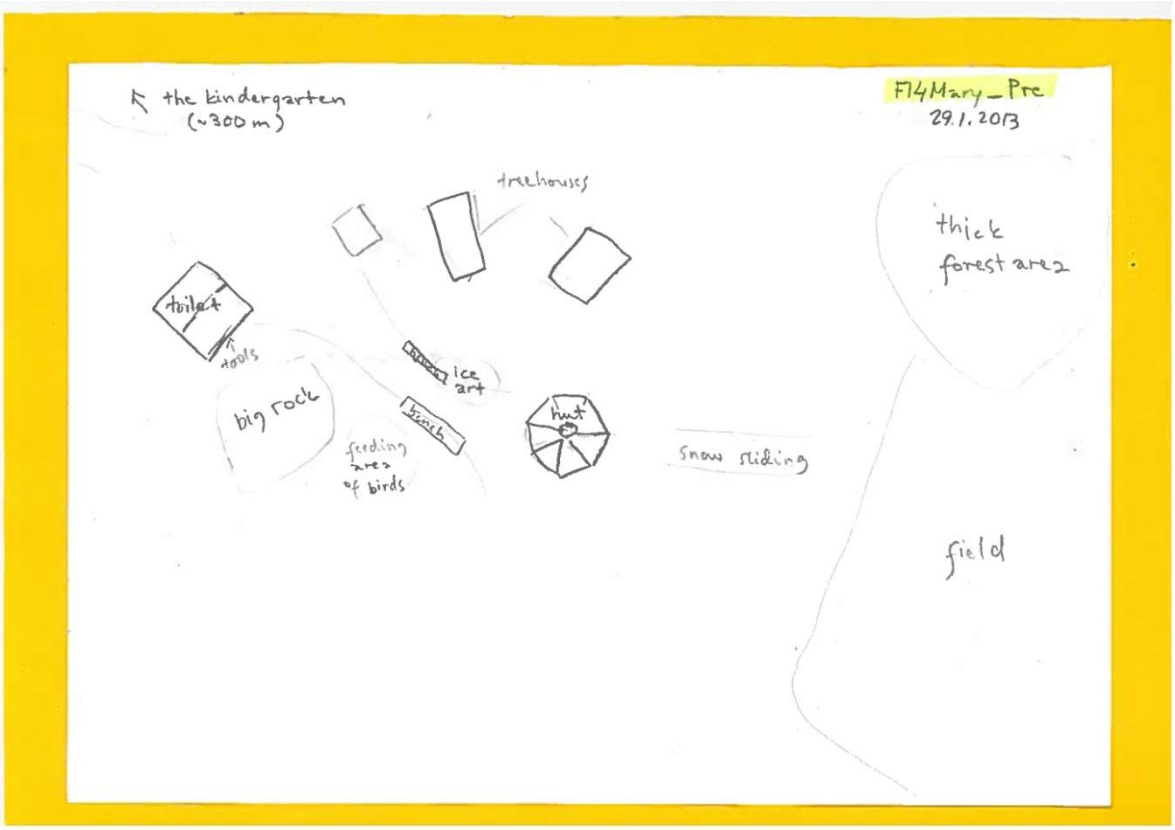

Picture 1. Map of the learning environment (FI4Mary)

3.1.2 Description of episodes

The following episodes were produced from Mary's data:

1. FI4Mary_Pre_PairsOfTen (Appendix 1)
2. FI4Mary_Pre_Snowflakes (Appendix 2)
3. FI4Mary_Pre_MeltingSnow (Appendix 3)
4. FI4Mary_Pre_FreePlay (Appendix 4)

Narrative episodes are attached as an appendix to this report. The episodes are discussed in terms of the mapping and comparison factors which focus on teaching, learning and assessment approaches and the role of creativity in them. The detailed, authentic descriptions of the learning activity processes are to be found in the appendices.

<u>Episode 1: Pairs of ten</u>

Introductory Comments

This episode took place on the way to the learning environment. Every day the children walk to the cottage and when leaving the playground, they have to count how many children are present. In this phase, Mary is considering several mathematical calculations with the children.

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Pedagogical Framing

The children were learning the pair of ten. The learning objective was to understand how to sum up the numbers to get 10. This was applied by creating two groups of children.

Pedagogical Interactions

The 'pairs of ten' episode focused on both the cognitive and social dimension. This episode is an example of mathematical activities in which children learn mathematical operations through the problem solving approach. The children are asked to solve the problem: how to find a pair to get number ten. The children need to make observations, show their solutions and thus explain the evidence. The children themselves are the material needed for counting, so they have to negotiate together about what to do.

Teacher "Here we have 3 children. What is the pair of ten for number 3?"
Child "Four"
The teacher asks again and the answer is the same.
Teacher "Ok, let's try to put 4 here. Are there 10 children now?
Children "No"

One child suggests number 5. The teacher adds one child and asks is it now ten. The children agree that it's not.

There is a strong role of motivation, dialogue, problem solving and agency, questioning, reasoning and scaffolding. The teacher aims to link the mathematical skills to everyday activity (how to build up one group of ten children). She actively sets questions, accepts the children's suggestions and scaffolds further, basing it on the children's ideas. She regularly engages the children to reflect on and solve the "problem", actively working as a facilitator.

They add 3 children.

Teacher "How many children do we have here now?"
A couple of boys think that there are 7 in the group. Finally, others disagree and one boy says there are 8 altogether.
Teacher "Let's go 3 numbers forward from number 8."
The children count.
Teacher "Is number 8 the pair of ten for number 3?"
Children "No"
Teacher "What do I need to do to have a pair of ten for number 3?
Child "Take CH [*child's name*] away"
Everybody laughs and Teacher takes the child away.
Teacher "Now let's check if we got it right. Here are 3 children, how many are there?"
Child "Seven"
Teacher "Please, count how many children there are altogether"

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Child "Ten"
Teacher "So what is the pair of ten for number 3?"
Child "Seven"
Teacher "Good"

The purpose of assessment was to improve the children's abilities to combine two numbers to reach the sum of ten.

The teacher systematically used self-/peer assessment and asked the children to make judgements. Finally the focus was on the outcome of solving the problem. The formative assessment process which occurred, was very context based and the locus of assessment judgement was the child.

Opportunities for Scientific Learning

In these episodes, the children learned to sum up the numbers and in practice, see the parts of the sum. Numbers up to 10 are the content of learning in preschool and these are practised in several contexts. In particular, the children learn problem solving, reflection and self-assessment.

Opportunities for Creativity

The teacher's role was that of facilitator, she only provided questions and worked as the children suggested. There were several opportunities for creative thinking and the activity was carried out with particular focus on the children's engagement and initiation.

Episode 2: Snowflakes

Introductory Comments

The learning activities firstly took place in the hut and later outside in the forest area. The aim of the activities was to figure out the shapes of snowflakes and learn to use magnifying glasses.

Pedagogical Framing

Here the children are learning about snow and snowflakes and in this process, they reflect on water circulation and forms of show. The teacher explains how snowflakes form and the children play a game in which they can be parts of a snowflake. The children then explore snowflakes, examine them with magnifying glasses and create a drawing**.**

Several formative assessment strategies were involved. The teacher provided feedback during the whole-group discussion, observed the children's activities, and collected the children's drawings. Reflection with the children also provided an arena for self-evaluation.

Pedagogical Interactions

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In the snowflake episode, the children focused on cognitive rather than social dimensions, although explanations and communications were involved. The exploration of snowflakes were discussed together with the teacher and linked to the circulation of water; how snowflakes are formed.

Teacher "The snowflakes can form e.g. around a speck of dust. We will soon go outside and play a game to try this." "All of the snowflakes are different, as all of you are too."

Teacher "You can't bring the snowflake inside because it melts. Make a picture of it in your mind and then draw it on this blue paper."

After discussion, a game was organised by the teacher in which the birth of snowflakes was modelled according to the guidelines given to the pupils.

During the second phase of learning activity, the children observed and gathered data; they tried to pick up the snowflakes and observed and described them using a magnifying glass. They worked together, all having their own instruments. The children came to the teacher to show their findings, which were then described and saved with their drawings.

In the beginning of the activity, the teacher's role was that of leader; in the second phase of the activity she moved into the background and the activity became more child-led. When presenting questions to the children, the teacher showed sensitivity towards their ideas and existing knowledge; through the use of several approaches, she encouraged the children's motivation in activities which were related to scientific knowledge, everyday knowledge (using newspapers), questioning, play, explorations and drawings.

Photo 1. Modelling snowflakes with play

Photo 2. Exploring snowflakes

Opportunities for Scientific Learning

The episode provided the children with a brief insight into scientific exploration: look for evidence, use an instrument and describe the snowflake both orally and with a drawing. They learned to gather information and compare this with existing scientific information (pieces of paper in the shapes of flakes). The children learned to use a magnifying class,

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orally describe their findings to the teacher and then reflect on them. They also learned to report on their findings.

Opportunities for Creativity

Based on the descriptions above, the activity provided opportunities for the following creative dispositions:

Exploration- looking for different kinds of flakes

Motivation and affect – modelling a snowflake through play

Dialogue – throughout the activity, the teacher asked questions and shared ideas with the children

Episode 3: Melting snow

Introductory Comments

The learning activities took place in the same environment as in the previous episode. The teacher conducted the experiment twice and 5 to 6 children participated in the activity at one time.

Pedagogical Framing

The children worked in small groups and each had individual responsibilities to a) collect snow b) follow the experiment and c) mark down the results of the experiment. A camping cooker was used for heating and different kinds of measures were used for collecting and measuring the snow and water.

Several formative *assessment* strategies were used and there were signs of learning assessment. The teacher provided feedback during the whole-group discussion and asked questions, observed the children's activities and shared reflections with them. She also collected the children's drawings to evaluate their understanding. Reflection together with the children, and the teacher's questions e.g." how do you know that we have 1 litre water of water here?" also provided an arena for self-evaluation.

Pedagogical Interaction

In this learning activity the children study snow and the state of water. Here they had a problem- based activity; what happens when snow is heated? The children collected snow using various measures, through these they also learned measurements e.g. 1 litre, ½ litre, 3 decilitres. Because the camping cooker was used for heating the snow, the activity was partly in the form of a demonstration; the teacher was strongly involved in the activity and asked questions about the phenomena.

Teacher "What do you think, how much water will we have when the snow has melted?
Children "More", "Less"

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Teacher: What you can see here? [pointing to the steam]
Children" Steam"
The teacher pours water back onto the dish.
Teacher "What do you think now: Is there more or less water than when there was snow?"
Children "Less"
Teacher "Could you tell me how much there is approximately?"
Children: There are 3 litres, there is ½ litre, there is 1 litre.
After discussion they agree that there's about half a litre of water.
Teacher" How much snow did we have?
Children: "One litre"
Teacher" So when water is in the form of snow it need more space"

The teacher motivates the children's learning process through organising an experiment. They had presented a problem to be solved through the activity (what happens when snow is heated?) and together they tried to find an answer to the problem, thus there is a high level of children's engagement in the activity. Results of the experiment were individually reported by making drawings.

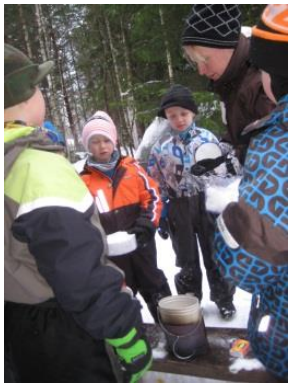

Photo 3. Melting snow

Photo 4. Making a drawing of the results

Opportunities for Scientific Learning

This experimental activity was typical of the sort used in which the children learned to plan an experiment. They also learned how to estimate and conduct the experiment, observe the changes during the experiment (follow the process of boiling) as well as becoming familiar with the scientific concepts such as melting, boiling, heating, evaporation, liquid and solid.

Opportunities for Creativity

Problem solving and agency was clearly involved in this episode. Through collaboration, the children tried to solve the problem, follow the state of water and discover the reasons for it. Teacher scaffolding and involvement varied during the activity but she did clarify the concepts and the changes in the process.

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Episode 4: Free Play

Introductory Comments

This episode focuses on the Free Play activities that the children were involved in during the site visits. The role of free play is crucial in early years education, especially in preschool (National Board of Education, 2000).

Pedagogical Framing

The children are allowed to use all the equipment and places available; they can decide themselves what they do as long as they follow the instructions created at the beginning of the school year. There is no active assessment involved in these activities.

Pedagogical Interactions

The children can create their own activities during free play or work with some existing activities that have been going on for a longer time. The social dimension is under special focus in these activities, encouraging children to communicate and make judgements together.

Here the teacher provides a learning environment and helps with some particular equipment, but she is not actively involved. She is an observer and facilitator, helping the children when they need it.

Photos 5 and 6. Children looking for parts of a dead bird and climbing in the tree

Opportunities for Scientific Learning

The free play activities especially provide opportunities for developing process skills, problem solving and exploration. The following free play contexts were observed:

- Play in thick forest area
- Play in tree houses
- Using tools for knocking rock
- Building igloos
- Creating ice lanterns

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- Cleaning up the snow castle

Opportunities for Creativity

Free play activities support children's creativity in many ways, especially in an outdoor environment in which they use their imagination. The environment itself and the possibilities it offers for choosing a variety of activities, encourages their creative thinking skills, exploration, collaboration and affect. According to the children, free play activities are the most motivating (Informal discussion, FI4Mary_Pre_Int_Children_200213).

3.1.3 Summary and conclusions

In this section, we have discussed the main findings of *Case Mary,* aiming for a response to the RQ2 and RQ3. The justifications are based on the material from the episodes, complementary information from interviews and other supplemental material.

RQ2: Probing practice
What approaches are used in the teaching, learning and assessment of science and mathematics in the early years?

In **Case 1,** the approaches used in teaching and learning are clearly linked to the guided problem solving approach in which the teacher's questions play a crucial role. The teacher's role is active, and group situations vary from being teacher-led to child-led. Children's engagement and activities are strongly supported, aiming to foster their science process skills, especially observing, describing, and measuring.

Assessment strategies and approaches are mostly formative, although summative assessment is also involved. The aim of this assessment focuses on the promotion of learning; there were no signs of assessment of teaching or curriculum.

What role if any, does creativity play in these?

How creative dispositions are intentionally aimed at does not become evident, but there are several indicators which reveal creativity in these activities. The teacher systematically encouraged the children's problems solving skills, reasoning skills and connection making. In addition, there were signs of fostering the children's curiosity and motivation (e.g free play). In general, the learning environment in the forest systematically supported the children's creativity.

RQ3: Probing practices
In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics?

The teacher's role is to introduce the activities and help the children understand what they need to do. The teacher also provides feedback for the children: "if we do something stupid, we will be grounded".

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The role of the teacher is also to study together with the children and scaffold them during the activities: *"Mary does not want to leave us alone, she studies with us and supports us. When Mary is reading, the assistant teacher Trish will scaffold us to follow the reading, and show where we are going".* (FI4Mary_Pre_Int_Children_200213.)

The children were motivated to learn science in the forest and said that it is important to learn science and to follow processes in nature. Many of the tools and materials used for learning/exploring, were made by the children themselves.

How do teachers perceive their role?

Mary aims to

- Increase the children's motivation rather than increase their knowledge
- Foster the children's abilities towards exploration and problem based learning
- Use child-centred investigations
- Foster children's engagement
- Listen to the children's ideas
- Collaborate actively. Social interaction is a significant part of the learning process.

(FI4Mary_Pre_Int_200213)

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3.2 Case 2 Kirsten – Learning science and maths through exploration

3.2.1 Context and teacher's background

Where?	Country	Finland		
	Setting name	FI1		
	Location within setting	Pre-school		
Who? (children)	Year group/age of children	6 years old (4-5 years old; not in the episodes)		
	Number of children in class	13 +6 (participated); totally 20-21 children in group		
Who? (adults)	Number of adults	4		
	Role of adults	Teacher and 2 assistant teachers, student teacher		
	Case teacher role	Learning science and maths through exploration		
When?		1&2	3&4	
	Dates of visits	22/1/13	8/3/13	
	Times of visits	8.50-12.30	9-12	

a) School/setting

This kindergarten is located in Saimaanharju (South-East Finland, population of 4 855), is mainly surrounded by natural environments and is run by the Local Educational Authority. There are two preschool groups (5-6 year olds) and five groups for younger children, totalling 101-150 children. (Teacher survey questionnaire; Statistical Centre 2013b; Kindergarten Metsäpolku 2013a; Kindergarten Metsäpolku 2012 – 2013.)

Activities emphasize the focus on exploration of nature and sustainable development; planning is child-based, meaning that children are heard and encouraged in their activities. The kindergarten holds three values that lead their daily activities: safety, equality, and respect. In their early year education plan, they state that children learn through play, by moving around, through art and by exploring. Children are encouraged to learn the basics of science and mathematics by observing, through problem based learning, and by playing games. (Kindergarten Metsäpolku 2011.)

b) Teacher background information (FI1Kirsten_Pre_Int_080313)

The teacher is female and is less than 50 years of age. She has a Master's of Education degree and has worked as a kindergarten teacher for 24 years. In continuing professional

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development, she has completed the in-service studies of early years education. In addition, she has studied empowering photography, for which she has received a grant for making a project with the children; she has also finished a programme called Metsämörri (*The troll of the forest*). (FI1Kirsten_Pre_Int_080313) In this programme, children learn to enjoy nature through their own experiences and senses; it includes plays, stories and songs. (Suomen latu 2013.)

With her group of children, this teacher has participated six times in a competition for early years science education (explore, try and develop) and each time they have won. She has taught the children ways of scientific play by going over the boundaries of different subject areas, leading, for example, scientific projects about stones and magnetism. The themes of these projects have arisen from the children's questions. The teacher has planned to make a publication about science projects. (Rehunen 2011, 10; Tikkanen 2012, 22.) Participation in competitions greatly motivates some children to learn scientific issues, and the teacher has noticed that it is important for them to make projects together as a group, because "then we succeed as a group". The teacher thinks that because the environment around the kindergarten is so wonderful and so close, one should take advantage of it. (FI1Kirsten_Pre_Int_080313.)

This current school year she has addressed the following topics in her teaching: Lake Saimaa/water, floatation, freezing, cleaning water and sustainable development (Teacher survey questionnaire).

c) Classroom, children and curriculum

The kindergarten is open on weekdays from 6.30am to 5pm (Kindergarten Metsäpolku 2012 – 2013). This kindergarten starts teacher-led activities with groups around 9am and lunch is at 11am; this is followed by free play and rest time. Later in the day, there may still be free play or some teacher led activities. On Tuesdays, this kindergarten group usually goes to the forest (*The troll of the forest-expeditions*); on many Mondays during wintertime this year, the group has been ice-skating as well as doing a lot of skiing in January. This kindergarten group has a total of 21 children aged 4-6 year olds, the majority of whom are pre-schoolers (6 year olds). (Kindergarten Metsäpolku 2013b; informal discussion with teacher.)

There are six orientations that are related to the kindergarten's activities:

- Mathematical orientation: The children are surrounded by mathematics and the staff use it in many of their routines, helping children to develop a positive attitude towards mathematics by playing games, comparing and categorizing.
- Natural scientific orientation: The forest is near and many activities take place there. Children learn how to observe, explore and wonder about nature. The kindergarten aims at sustainable development and children participate in taking

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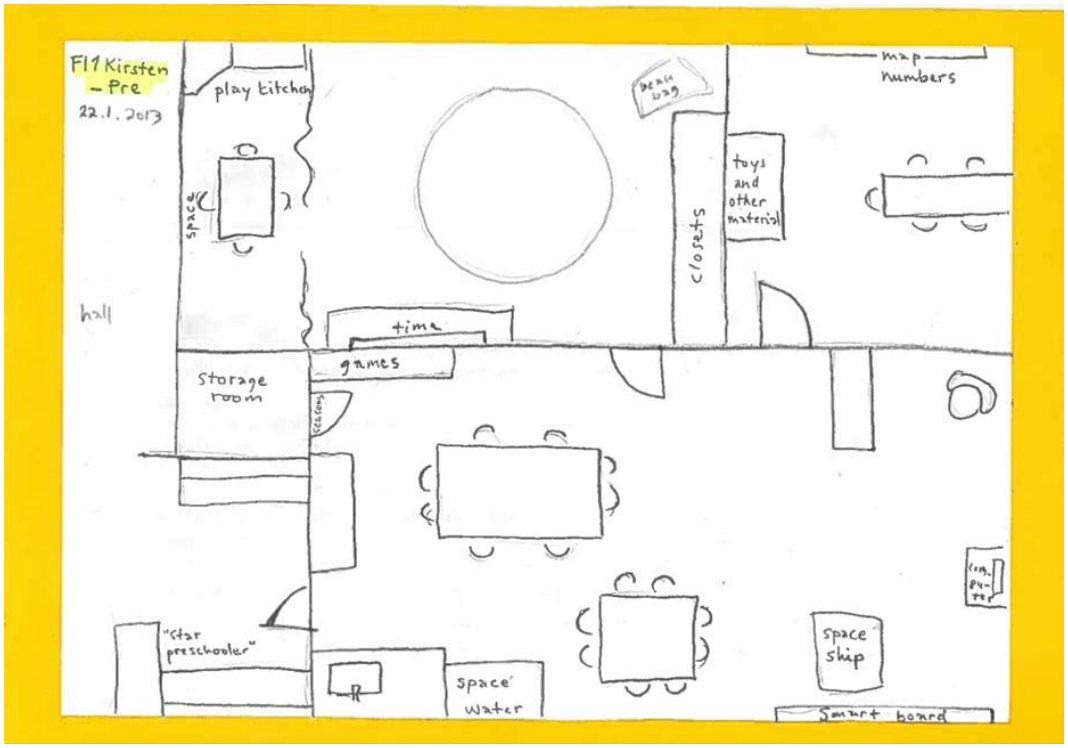
care of the immediate surroundings. The staff does not give complete answers to problems but rather searches for them together with the children.

- Historical and sociological orientation: Children get to know about the history of their surroundings and families through story-telling, looking at pictures and observing items. The kindergarten groups take trips to the surrounding area and use its services, they also learn how to use maps and are picture orienteered.
- Esthetic orientation: Children are taught to search for beauty in nature and in built-up surroundings. Efforts are made to ensure the kindergarten is comfortable and peaceful. The staff allows children to create their own performances and other such activities, and show the children their appreciation of them. Children also participate in cultural events.
- Ethic orientation: Children are taught good manners, how to solve conflicts in a positive way, to take responsibility for their actions and to prevent bullying, which creates a sense of security.
- Religious orientation and views of life: The family conviction is respected and children are also taught about other convictions. The church arranges some informal meetings with the children and the children participate in a service at the end of the preschool year and before going to school. The staff creates the sort of surroundings which allow children to freely talk about and encounter religion related questions. (Kindergarten Metsäpolku 2011.)



Picture 2. Map of the learning environment (FI1Kirsten)

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3.2.2 Description of episodes

The following episodes were produced from Kirsten's data

1. FI1Kirsten_Pre_MeasuringOutside (Appendix 5)
2. FI1Kirsten_Pre_MeasuringInside (Appendix 6)
3. FI1Kirsten_Pre_Animals (Appendix 7)

Narrative episodes are attached as an appendix to this report. The episodes are discussed in terms of mapping, and comparison factors focus on the teaching, learning and assessment approaches in relation to the role of creativity. Detailed, authentic descriptions of the processes of learning activities are presented in the appendices.

Episode 1: Measuring outside

Introductory Comments

The learning activity took place in the forest, near the lake. The preschool group walked from the kindergarten near the lake, to pursue activities related to snow, ice and measuring.

Pedagogical Framing

The children stay in the forest with the teacher and observe the environment; the aim is to make comparisons e.g. using the concepts smaller, bigger and equal. They also measure the temperature on and inside the snow, as well as the temperature of water. The teacher assesses the children's findings, giving individual feedback and separately recognising their outcomes. The purpose of the assessment is the improvement of learning.

Pedagogical Interaction

The learning activities strongly focused on the cognitive dimensions, such as gathering evidence and making connections. The activities were carried out both in large and small group settings in which the teacher had the role of facilitator, setting questions. The teacher presented a problem or task e.g. "try to find a plant that is smaller than yourself" and scaffolds the children by providing instruments and posing supportive questions.

Teacher "What have we done every time we've been here?"
Child "Measure."
Teacher "What have we measured?"
Children "Ice" "Water" "The temperature of water"
Teacher "What else have we done every time since August?"
Teacher "You have done this before, in August"
The teacher says that they are going to find something smaller and something bigger and also that they are going to use measuring sticks.

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Teacher "Now look for something smaller than yourself" "Think for yourself, don't follow anyone else"
Teacher "What did you find?" "What could that be?"
Teacher "Look for something bigger than yourself"
Child "I found a pine, it's bigger than me"
Teacher "What tree is it?"
Teacher "Can you find something this long? This is one metre."
The teacher gives measuring sticks to everyone.

Here the guided inquiry approach is being used in which the teacher sets the task/problem and creates the learning environment. In the second phase of the learning activity, the children measure the temperature of snow:

TA "What's the number now?" "Is there a minus or a plus sign?"
TA tells the children to put the thermometer above the snow.
TA "What happens now? Is it warmer under or above the snow?"
CH "Above"
TA "When there are minus degrees the bigger the number, the colder it is"

Photo 7. Trying to find something equally big as the stick (1m).
Photo 8. Measuring temperature of snow.

Activity 3 was held on the ice and for measuring the ice. One child measured the temperature of water.

Teacher "The temperature is the same as last time"

The teacher and some children followed when one child goes to measure the thickness of the ice with an instrument he has created himself. The teacher helps the child.

The emotional phase of the activity came at the end when the children had the opportunity to fish through the ice; after this they started to eat their packed snacks.

Opportunities for Science and Mathematics learning

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The teacher introduced the activities, asking the children to observe the environment, and to find objects (plants, trees etc.) which had either some same feature (the height) as themselves, or that were bigger or smaller. After finding the appropriate object, the teacher asked the children to describe what they had found. They named all the plants separately. The activities fostered the children's processing skills, especially observing, comparing and describing. In addition, the activity gave them a sense of initiative to find their own particular plant for this purpose.

Opportunities for Creativity

The activity of finding the proper plant supported the children in the use of creativity. One child took some snow in order to "make" the plant taller. The activity provided an arena for problem solving and agency, because each of the children had the opportunity to find his/her own solution. Reflection and reasoning were always present in discussions with the teacher: why did you select that plant? Can you show that this plant is shorter /taller than you are? Naming the trees and other plants provided the opportunity for dialogue and collaboration.

Episode 2: Measuring Inside

Introductory Comments

This episode took place right after the morning meeting with three groups of children. Firstly the activities started by sitting down together on the floor in a circle. In the second phase, the children worked in three groups with the teacher and assistant teachers. The activity finished with a session involving the whole group.

Pedagogical Framing

The activity session was planned in three parts; firstly a whole group discussion, secondly, small group activities in separate rooms and thirdly, finishing with a session involving the whole class. The activities were: 1) measuring length 2) measuring weight 3) combined measurement of length and weight.

The materials used in these activities were brought from the children's homes. The children were asked to bring some of their toys with them, trying to estimate it as being the heaviest/lightest or biggest/smallest.

The learning activity is assessed and reflected together with the children. The teacher asks both groups about the outcomes and they evaluate together the performance in the activity. The assessment has a comparative purpose; what are the differences between the groups?

Pedagogical Interactions

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

Kirsten led the introduction for the whole group and each child had an opportunity to present his/her toy. Very quickly they turned to the small group work, which were organized in different rooms.

During this activity the children were learning how to take measurements as well as learning the concepts used in measuring (1 metre, 1 cm etc.). This activity has cognitive, affective and social dimensions. They gather the evidence, observe, describe and compare their findings (results of measuring). They learn to measure the length and weight of an object.

The children worked in small groups when measuring their toys. Group 1 firstly measured the weight of the toys with the teacher, while group 2 measured the length of them with the assistant teacher. Younger children (group 3) worked with the assistant teacher and the student teacher.

Assistant teacher "What do think is the longest toy here?"
Children agree that the longest toy is the snake.
Assistant teacher "What is the shortest toy?"
Child "These two are the same length and this is the second longest"
Assistant teacher asks the owner of the snake to draw a picture of the toy on paper.
Assistant teacher "What do you think is the length of the snake?"
Children's estimations are from 1 to 3 meters.

The children were actively engaged in the activity; the role of the teacher was to support exploration and to foster problem solving and agency through asking questions and encouraging the children to make comparisons. The children marked down all their results, showing the highest, heaviest and smallest toy.

Discussion from group 2:

Teacher "What could be the heaviest toy?"
The children have different opinions.
They decide which toys they want to measure together first.
[*Teacher puts the first two toys into bags which are attached to a hanger*]
Teacher "Which sides goes down, the heavier or the lighter?"
Child "Heavier"
The teacher praises how well they remember.
Child "And the lighter stays up"
The teacher first lifts the toys up and they discuss which they think is heavier.
Teacher "Why is it difficult to say which is heavier?"

Opportunities for Science and Mathematics Learning

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These activities provided a place for several process skills such as observing, comparing and reasoning. In addition, measurements and measuring became apparent. The children not only learned to use and read a measuring tape they also learned to express the results using scales (see appendix 6).

Opportunities for Creativity

Because they were using their own toys, the activities motivated children to take measurements. The children were curious to know how heavy or how high/long their toys were. They discussed and compared the results in peer groups. In addition, with the support of the teacher, the children conducted the measurements themselves; the activities therefore increased their agency and engagement.

Photo 9. Child's drawing of the results.

Photo 10. Measuring the length of the toys

Episode 3: Animals

Introductory Comments

The episode took place in the same environment as in episode 1. The children sat down in a circle and the teacher had lots of animals (toy animals) in the centre of it.

Pedagogical Framing

The children worked with the teacher and activity was a teacher-led, questioning session. Collaboratively with the teacher, the children tried to decide how snow affects an animal's life, does it support it or make it more challenging. There was no clear evidence for assessment in the episode data, but through questioning, the teacher receives information about the children's knowledge and experiences as well as their abilities to make connections and reasoning.

Pedagogical Interactions

Episode 2 is linked to episode 1, because the activity was conducted in the same place, immediately after episode 1. In Episode 2, the children are learning in a teacher-led collaborative group. The teacher asks questions (set problems) and the children provide their ideas. The learning activity has both an affective and cognitive dimension: Using their

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toy animals, the children are learning the disadvantages and advantages of snow in the lives of animals.

Teacher "What is this animal?"
Children know it's a ringed seal.
Teacher "Does the ringed seal like plenty of snow or a little snow?
Children "Plenty!"
Teacher "How does the ringed seal benefit from snow?"
Child "It has a home there"
Teacher "Yes, it digs a hole in the snow. It has babies around the same time as you have your birthday."
[*TA takes a plastic ant in her hand*]
Teacher "Does this one know it is winter?"
Children recognize that it's an ant.
When TA asks if it benefits from snow, most of the children think that it doesn't. TA asks more questions and CH tells her it's hibernating.
Teacher "Yes, it's inside the ant nest. And there's snow on top of it so it doesn't feel cold"

The teacher uses an outdoor activity to give the children a clearer impression about the role of snow. She asks questions which incorporate their prior experiences and existing knowledge. In collaborative discussion, she fosters reflection and reasoning in her questions; teacher involvement is active and she leads the learning situation.

Opportunities for Scientific Learning

This episode clearly provided opportunities for scientific learning. It enabled the use of existing experiences and was based on their previous knowledge about animals, justifying the role of snow in animals' lives. The characteristics of animals were discussed, the animals were named and their living habitats described, so increasing the children's knowledge about animals and their ecosystems.

Although the activity was teacher guided, it developed the children's skills in sharing opinions, justifying them and drawing conclusions. The activity was a good example of large group discussion in which child engagement was high!

Opportunities for Creativity

The teacher had selected toy animals for the learning activity in order to provide practical examples of animals. This seemed to motivate children to talk about animals and compare them. The activity encouraged the children to make connections and use reflection, because they had to think about animals and their lives without having authentic animals, only an authentic environment. The activity provided an opportunity for creative thinking.

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3.2.3 Summary and conclusions

In this section, the main findings of *Case Kirsten* are discussed aiming to respond to the RQ 2 and RQ3. The justifications of this section are based on the material used in the episodes as well as the complementary information from interviews and other supplemental material.

RQ2: Probing practice

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

Here Kirsten uses both large and small group activities. The observed episodes were teacher guided, but the children also had lots of opportunities for play in small groups without teacher guidance. The learning activities nearly always involved a cognitive dimension integrated with social and affective dimensions. Learning science and maths is seen as content in which to learn processes such as working together, sharing turns and equipment and waiting for one's own turn to express oneself.

The children's lives and interests are taken into account in the activities. In two episodes, the teacher uses toys with different learning intentions.

Collaboration and questioning are often used in Kirsten's teaching and learning and the children are encouraged to solve problems themselves.

What role if any, does creativity play here?

Creativity dispositions are included in Kirsten's teaching, learning and assessment activities; creativity is encouraged in problem solving tasks and exploration tasks, in which children have the opportunity to choose methods to carry out the activity or solve the problem. The large group discussions, often at the end of the activities, promote their reflections skills.

Creative thinking skills did not become apparent in these episodes, but there were several signs as to how the teacher supports the children's creativity. In addition, she mentioned in the interview that creativity plays an important role in her pedagogy (FI1Kirsten_Pre_Int_080313); this was clearly evident in the kindergarten. The teacher continuously has different kinds of inter-curricular projects going on in which children have the opportunities to create experiments such as the tool for measuring ice, or take part in other creative activities (taking photos, creating robots, etc.)

RQ3: Probing practice

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

According to data from the children's interview, Kirsten teaches and guides them when needed. She provides enjoyable games and activities and she shows the children how to use different tools and materials, such as the ice-fishing tool. The teacher's role is also to

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monitor children's interaction and collaborate with them. The children saw that the teacher set the rules and if there were difficulties in working together, the teacher talked with the child in question.

Pre-school activities motivate children because they feel that they need the skills at school; the children also reflected that at home too, they could practise and use the skills they have learnt. They mentioned that the activities at pre-school are nice, although sometimes difficult.

The most interesting approaches to learning were the plays and games outdoors. The children felt there were more opportunities outdoors as well as having more so-called free time there.

None of the children liked to learn alone; they mentioned that it is much more convenient to work in small groups or in pairs as then they can help each other while they are working together. (FI1Kirsten_Pre_Int_Children1&2_080313)

How do teachers perceive their role?

Kirsten aims to

- Carry out child-initiated activities
- Provide opportunities for problem solving both together and alone
- Take into account the child's own life and meaningful issues
- Provide positive feedback for everyone when it is appropriate.
- Use playful activities
- Utilise the natural environment around the kindergarten

3.3 Case 3 Rita – Learning science and maths through game activities

3.3.1 Context and teacher's background

Where?	Country	Finland
	Setting name	FI2
	Location within setting	Pre-school
Who? (children)	Year group/age of children	3-6 years old
	Number of children in class	totally 18 children, 11 participated
Who? (adults)	Number of adults	3
	Role of adults	2 kindergarten teachers and 1 assistant teacher
	Case teacher role	Learning science and maths through game activities

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When?		1&2	2&3	
	Dates of visits	24/1/13	7/2/13	
	Times of visits	8.30-12	8.40-11.30	

a) School/setting

This private kindergarten is located in Iisalmi (Eastern Finland, population of 22 147). It is surrounded by a rural area and there is a horse stable next to the kindergarten. In addition, a dog and a stable cat are part of the kindergarten's daily life. This kindergarten was founded in 1996. A homelike atmosphere and a child-centred philosophy are important for this kindergarten. Here the children are allowed to work quite freely without any strict timetables; they help the adults in everyday routines, for example with cooking, feeding animals and watering plants. This kindergarten emphasizes play as an important part of development and the surroundings enable self-directed, structured exploration and experimentation. Materials and other resources are available to children at all times. (Kindergarten Hepokatti 2012-2013; Iisalmi 2013.)

There are two kindergarten teachers here, both of whom have a Master's of Education degree, and one socionomist, who has a Bachelor's degree; at times they also have trainees and students. The children are mainly over 2 years old and there are places for 21 children. During the current semester, there are only three pre-schoolers (6 year olds) in the kindergarten. (Kindergarten Hepokatti 2012-2013; informal discussion with teacher.)

b) Teacher background information (FI2Rita_Pre_Int_070213)

The teacher is a female less than 50 years of age; she is qualified with a Master's of Education degree. She has taught for less than 20 years. In addition she has completed her mathematical and science studies (totally 25 ECTS) in 1996 and found these to be very useful in her work. In activities in the kindergarten, she emphasizes the idea of learning by doing. She thinks that basic information is not as important to children as different kinds of experiences and likes to add a feeling of excitement to her activities; appreciating manual skills and perseverance, she considers that these can help to increase the feeling of excitement. The teacher wants to encourage the children's own interests and has published learning material (exercise book) for early years mathematics and science education (2004). (FI2Rita_Pre_Int_070213; Teacher survey questionnaire.)

During the current school year she has addressed the following topics in her teaching: getting to know the immediate surroundings, different kinds of activities related to the senses, different forms of water, exploring different ingredients, examination of mould, how to store food (Teacher survey questionnaire).

c) Classroom, children and curriculum

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There are 18 children ranging in age from 2-7 year olds. The kindergarten is open from 6.30 am to 5 pm but the staff is flexible with the opening hours. There are no strict timetables and continual daily routines were mainly to do with mealtimes and rest; between these there can be free play, teacher- led activities, pre-school or outdoors activities. (Kindergarten Hepokatti 2012-2013.)

The kindergarten has six orientations that are related to learning and early years education.

- Language and communication: This is of central significance to the development of the child's personality. Language is the basis for all learning, thinking, imagination and the development of social skills. Emotions, experiences, experiments and reasoning, contribute to children's learning. Interaction skills develop in conversational situations. The kindergarten has a lot of books and the staff frequently uses stories and rhymes in their activities.
- Mathematical orientation: A child's mathematical reasoning best develops in everyday situations. Topics such as time, and concepts which are related to numbers, are used daily in conversations with the children. The aim is to awaken their interest towards mathematics with the aid of equipment and games.
- Natural scientific orientation: Making observations has an essential significance in this orientation; the senses are sharpened when exploring nature. The kindergarten has lots of equipment for the children to use.
- Historical and sociological orientation: Children learn about their surroundings and the traditions of their hometown. Discussions are also held about the time when their parents were children.
- Ethic orientation: Everyday situations include discussions about the meaning of proprieties on a daily basis, right and wrong, true and false etc. The aim is to bring up individuals who have respect for themselves and for others.
- Religious orientation and views of life: This is based on the traditions and customs of the child's own religion or view of life. The family's conviction and wishes are respected. (Kindergarten Hepokatti 2012-2013.)

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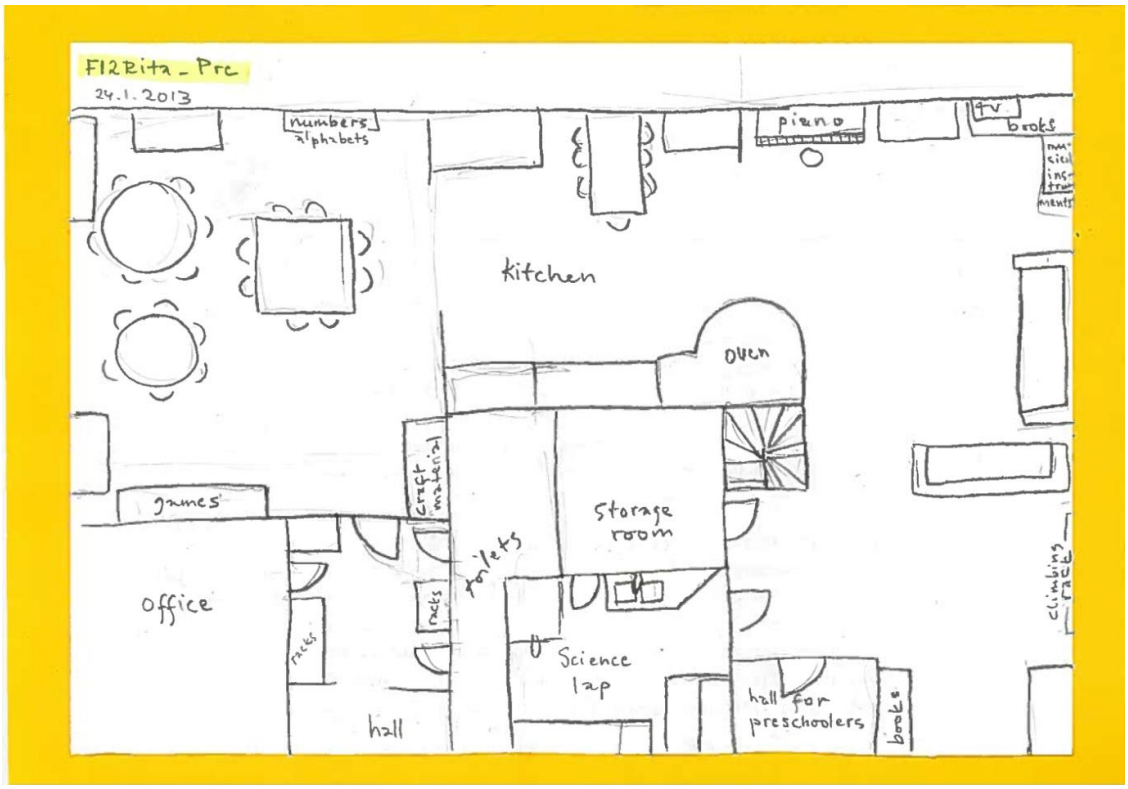

Picture 3. Map of learning environment (FI2Rita)

3.3.2 Description of episodes

The following three episodes were produced from Rita's data

1. FI2Rita_Pre_TreasureChest (Appendix 8)
2. FI2Rita_Pre_BurrGame (Appendix 9)
3. FI2Rita_Pre_Volcano (Appendix 10)

Data from the episodes was gathered during the half-day visits to the kindergarten. Two observers followed the activities, documenting them with videos and photos. These episodes illustrate the teacher's play based approaches, in which teacher engagement was active.

<u>Episode 1: Treasure Chest</u>

Introductory Comments

The episode took place in the morning with three pre-schoolers. Other children (5 year olds and younger) had their own activities with another teacher. The teacher had created the game herself.

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Pedagogical Framing

The aim of the game (session) was to learn to count numbers and learn to calculate sums and subtractions. The idea of the game was to collect one number card (from 0 to 10) and one calculation sign (+ or -). Based on the cards, the child was allowed to move a certain amount of steps backward or forward. There was a path (from 1 to 9 steps) to the Treasure chest and the only way to move onwards was via the path. The game also included also the aspect of competition; whoever reaches the treasure chest first will be the winner.

Pedagogical Interaction

Three boys participated in the game. Firstly, the teacher explained the rules of the game; the boys were allowed to choose their own colour, they negotiated about who would start the game and it was decided that it would be the youngest of the three. The teacher provided a small pouch containing the number cards and calculation signs. Each child took his turn in order.

Teacher "Look again (CHILD A), how many steps can you take? ... And where are you now?"
[*The observer asks the other boys*]
Teacher "What's the situation now? Who's leading at this moment?"
Teacher "Child A is near the chest. What number does he need to get?"
[*CHILD A gets to look inside the chest, the others look away so that they don't see what is in the chest*]
Teacher "You know what, if you feel up to playing the game right to the end, you can also look inside the chest."

The boys played the game until all of them reached the Chest. The teacher observed and guided the boys, checking that they moved correctly and understood the idea of the game. She also provided supportive questions if the calculation was problematic for the child.

Photo 11. Starting to play the game

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Opportunities for Scientific Learning

This episode provides opportunities to learn mathematical calculation and to understand the meaning of plus and minus signs. When moving along the path, the children experienced in practice the meaning of minus, because they then had to move backwards. They also learned to estimate the appropriate number needed to reach the Treasure chest. The episode included lots of negotiation between the boys and the teacher, thus supporting their decision-making, problem solving, and evaluation skills.

Opportunities for Creativity

The activity motivated the children and gave them a sense of initiative when personally participating in the game. The competitive spirit increased their motivation to calculate and concentrate on the game. In addition, they found treasure from the Chest, which was exciting and had a very affective role in the game.

Episode 2: Burr Game

Introductory Comments

This episode was meant for children over five years of age and one pre-schooler; they played a game called Burrr which had been created by the teacher. The teacher played the game with the children, but her role was that of facilitator and she scaffolded when needed. The children sat down in a circle and the playing cards were in the middle.

Pedagogical Framing

The aim of the activity was to support the children in learning and naming mammals. In addition, the game strengthened the children's observation skills, concentration and reactivity.

The idea of the game was to name all mammals. In turns, one child went outside and the rest of the children selected one mammal card. The child came back in and started to name some mammals; a card was given for each mammal that was named right up until the card that had been selected by the group, was in question. The children in the circle then shouted BURRR. Finally the cards were counted and the game started again with the turn of another child.

The teacher participated in this activity with the children and her role was mostly one of evaluator. She gave feedback, encouraged the children and supported those who needed help.

Pedagogical Interaction

The children sat down together in a circle and shared their knowledge about the mammals. They went through all the cards so that everyone recognised the mammals on them. They helped each other make decisions and took turns in responding. MENIKÖ OIKEIN?? In the

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beginning of the game, the children also syllabified the names showing the rhythm with hand clapping, e.g. RAB-BIT.

In the beginning of the game, the teacher asked what the word 'mammal' meant. She introduced the game to the children and supported them in naming all the mammals on the cards, also encouraging the children by saying, "Please be as sharp as a carrot", and giving feedback. She also asked children if she had their permission to participate in the game: "Do you want me to participate?" the children answered, "YES!"

Photo 12. Playing the Burr game

Opportunities for Scientific Learning

During this activity the children learned to memorise the name of typical Finnish mammals, some of which were easy but others were less common. The activity fostered their decision making skills and observation skills. The activity was crosscurricular; here both the Finnish language (syllables) and counting skills (the number of cards collected) were learned.

Opportunities for Creativity

The activity presented in this episode was motivating for the children and at the end of the game they asked "When can we play this game again?" They enjoyed shouting Burr, it was affective. Reflection was also involved when checking the activities of the other children (had the collected card been named correctly).

Episode 3: Volcano

Introductory Comments

Using recycled paper (newspaper) and paste, the children had created lovely volcanoes which they had coloured and decorated themselves. This episode is part of longer project that ended with this particular experiment. The pre-schoolers wanted to make a show for the younger children on how to get a volcano to blow up!

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Pedagogical Framing

The aim of the activity was to explore which ingredients are needed to get a volcano to explode**.** This seemed to be the pre-schoolers' show put on for the younger children, who sat like an audience in front of them. The teacher provided the ingredients and supported the children in filling out the sheet for the experiment.

Ingredients used in the experiment: sugar, salt, baking soda and vinegar.

Pedagogical Interaction

The children had their own volcanoes and they all stood close to the table. The teacher provided a working sheet which was intended for making predictions: which ingredients, when mixed together, make a volcano blow up? Before each experiment, the children marked down their prediction and after it, they marked down the results.

The teacher provided the ingredients and asked questions about them: "Who knows what this is? How can you use SUGAR…?"

Children's answers:

- in baking
- in coffee
- in buns
- in ice cream
- in cakes

You can use SALT…

- in food
- in healthy food

You can use BAKING SODA…

- in cakes

Teacher "What's this (VINEGAR)?"

- ketchup
- blood
- oil

You can use VINEGAR…

- in mother's beetroot soup

Children measure the sugar into the volcano and the teacher gives them the vinegar, allowing them to smell it.
Children "Terrible smell"
Teacher "Who knows how much vinegar is in this dish?"
Children "600 litres", "litre", "half litre"
Teacher "The size of a milk bottle is one litre. Is this the same size?
Children "No"

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Teacher "This is one decilitre and you can put ten of them in one milk bottle"
Teacher "Many of you predicted that the volcano is going to boil over with these ingredients. Let's see what happens"
Teacher "When you have poured the vinegar into the volcano, you should move back. Please, now you can start"
Children pour the vinegar and move back looking excited
Children "No, nothing is happening"
Teacher "Nothing, please come and mark your result on the work sheet"
Nothing happens and the children mark the outcome onto the work sheet. Then they pour the sugar and vinegar away and mark down the second prediction.
Child "I knew it!"
Children measure the salt into the volcanoes and the teacher gives them the vinegar.
Teacher "How did we work in the first case?
Child "You will give us permission and then we will carefully pour"
Teacher "Yes!" And then?
Child "We step backwards"
The teacher asks the children how they should work with the ingredients and then gives permission for them to pour the vinegar.
Children "Nothing!"
Nothing happens, and the children once again mark the outcome onto the paper form. Next they mark the predictions for the last pair of ingredients (baking soda and vinegar). Children measure the baking soda into the volcanoes and the teacher gives them the vinegar, asking them to move the volcanos into the middle of the table. Children pour the vinegar and look happy and excited when the volcanos boil over. *Also the* audience seems to be very excited.
Children Laughing
Teacher "Did you manage?"
Children "Yes"
Child "My volcano can erupt once again!"
Children mark the outcome onto the work sheet.
One child wonders why the liquid on the table is violet and is told that the color is from the paint on the volcano.

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Photo 13. Volcanoes erupt

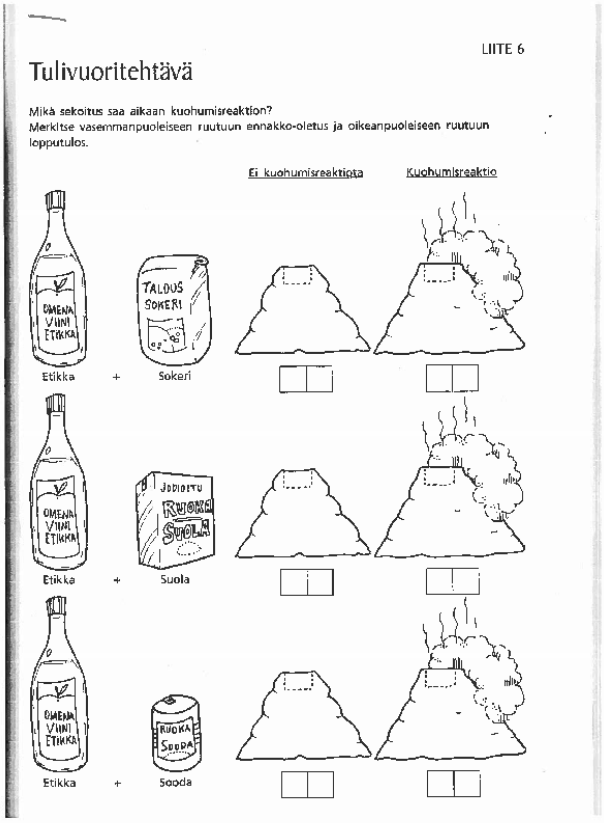
Opportunities for Scientific Learning

As described above, the episode provided several opportunities for scientific learning. The activity comprised of a scientific experiment in which the predictions and outcomes were marked down and compared. Several combinations were experimented with, to find a solution to the problem (how to get the volcano erupt?) The children learned problem solving in which they used their existing knowledge/experience, observation skills, comparison skills, reasoning and reflection. They also learned to follow strict rules which are necessary in scientific experiments.

The children became familiar with certain ingredients and shared their knowledge about the use of these substances.

Opportunities for Creativity

The experiment was appealing, because the younger children also wanted to come and follow what was happening. The children were fully engaged and motivated. The activity included problem solving and agency, but also lots of dialogue with peers and especially with the teacher whose involvement was active, asking questions.


LIITE 6

Tulivuoritehtävä

Mikä sekoitus saa aikaan kuohumisreaktion?
Merkitse vasemmanpuoleiseen ruutuun ennakko-oletus ja oikeanpuoleiseen ruutuun lopputulos.

Ei kuohumisreaktiota | Kuohumisreaktio

Etikka + Sokeri

Etikka + Suola

Etikka + Sooda

Picture 4. The sheet from the volcano experiment (Puumalainen 2005, p101)

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3.3.3 Case summary and conclusions

RQ2: Probing practice

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

Teacher-initiated, play orientated practices were common during the site visits. In the interview, Rita highlights children's engagement and initiative; her activities are derived from the children's interest. She uses approaches in which the teacher's role is to motivate the children and be involved herself, while at the same time taking a background position. (FI2Rita_Pre_Int_070213; observations.)

Questioning is also common in her approaches. Through questions, she guides the children from practical to abstract and conceptual thinking (FI2Rita_Pre_Int_070213) and considers that integration and cross-curricular phenomena and activities are important for children of preschool age.

What role if any, does creativity play in these?
How do teachers perceive their own role?

In her pedagogy, Rita emphases child-initiative activities and engagement; the teacher's role is to encourage the children towards the activity and follow the children's ideas and creative solutions. She wants to provide space for exploration. She sees that motivation is really important and that increasing it and providing a learning environment in which the child can experience affective experiences, is one of the teacher's main tasks (FI2Rita_Pre_Int_070213.)

RQ3: Probing practice

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

The role of the teacher is to provide good guidelines and set the rules. This confirms that everything goes well in the learning activities.

The children felt that they learn a variety of skills when they work with Rita. Mostly they are interested in the activities that give them the opportunity for active engagement, but in addition, they said that they learn skills such as concentration, listening, and painting. In the Burr- game, they learned about animals, mammals, and syllables. The Treasure Chest game supported their skills of counting:" *We learned to count up to nine".* (FI2Rita_Pre_Int_Children_070213.)

How do teachers perceive their role?

Rita does not make long term plans but focus on child-initiative activities. Her role is to create appropriate learning environments and respond the children's interest. She aims to

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plan activities in which children are able to play and explore using their own senses and skills.

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3.4 Case 4 Rachel – Learning science and maths with multiple approaches

3.4.1 Context and teacher's background

Where?	Country	Finland			
	Setting name	FI5			
	Location within setting	Primary school			
Who? (children)	Year group/age of children	6-9 years (1 preschoolers, 6 1st-graders, 12 2nd-graders)			
	Number of children in class	19 totally, 17 participated			
Who? (adults)	Number of adults	1			
	Role of adults	teacher			
	Case teacher role	Learning science and maths with multiple approaches			
When?		1	2	3	4
	Dates of visits	27/9/12	15/11/12	1/2/13	15/2/13
	Times of visits	9-11	9-11	8-8.45	8-8.45

a) School/setting

The school is located in Joensuu (Eastern Finland, population of 73 758). The school is a public, University school and comprises of grades 1-9 and an upper secondary school. Altogether the school has more than 750 students. There are 32 teachers for grades 1-6 (6 classes in the 1st and 2nd grades, 3 classes in each of grades 3-6) and 67 teachers for grades 7-9 and the upper secondary school. The school belongs to the University and student teachers are part of the school's routines. (Joensuu 2013; Joensuun Normaalikoulu 2013a.)

b) Teacher (FI5Rachel_Pri_Int_260213)

The teacher is a female of over 50 years of age. She has a Bachelor's degree in Humanities and is also a qualified special education teacher. She has taught for more than 20 years. She has participated in courses of Hungarian mathematics and tested mathematical materials created by the Professor of Mathematics Education, George Malaty. These materials are mainly used in afternoon clubs. She has studied science and young children's mathematics (25 ECTS) in in-service education. Science and mathematics are areas emphasized in the school and for this reason the teacher wants to update her skills and

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knowledge in these subjects. The Finnish language is her main subject. She works as a teacher educator and is responsible for the students' teaching-practices. She teaches a preschoolers' multigrade class of first and second graders. She has a working partner (Case FI6Helen) and they mix their classes when feasible. (FI5Rachel_Pri_Int_260213; Teacher survey questionnaire.)

This current school year, she has addressed the following topics in her science teaching: animals around children, maps, water, and the overwintering of plants and animals (Teacher survey questionnaire).

c) Classroom, children and curriculum

There are 19 children in this multigrade class with 1 preschooler, 6 1st-graders and 12 2nd-graders. The children range from 6-9 year olds. This class is often mixed with another multigrade class (Case FI6Helen). (FI5Rachel_Pri_Int_260213.)

The structure of the school day	
The school starts	8am-10am
Lessons	8am-11am
Lunch break	11am-12pm
Lessons	12pm-14pm

The aims (and the main learning contents) of the mathematics education in 1st and 2nd grades are that the pupils:

- learn to concentrate, to listen, to communicate, develop reasoning and to find joy in understanding and solving problems (1st and 2nd grade)
- understand the concept of addition and subtraction (1st and 2nd grade)
- understand the similarities and differences, causes and effects (1st and 2nd grade)
- understand the principle of the decimal system (1st and 2nd grade)
- recognize and name geometrical items and shapes (1st and 2nd grade)
- understand the concept of measuring (1st and 2nd grade)
- make observations of mathematical problems that have significance for the pupil him/herself and learn to solve them (1st and 2nd grade)
- learn to classify, to model, to organize, to group and to compare different mathematical phenomena with concrete tools (1st grade)
- learn to use mathematical concepts in versatile ways (1st grade)
- learn to write and verbalize reasoning with concrete models, tools and pictures (1st grade)
- understand the concept of a natural number (1st grade)
- strengthen their knowledge on how to use the concepts learned in the 1st grade (2nd grade)

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- confirm the understanding of the concept of number (2nd grade)
- understand the concept of multiplication and division (2nd grade)
- understand the principle of division (2nd grade)

(Joensuun Normaalikoulu 2013b.)

According to the school curriculum, the main learning contents in science in the 1st and 2nd grades are:

- life forms and habitat
- phenomena in the surroundings
- the human and health
- the close surroundings, the domicile and the Earth as a human habitat
- substances in the surroundings

(Joensuun Normaalikoulu 2013c.)

The aims of science teaching in the 1st and 2nd grades are that pupils:

- learn to make observations (1st grade: learn to use different senses, 2nd grade: learn to use simple tools)
- learn to describe, compare and classify observations (1st and 2nd grade)
- learn to search for information about built-up surroundings with observations and to notice changes in the schoolyard during the different seasons (1st and 2nd grade)
- learn to know nature and the built-up surroundings of their home town (1st and 2nd grade)
- take notice of and influence the well-being of the nearby surroundings (1st and 2nd grade)
- learn positive interaction skills (1st and 2nd grades)
- learn to know nature and the built-up surroundings and how to move around safely in the nearby surroundings (1st grade)
- learn to make simple scientific experiments (1st grade: with the help of teacher, 2nd grade: in small groups)
- learn to make simple maps (1st and 2nd grade, 2nd grade: learn to find places from the map of Finland)
- learn to use the correct concepts of science (1st and 2nd grade)
- learn to know issues related to water and how to use it
- learn to recognize issues related to one's own well-being and safety and how to act accordingly (1st grade)
- learn preliminary issues related to electricity and how to consume it (2nd grade)
- learn to know different substances and become familiar with recycling (2nd grade)
- learn issues related to maintaining human health and well-being and how to act in an emergency (2nd grade)

(Joensuun Normaalikoulu 2013c.)

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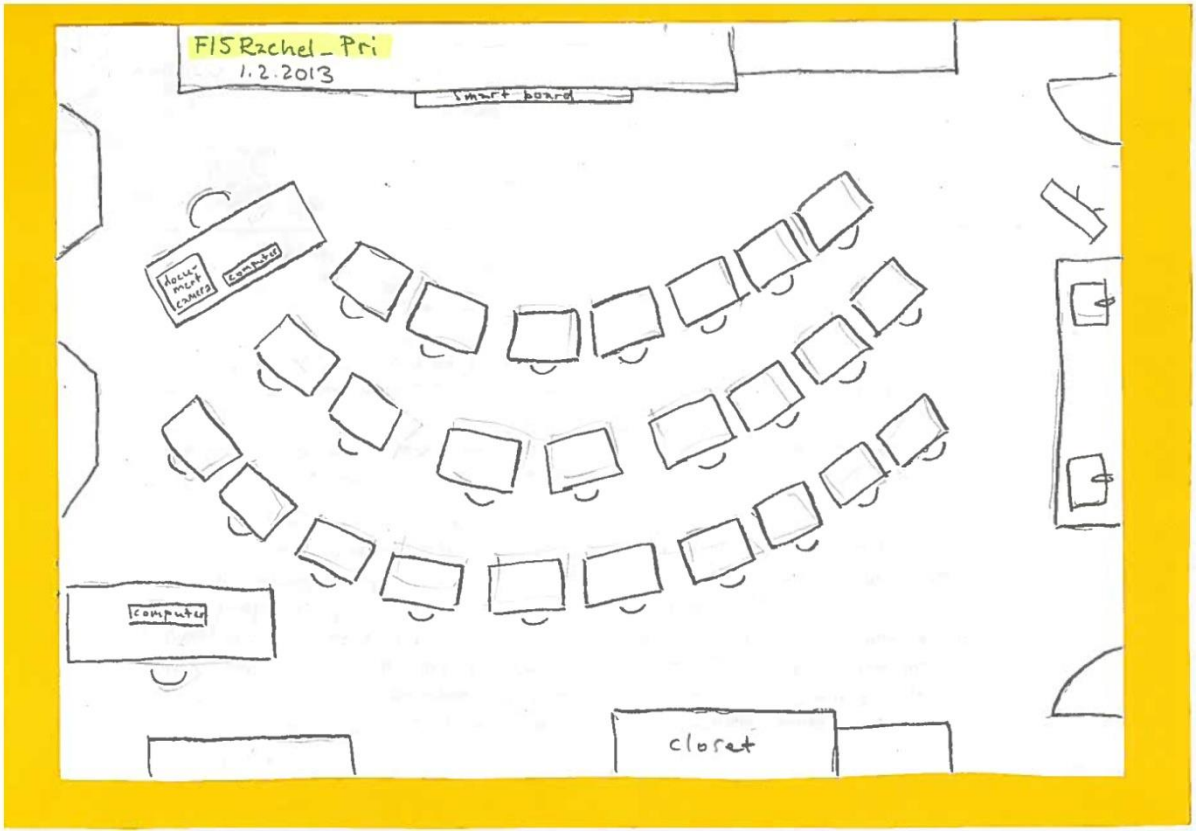

Picture 5. Map of classroom (FI5Rachel)

3.4.2 Description of episodes

The following episodes were produced from Rachel's data

1. FI5Rachel_Pri_Plants (Appendix 11)
2. FI5Rachel_Pri_WaysToCount (Appendix 12)
3. FI5Rachel_Pri_MapSymbols (Appendix 13)

<u>Episode 1: Plants</u>

Introductory Comments

The learning activity took place in Rachel's own classroom, during the morning hours before lunch. The student teacher on teacher-practice also participated in the lesson; Rachel and the student conducted several activities together.

Pedagogical Framing

One aim of the lesson was to recognise plants in the close surroundings and learn to classify them into categories, the other was to learn to study at activity stations using ICT tools. In addition to the student teacher, there were three other adults in the classroom to help the children when needed. At most of the activity stations, the children worked independently. The 1st and 2nd graders were learning together in the mixed groups.

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During the lesson, the teacher followed the children's independent work and took photos to be used for assessment in the reflection phase.

Pedagogical Interaction

At the end of the previous lesson, the student teacher had given instructions for the activities. The children work in 6 small groups (3 children/ group). The groups each have a card to be marked when they have completed work at the learning activity station.

1. *Learning activity station: Categorising*
   There are pictures of 9 plants; the children's task is to categorize them. At the station, the student teacher helps the children by asking questions and also in naming the groups. The solutions were photographed by the teacher with an iPad.

Photo 14. Children's classification of the plants

2. *Learning activity station: Smart Board game*
   Children work independently and play with some Smart Board activity in which they have to select the right plant with the right name. In turns, each child selects the plant and together the children decide its name.
3. *Learning activity station: Memory card game*
   The children work in collaborative groups and play a memory card game in which they try to find pairs of plants and give them names. The other children in the group assess whether the name is correct.
4. *Lap top activity station: Naming trees*
5. *Lap top activity station: Naming trees*
   The children had laptops at two different stations, on these they had two rather similar activities. With notebook software, they had to recognize different trees and select the right name for them. They had to make a shared decision in the group.
6. *Learning activity station: Colouring pictures*
   At this station the children were able to choose individual activities; there was a colouring sheet of different plants. They were able to use workbooks and colour the plants as shown in the book.

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At the end of the lesson via the Smart Board, the teacher student shows photos of the categories (Station 1) that each group has made. She asks the children some clarifying questions e.g.” Why did you group them in this way? “

She also introduces her classification, categories such as wild plants, useful plants, ornamental plants.

Teacher student: “Your categories are just like these but you have given them different names.”

They continue to discuss the meaning of useful plants and ornamental plants. At the end of the lesson, the teacher student praises how well the children have succeeded in making the categories.

Opportunities for Scientific Learning

This activity provided several opportunities for naming the plants that had been observed in the surroundings during the previous phase. The children were strongly engaged in the activities; nearly all the children worked independently at the stations and no teacher was involved. They also learnt decision making and had to make shared decisions, thus peer evaluation was also fostered.

The episode fostered the children’s classification skills. They had to create groups (somehow putting similar plants together) and create a name for the group.

Opportunities for Creativity

The significant role of ICT tools in the activities (Smart Board, laptops, iPad) motivated and affected the children to learn. After the lesson, the children evaluated the activities with drawings. In the following (drawing 1), the child drew a Smart Board and wrote “It was nice to work with an interactive whiteboard and play the memory game.”

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Drawing 1. Draw the activity that you thought was the most interesting

The lesson not only provided a number of opportunities for dialogue collaboration with peers, but also with the teacher and student teacher. In addition, problem solving and agency was evident at the working stations where the children had to solve the task independently. Reflection and reasoning took place at the end of the lesson after the classification results had been defined and justified.

Episode 2: Ways to count

Introductory comments

This lesson took place in Rachel's classroom involving the 1st graders both from Rachel's classroom as well as from the neighbouring class.

Materials and learning tools such as rulers, fingers and pearls were used in the lesson to model the different approaches for counting and to solve mathematical problems.

The children had done a test and many of them had made a mistake with one mathematical problem: *What number is 4 numbers smaller than 18*. The teacher takes this problem under consideration once again and scaffolds the pupils to find different ways of how to solve the problem, using different approaches and supportive materials.

Pedagogical Framing

Through the use of a number of additional materials and tools, the aim of this lesson is to support the children in solving a mathematical problem. The children work in pairs and each pair has their own material or equipment. The children have to try to solve the mathematical problem and teach it to the others.

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Pedagogical Interaction

In the beginning of the lesson the teacher says that in the test that the children did earlier, there was one mathematical problem that was rarely solved correctly. The teacher introduces the equipment and sets a task.

Teacher "If it's difficult to count in your head there are several ways of making it easier"
The teacher says that the children could use fingers, rulers and pearls as supportive equipment.
Teacher "What do you usually do with rulers?"
Child "You can measure length, for example"
Teacher "That's right, but you can also use it as a continuum"

The children work in pairs and the teacher walks around and scaffolds them when needed:

Child "How can you count up to 18 with fingers? I don't have so many fingers."
Teacher "That's a good question. Let's see if we can soon find a solution to your problem."

After a short time of working in pairs, the teacher asks the children to come in turn to the front of the classroom and using the equipment provided, present their solution for the problem. The teacher then sets additional questions:

Teacher "So what did you do to number 18? Did you make it bigger or smaller?" "What kind of problem is it then?"

After each presentation the class applauds the pairs of children.

Teacher "As you can see, there are many ways of solving these kinds of problems."

Photos 15. and 16. Thinking how to solve a mathematical problem in three different ways; presenting the results.

Opportunities for Scientific Learning

This lesson supported the children's skills for solving mathematical problems. The teacher had noticed that one particular problem had not been understood in the test and she

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wanted to show the children how this problem could be solved in different ways. The activity encouraged collaborative problem solving, including processes such as defining the problem, trying out the method, solving the problem and presenting it to the others (describing).

Opportunities for Creativity

Through working in pairs, this lesson provided opportunities for problem solving and agency. They were able to use their creativity in solving the problem and by using the equipment provided for them. In pairs, the children had to collaboratively solve problems and negotiate the approaches. When they presented their solutions to the others at the end of the lesson, the teacher encouraged the children in reflection and reasoning which was supported by teacher scaffolding and involvement.

Episode 3: Map symbols

Introductory Comments

This lesson is part of a map project conducted in the classroom. The children had learned map symbols in an earlier phase and this lesson was aimed to confirm their understanding. The lesson took place both in the schoolyard and in the classroom. All grades (the preschoolers and the 1st and 2nd graders) participated in the lesson.

Pedagogical Framing

The aim of this lesson was to apply map symbols to objects in the schoolyard. The children's understanding of the map symbols was confirmed and in addition, the children learned to use iPads for both reporting their findings and sharing them with other children in the classroom.

The teacher had divided pupils into small groups and they had a paper copy of map symbols with them. With the iPad, their assignment was to take photos of objects in their schoolyard and then describe them with the map symbols. After the outdoor activity, the children returned to the classroom and one pupil explained how to send the pictures to an e-mail address (they had learned this earlier). At the same time, the teacher showed how it's done via the Smart Board. Later on they drew a map of the schoolyard with the iPad, using the map symbols.

Pedagogical Interaction

At the beginning of the lesson the whole group of children stood in front of the teacher and listened to her. The teacher gave guidelines and clarified what the children had to find out in their activity with the iPads. The teacher set the children's agency for the task:

Teacher "Now each group is going to take pictures of different objects, please listen. Each member of the group takes one photo and all the photos must be of different objects. Can you each take four photos, Niklas?"

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Child "No!"
Teacher "That's right, no! Now you try to find objects which meet the map symbols! Now you can go, Good luck! When I ring the bell, you should come back!"
The children are looking for the objects and taking photos in the playground. The teacher observes and provides feedback.
Teacher "Okay, let's look! Who has taken this? Okay, what is it?"
Child "Lintuemo (Name of the climbing frame)"
Teacher "Yes, and what is this?"
Child "Pine"
Teacher "Yes, pine tree! Okay!"
The children return to the classroom. Teacher gives feedback to the pupils:
Teacher "I was very happy about your way of working outdoors. Did all groups manage to take those four photos?"
Children "Yes [all together]"
The teacher and children together learn to send photos from the iPads to the e-mail box.
Teacher "Could you explain to me, how can we transfer the photos from the iPad to our email box?"
Child "First you take the pictures and then you take the arrow."
Teacher "Yes, that is right! Did you notice what happens?"
Child "Then you press the button 'email'"
Teacher "Yes"
Child "And then you write norssi 12C gmail dot com."
Teacher "Yes, that is the sender, and what is the subject?"
Child "My name"
Teacher "Yes, the name of the child who is sending the message."

Opportunities for Scientific Learning

This lesson encouraged the children to observe, compare and gather information. The abstract map symbols were linked to the objects, which supported the children's understanding of map symbols and how they are presented. The children learned to report their findings with an ICT tool and the iPad was used collaboratively in the group.

Opportunities for Creativity
Based on the creative dispositions defined in the project, the following evidence can be found in this episode.

- Dialogue and Collaboration during small group work
- Problem solving and agency during photography of the correct objects in the schoolyard and when the results were sent to the e-mail.
- Children were motivated to use iPads for reporting their findings.

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3.4.3 Case summary and Conclusions

RQ2: ***Probing practice***

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

In the episodes described above, Rachel's lessons involved multifaceted approaches and different ways of learning. ICT tools such as computers, iPad and Interactive whiteboard were systematically used both by the teacher and the children. Problem solving and small group work were common in her lessons.

What role if any, does creativity play in these?

Rachel frequently used small group work or learning in pairs. This encouraged the children's skills of negotiation and collaboration, but it also seemed to motivate studying. Problem solving and agency were involved systematically, although the teacher often set the problems herself??? Rachel also used reflection and reasoning; this occurred mostly at the end of the lesson, but reflective questions were systematically asked also during the lesson.

RQ3: Probing practice

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

According to children's interview the teacher supports the children when they need help. She asks questions and provides tools to solve mathematical problems. The children felt that learning mathematics in small groups is more effective than in large group discussion. In pair work, the children can help each other more easily.

The children think that mathematics is important to learn and it is also fun, when you know what to do. They also thought that approaches used at school are relevant and motivating. The different tools support their problem solving process.

How do teachers perceive their own role?

- Rachel aims to teach children using a problem based approach
- Material and resources must be suitable for young learners
- The teacher's role is to provide several approaches for learning
- The teacher's role is to provide support for those who need it
- The teacher's role is to be involved remembering the importance of humour
- The teacher's role is to affect attitudes and motivation

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3.5 Case 5 Helen – A case of active questioning

3.5.1 Context and teacher's background

Where?	Country	Finland			
	Setting name	FI6			
	Location within setting	Primary school			
Who? (children)	Year group/age of children	6-9 years (3 pre-schoolers, 9 1st-graders, 10 2nd-graders)			
	Number of children in class	22 children totally, 17 participated			
Who? (adults)	Number of adults	1 + student teachers			
	Role of adults	teacher			
	Case teacher role	A case of active questioning			
When?		1	2	3	4
	Dates of visits	20/9/12	8/11/12	4/2/13	11/2/13
	Times of visits	9-11	9-11	11.15-12	11.15-12

a) School/setting

The school is located in Joensuu (Eastern Finland, population of 73 758). The school is a public school and comprises of grades 1-9 and an upper secondary school. Altogether the school has more than 750 students. There are 32 teachers for grades 1-6 (6 classes for 1st and 2nd grades, 3 classes for each grade 3-6) and 67 teachers for grades 7-9 and the upper secondary school. The school belongs to the University and student teachers are part of the school's responsibility. (Joensuu 2013; Joensuun Normaalikoulu 2013a.)

b) Teacher (FI6Helen_Pri_Int_270213)

The teacher is female and is more than 50 years of age. She is a class teacher and has a degree in Master of Philosophy (Education). She has specialized in biology and geography and has taught for more than 20 years, mainly with early years education. She has participated in courses of Hungarian mathematics and she has tested mathematical materials crated by the Professor of Mathematics Education, George Malaty. She has participated in several research projects for the development of science and mathematics education. She works as a teacher educator and she is responsible for organizing teaching practices for students. She has a multigrade class with preschoolers, first and second-

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graders. She has a working partner (Case FI5Rachel) and they mix their classes when it's feasable. (FI6Helen_Pri_Int_270213; Teacher survey questionnaire.)

Helen's interest in biology and geography was aroused in her childhood when she helped her grandfather in his garden. She feels that in school she was full of ideas, but the teachers didn't encourage this, that is why she wants to enable children to make experiments and encourage them to think for themselves. (FI6Helen_Pri_Int_270213.)

This current school year, she has addressed the following topics in her science teaching: animals around children, plants and trees, different kinds of surroundings, how nature changes in the autumn, the map of the yard and the surrounding environment (Teacher Survey Questionnaire).

She has been the author of several publications for teacher education and learning materials for preschoolers and 1st and 2nd graders (e.g Aho & Järvinen, 1999; National Board of Education, 2005: Havu-Nuutinen & Järvinen, 2007).

c) Classroom, children and curriculum

There are 22 children in this class and it is a multigrade class with 3 pre-schoolers, 9 1st-graders and 10 2nd-graders. The children are aged from 6-9 years old. This class is often mixed with another multigrade class (Case FI5Rachel). (FI6Helen_Pri_Int_270213.)

The structure of the school day	
The school starts	8am-10am
Lessons	8am-11am
Lunch break	around 11am-12pm
Lessons	12pm-14pm

The aims (the main learning contents) of the mathematics education in the 1st and 2nd grades are that pupils:

- learn to concentrate, to listen, to communicate, develop reasoning and to find joy in understanding and solving problems (1st and 2nd grade)
- understand the concept of addition and subtraction (1st and 2nd grade)
- understand similarities and differences, causes and effects (1st and 2nd grade)
- understand the principle of the decimal system (1st and 2nd grade)
- recognize and name geometrical items and shapes (1st and 2nd grade)
- understand the concept of measuring (1st and 2nd grade)
- make observations of mathematical problems that have a significance for the pupil him-/herself and learn to solve them (1st and 2nd grade)

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- learn to classify, to model, to organize, to group and to compare different mathematical phenomena with concrete tools (1st grade)
- learn to use mathematical concepts in versatile ways (1st grade)
- learn to write and verbalize reasoning with concrete models, tools and pictures (1st grade)
- understand the concept of a natural number (1st grade)
- are able to deepen their understanding and know how to use the concepts learned in the 1st grade (2nd grade)
- confirm their understanding of the concept of number (2nd grade)
- understand the concept of multiplication and division (2nd grade)
- understand the principle of division (2nd grade)

(Joensuun Normaalikoulu 2013b.)

According to the school curriculum the main learning contents in science in 1st and 2nd grades are:

- life forms and habitat
- phenomena in the surroundings
- the human and health
- the nearby surroundings, the domicile and the Earth as a human habitat
- substances in the surroundings

(Joensuun Normaalikoulu 2013c.)

The aims of the science teaching in 1st and 2nd grades are that pupils:

- learn to make observations (1st grade: learn to use different senses, 2nd grade: learn to use simple tools)
- learn to describe, compare and classify observations (1st and 2nd grade)
- learn to search for information about built-up surroundings with observations, and to notice the changes in the yard during different seasons (1st and 2nd grade)
- learn to know nature and the built-up surroundings of their home town (1st and 2nd grade)
- take notice and have influence on the wellbeing of their nearby surroundings (1st and 2nd grade)
- learn positive interaction skills (1st and 2nd grade)
- learn to know nature and built-up surroundings and learn how to move around safely in the nearby surroundings (1st grade)
- learn to make simple scientific experiments (1st grade: with the help of the teacher, 2nd grade: in small groups)
- learn to make simple maps (1st and 2nd grade, 2nd grade: learn to find places from the map of Finland)
- learn to use the correct concepts of science (1st and 2nd grade)
- learn to know issues related to water and how to use it

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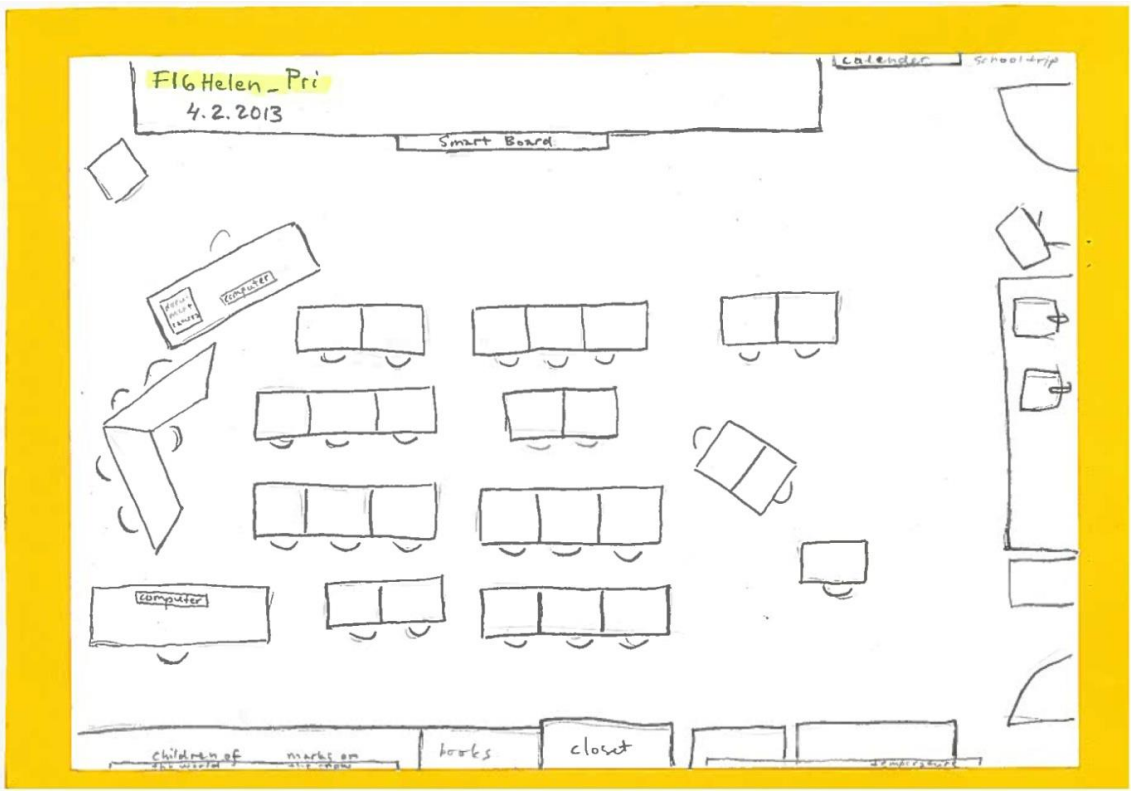
- learn to recognize issues related to one's own wellbeing and safety, and how to act accordingly (1st grade)
- learn preliminary issues related to electricity and how to consume it (2nd grade)
- learn to know different substances and become familiar with recycling (2nd grade)
- learn issues on how to maintain human health and wellbeing and what to do in a case of emergency (2nd grade)

(Joensuun Normaalikoulu 2013c.)



Picture 6. Map of classroom (FI6Helen)

3.5.2 Description of episodes

The following episodes were produced from Helen's data:

1. FI6Helen_Pri_FloorPlan (Appendix 14)
2. FI6Helen_Pri_AnimalFence (Appendix 15)
3. FI6Helen_Pri_MutiplicationStory (Appendix 16)

<u>Episode 1: Floor Plan</u>

Introductory Comments

The lesson was conducted in Helen's classroom and the 1st and 2nd graders participated in it. This lesson was the first of the map project planned in the classroom.

Pedagogical Framing

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The aim of the lesson was to understand floor plans and what and how they show the space in question. iPads and boxes with little blocks were used as materials during the lesson.

As a pre-activity to learning about maps, the class discussed floor plans; what they are, what items can be marked on them and how. The first-graders worked in small groups and built models of the classroom, took photos of it with the iPad and sent them to the e-mail. The second-graders mostly worked alone with the iPads. They drew the floor plan of the classroom and sent it to the e-mail. They learnt to use the iPad as a tool for reporting outcomes.

Pedagogical Interaction

The student teacher introduces the lesson and asks questions:
Student teacher "How could you describe this classroom to a person who hasn't ever been here?"
Child "There are lots of desks here"
Student teacher "How about if you couldn't describe it with words?"
Children "With a picture" "With a video" "With a drawing"
Student teacher "How could you draw it?"
Child "From above"
Student teacher "What could you call it then?"
Child "A map" "A room map"
Student teacher "It's called a floor plan"

The second-graders started to work alone and drew the classroom with iPads, having been told by the teacher that the edges of the iPads were the walls of the classroom. The student teacher also explained how the first-graders could work with small boxes to create a floor plan of the classroom.

Teacher "At first you could think where the doors are but you don't have to use blocks to mark them."

Children negotiate how the items could be placed and begin counting e.g. the desks.

The teacher and student teacher observe and scaffold during the activity. They also provide some feedback.

Some children talk about the shapes of the blocks and furniture in the classroom.

Teachers help the 1st graders to take photos of their completed models. 2nd graders send the electronic drawings to the e-mail and help each other.

At the end of the lesson, the student teacher asks children to take out their photos:

Student teacher "Open the photo you have taken or drawn. Can you find your own desk from there?"

She observes how the children found their place and are pointing to it.

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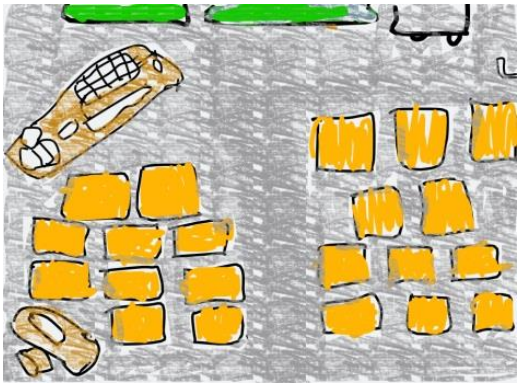
Opportunities for Scientific Learning

This lesson provided children with the opportunity to learn the idea of a map and learn to observe their close environment from a perspective which differs from the general one. This kind of problem solving task fostered their thinking and process skills (observing, gathering evidence etc.).

Opportunities for Creativity

Several creativity dispositions took place in this lesson:

- Problem solving and agency was evident in the small group work
- Dialogue and collaboration occurred with the teacher and with peers
- Creative thinking skills, imagination and connection making were needed when making the floor plans



Drawing 2. Child's iPad drawing of the classroom floor plan (2nd -grader)

Photo 17. Child's model of classroom (1st -grader)

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Episode 2: Animal Fence

Introductory Comments

The 1st and 2nd graders learned about Finnish animals. The lesson took place in Helen's classroom, in which the children aimed to classify the animals. The lesson lasted for 2 hours.

Pedagogical Framing

The aim of the lesson was to learn how to categorize Finnish animals and work in small groups. In addition, the children learned to use an interactive whiteboard and laptop computers. The teacher provided the assignments.

Firstly there was a teacher-led session in which they named the animals together, after which the children started to work in small groups. When the groups had finished working, they discussed the categories they had made themselves and categorized animals together once more, according to the teacher's categories.

Pedagogical Interaction

The teacher shows the animals and fences on the Smart Board and together the children start to name the animals. Through questioning, the teacher confirms that the children understand the scientific concepts:

Teacher "Yes, it's a snake. What snake is it?"
Child "A viper"
Teacher "How do you recognize a viper?"
Child "It has a line there", "It has a pattern on its back"
Teacher "It's a saw-edged pattern"
Teacher "And what can you see over there?
Child "A tongue"
Teacher "And what's in that tongue?"
Child "There's poison"

The teacher defines all new concepts (names of animals) and asks the children to differentiate between similar animals such as elk and reindeer.

Teacher "Now you can begin to categorize these animals with your group. You can decide together what kinds of categories you want to make."

The Teacher shows how to add fences and how to move the animals with a finger.

Teacher "The first group can come here and work with the Smart Board, others can start to work with computers. Try to remember to decide together what your answers will be".
Children work independently in small groups.

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After the group work session, the teacher asks what the children thought about working with computers and the Smart Board. Most of the children liked to study with ICT tools; they also reflected and assessed why they liked or disliked working with them.

The teacher praised the children for working so well with the computers and Smart Boards and acknowledged that they had worked very well within the groups too.

Teacher "You worked very well in your small groups even though you're so young. You were able to decide your categories together."

The children came near to the Smart Board and all the groups presented their categories.

Discussion arose about some categories, why the children thought that some animals would belong to a particular category. The teacher did not correct the categories at this phase.

Teacher "What does 'pet' mean?"
Child "They stay inside" "They don't live outside but they can go there" "You take good care of them"
Teacher "Who do those pets live with? Where do they live?"

The children once more categorized the animals together but this time with the categories that the teacher had given: domestic animals, pets, wild animals. They also put within one fence, animals that live near the school. One child moved the animals and the others said where to put them.

Opportunities for Scientific Learning

In this lesson, children had the opportunities to learn to recognise animals that live nearby; they also learned to describe and classify them. During the small group work, they learned to negotiate, define and justify their solutions into categories that had been collaboratively created.

Opportunities for Creativity

During this lesson, the children had an opportunity for problem solving and agency and were motivated to study through using ICT tools such as laptop computers and Smart Boards. Dialogue played a crucial role in the lesson and this fostered their collaboration; in discussions with their teacher, reflection and reasoning were involved.

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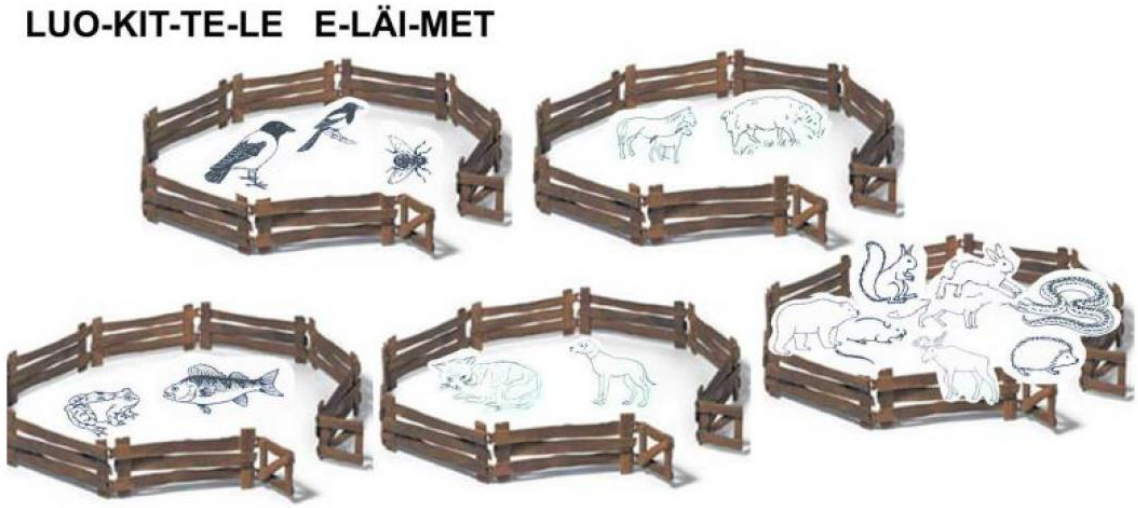

Picture 7. Classification outcomes (Notebook document used with Smart Board)

Episode 3: Multiplication Story

Introductory Comments

The lesson took place in Helen's classroom in which the 2nd graders from her own and Rachel's class were involved.

Pedagogical Framing

The aim of the lesson was to learn multiplication. The teacher had drawn a tree with three branches. In the first phase of the lesson, the teacher discussed with the whole group, how to make multiplication stories from the picture she had made. The children then made up their own stories in pairs (five special needs children worked in a bigger group with an assistant teacher) using a shared paper form. The teacher observed and scaffolded. At the end of the lesson the children told their stories to the whole class. In addition, they were all asked to fill in the paper form, giving feedback on the assignment.

Pedagogical Interaction

The teacher asks questions about the tree and several children answer.

Teacher "I have drawn a tree on the chalkboard. How many branches are there?" "Think what kind of multiplication you could make from this tree?
Teacher "What kind of tree is this?" "What kind of multiplication could you make from apples and branches?"
Teacher "What do you see on the apple?" "How many leaves are there on one apple?" "What kind of multiplication can you now make?"
The teacher and children count the leaves together then one child says how many leaves there are in altogether.

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Teacher “Come up with a short story which includes the branches and the apples”
Child “There was one tree with three branches. There were two apples on every branch ”
Teacher “Once before, we have made a multiplication story together. Now you can make new ones in pairs and in small groups.”

The teacher told the observer that in an earlier lesson they had made up this kind of story using the same paper form, so it was already familiar to the children. She said that it’s important to use different kinds of examples so that children understand that they can use any sorts of objects or things in the stories.

While the children were working in small groups, the teacher observed and scaffolded the stories:
Teacher “What is your question?”
At the end of the lesson, each group presented their story to other groups.

Opportunities for Scientific Learning

The stories created in the activity supported the children’s understanding of multiplication. The mathematical operations were discussed and the children learned how multiplications are created.

Opportunities for Creativity

The activity of writing their own stories encouraged the children’s creative thinking skills, and working in pairs motivated them and provided an opportunity for engagement and agency. Questioning was a crucial part of collaboration with the teacher, and dialogue was fostered in peer interaction.

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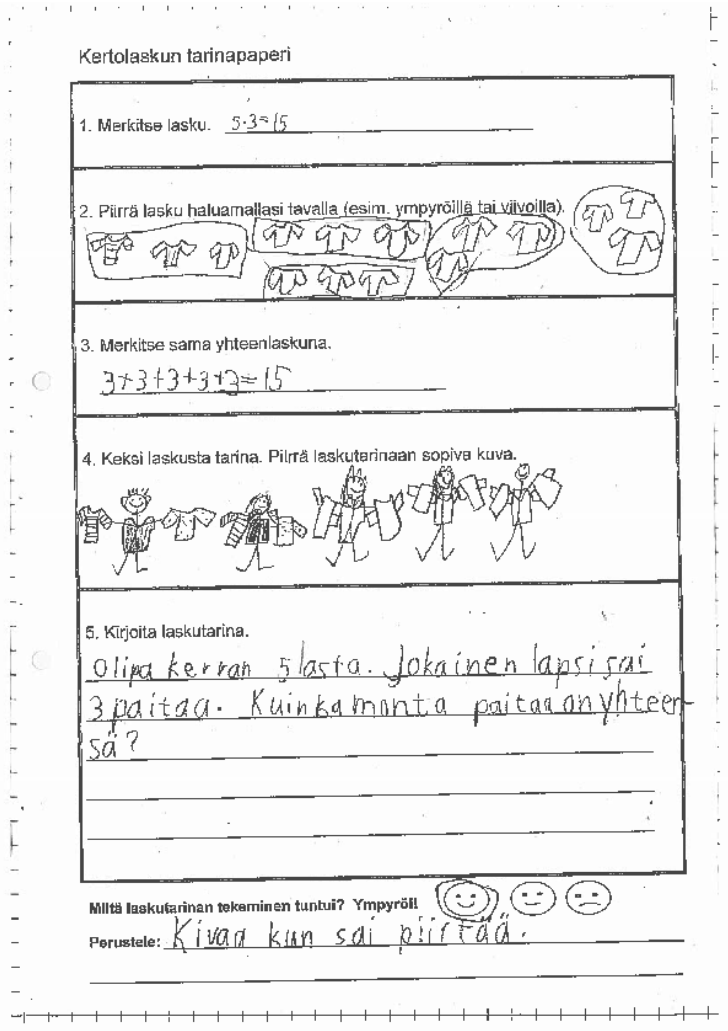
Kertolaskun tarinapaperi

1. Merkitse lasku. 5·3=15

2. Piirrä lasku haluamallasi tavalla (esim. ympyröillä tai viivoilla).

3. Merkitse sama yhteenlaskuna.
3+3+3+3+3=15

4. Keksi laskusta tarina. Piirrä laskutarinaan sopiva kuva.

5. Kirjoita laskutarina.
Olipa kerran 5 lasta. Jokainen lapsi sai 3 paitaa. Kuinka monta paitaa on yhteensä?

Miltä laskutarinan tekeminen tuntui? Ympyröi!
Perustele: Kivaa kun sai piirtää.

Picture 8. Multiplication story written by a pair of children

3.5.3 Case summary and Conclusion

RQ2: Probing practice

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

Helen uses lots of multiple approaches in which some kind of problem solving is evident; she also uses questioning as a teaching approach. In every episode, child-centered approaches were used, thus peer interaction and collaboration clearly prevailed in these episodes. She also seems to use cross-curricular approaches in which there is an integration of science, mathematics and Finnish language learning.

What role if any, does creativity play in these?

All episodes included some creativity dispositions. There were a number of opportunities for creative thinking skills but mostly collaboration and dialogue were evident. Questioning

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was used systematically. The ICT tools and multiple approaches were used to motivate the children to learn.

RQ3: Probing practice

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

Generally, the children were motivated to learn science and mathematics. The lesson in which ICT tools such as iPads were used, particularly motivated the children to learn. The children said that they liked the activities in which they were able to have high engagement and the possibility of working personally with ICT tools.

The children saw that the teacher's role is to support them with difficult assignments. They thought that Helen is nice, because she really helps them and does not shout.

The children also expressed that although the activity was not so easy for them, making up stories of mathematics (FI6Helen_Pri_MultiplicationStory) was motivating, because they had the opportunity to create the stories themselves.

Working in pairs also motivated children to learn science and mathematics. It increased their interest towards science when they could create and solve problems with their classmates and they did not have to study alone (FI6Helen_Pri_Int_Children)

The children also enjoyed the teacher's approach of listening to music during the science and mathematics lesson; they thought it was nice when there was no noise in the classroom and everyone could work quietly.

How do teachers perceive their role?

Helen sees the following issues as being significant in her teaching:

- Creativity is important. She aims to encourage the children towards creative thinking, active engagement and reflection on issues.
- The close environment is significant. It is important to support the children to observe their surroundings and use their senses.
- The teacher has to support the children with problem solving skills
- The teacher is also involved when the children are working with peers.

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3.6 Case 6 Tina – A case of active scaffolding

3.6.1 Context and teacher's background

Where?	Country	Finland		
	Setting name	FI3		
	Location within setting	Primary school		
Who? (children)	Year group/age of children	9-10 years old		
	Number of children in class	13		
Who? (adults)	Number of adults	1		
	Role of adults	Teacher		
	Case teacher role	A case of active scaffolding		
When?		1& 2	3&4	
	Dates of visits	28/1/13	21/2/13	
	Times of visits	11-14	10-13	

a) School/setting

This primary school is located in Lavia (South-west Finland, population of 1 948). The school is run by the Local Education Authority and it is the only primary school in this particular municipality. This school building has grades from 1-6, a total of 150 pupils (one class for each grade). In addition to the teachers, there is one special education teacher and three school assistants. A preschool also operates in the same building. Although the secondary school belongs administratively to the same school, it is located in a separate building nearby. (Lavia 2013; Lavian Keskuskoulu 2013; informal discussion with the teacher.)

b) Teacher (FI3Tina_Pri_Int_210213)

The teacher is female and is less than 50 years of age. She has a Master of Education degree and has taught for less than 20 years; she has specialized in environmental and natural studies. In her free time she practices orienteering and enjoys walks in nature. She has consciously strived to stay close to nature in her teaching, using outdoor activities to teach different subjects. Inside school she also combines different subjects e.g. mathematics can be combined with sports. The teacher has noticed that children have rather poor mathematical skills when they start primary school and she has tried to encourage parents to "speak mathematics" more at home, so that mathematics starts to be linked more to children's everyday lives. (FI3Tina_Pri_Int_210213; Teacher survey questionnaire.)

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This current school year she has addressed the following topics in her teaching: winter, spring, solar system, recycling and maps. (Teacher Survey Questionnaire)

c) Classroom, children and curriculum

There are 13 children in the class and they are 8-9 years old. The teacher feels that a small sized class gives opportunities to support children individually. (Informal discussion with teacher) Tina has worked with these children for two and half years.

The structure of the school day	
The school starts	8am-10am
Lessons	8am-11am
Lunch break	11am-12pm
Lessons	12pm-2pm

According to the school curriculum, the main learning contents in mathematics (1st, 2nd and 3rd grades) are:

- numbers and calculations
- Algebraic reasoning
- concepts of geometry
- measuring
- data processing and statistics

(Lavian Keskuskoulu, 2011-2013)

The aims of learning mathematics in the 1st grade are that pupils:

- learn to observe, compare and classify items, things and phenomena in their surroundings
- learn to concentrate, to listen, to communicate and take pleasure in learning mathematics
- learn to develop mathematical reasoning and concepts, systematically and in versatile ways
- learn to validate solutions with models, pictures, verbally and in writing
- build a good foundation to develop the understanding of the concept of number and measuring

(Lavian Keskuskoulu, 2011-2013)

The aims of learning mathematics in the 2nd grade are that pupils:

- receive versatile experiences of different ways of presenting mathematical concepts. Pupil notices that concepts form structures with sub-concepts
- receive fulfillment and joy from understanding and solving problems
- develop mathematical reasoning and concepts, systematically and in versatile ways

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- understand the concept of number and master addition, subtraction and multiplication

(Lavian Keskuskoulu, 2011-2013)

The aims of learning mathematics in the 3rd grade are that pupils:

- learn to form mathematical concepts through inquiry and observation
- learn to use mathematical concepts
- learn basic calculation skills
- learn to concentrate on their work
- learn to validate their actions, to ask questions and draw conclusions from their observations

(Lavian Keskuskoulu, 2011-2013)

The aims of learning science in the 1st grade are that pupils:

- get experiences from nature and the built-up environment by observing, exploring and experimenting
- get to know different tools of exploration and study, and different sources of knowledge
- get to know the concepts which are used to describe and explain the phenomena of nature
- learn how to take care of the nearby environment
- learn positive interaction skills by working in groups
- learn to understand the meaning of one's own safety and health and act accordingly
- learn to move around safely in traffic

(Lavian Keskuskoulu, 2011-2013)

The aims of learning mathematics in the 2nd grade are that pupils:

- learn, in different ways, to search for information from nature and the built-up environment, including through experience
- learn to use different tools of exploration and study, and different sources of knowledge
- learn to use the concepts which describe and explain the phenomena of nature
- reflect on the meaning of a good environment and learn to operate responsibly in it
- develop positive interaction skills by working in groups
- learn to understand the meaning of mental and physical safety and act accordingly
- learn to influence safety in one's own nearby surroundings

(Lavian Keskuskoulu, 2011-2013)

The aims of learning mathematics in the 3rd grade are that pupils:

- learn to safely move around in their surroundings by protecting themselves and by obeying instructions given in school regarding the nearby surroundings and traffic
- learn to know nature and the built-up environment of the nearby surroundings; to observe changes in these and perceive one's own home as being a part of Finland (and Scandinavia)

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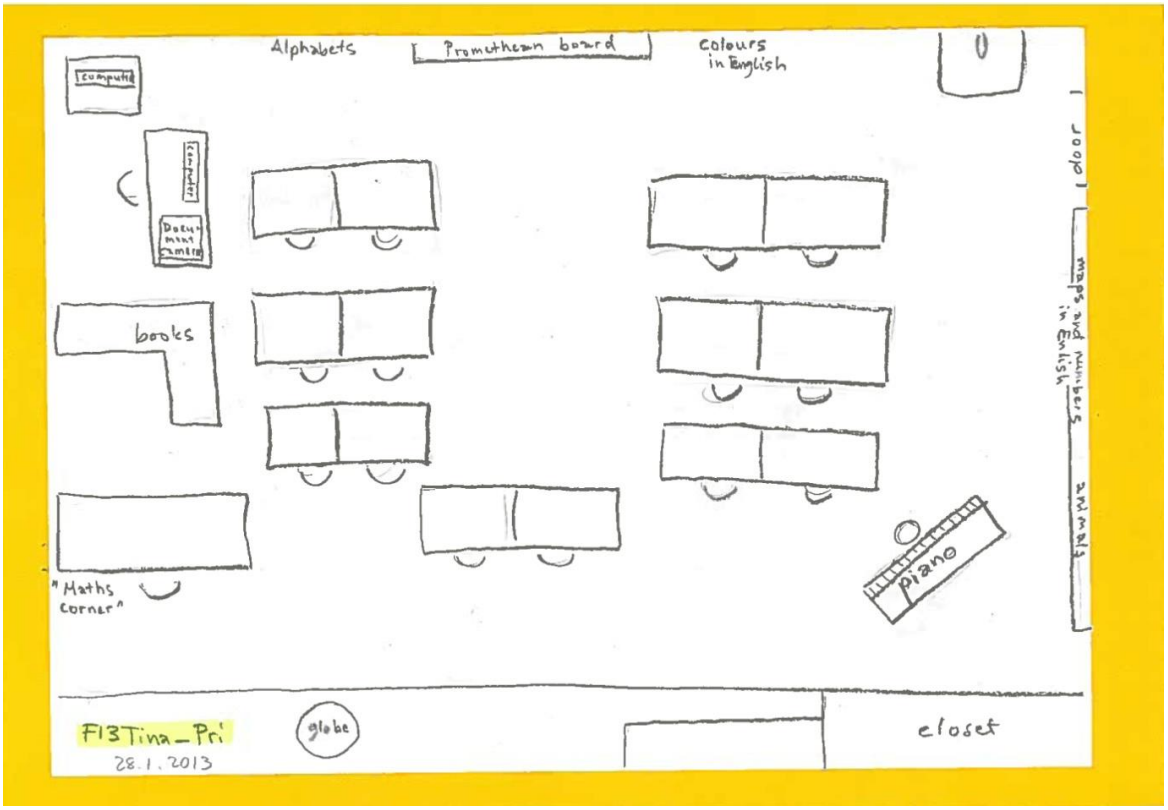
- learn to search for information about nature and the environment by observing, exploring and using different sources of material
- learn to make observations with different senses and with simple exploring tools, to describe, compare and classify observations
- learn to make simple scientific experiments
- learn to make simple maps and to use an atlas
- learn to present information about nature and its phenomena in different ways
- learn to use concepts to describe and explain the phenomena of nature
- learn to preserve nature and save energy
- learn mental and physical knowledge about oneself, respect for oneself and for others, social knowledge about health and illness, the concepts and vocabulary used, and to behave and make choices that promote a healthy life

(Lavian Keskuskoulu, 2011-2013)



Picture 9. Map of classroom (FI3Tina)

3.6.2 Description of episodes

The following episodes were produced from Tina's data

1. FI3Tina_Pri_Fractions (Appendix 17)
2. FI3Tina_Pri_Presentations (Appendix 18)

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Episode 1: Fractions

Introductory Comments

The lesson took place during the morning hours and was a lesson for the whole class (all the children were involved).

Pedagogical Framing

The aim of the lesson was to learn fractions; it particularly focused on dividing the circle into different parts and learning to sum them up. The teacher used formative assessment, talking with each child and evaluating his/her learning. When she noticed that the child did not understand, she provided extra support.

Pedagogical Interaction

The children are learning fractions. At first, in the beginning of the lesson, the teacher uses pieces of circles with the whole group to make sure the children understand how to work with them. She sets some questions and uses an interactive whiteboard to show the solutions to the problems.

Teacher "What could you say about this circle? What's it like?"What kind of circle do we have here?
Children "round", "four parts"
Teacher "Yes, but what about if you think that it would be an apple?"
Children "Green", "there's a cross inside it, or a plus sign", "it's divided into four parts"
Teacher "If you cannot see that it's been divided into parts, what would you say?"
Children "Round", "a half"
Teacher "Is it a half?
Child "No, it's whole"
Teacher "Yes, that right!"

The teacher asks the children to get their own pieces of the circle and says that next they will work in pairs in the same way as they had just worked as a whole class. The children start to work in pairs; they have their own pieces of the circle and they create problems for each other to solve.

Photo 18. Children working in pairs

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The teacher observes and follows the children's work, scaffolding when needed.
After the exercise in small groups, the children take their textbooks. The teacher asks the children to look at the picture:

Teacher "This picture shows the route that this girl has to ski. What part of the route has she skied when she's at the first flag? This whole route has been divided into four parts. How much has she got left? When she's at the finishing line she has skied the whole route and that's 4/4. We have talked earlier about circles, but you can also use line segments."

The children start to do the exercises in the textbooks

The teacher walks around and scaffolds: she sets questions and new examples.
The children come to the teacher and she checks their exercises.
At the end of the lesson, the teacher encourages some children to use the pieces when they try to do their textbook exercises.

Opportunities for Scientific Learning

In this lesson the children studied fractions for the first time. They started to understand numbers smaller than 1 and combine them. They also learned to set questions to each other about the fractions, which fostered their understanding and thinking skills.

Opportunities for Creativity

In this lesson the children had an opportunity for problem solving and agency, they also had dialogue and collaboration both with their teacher and peers. Reflection was supported by teacher scaffolding and involvement not only during the whole class activities, but also continuously during the work in pairs.

The children made up their own kinds of problems for each other to solve. This activity fostered not only their imagination and their ability to make connections, but also creative thinking skills.

<u>Episode 2: Presentations</u>

Introductory Comments

The class had been studying Finland and its geography. They have had a project in which each small group of pupils has concentrated on some particular area of Finland. This was the last lesson of the project and the children had prepared their presentations for it.

Pedagogical Framing

The aim of the lesson was to learn to prepare a presentation and focus on the key issues of the project. Each group had studied independently (gathered data and created a power point show).

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The groups had the following titles:

- Lapland
- Eastern Finland
- Lake Finland
- The capital
- Insular Finland

Opportunities for Scientific Learning

This lesson itself provided somewhat weak links to scientific learning, but if we consider the project in general, in this, there was more evidence of scientific learning. During the project the children learned to gather information and in particular, select what was appropriate. Data selection was assessed by the teacher also during the presentations. Based on this, the children learned geographical information about the lakes, cities and other characteristic parts of Finland. They also compared their presentations with each other.

Opportunities for Creativity

The process of creating a power point presentation provided an opportunity for creation and agency. In addition, the activity supported problem solving skills (how to present it, what kind of information is needed, how to find the proper information etc.). The presentations were created in small groups or in pairs, so the activity fostered their collaboration.

During the presentations, the teacher asked questions and encouraged the children to reflect on their outcomes and the learning process. This developed their metacognitive skills, especially that of reflection.

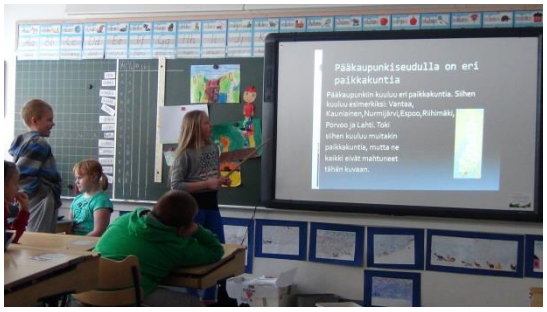

Photo 19. Children presenting their project

3.6.3 Case summary and Conclusion

RQ2: Probing practice

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

Based on these episodes, through questions and peer group work, the teacher encouraged the children towards active participation and a problem based learning process. She

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continually scaffolded the children by setting questions, but not giving the answers. In addition, several forms of collaboration were systematically a part of her pedagogy.

In the interview, she could not specify any particular approach but felt that she always aimed to support children's learning in a holistic way. She aims to use approaches that support both the children's understanding and their individual way of learning.

What role if any, does creativity play here?

According to data from the interview, creativity has a crucial role in her pedagogy. She aims to use approaches which in turn, encourage the children to create their own approaches and solutions. Affective issues such as undergoing experiences are important, and she has also considered the role of motivation in her teaching. Multiple approaches and teacher scaffolding are important; some children need this more than others but the teacher must always be available.

RQ3: Probing practice

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

Tina uses problem solving and collaborative approaches that seem to motivate children. In addition, systematic and continuous collaboration through questions encourage them to think and engage.

Tina's pupils were motivated to learn and work with their teacher. They said that Tina's approaches are good and she teaches very well, mentioning several issues in which Tina's approaches are appropriate for learning science and mathematics:

- She keeps control and actively scaffolds in the classroom
- She explains in great detail the issues and phenomena
- If we do not understand, she explains so many times and in so many ways that everyone understands.
- She always helps us when we need it.

(FI3Tina_Pri_Int_Children 1&2_210213.)

Some children were not motivated to learn mathematics because it was too easy for them. However, all the children felt that learning mathematics is significant and useful for everyday life.

In the case of learning science, the interactive whiteboard and mini computers were seen to motivate the children in their learning. However, traditional science tools such as microscopes, magnifying glasses, and taking samples, were also considered interesting and activated them to learn. (FI3Tina_Pri_Int_Children 1&2_210213.)

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How do teachers perceive their own role?

- Tina uses multiple activities such as outdoor activities, small group activities, individual work etc.
- She uses multiple materials and resources
- She always tries to organize an authentic learning environment whenever possible, taking into account both the physical and emotional part of the learning environment.
- She uses both homogeneous and heterogeneous groups. She is planning to use multigrade teaching.
- She uses various forms of assessment

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4. Discussion of findings

4.1 Enabling Factors and Barriers at the Contextual Level

Preschool (in this report, ages 3-6) in Finland, has no set aims for learning outcomes; this education is voluntary and is provided for children aged 0-5. The teachers working with 3-5 year olds are often socionomists or kindergarten teachers who are not qualified to conduct teaching activities in academic subjects such as science and mathematics. This might be one reason why the teachers discussed in this report who voluntarily participated on the study, are mainly working with children who are 5-6 years old and are in their preschool year (Finnish preschool is intended for 5-6 year old children). Preschool teaching activities are more relevant for the child; the teachers are more experienced and confident about pedagogically reflecting on their work from viewpoints other than child development and care.

Teachers in this study were selected, based on their experience and willingness to participate on the study. It must be noticed that these teachers serve as examples of average levels of teacher competence and the average approaches frequently used in Finnish early years science and mathematics.

4.1.1 Differences between preschool and primary school

Preschool and primary school have separated curricula and there are several differences such as the nature of the aims, learning contents and role of assessment. In preschool, the aims and learning content is not subject based but orientation areas for learning are established. In addition, the approaches for assessment are not defined. In primary school, the learning content and aims are more strictly defined. The curricula for preschool and primary school are under revision and the new curricula will be published in 2016.

Teachers at primary school generally have a higher educational degree than teachers at preschool. Similar trends were also noticed in this study with the exception of one preschool teacher who had a Master's degree in education like all the primary school teachers.

4.1.2 Differences between science and mathematics

In Finland, the Finnish language and mathematics are the two core academic subjects. There are several studies that focus on children's development in language skills and mathematics (e.g Lerkkanen et al. 2011; Niemi et al. 2011), but only a few on science education (Havu-Nuutinen 2005). In addition, in-service education for teachers is provided more in mathematics education than in science education. According to the teacher survey questionnaire, Finnish teachers are more confident in mathematics education than in science education so the teachers in this study can be considered exceptional in their abilities to teach science.

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4.1.3 Opportunities and challenges for creative learning and teaching

Creativity is rarely considered in the Finnish curriculum and is not understood in the way meant in this study. Creativity is mainly understood as a part of art education or innovative thinking, not in a sufficiently broad sense. However, several creative dispositions stated in the Creative Little Scientists –project, can be identified either from the curriculum or from the activities conducted in this study.

Teachers highlighted the role of creativity as part of their pedagogy and this can be considered as an important opportunity for Finnish early years education. Creativity as a part of child development or learning is not commonly discussed among policy makers or teachers in general.

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

In this section, we summarise the issues drawn from the episodes and analyse them according to the spider categories and mapping and comparison factors. Conclusions are based on findings from the narrative episodes described in previous sections, and the information gathered in teacher interviews.

4.2.1 Aims and Objectives

In one particular learning setting, the episodes revealed a variety of aims. One activity often comprised of social, affective, and cognitive aims of learning; the episodes (except the free-play episode) nearly always aimed at the knowledge and understanding of science or maths. Science processing skills were systematically included in the episodes, mainly focusing on observing, classifying and describing. Similar findings were concluded in D 3.2 and 3.3 and the trend follows the national core curriculum for preschool and primary school.

Social factors have a crucial role in Finnish learning aims. Collaborative and communal engagement was emphasised in the teaching and learning aims, thus both teacher guided and peer related collaboration was systematically used. This supports the trend of the teacher survey questionnaire in which the teachers mostly highlighted the social and affective factors of learning.

Although affective factors of science mathematics learning occurred in several episodes, it was not evident as to how those affective factors such as play orientation, active engagement and exploring, increased the children's attitudes to science or science learning. In the teacher interviews, affective factors were seen to be crucial. Teachers systematically reflected that creativity in learning should have its own place and must always be taken into account.

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Creative dispositions (see D 3.1) were clearly involved in practice. Problem solving skills, imagination and reasoning skills were particularly aimed at in several episodes, while aims for innovative thinking, creative thinking skills and curiosity were less evident.

4.2.1.1 Differences between preschool and primary school

Both primary and preschool teachers seemed to have very similar aims regarding teaching and learning; only a few nuances were recorded. Preschool teachers highlighted the affective aims in learning. The children's motivation and sense of initiative were seen to be significant, although there wasn't clear evidence of these in practice. Primary school teachers focused more on reasoning and reflection than the preschool teachers; they did not aim to explain scientific phenomena or mathematical processes.

4.2.1.2 Differences between science and mathematics

The main difference between science and mathematics was noticed in the aims regarding the learning of concepts and processes. In nearly all the episodes that focused on science, some particular scientific concept was included in the learning aims. In the case of mathematics, the aim focused on mathematical processes and the mathematical concept was rarely defined.

4.2.1.3 Opportunities and challenges for creative learning and teaching

It seems that the aims of teaching and learning are not systematically analysed by teachers, also that the aims and objectives are not interlinked with each other. Nearly all the episodes were fragmented parts of the curriculum and sometimes it was difficult to identify the long term goals, as such, presenting challenges in terms of aiming to foster children's creative learning. Creativity was more explicitly evident from the viewpoint of teaching and was supported by the teacher interviews. Challenges were presented regarding innovative thinking and making connections. The aim most strongly represented was problem solving –it was systematically evident both in preschool and primary school.

4.2.2 Learning Activities

Parallel with the aims and objectives, learning activities focused rather equally on cognitive and social development. For example, questioning and data gathering were systematically a part of early years science education, all of these activities embodying some social aspect.

Dialogue and collaboration were very strong characteristics of learning activities. Commonly used were teachers' introductions at the beginning of the episodes and reflective discussion at the end of them. Communication and decision making were often part of small group activities. This supports the results of the teacher survey questionnaire in which also the social factors were highlighted.

4.2.2.1 Differences between preschool and primary school

Learning activities in preschool were often play or game orientated. Using several play orientated activities or by including some specific emotional aspect such as using toys for

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activity with cognitive aims, the scientific learning content was absorbed. In addition, learning activities in preschool had more cross-curricular characteristics than in primary school. Science and mathematics or science and the Finnish language were learned by using integrative activities such as measuring toys. In primary school, however, paper-pencil activities were used more often in strictly subject (science or mathematics) orientated activities.

4.2.2.2 Differences between science and mathematics

In both science and mathematics, the learning activities nearly always had cognitive and social features. However, data gathering and exploration were more common with science phenomena than with mathematics. In addition, process skills and their development were included in several science activities, but not so regularly in mathematics.

4.2.2.3 Opportunities and challenges for creative learning and teaching

The learning activities were generally teacher planned in advance, which left no room for child-initiative. In addition, the learning activities did not provide an opportunity for connection making nor very often for creative problem solving skills.

4.2.3 Pedagogy

The general feature of the episodes was a strong pedagogical role of dialogue and collaboration. Small group settings were used systematically across the episodes and in addition, there is clear evidence of the problem-solving agency in the activities. Teachers often used approaches in which guided inquiry was involved and the children and their explorations had an essential role in these processes. In problems solving situations, the role of the teacher was that of facilitator, scaffolding the process through questions fostered reflection and reasoning. The teachers activated the children to think, questions and statements were used, and the children had an opportunity to react, think aloud, and express their own opinions.

4.2.3.1 Differences between preschool and primary school

The essential difference between preschool and primary school was the role of play and exploration. In preschool the teachers used pedagogical games, plays and free play more often than at the primary level. When play activities were used at the primary level, they represented only a small part of the learning activity.

Digital technologies were not used in the preschool episodes, but very often in those in the primary school. Interactive whiteboards were available in all three classrooms and teachers used them systematically both in science and mathematics teaching. One preschool teacher had an interactive whiteboard in her classroom and she said in the interview that they do use it, but no so often in science.

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4.2.3.2 Differences between science and mathematics

There were no clear differences between science and mathematics although it does seem that mathematics is more often learned through a crossdisciplinary /curricular context than science. Mathematical issues were often linked to language learning or everyday situations.

4.2.3.3 Opportunities and challenges for creative learning and teaching

Creative dispositions were generally involved in the episodes in several ways; teachers highlighted the role of creativity in their pedagogy, focusing on motivation and the cognitive features of creativity. However, there was no strong evidence of pedagogy that would foster children's innovative and creative thinking. Not enough room was left for imagination or curiosity, and learning activities were often planned by the teacher in advance. The children did not participate in planning the episodes with teacher.

4.2.4 Assessment

Analysis of the role of assessment in early years science and mathematics education proved to be rather challenging, because the teachers' strategies of assessment during the episodes were not explicit. The teachers were actively involved during the learning activities, continuously observing the children's learning and providing feedback, mainly positive. The assessment was rather context based and was more often formative than summative. The learning results or outcomes were often recorded using multimodal approaches.

According to the interviews, teachers (especially preschool teachers) assess the children mainly on daily observation and communication situations. Teachers do not keep any systematic records themselves, but they do save the children's artefacts and other products to show in parental discussions. More systematic assessment is conducted in primary school and exams and tests are used as well. Teachers keep their records and compare them with curriculum guidelines.

4.2.4.1 Differences between preschool and primary school

The main difference between preschool and primary school were the aims regarding assessment. In preschool, the teachers focused their assessment on the engagement and progress of activities rather than the learning outcomes. At primary school, the outcomes were assessed in addition to the process, and self-assessment was more regularly a part of the activities than in preschool.

4.2.4.2 Differences between science and mathematics

There were no essential differences between the assessment of science and mathematics.

4.2.4.3 Opportunities and challenges for creative learning and teaching

There seems to be a need to consider assessment in multidimensional terms and link it to the improvement of teaching and the curriculum. Teachers focused their assessment on the children's performance, not taking into account the assessment of teaching. In addition,

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children's active role in assessment processes could foster their thinking and metacognitive skills.

4.2.5 Materials and Resources

Materials and resources were widely used and teachers were confident and satisfied with them. In addition, there were sufficient human resources to give the children the support they need. In all cases there was more than one teacher available; teacher assistants in preschool and teacher students in primary school. However, in the communal school (see FI3Tina_Pri_Presentations; FI3Tina_Pri_Fractions) there was no assistance available.

4.2.5.1 Differences between preschool and primary school

The preschools (FI1Kirsten, FI2Rita and FI4Mary) had rich physical environments for exploration as all the kindergartens were located close to the natural environment. Both teacher and children had wonderful access to forest and parks and these were systematically utilized. As some of the kindergartens had taken the natural environment as a leading philosophy in their pedagogy, outdoor activities were often conducted in the preschools, but only once in the primary schools (FI5Rachel_Pri_MapSymbols).

ICT resources were used only in primary school (see for example FI6Helen_Pri, FI5Rachel_Pri, FI3Tina_Pri) and there was no evidence of their use in the kindergarten episodes. One kindergarten teacher said in the interview that they did not have any computers for use, they only searched for information together on the teacher's computer; however, there was an interactive whiteboard available in the other kindergarten.

Published resources were available more at primary school than preschool. In preschool mainly self-made booklets or working sheets were used for activities or for reporting the result, whereas at primary school learning books were used, more systematically in mathematics than in science.

4.2.5.2 Differences between science and mathematics

Practical, informal resources were used both in science and mathematics, but so called additional supportive materials, more in mathematics. This means that in mathematics, the children used materials that supported their learning such as tape rulers, fingers, pieces of papers etc. (FI5Rachel_Pri_HowToCount, FI3_Tina_Pri_Fractions). In addition, games and toys were used more for mathematics than for science.

Outdoor activities in the close natural environment were used for explorations and problem solving more often in science than in mathematics.

4.2.5.3 Opportunities and challenges for creative learning and teaching

Rich learning environments, informal learning materials, plays and games, fostered the children's opportunities for creative exploration and problem solving. In addition, using tools to support the use of their senses in observation increased the children's motivation

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to gather data and describe it (see for example FI5Rachel_Pri_Plants, FI4Mary_Pre_SnowFlakes, FI1Kirsten_Pre_MeasuringOutside).

In both primary school and preschool science and maths, more time and opportunities for creative thinking skills are needed. The children could have more time and room for their individual exploration and investigations, in which creativity would be able to come across more clearly.

4.2.6 Grouping

In general, the children learned in rather big groups, especially in preschool education. The following distribution occurred in the cases observed:

Teacher	Group size
FI4Mary_Pre	14
FI1Kirsten_Pre	21
FI2Rita_Pre	18
FI5Rachel_Pri	19
FI6Helen_Pri	22
FI3Tina_Pri	13

Although the group sizes were rather big, there were often several adults working with the children; in only one primary school (communal school) did the teacher work alone with 13 children. All children received support during the activities and classroom management was under control.

4.2.6.1 Differences between preschool and primary school

In both preschool and primary school, whole group and introduction sessions were conducted, but only as a part of the lesson. The main focus was on small group settings in which the children worked either with the teacher or collaboratively with peers. The free play activities were not as orderly as the other activities, the groups being based on the children's relationships with their friends. Small group play and pair work was noticed in the free play episodes.

4.2.6.2 Differences between science and mathematics

Small group work was used in both science and mathematics activities and the children rarely worked with individual tasks. However, it does seem that especially in primary school mathematics, teachers used learning books more; when books were used, then the children

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worked individually. In addition, when iPads or other tools were used collaboratively, each child had his/her own computer or tool.

4.2.6.3 Opportunities and challenges for creative learning and teaching

In most cases the groups were formed by the teacher and very rarely were the activities organized by the children, nor did the teacher discuss organization of the activities with the children. It might therefore be reasonable for children to create their own working groups more often and use their own creative approaches for problem solving. Child-initiative and engagement were involved in the activities but inquiry approaches were rather structured, thus limiting the opportunities for creativity.

4.2.7 Location

The education system in Finland is rather localized and all schools have their own settings and curricula. All sites provided their own school curriculum upon which the episodes were based. The majority of the schools and kindergarten are public, like those in this study. Only one of the schools was an exception to this. At the classroom level, in both preschool and primary school, activities were held indoors and outdoors. The groups had appropriate rooms for activities and the opportunity to use both informal and formal settings.

4.2.7.1 Differences between preschool and primary school

In preschool, outdoor activities were used more often than in primary school; the children spent long times outdoors with their teacher and learned with informal settings, mainly in forest. In primary school, the learning activities were located indoors, mainly in classrooms or in the schoolyard.

One primary school teacher said that they use the nearby forest and lake environment a lot, but not so often in wintertime. The autumn and spring terms in Finland are those best suited for learning science phenomena. It would seem therefore, that in primary school, the outdoor and informal learning environments are used when learning cognitive dimensions, but in preschool, the outdoor environment is also used for developing affective dimensions.

4.2.7.2 Differences between science and mathematics

There were no crucial differences to be found between science and mathematics but according to the teachers' interviews, science activities occur more frequently outdoors and mathematics indoors.

4.2.7.3 Opportunities and challenges for creative learning and teaching

In this study, much of the science exploration occurred in the winter outdoor environment. The teachers (FI4Mary_Pre_Snowflakes; FI4Mary_Pre_MeltingSnow; FI2Kirsten_Pre_MeasuringOutside) took the children outdoors to work with snow and phenomena related to it. Snow and winter as a local characteristic, provides a good opportunity to foster children's creativity and understanding of substances.

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In primary school, the location and available space could be used more creatively to widen the opportunities for learning. Primary school teachers mentioned the significant role of the learning environment for creativity and for learning in general, however, there was no evidence of this in the episodes.

5. Implications

5.1 Implications for teacher training

The teachers involved in the study were selected on the basis of particular excellence in science or mathematics education. They all had a teacher qualification and several had additional degrees or merits in science and mathematics education. According to annual statistical reports (Kumpulainen, 2010) Finnish teachers are well qualified, more than 95 % of teachers have an appropriate degree. In interviews, the teachers in this study expressed that as well as having pedagogical confidence they are also interested and confident to teach science and maths. The results were not similar to those from the teacher survey questionnaire, in which despite having high pedagogical confidence, teachers did not have such a good level of confidence with science issues. According to the results of this study, Finnish teacher education could more systematically provide courses for student teachers, which would improve their confidence with science and in particular, give them the competence needed to use multiple approaches of teaching, learning, and assessing science and mathematics education, both indoors and outdoors.

Teachers used several creativity dispositions defined on the Creative Little Scientists – project (see D.2.2 and list of factors D3.1) and they saw creativity as a significant part of the learning process. However, there were a number of dispositions such as curiosity, creative thinking skills, connection making and a sense of initiative, which did not appear so explicitly. In teacher education, student teachers could foster their abilities so that they are able to consider creativity in a broader context, and learning as a process of creativity.

Problem based learning activities occurred throughout the episodes implemented in this study; investigations were rarely conducted and open inquiry methods in particular, had a minimum role; inquiry approaches, especially investigations, were also rarely planned and were generally made in early years education (Teacher Survey Questionnaire). Based on the results of this study, student teachers should acquire more experience in inquiry methods so as to become confident in using them. This can achieved through research based teaching and diverse school experience.

Outdoor activities were more often, systematically used in preschool, but not in primary school. Teacher education should provide more opportunities for outdoor activities, showing how essential an authentic learning environment is both for the cognitive and affective dimensions of development and learning.

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5.2 Implications for policy development

The Finnish National Curriculum for preschool and primary education is under revision, and a new curriculum will be published in 2016. This study fosters current discussions among educators, about the essential role of child initiative and curiosity in early years education. The episodes of this study involved learning activities that were mainly planned by teachers, leaving the children with limited opportunities for regulating the activities. To foster creativity and children's engagement, it must be recognised at policy level, that child-initiative activities are significant for children's future learning and the development of their metacognitive skills.

The Finnish National Curriculum for primary education emphasises the role of problem based learning and inquiry approaches (Finnish National Board of Education, 2004), however, to some extent these aims are not fulfilled and teachers tend to focus on process skills. At policy level, the aims of investigative approaches should be considered in more detail, giving teachers access to supplemental material in order to confirm the role and meaning of inquiry approaches in teaching and learning. In preschool, the role of inquiry approaches could be reduced and focus placed more on the systematic use of fostering active engagement, process skills, reflection and reasoning. Reflection and reasoning were rarely observed in preschool.

The children were motivated towards learning science and maths and especially in preschool, children highlighted the approaches in which they have an active role. Play orientated activities are emphasised in the current core curriculum for preschool and these should be fostered and expanded to incorporate learning approaches with academic subjects. Activities should have aims and learning goals, but the approaches must always be organised to enable children to experience high engagement and creativity.

Resources and materials are an essential part of high quality education and Finnish teachers are satisfied with their accessibility. It does seem, however, that there are some contextual differences between the municipalities regarding the availability of materials and resources. Policy makers should confirm equal opportunities for children to follow technological development and the pedagogical use of ICT tools. Some rural areas seem to suffer from a lack of resources.

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