



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

D4.3 Country Reports

Report 1 of 9:

**Country Report on the in-depth field work in
Belgium**

Author(s):

Dr. Hilde Van Houte, Artevelde University College, Belgium
Kirsten Devlieger, Artevelde University College, Belgium

www.creative-little-scientists.eu



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Contact Information

Coordinator

Ellinogermaniki Agogi, Greece:

Dr. Fani Stylianidou

Lead partner for this deliverable

Ellinogermaniki Agogi, Greece:

Dr. Fani Stylianidou, Dimitris Rossis

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

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1. Aims of this Report

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

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

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

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

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

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

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



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



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2. Methodology

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

2.1 Research Questions

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

- RQ1** How are the teaching, learning and assessment of science and mathematics in early years in the partner countries conceptualised by teachers and what role if any does creativity play in these?
- RQ2** What approaches are used in the teaching, learning and assessment of science and mathematics in early years in the partner countries and what role if any does creativity play in these?
- RQ3** In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics, and how do teachers perceive their role in doing so?
- RQ4** How can findings emerging from analysis in relation to questions 1-3 inform the development of practice in the classroom and in teacher education (ITE and CPD)?

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

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

Sub-questions running across all research questions probe:

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

- **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.

Table 1: Dimensions, Sub Questions and Factors

	Dimensions	Sub questions	Factors important to nurturing creativity in science and mathematics in the early years	Coding
PEDAGOGICAL INTERVENTIONS	Learning Activities <i>Interaction</i>	How are children learning?	<p><i>Focus on cognitive dimension incl. nature of science</i></p> <ul style="list-style-type: none"> Questioning Designing or planning investigations Gathering evidence (observing) Gathering evidence (using equipment) Making connections <p><i>Focus on social dimension;</i></p> <ul style="list-style-type: none"> Explaining evidence Communicating explanations 	<ul style="list-style-type: none"> LA: Ques LA: Plan LA: Obs LA: Equip LA: Connect <ul style="list-style-type: none"> LA: Expl LA: Comm
	Pedagogy <i>Interaction</i>	How is teacher facilitating learning?	<ul style="list-style-type: none"> 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; <i>collab. between children valued</i> 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 	<ul style="list-style-type: none"> P: Play P: Affect <ul style="list-style-type: none"> P: Collab <ul style="list-style-type: none"> P: Agency P: Ques <ul style="list-style-type: none"> P: Express P: R and R <ul style="list-style-type: none"> P: Scaff
	Assessment <i>Framing and Interaction</i>	How is teacher assessing how far children's learning has progressed, and how does this information inform planning and develop practice?	<p><i>Assessment function/purpose</i></p> <ul style="list-style-type: none"> formative summative recipient of assessment results NO CODE <p><i>Assessment way/process</i></p> <ul style="list-style-type: none"> 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 	<ul style="list-style-type: none"> A: Form. A: Summ. <ul style="list-style-type: none"> A: Strat. A: Evid. <ul style="list-style-type: none"> A: Peer/self
	Materials and Resources <i>Framing and Interaction</i>	With what are children learning?	<ul style="list-style-type: none"> 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 	<ul style="list-style-type: none"> 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 <i>Framing and Interaction</i>	Toward which goals are the children learning?	<ul style="list-style-type: none"> 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 	<ul style="list-style-type: none"> AO: Kn.Sc AO: Und. SI AO: Sc Proc Skills AO: IBSE/PBL AO: Social AO: Affect AO: Creative
	Location <i>Framing and Interaction</i>	Where are they learning?	<ul style="list-style-type: none"> outdoors/indoors Recognition of out of school learning formal/informal learning settings/ small group settings 	<ul style="list-style-type: none"> L. Out/ Indoors. L.Formal/ Informal L.grp
	Grouping <i>Framing and Interaction</i>	With whom are they learning?	<ul style="list-style-type: none"> multigrade teaching ability grouping small group settings number of children in class 	<ul style="list-style-type: none"> G:MG G:Abil. G:SmallIG G:No.

2.2 Research Instruments

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

- WIDER SITE CONTEXT:** encompassing data from existing Deliverables D3.2, D3.3, and D3.4.
- 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.
- 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.

All core research instruments were used: detailed fieldnotes of observations with a timeline, sequences of digital images, audio recordings (in one case), artefacts, individual interviews with teachers, group interviews with children and learning walks. Additionally, from the repertoire instruments we used video and in some of the cases also teacher journals.

2.3 Data Collection

2.3.1 Sampling principles

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

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

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

2.3.2 Ethical issues

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

Each partner was required to identify and meet the ethical approval policies for their institution,

school system, region and country as appropriate. In addition, the consortium identified the following minimum standards that were applied by all partners in all cases:

- Participation to the research was on an informed voluntary basis. Letters for school staff and parents were developed for this purpose (see D4.1, Appendix 4, p72). Written consent was obtained before the fieldwork was undertaken. The right to withdrawal was clearly communicated.
- Explicit permission was requested to take and use photographs (and videos where appropriate) of the children and staff for the project in project reports and publications.
- Explicit permission was requested to interview children as part of focus groups.
- 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).

In addition the sites used, the adults and children who were involved were given pseudonyms to protect their identities.

2.4 Data Analysis

2.4.1 Process

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

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

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

2.4.2 Final sample

The characteristics of the original final sample of sites used for the fieldwork are given in the table below (Table 2):

Table 2: Sample of fieldwork sites used in Belgium

Fieldwork Sites		AUC 1	AUC 2	AUC 3	AUC4	AUC 5
		School of the city of Antwerp	School of the city of Ghent	Catholic School	Catholic School	Catholic School
General Selection Criteria		All CLS Dimensions	All CLS Dimensions	All CLS Dimensions	All CLS Dimensions	All CLS Dimensions
Phase	Preschool	0	1	1	1	1
	School	1	0	0	0	0
Governance	Non-fee paying	1	1	1	1	1
	Fee paying	0	0	0	0	0
Age(s) of children	3	0	0	1	0	0
	4	0	1	0	0	1
	5	0	1	0	1	1
	6	1	1	0	1	0
	7	1	0	0	0	0
	8	1	0	0	0	0
Mixed age groups		0	1	0	0	1
Special school		0	0	0	0	0
High Diversity	SEN	1	1	1	1	1
	Non-native speakers	1	1	1	1	1
	Socio-economic disadvantage	1	1	1	1	1
Location	Urban	1	1	0	0	0
	Suburban	0	0	0	0	1
	Rural	0	0	1	1	0

In these 5 sites we originally identified 7 possible cases: 2 sites with 2 teachers each and 3 sites with 1 teacher each. Unfortunately, due to problems with her arm the teacher of school AUC 5, wasn't able to participate finally in the fieldwork. As a consequence, 6 cases are described in this report.

2.4.3 Limitations

During the in-depth field work some limitations were encountered, some of them are due to local issues others are linked to the project itself.

- In Belgium there is freedom of education, as a consequence all schools have their own curriculum (curricular objectives, pedagogical project, approaches ...). As such there is a large variety in schools, in Flanders as well as in the French Community. For example, only in Flanders there are more than 3600 elementary schools, with all different concepts and strategies. In order to select schools or teachers which could provide good practices for the CLS project, the project team decided to screen:

- schools and/or teachers who participated in the questionnaire – mainly Flemish teachers;
- schools and teachers who already participated in other research projects or professional development courses – these were all Flemish teachers

Consequently, all selected schools are situated in the Flemish region, however they all have a strong vision (pedagogical project) which is very interesting for the project. The selected schools belong to the publicly funded education, either publicly run (school 1 and 2) or run by a private organisation (school 3 and 4).

- Four of the teachers are well known by the researchers, they participated in other projects in which in-depth field work was done. These teachers are used to be observed and to reflect on their teaching practice (video recall is well known for them). Based on earlier experiences we know that it is necessary to connect with the participants. In this project the time period was too short to do this with the teachers that haven't worked with the project team. As such there is a difference in data and in process. With four of the teachers, much more informal talks, mails, discussions, etc. were done. Qualitative research asks for more in depth information and data, as such it is necessary to connect with the participants.
- Two researchers were involved in the in-depth research, however because of time limits it was not possible to observe with both researchers at all moments. In the cases this was possible, richer data could be sampled. For example, during corner work you are able to sample data in two places (corners) at the same time instead of one.

In addition, due to time limits it was impossible for the researchers to code all data; as such triangulation wasn't always possible.

- Although there was a limitation in data sampling, the in-depth research resulted in lots of rough and rich data. Because of translation and time issues, it was impossible to translate all data; a selection was made based on the factors and the experiences of the researchers. Particularly, the translation of the video fragments and the formulation of interpretations and conclusions were very time consuming.

3. Case Studies

3.1 Case 1&2 – Maaïke & Sarah – A case of teamteaching in an experiential environment

3.1.1 Context

Where?	Country	Belgium					
	Setting name	AUC2					
	Location within setting	Pre-school					
Who? (children)	Year group/age of children	4 – 6 years					
	Number of children in class	50 (combined classes)					
Who? (adults)	Number of adults	2					
	Role of adults	Preschool teachers					
	Case teacher role	Teachers					
When?		1	2	3	4	5	6
	Dates of visits (2013)	27/11	24/01	29/01	04/02	21/02	15/03
	Times of visits		8h25-12h	8h25-12h	13h30-16h	8h25-12h	8h25-12h
	Goal of visit	Intake	Observation and informal interview	Observation and informal interview	Observation and informal interview	Observation and informal interview	Interview with both teachers

a) ‘AUC2’: a school with a specific pedagogical project

‘AUC2’ belongs to the publicly funded, publicly run education. The school board is the city of Ghent. As a public setting, the school is open to all children, whatever the ideological or cultural background of the parents. The school advertises itself as a high-quality neighborhood school, where the latest educational methodologies and didactics are applied. Education in the school is intended from the age of 2,5 years. The school has three locations; a primary school, a preschool (ages 4 to 6 years) and a second preschool (ages 2,5 – 4 years). In this case we focus on the preschool level, the ages 4 to 6 years. The building of this preschool is located in a neighborhood with young families, new buildings (houses and industry), however on the other hand the neighborhood is also quite cultural. The preschool is situated in close proximity to the downtown area of a Flemish provincial town (Ghent) but is also situated near the river ‘de Schelde’.

‘AUC2’ has a specific pedagogical project, which is illustrated in the vision of the school and which is approved by the organising body ‘the city of Ghent’:

A viable school with inquiry-based learning as central objective where each talent counts in order to realise equal educational opportunities for every child, taken in account the social economic evolution.

Specific goals of the school:

1. Realising experiential education
2. Attention for the development of talents
3. Attention for inquiry learning
4. Development of a broad assessment strategy in order to children to evolve

The preschool works with projects which emerge from the interests of the children. In this case the project 'Europe and beyond' is covered. This specific project resulted from the multicultural composition of the classes of Maaïke and Sarah.

In the afternoon there are ateliers in which a teacher works with a group of children from different class groups. The ateliers are spread over 2 weeks and what happens in the atelier has to be finished in 14 days. The ateliers are based on the teachers' talents. As a consequence there are 5 different ateliers: ICT atelier, word/drama atelier, art atelier, zen atelier, inquiry and design atelier. During the atelier time, the teacher and the children are deeply exploring a particular topic, for example the green teacher looks for recipes which she can prepare with ingredients which grow in her garden. The children investigate and explore what is growing in the garden, they map it and they try some of the recipes. They collect existing and new recipes in an handmade cookbook or in their portfolio. In one of the episodes the focus is on the inquiry and design atelier. This atelier takes place in the classroom of Maaïke.

Since the school year 2010 – 2011 the school has launched a digital portfolio, in the preschool and the first grade. A digital portfolio is a showcase of the possibilities of a child and of what the child has achieved at school and in the spare time. It shows what the progress is in different domains/areas. The digital portfolio is made by the children themselves.

Based on the information above it is clear that the school attaches great importance to technology, ICT and inquiry-based learning. Technology and ICT enhance the teachers to work creative and innovative with the children. The school team wants to create as many situations as possible in which they encourage children to think and find solutions.

b) Maaïke and Sarah: teachers with a strong pedagogical concept

Maaïke and Sarah are both teachers in one of the preschool settings of the 'AUC2' (setting for the ages 4 to 6 years). They have classrooms which are next to each other and are connected by a door. The classrooms are on the ground level. Outside the building there is a playground-garden with grass, trees, flowers and other natural materials. A great place to use for outdoor activities, to relax, to 'ravotten', ...



Since last year the teachers decided to start with team teaching, meaning both class group are combined in their daily practices. For example the 'kring' moments are situated in one classroom, the classroom of Sarah. During these 'kring' moments, all the children and both teachers sit down in a circle before the digital board.

During corner work the children can choose to play in the corners of both classrooms or the corridor, the teachers are guiding the children in the different corners.

As a teaching team, Maaïke and Sarah have a strong pedagogical vision which is based on the pedagogical project of the school. They focus on:

- ***Experiences, interests, questions and theories of children***

The practice of Sarah and Maaïke is strongly influenced by the principles of experiential education. Maaïke, who is the oldest teacher, has worked with Ferre Laevers. So, based on experiences, questions, interests or theories of children, projects and activities are developed in close cooperation with the children, and these are focused on the children's world and fantasy or imagination. For each activity they have to write down one curriculum goal, a broad and essential goal. Of course, they also work to other goals during these activities. However, they stress that they reach different targets



with different individual children. According to them, as a teacher you should not look at the age of a child, but you have to look at the child and what he or she is able to do and knows.

Each activity also has to be in accordance with their strong pedagogical vision.

For example, at the start of 2013, after the Christmas holidays, the children were very interested in countries, European countries and beyond. Several of the children have

one or two parents, who have other nationalities (UK, Chili, ...). Consequently a new project started 'Belgium in Europe and beyond'. Parents and children were asked to select photographs and books of other countries, visits and holidays. In the episode of the waterfall, a photograph of one of the girls is discussed.

As a consequence of this very experiential approach, these teachers are also creative in interacting to unexpected moments, which is illustrated in several of the episodes, for example in the episode of the Giant.

During the projects and activities, all learning areas are integrated, also science and mathematics. It is unnatural, according to these teachers, to separate areas. Children have to be oriented to the world in a broad way since the world is no compartmentalized reality. The latter is also advised in the national core curriculum.

- **Ownership, initiative, agency of children**

Or as Maaïke phrased it *'Self-control, ownership or agency are encouraged tremendously here. It may first seem somewhat chaotic.'*

The teachers also don't work with textbooks. *'No, everything is in our head and in that of the children.'* For example *'The design have to come from the own thinking and creativity, no creation of the children is just copied, they all are original. In the beginning of the design it is possible that it is the same, because you give a hint or they watch each other, however during the design they choose for different materials. They also have to evaluate what they have made themselves.'*

The teachers work explicitly with what children say or do. Sarah has stated this as follows *'I try to make as much use of what other children do or say, I'm convinced that this is much more interesting for the children and important. Children are strong in helping each other, however they don't copy, they have to have some individuality. By watching and hearing other children, some children are going a step further, especially the children who pick up things very easily.'*

The episodes of the carpenter corner and the mask illustrate very well how children select or choose their own materials to work with, even if these materials are outside the classroom. They also illustrate how they interact to each other.

- **Fostering the critical, innovative and problem solving thinking of children**

The teachers try to encourage the innovative, creative and problem solving thinking of the children as much as possible. Sarah formulated this as follows:

'The children can take a lot of things themselves but sometimes there is a restriction. Because we want children to think, so the drawers with adhesive tape are closed. Other times they get only a few things in order to promote their creative thinking even more. Adhesive tape for instance is too easy; children are not encouraged to think.'

It could also happen that one child has an idea immediately. The other children hear the idea and want to do the same. Sometimes this child is placed separately (with the materials he or she wants to use) and the other children have to further reflect, so they also can come to creative thoughts or solutions.'

In the episode of the pizza, Maaïke encourages one of the boys to search for another solution in order to divide the mushrooms in pieces. He is not allowed to use a knife or scissors, because two other boys have chosen for these solutions.

- **Team teaching**

The teachers find it more interesting to work and teach together. One teacher is leading the kring, while the other teacher is observing and listening to the children. As such the teachers can interact more quickly to questions, behavior, remarks, and theories of the children. Teaching together is also an interesting way of lifelong learning and of stimulating and respecting each other's strengths.

Although the group is large, about 50 children when they all are present, they notice that children

are more at ease then when the spotlight is on them in a smaller group.

Both teachers have similar ideas about team teaching when they were asked about the added value of working together.

Maaïke: *'You should be able to work together. It is very interesting if you trust each other and you know each other quiet good. You exchange talents and strengths. If you are with two, you can feel or interact different, but you accomplish the same things with the children, resulting in a deeper and richer approach.'*

Sarah: *'Complementing each other. You pick up more things in the kring. It also offers some ease because you have a back-up.'*

- **Time and Space**

It is necessary to give children time and space, to design, to interact, to think ...

Sarah: *'As a teacher, it is important to ask questions at the right time. You are continuously thinking about that, it is an art to do or say as little as possible yourself. Depending on the child you have to adapt. Many or few questions or additional help. You also have to make use of the peers.'*

- **Outside school learning**

The teachers often go outside with the children. The school is situated near the River, so there is some interesting nature in the immediate environment of the school. However the school is also close to the centre of Ghent. The children quite often visit museums and other places in Ghent. Visits to educational centers or museums result in designs or projects. For example: Just before the Eastern holidays the children visited the nature educational centre 'De Kaaihoeve'. Based on this visit they wanted to create Easter baskets with natural materials. The children were not allowed to use glue, tape or iron wire. The children decided to use weaving as technique. Of course the teacher offered them the technique, and showed them how they had to weave. However, the children had to figure out how they had to create the form of the basket.



- **Participation of parents**

Maaïke: *'We are tremendously in favor of parental participation. However, it is easy to have parents to read a book; it is more difficult to have parents who want to help. Although if parents really help, you get to hear beautiful things. 'Now I understand why W. likes school so much. I would also like to be a little child again.'*

Since the school has a specific vision, the parents need some coaching. The process have to be explained to the parents so they know why the children all have other products, or some children have more esthetic products than others. They need to know the focus is much more on the process.

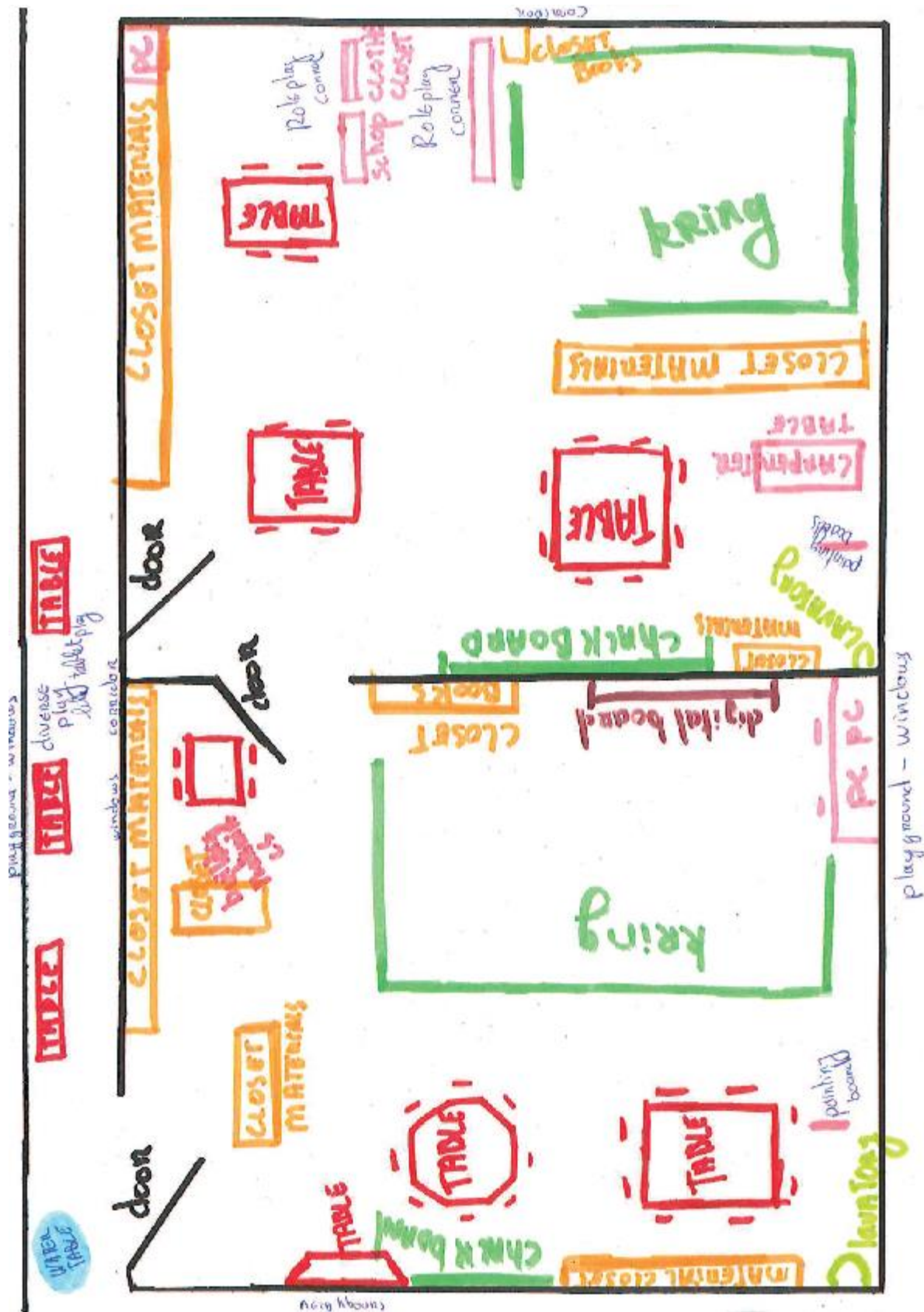
Parents are also informed about the topics in the classroom. For example there is a blog on the website, they also receive a week overview in which they often are asked to bring materials to the school, to help or to visit the classrooms in order to view what their children are doing or have produced (process and products of their children).

c) The children

As mentioned before the school is an example of a multicultural group setting. The children are aged between 4 and 6 years old. Together they are with 50 and two teachers.

d) The classroom





3.1.2 Episodes

The episodes below are used to exemplify the vision of these two teachers, especially concerning integration of science, mathematics and creativity in their everyday practices and activities. The episodes are also used to illustrate some typical activities such as the 'kring' moments, the ateliers, small group working, storytelling, interaction to unexpected moments ... In each episode the pedagogical framing, pedagogical interactions, opportunities for mathematics/science learning and creativity are highlighted.

The first episodes, the episode of the giant, the waterfall and the crooks, are situated in the 'kring', the other episodes are situated in the corners.

a) Episode of the giant

In this episode a book of one of the girls is discussed. It is a book about giants ('Het reuze reuzenboek' from Yvonne Deutch and Michelle Misra). In the book there is also a large poster of a giant. All children are sitting in a circle, the teachers are also in the kring (they are sitting both on one end). The girl presents the book and the poster to the other children. The children are very amazed about the large book and poster.

The poster of the giant results in a comparison between the giant and the children. How large is a giant in comparison with a boy in the classroom? Do the children have also mushrooms growing in their armpits? Based on these questions some investigations are done, evidence is gathered by using the body of the children.



Based on the demands of the children, one of the teachers starts to read the story of 'Jack and the Beanstalk.' At a certain moment she stops reading. Jacques is trapped in the oven. What does Jacques has to do to escape? This is a question which stimulates the problem solving and creativity of the children. Several solutions and theories are considered. The children are interacting to each other, and collaboration is stimulated. At the end, the book is used to assess the theories and solutions of the children.

- Pedagogical Framing

The children are allowed to bring several things to the classroom from home, such as books and stories they like. They are then stimulated to talk about these books in the 'kring'. About 50 children (ages 4 to 6 years old) are seated in a 'kring' on benches before a digital board. The teachers are in between them. The children all have their own strengths and talents, meaning the teachers work with a mixed ability group. These 'kring' moments take place in de morning when the school day starts, however also after corner work. The teachers have one central goal for these 'kring' moments:

presenting you own wishes, opinions and ideas to the group. For these teachers discussion and communication is important. During these 'kring' moments creations, experiences and solutions of children are also evaluated (these are called flashback moments).

Sarah: 'An evaluation of the child's work is important, did it work or not. For example, which glue did we use and did it worked? We bring it in the kring and the children have to tell how they did it and what worked or didn't work. So a reflection is very important.'

In this episode, several of the children are very excited by the book and the poster of the giant. As such, these resources initiate an activity in which the problem solving of the children, their inquiry skills, their reasoning and their understanding of their own body and of nature, is stimulated. Yet, the book and the story were new for the teachers, consequently the interaction with the children and the activity isn't planned. As mentioned earlier, these teachers are experts in experiential education and in stimulating inquiry and problem solving. In all activities, their strong vision and pedagogical concept is visible.

By using fantasy, the teachers also enhance the attitudes of children in science and mathematics. Or as Maaïke mentions it in her journal: *'The giant is viewed and compared: what is apparent? What does a giant do what people don't do? The fantasy is tickled by the large poster and by the story that goes with it.'* She also mentions that they always work integrated and for them fantasy is very important.

These teachers developed a specific assessment strategy, which is also seen in the episode. The children are allowed to give their own ideas and opinions. These teachers appreciate all opinions, theories and solutions of the children. They use the internet or other resources to compare them or to check them, in the episode the text on the poster and the story of Jacques is used to assess the theories and ideas. By using this strategy, they try to promote information and inquiry skills of the children. So, as a teacher they never say it isn't correct or they never give the answer. They use peers and resources to check answers, theories and ideas.

- **Pedagogical Interaction**

The teachers use questions to activate prior knowledge, experiences and imagination of children. They are experts in combining fantasy and reality or everyday life. As such the imagination and creative thinking of the children is activated.

By using questions they also promote reflection and reasoning, evaluation of alternative ideas. As you will notice in the episode beneath the answers and ideas of the children boost other children to interact, and they are allowed to do so.

Sarah *'What does Jacques has to do to escape?'* Several children are now reacting on each other.

Child 1 *'I know, maybe there is a key nearby to open the oven.'*

Other Child 2 *'No, the giant has the key.'*

Other Child 3 *'If the giant opens the oven and he sees the child.'*

Maaïke *'Yes, what then?'*

Child 4 *'Then the child have go the between the legs of the giant. He has to loosen the goat and then the goat will attack the giant, who will fall.'*

Sarah *'But a goat against a giant. How large is the goat?' One of the children is showing how large a goat is, almost his own length.*

Sarah *'Look at how large a goat is and C is a small child. C is maybe as large as Jack.*

Child *'oepsie'*

The children are very excited to bring in more ideas and solutions for Jacques. Children are allowed to give their opinion however when there is too much commotion the teachers are interacting by bringing in another question. So, the children again have to reason and reflect. In the episode Maaïke interacts: *'I just think of something. Who lives with the giant?'*

The group is large however the teachers have good experiences concerning working with this larger group. Sarah: *'We have indeed a larger group however we have noticed that the larger the group, the more children are engaged. Not all children are equally actively involved (meaning they say something in the kring), but in retrospect in the corners you hear that also the children who were quiet have picked up a lot of things. You give children also confidence: I may be quiet and that's OK. It's not required to say something in the kring. In a smaller group, you often notice that every child is obliged to say something.'*

- **Opportunities for Mathematics/Science Learning**

Fantasy, the giant and the goat of the giant are used to make comparisons with humans and children. Who is larger? How large is a giant? How large is the goat?

So the teachers integrate mathematics in their daily practices, during story telling or during 'kring' moments. They have no separate mathematic activities. The thinking and the problem solving of the children is activated during the whole day, even combined with fantasy. As you have noticed the teachers interact in the story and they give the children the opportunity to find solutions for Jacques. The children have to predict how Jacques is going to escape from the oven.

They stimulate inquiry and scientific understanding of children by using the body of the children. Where are your armpits? Do we also have mushrooms growing in our armpits? Why the giant does has mushrooms growing? Investigations and observations are planned, evidence is gathered and communicated.

Maaïke *'Where is your armpit?' The teacher is asking this to all the children.*

Sarah *'Show your armpit.' Every child is showing and pointing to the armpit.*

Maaïke *'Yes, here is the hole under your arm.'*

Sarah *'Are there also mushrooms growing under your arms?' The children are saying no and are also shaking their heads.*

Maaïke *'You know what, I'm going to check it by C2.' 'We are going to see if there aren't any mushrooms growing in her armpits.' All the children are watching the teacher and C2. The teacher is pulling the clothes of C2 up.*

Sarah *'Look at C2 her armpit.'*

Teachers 'Are there growing mushrooms?' The children are saying no.

Sarah 'Why does it happened with the giant?'

Child 'Because he is dirty.'

Maaïke 'Because he is dirty?'

Child 'He has a pimple.'

Maaïke 'Yes and it looks dark at his nose and his ears.'

Child 'Giants eat people.'

Sarah 'What, do they eat people?'

Maaïke 'Do you get mushrooms if you eat people?'

Children 'No' 'Yes' 'That is only with giants.'

To assess the solutions and the data, the poster of the giant (information about the mushrooms in the armpits of the giant) and the story of Jacques (how does Jacques escape from the over) are used. For example, according to the poster, the giant has mushrooms growing in his armpits because he sleeps during the winter.

This activity is situated in the vision and the objectives of the school; however they are also closely linked with the developmental aims from the national curriculum.

World orientation (nature)

- 1.2. The children show an exploring and experimenting approach to find out more about nature.
- 1.3. The children can handle sources, with the help of an adult, to learn more about nature.

Mathematics

- 2.1. Acting, the children can compare and articulate two things on their qualitative properties.
- 2.2. The children can compare things qualitative and bring them together based on one or more common characteristics.
- 3.1. The children can use, acting in concrete situations, the terms "in, on, above, below, beside, in front of, behind, first, last, between, oblique, on each other, far away, close to, inside, outside, up and down" in their proper meaning. They can use icons related to "directions" as symbols.
- 3.3. The children can, in a specific case, find solutions to a spatial problem.

- **Opportunities for Creativity**

In this episodes al lot of opportunities were created for creative thinking, problem solving thinking and imagination. The story and the poster tickled the curiosity and the fantasy of the children and the teachers just interacted on their ideas. Children have a lot of freedom to bring in their own ideas, fantasy and solutions.

Child 'To hide in a different place, where it is hard for the giant to find him.'

Maaïke 'Yes but that is a bit a problem, Jack can't get out of the oven on his one.'

Child 'Then he could ask the wife, can I get the key.'

Other Child 'But then the giant can hear it.'

Other Child 'And the key can't go through the glass.'

Maaïke 'Yes, but do we need a key to open an oven?'

Children 'No'

Child 'You simply have to pull and then the oven opens.'

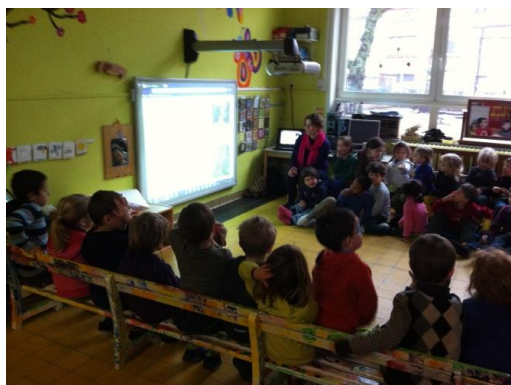
Maaïke 'But if you are in the oven, he is in the oven.'

Child 'Someone else have to pull.'

Other Child 'No, the giant can see this and will say: haha my meal is there.' Again different children have solutions and other theories.

b) The episode of the waterfall

On the digital school board in the classroom of Sarah, a photograph of a big waterfall is projected. It is a holiday photo of one of the girls in the classroom. She went to France and she brought digital images from mountains and waterfalls and from the Eiffel Tower to the classroom (as mentioned before these photographs are a part of the project 'Belgium in Europe and beyond'). The girl is sitting next to Sarah, the teacher who is handling the computer. Next to them the other children are sitting in an open circle before the digital school board. The second teacher, Maaïke, is sitting between them, more or less in the half of the circle. Based on this photograph a discussion starts about the origin of a waterfall. The different opinions and theories of the children are asked for. At the end the internet is used to search for evidence and to check the different theories.



- Pedagogical Framing

In this episode the focus is on the interaction between the two teachers and the children. This activity gives a good example of how the teachers are experts in stimulating the reasoning skills of the children and in incorporating children's prior experiences. Since the activity is initiated by a photograph of the children, it is not prepared. Yet, the teachers know very well which goals and objectives they want to reach.

The specific objective, written down by Maaïke, during these 'kring' moments is on communication and on presenting your own opinion and wishes to the whole group. During the 'kring' moment of the waterfall, the focus was also on understanding/knowledge of world orientation content – the origin of a waterfall.

As already mentioned in the episode of the giant, these 'kring' moments takes place every morning. There are about 50 children (ages 4 to 6 years, mixed ability group) sitting in a circle before the digital board. In this episode the digital board is used to project the photograph and to search for information on the internet.

- **Pedagogical Interactions**

The interaction of the teachers is focused on questions in order to initiate prior knowledge and experiences of children. As such, several children are interacting to each other and are constructing their own theories.

'That is that there is a water flow ... that there is an abyss ... and then that the water falls.'

'It could also be that they are opening a water well and the water is very high. Then it may be that the water falls out and then it becomes a waterfall.'

'Stones between, as such water will not fall, because otherwise the forest will be full of water.'

In order to stimulate conceptual understanding, all theories and reasoning of children are sampled. So time is given to the children to formulate their own opinions and theories. Teachers are not correcting the answers of the children, instead they are listening very well to what children are saying or they look what they are doing. Based on these observations they are using other questions to stimulate their critical thinking or to elicit other opinions.

Maaïke 'How do we call them, those great big stones?'

Child 'Rocks'

Other Child 'Rocks are stones of the mountains.'

Third child 'Yes, a mountain is collapsed and because of that, a waterfall arises.'

Sarah 'Yes, that could be Maaïke.'

Maaïke 'From where the water comes?'

Child 'From the city.'

Maaïke 'From the city?'

Other child 'From the river.'

Maaïke 'Yes, water flows in a river. Or is there a river in the mountains above?'

Child 'It could be from the sea.'

Sarah 'It could be'

Other Child 'The water is clean. It comes from the rain.'

Sarah 'Of the rain, then there should be a lot of rain.'

Maaïke 'In the winter in the Mountains, what can we find there?'

Child 'Snow. Snow can melt and then it becomes water.' After this there is a short break because the children are very excited and want to give their explanations and ideas. So they are talking at the same time.

Other child 'It could also be that they are opening a water well and the water is very high. Then it may be that the water falls out and then it becomes a waterfall.'

Maaïke 'A well above, who knows?'

Child 'Water all comes from a well and then that becomes a waterfall. And then the water runs over the mountain and you will no longer see the mountain.'



Maike 'Sarah, maybe we can look it up, because everyone thinks differently.'

Sarah 'Yes, hey.'

Maike 'How a waterfall arises? And what types of waterfalls exist?'

At the end, the internet is used to check the different theories and concepts of the children, and to discuss what is written by experts. In order to stimulate their visual and audio senses, YouTube films of waterfalls are used.

The children can bring in their solutions and ideas immediately without raising their finger. The teachers allow some noise, however if the children are too excited a little break is necessary. The reason for these discussions, even in this large group, is mentioned by Sarah: *'The children may also think further and react on each other, integrating fantasy. So children are then discussing and leading the kring 'talk'. At those moments, as a teacher, you have to let go. Children should be able to talk to each other and to discuss. Because you're with two teachers, you can much easier hear what all the children say and you can easily interact at the right time. We also believe that children don't have to wait to intervene, or that they have to put their finger on. Often when they have to wait, they have lost what they wanted to say. Eventually they also listen to each other. The more the children are going in discussion, the less they feel that they are the only one talking and they got less blocked. However as a teacher at some point you have to interact again. So, as a teacher you have to let go and then again interact.'*

- **Opportunities for Mathematics/Science Learning**

In this episode the teachers are using the experiences and interests of children, photographs of their holidays, to facilitate science learning. As mentioned in the paragraph above the children's prior knowledge and theories (imagination) are activated (by using questions) to stimulate their conceptual understanding. The internet is used for gathering evidence. The theories of the children are compared with the evidence on the internet, resulting in critical thinking and reflection.

The following aims, present in the national curriculum are covered.

World orientation (nature)

- 1.2. The children show an exploring and experimenting approach to find out more about nature.
- 1.3. The children can handle sources, with the help of an adult, to learn more about nature.

- **Opportunities for Creativity**

The teachers create opportunities for creativity by appreciating the reasoning and imagination of the children, resulting in interesting theories. They do not interact in their thinking by giving answers or disagreeing with what they are saying. They are using information sources to compare all theories and to make connections.

c) The episode of the crooks

It is morning and the children are all sitting in the kring. Suddenly some workmen enter the playground and start to work next to the classroom. One child is looking outside and sees them. She calls for the teacher (Sarah) and says 'The crooks are there'. Sarah, who is leading the morning talk, interacts with the child. Then the second teacher, Maaïke, is also interacting, she knows why the child compares the workers with crooks. She starts asking questions in order to rebuild what happened some weeks ago. The police was in the street because someone lost his car. Based on this experience, the children have created a role play and two workmen got a role in their play, they were the crooks without knowing it. During the role play several things happened.



Based on this role play the conversation in the kring goes further and suddenly 'Sinterklaas' is mentioned. Because 'Sinterklaas' has a hook, according to one of the girls. Maaïke thinks she knows what the girl means and she draws the hook on a piece of paper. It is in fact a lock.

Then the hook, or lock of 'Sinterklaas', is linked to the hook of Captain Hook. A discussion about the hook of Captain Hook starts. Why does captain Hook has a hook? What does he do with it? Several ideas and options are suggested.



Sarah, who left the classroom, comes back and asks why they are talking about captain Hook. The children have to repeat what happened, in a good order.

- Pedagogical Framing

In this episode the focus is on the interaction between the teachers and the children. There is also a lot of interaction between the children themselves, even in this group of 50 children. The teachers are fostering the learning process by asking question, making drawings and building foreword on the imagination of the children.

Because the interaction started from a remark caused by something that happened suddenly and unexpected, we can't say the teachers had planned this conversation in advance. Nevertheless the teachers know very well what happened before and are able to make the process of linking concept smooth, with their main goals in the back of their minds.

This activity gives a good example of how the teachers are experts in stimulating the reasoning skills of the children and in combining it with the fantasy of the children. They are able to bring a remark of a child to the next learning level. In that way they reach high level of commitment and wellbeing with the children. An important objective for these morning talks is: communicating and presenting your

own idea and wishes to the whole group.

- **Pedagogical Interactions**

The teachers interact with the children using questions and building further on their ideas, in order to support their construction of theories (even very imaginary theories) and to encourage them to make their ideas and concepts explicit.

In order to know the answer to the questions about the hook of Captain Hook, the internet is used to search for the real reason. However, first the ideas of the children are discussed and valued.

Maaïke: "C6, do you know why captain hook needs his hook?, how he gets it?, how he uses his hook?, what he does with his hook?"

Maaïke: "C2, is now the teacher. Can you say which child may answer?"

Child 2: "C3"

Child 3: "Maybe to kill someone?"

Maaïke: "This is a bit ugly, isn't it? But, is captain Hook, born with a hook?"

Child: "yes!"

Maaïke: "But C4 has told me something else. Maybe we don't know this yet. C4 can you tell us?"

Child 4: "A crocodile has bitten in his hand. And he has bought a hook."

Maaïke: "Did he go to the shop himself?"

Child 4: "Himself!"

Maaïke: "Was he already a bit bigger or still small? Did he go with his parents or alone?"

Child 4: "Alone"

The children are also given the opportunity to take responsibility and they are fostered to make the learning process something of their own. So, one of the children is given the role of leader of the whole class group, another way to foster the children's agency.

- **Opportunities for Mathematics/Science Learning**

Although this episode is very much linked to the imagination and fantasy of the children, there are some opportunities for mathematics and science learning.

In science, information skills are necessary to encourage. In the national curriculum this is illustrated by the following goal. World orientation (nature): 1.3. The children can handle sources, with the help of an adult, to learn more about nature.

In the episode the ideas of the children about the hook of captain Hook are sampled and then these ideas are evaluated by using the internet for more information. Several sources are used to check the answer. As such the information skills and the critical thinking of the children are promoted.

During the discussion, the children are encouraged to criticize their own solutions, even if they are very imaginary. In the episode below, Maaïke has some critical thoughts about the solution of one of the children.

Maaïke “And why we started to talk about a hook? Can you come to the board?”

Child: “For the crooks at the school, we had to call Sinterklaas”

Maaïke: “Because Sinterklaas has a ...”

Child: “a hook”

Other child: “But the hook can do magic!”

Maaïke: “And what conjures it?”

Child: “It can open all the doors! One key and he can access al the doors.”

Maaïke: “Who has that key?”

Child: “Sinterklaas”

Sarah: “So Sinterklaas can access every room!”

Child: “Yes”

Maaïke: “But now I have a problem, because Sinterklaas has a key to open all the doors! But the crooks should be lock up!”

Child: “But he can close the doors too”

Maaïke: “Oh he can close the doors with the same key?”

Child: “yes”

Child: “Because if he goes outside, he has to go outside and close the door again. Otherwise, it’s yet too cold inside?”

Maaïke: “If the doors are still open?”

Child: “Yeah, because the heating is on and that it needs more energy.”

In mathematics and science, it is important to have some insights in time. These insights can be practiced by reorganizing a story. In the episode this is practiced by rebuilding the story (role play) of the crooks, which happened some weeks ago, and by repeating how the children ended with the hook of captain Hook (which was necessary because Sarah needed to leave the classroom).

Apart from this, children are getting some knowledge about the form of a hook, of a lock, and about the concepts open and close.

- **Opportunities for Creativity**

In this episode the teachers are using the fantasy of the children to build their activity on. They make use of the imagination of the children in order to construct knowledge about the use of a lock and on how to solve problems that occur. Time and space are given to the children to find their own solutions and to formulate their own ideas. The teachers also interact to these very imaginary ideas and solutions of the children.

d) Episode of the Pizza

In this episode the children are divided in small groups. The children have to choose themselves in which groups they want to be. In one of the groups, guided by Maaïke, pizzas will be prepared. The children in her group are in fact the cooks on a pirate ship. The reason for this is quite interesting. The day starts in the ‘kring’. Suddenly a girl sees two men entering the schoolyard and she says ‘The crooks are there’. This fact is the start of a whole discussion about crooks and catching crooks (see

the episode of the crooks). The discussion is ending with the hook of Captain Hook, the moustache of captain Hook and pirates. Since the children are that interested in these subjects, the teachers decide (at that moment) to reorganize the group activities and to link all the activities to the subject pirates and captain Hook. So, one of the activities 'making a pizza with ingredients given by the parents' is now integrated in the Pirates idea. The children are pirates on a ship and they have to make the pizzas for all the other pirates (children) on the ship.

The activity runs the whole morning. The teacher and children start with observing the ingredients the parents have given. In the beginning, their attention is caught by the cans with pineapples, they are discussing how to open the cans, and they also notice the different forms of the pineapple. Then some children and the teacher are searching for bowls. Others are placing the ingredients on a big table. Then the tomatoes and paprikas are washed. Meanwhile the teacher is stimulating the reasoning of the children. Why do we have to wash the tomatoes? Why can't you put a bowl on your head?

Finally all ingredients and tools are on the table. From now on several events are running through each other. The teacher is dividing her time between the 9 children around the table which are all doing different things. Some of them are cutting mushrooms or tomatoes or paprika, others are making dough with the pizza mix, then there are children putting tomato on the roll out dough. During these different activities the problem solving of the children and their reasoning is continuously stimulated. They have to find solutions for cutting the mushrooms without a knife, for rolling out the dough without a rolling pin. They also have a discussion about the difference between onion and chicory.

- **Pedagogical Framing**

The activity takes place with a smaller group of children. There are boys and girls in the group; the ages are between 4 and 6 years old. It's a mixed ability group.

The teacher explicitly want to work with different forms of the same ingredients, since she want to stimulate observation, comparison, critical thinking. For example: What is the difference between fresh tomatoes and tomato in brick? The ingredients were asked to the parents. There are a lot of different ingredients. The children are using all these different ingredients, they are comparing the different ways to make a pizza (using pizza mix, using roll out dough, are a prepared pizza). They are exploring and experiencing these ingredients and they learn a lot.



The teacher also wants to stimulate the problem solving of children by giving restrictions. There is only one knife, there is no mixer ... Children can use their own body to cut; to mix ... Children are obliged to evaluate their ideas or solutions.

Time is given to the children to think, to finish what they are doing ... The children are allowed to work the whole morning on making the pizzas.

Attention is also paid to safety and hygiene; even in these matters the agency of the children is stimulated.

- **Pedagogical Interaction**

Although collaboration is very much stimulated by the teacher – in the picture the boy with the blue shirt is giving the mushrooms to the boy who is cutting the mushrooms -, she also interacts to individual children. You clearly see how she knows very well the strengths of the children.

During the whole activity she also activates the innovative and creative thinking of the children, for example by leaving out tools. She stimulates the children to try out their solutions and to evaluate. She gives children time to think. However, she interacts when she notices that some of the children lose their attention, or don't find a solution (for example the second boy in the episode beneath).



Maaïke 'I only have one knife. What else can we do?'

Boy 1 'Cut' The boy shows with scissors what he wants to do.

Maaïke 'Are you going to cut with scissors? Try.'



Maaïke 'Are you also going to use scissors or what are you going to do?' She is asking this to another boy who has also a bowl in front of him.

Maaïke 'Try to think of another way to divide the mushrooms in small pieces.'

After some time the boy is still watching the others, he didn't started yet.

Maaïke 'You have to do the mushrooms in pieces'. The boy reaches out to the scissors. **Maaïke** 'But not with scissors. With something else.' The boy puts his finger on his chin and starts to think. After a while he heightens his shoulders. The teacher has to help other children and the boy again is watching the others. Then the teacher notices for the second

time, the boy still hasn't started.

Maaïke 'X. think very well, I give you a mushroom, you have a bowl, try to divide it in small pieces and think with what you will do it. What do you think?'

Boy 2 'With a knife?' 'Or with my hands?'

Maaïke 'with your hands? Is it possible? Try it.' The boy asks for a mushroom and starts to divide the mushroom with his hands. He has a piece in his hand s and he his very pleased.

Boy 2 'Yes, done.'

Maaïke 'Yes, try, is the mushroom hard?'

Boy 2 'No, soft.'

Maaïke 'Ha, yes, then it has to work, doesn't it?'

- **Opportunities for Mathematics/Science Learning**

Cooking is an activity which takes place in every preschool. These activities are very rich because the children experience science and technology in an everyday life activity. In this episode the teacher focuses on different ways to cut the mushrooms, to create the pizzas, to mix the dough. Special attention is also given to different forms of ingredients; for example fresh vegetables and fruits and vegetables and fruits in cans. The children also learn about hygiene and safety. They have to think why they have to wash the tomatoes; they have to think how they are going to wash the bowls. One of the boys also has to think how he can create a safe corner to bake the pizzas. The children are asked to clean the table without any help and to remove the cans.

Maaïke 'On the ship, we need to clean. What do we have to do with this? The teacher is taking the cans and shows them to the children.

Boy 'In the dustbin

Maaïke 'Which dustbin?'

Boy 'In the container.'

Maaïke 'Which container?'

Boy 'There outside.'

Maaïke 'Is it the paper container?'

Boy 'No, the big blue one.'

Maaïke 'Ha, the big blue.' Teacher says to the boy to go to the containers and to take all the cans with him. The other children are cleaning the table because they spilled juice from the pineapple on the table. The table has to be clean before they can start to make the pizzas.

So, also in cleaning, agency of the children is stimulated. Maaïke: 'The children have the responsibility to clean. As such they learn to be independent. They clean up very disciplined, they work with real brushes and all other real materials to clean.'

This activity fits very well in the vision of the national core curriculum and in the pedagogical project of the school. Science is not a separate learning area; children do not see the world compartmentalized. In preschool children are helped to develop competencies which lead to problem solving and self-efficacy in order to manage their way in real life. This cooking activity is in fact a real life setting, in which several daily materials are used.

More specific developmental aims in the area of World orientation:

- 1.1. The children can distinguish differences in sound, smell, colour, taste and feel.

- 1.2. The children show an exploring and experimenting approach to find out more about nature.
- 1.4. The children can organize organisms and common materials based on simple and self found criteria.
- 1.11. The children show good habits in their daily hygiene.
- 2.3. In a simple situation the children can determine which technical system best meets a need.
- 2.5 The children can choose suitable material and tools for realizing a simple technical system.
- 2.8 The children are willing to work hygienic, safe and caring.

- **Opportunities for Creativity**

In this episode the creativity of the children is encouraged by promoting the initiative of the children. They have to select which ingredients are observed in more detail, they are allowed to make their own pizza, they are allowed to choose their own materials cut tomatoes, paprika's, mushrooms. One of the boys likes to cut the mushrooms with scissors. However, in this episode the teacher also promotes the creative thinking and problem solving of the children. For example one of the boys has to look for another solution; he has to put the mushroom in pieces but can't use a knife or scissors.

One of the girls has to roll out the dough, however in the classroom there isn't a rolling pin. The teacher encourages the girl to think and to use the equipment she has. The girl has a very good idea; she will use the bowl to make flat the dough.



e) **Episode of the atelier work: the Carpenter corner**

This episode is situated during the atelier work. As mentioned before, during the afternoons there are ateliers. Ateliers are planned for two weeks. So, the children work on an assignment for 2 weeks long and then they go to another atelier. There are about 15 children per atelier. Today, however it is the first day of a new atelier cycle. Maaïke, who is responsible for the inquiry and design atelier, doesn't know all of the children. So, during this first day, she likes to observe the children, she wants to know what their interests are and their talents, before she plans the inquiry, design, problem based activities. She wants to work with these interests and strengths of children.

Two children, a girl of 4 years old and a boy of 5 years old, want to play and work in the carpenter corner. The carpenter corner is a very rich corner with a special work bench and with real carpentry



tools structured in boxes. The wooden materials, to use in the corner, are stored in a storage place. However, the children may select these materials by themselves. The boy, who has never worked in the carpenter corner, has a very good idea to transport these wooden materials.

Boy. *'Can I use that big bucket?'*

Teacher. *'Why do you need a bucket?'*

Boy *'I would like to transport the wooden materials in it, because otherwise I can get a splinter in my finger.'*

Maaïke finds it wonderful, she never thought of using a bucket to transport the materials, she will use this idea in the future and present it to the other children.

During the episode the two children decide to make a house, however they have to learn how to saw. The boy is also fascinated about measuring and using the different tools which are in the carpenter corner. Because it is his first time in this corner he has to explore everything, and he is allowed to do so, which he is not used to. Maaïke is guiding the whole process. Her instructions are focused on working with the tools (such as the saw) safely.

- **Pedagogical Framing**

This episode is situated in the carpenter corner during atelier work. As mentioned before, these ateliers take place in the afternoon and run for about 2 weeks. The children are placed in groups of about fifteen and they switch ateliers after a period of fourteen days. Maaïke is in charge of the inquiry and design atelier, that's why the carpenter corner is in her classroom. Two children are choosing for this corner. One of the children is a four year old girl; she belongs to the (morning) class group of Maaïke and Sarah. The other child is a five year old boy. For him everything is new, it's his first time in this atelier and this classroom.



Special in this atelier are the materials. During an informal interview with the teacher she stresses the importance of using real materials to design and inquire. The children may select the materials themselves and choose with which materials they want to explore and design. In the carpenter corner, there is a real and solid work bench, there are several saws, nails, pincers, hammers, and wooden materials ... These materials are structured in boxes and cabinets. And children are permitted to take materials from these boxes. So, ownership and agency is very much stimulated during atelier work.

During the design process evaluation is important. For Maaïke the process is much more important than the product. However, the product also has to be evaluated.

'The product is not always that beautiful but the process is important. Usually we have the following approach: we explore the material (it is in fact inquiry), then we design (with evaluation), then we make it more esthetic and then we look at the different properties of what

we created. The design have to come from the own thinking and creativity, no creation of the children is just copied, they all are original. They also have to evaluate what they have made themselves. So, working like this, you can really see which talents the children have, which strengths they have and which weaknesses. '

- Pedagogical Interaction

During this episode the teacher focuses on instruction to teach children the technique of sawing. However, she also stimulates collaboration between the girl and the boy. Both children work together to build a house.

Maaïke, however, does not know exactly what to do. **Maaïke** says to **the boy**: "Could you explain it."

The boy answers and shows what have to be done.

Although there is instruction, the children may select their own materials, their own design and they are able to make their own choices. They have time to think. They are also stimulated to reflect on what they are doing.

Maaïke "If you saw, you may never saw alone." Maaïke is saying this in a very friendly and encouraging way.

Maaïke "What do you want to do?"

The boy says something very quietly with the saw in his hands.

Maaïke "What has to happen?"

The boy shows what has to happen to the box and says "to saw a window"

Maaïke "A window"

Maaïke shows the boy and the girl how they must freeze the wooden box in the workbench. They need to turn the lever, so that the work bench opens. The girl starts turning the lever. Maaïke asks several times "Does the box already fits in the workbench?". Each time it is measured by the girl and the boy.



The teacher appreciates the initiative of the children. For example at a certain moment the boy wants to measure the wooden box. The teacher encourages him to do so. Here mathematics is integrated very playful and by initiative of the boy.

Boy "I'm going to have a look with the meter."

Maaïke. "Yes, you can measure it."

The boy finds a fold meter in one of the bins and he folds the meter open. .

The boy kneels on the ground, and says "I'm going to look how long this measures". He measures the wooden box.



Boy "That's not going."

Maaïke "Is it not good?"

Boy "I have to have a pen."

He draws a line on the wooden box.

Maaïke "M. is it already OK?"

Girl "No"

Maaïke "Maybe L. has to put there a line too, such as here." The teacher shows the other measurement that is done by L.

The boy takes the meter and goes to work.

During and after the activity Maaïke reflects on what she has observed. She wants to work further with these experiences and with the mathematical and design talents of this boy. In her journal the following is written down '*L. (boy) and M. (girl) worked in the carpenter corner, they worked together but actually L. is the creator, M. would particularly like to do. L. is very excited to work 2 weeks long in the corner and to design.*' In a more informal talk after the activity she mentioned the following: '*L. is very involved in this activity, he wants to learn and is also learning very fast. I like to observe him during the other days and I'm curious about the products and the ideas there will come.*'

The teacher let us know that L. created his house and worked further on the concept he started with M. designed a lot of other houses, smaller ones. She is very good in using wood glue.

- **Opportunities for mathematics/science learning**

The carpenter corner and the tools and materials in the carpenter corner provide a lot of opportunities for mathematics and science learning (as mentioned also above). When children are designing a lot of mathematics can be integrated. Depending on the child and the strengths of a child, the design can be very mathematical or abstract.

Maaïke: '*We always work integrated and for us fantasy is very important. The individual children are important. So, if we design then there are children who choose to integrate much more art, others choose to integrate more mathematical things, because they are more abstract thinkers. Children always make links with what they know; as such they come to very in-depth investigations. There are also children with a very high mathematical creativity.*'

The carpenter corner is a rich corner to obtain several developmental aims in the domain of mathematics and world orientation (national curriculum), which is also noticed in the episode.

World orientation (technology)

- 2.3. In a simple situation the children can determine which technical system best meets a need.
- 2.5 The children can choose suitable material and tools for realizing a simple technical system.
- 2.8 The children are willing to work hygienic, safe and caring.

Mathematics

- 2.4. In concrete situations the children can perform actions with shapes, magnitudes and figures, in function of a qualitative characteristic.
- 2.6. The children can "measure" an object approximately with a self-selected unit of measure.
- 3.1. The children can use, acting in concrete situations, the terms "in, on, above, below, beside, in front of, behind, first, last, between, oblique, on each other, far away, close to, inside, outside, up and down" in their proper meaning. They can use icons related to "directions" as symbols.
- 3.3. The children can, in a specific case, find solutions to a spatial problem.

- **Opportunities for Creativity**

Again the initiative of the children is encouraged tremendously. The children are allowed to work with all materials in the carpenter corner, however to work safely with several of the tools, some instructions are given. These different materials stimulate the imagination and the creative thinking of the children. By asking questions, the teacher also activates the reasoning and problem solving skills of these children.

f) Episode of the Mask

After the 'kring' moment the children have to choose what they like to do, there are corners which are regular (such as the construction corner, the book corner...) however there is also a more special activity. The children can choose to design a mask (because of the carnival). Children can choose to work in the classroom of Maaïke or in the classroom of Sarah. Both are guiding a mask activity.

In the classroom of Sarah, there are 6 children working at the 'Mask' table. They are creating a mask with a flag on it (because of the 'Belgium in Europe and beyond project'); however children who don't want a flag on their mask may use their own ideas. So two girls decide to make a sprout as mask.



At a certain moment a child (a boy) who has worked in another group, also wants to design a mask. He wants to make a bunny.

On the table there are several materials, there are different kinds of glue, different kinds of other 'adhesive materials, different kinds of decoration materials. The children are also allowed to take materials from the different bins in the classroom.

During the episode, Sarah interacts with the boy who wants to make a bunny mask and with the girl who is making a sprout mask. Sarah knows that she has to guide the boy more intensively because he gives up easily. During the episode he tries to make eyes in the mask, in doing so he is trying out

several tools.

- **Pedagogical Framing**

This episode takes place in a small group. It is an art and craft activity, where the children have to design a mask. During the activity science and mathematics learning is integrated. The teacher finds the process much more important than the product. The product is not a result for the parents but have to be a product of the children.

'Experimentation is important and not the end product, most of the time this is a result for parents. It should not at all be perfect. Why do you refine the work of a child as a teacher, is that what the child wants? Or do you do it because the parents want to have a good and beautiful result of their children.'

Refining the work of children, just in front of them, gives the child the feeling that it is not good. Even something small in the total process could be a big challenge for some children. It is important to reward this and not the end product, especially when you work with very young children.

If you are working with the older children, you can be more demanding and you can agree that they have finished their assignment or design. But as a teacher you do not refine their work.'

In order to promote the agency and creative thinking of the children, a lot of materials are placed on the table - there are different kinds of glue, different kinds of other 'adhesive materials', different kinds of decoration materials - and the children are allowed to search for other materials in the boxes. However, sometimes a restriction is necessary, because otherwise children choose always the same, especially when they know it is going to work well, as with adhesive tape.

The group is a mixed ability group and collaboration – peer tutoring - is enhanced very much.

- **Pedagogical Interaction**

The focus in this episode is on questioning (and standing back) and on stimulating peers to interact.

Teacher 'Eyes and how can you make those eyes?'

Child 1 'With scissors.'

Teacher 'With scissors? Are you going to try with scissors?' The teacher is saying this in a very encouraging way.

Teacher 'And how do you know where your eyes have to be?'

Child 2 'In the middle.'

T 'hm.' The teacher looks at Child 2 who is repeating what she has said.

Child 2 'In the middle' However straight after this she says 'No here' and she is pointing with her finger to her eyes. Child 1 is watching.

Teacher 'The eyes are indeed here in the middle.' She turns back to Child 1 and asks "How can you know that here?'. She points to the paper from which the mask will be made.

Child 1 shows with his finger where the eyes have to be. The teacher confirms this and asks the other children how they have worked earlier.

Two children show how they have done it and they also give a limited explanation while showing with their hands. They have held the paper before their eyes and the teacher has drawn circles on the paper at the height of their own eyes.

By using questions the teacher tries to stimulate the reflection and critical thinking of the children. Although she finds it not so easy to keep a balance between interacting and no interaction. Some children do not need many input, others, like the boy in the episode, need some more coaching otherwise he quits.

Sarah: 'As a teacher you don't have to reveal everything too quickly. You have to keep asking questions, so children can give the answer or solution themselves. The children have to experience themselves and have to do investigations on the materials. Some children may need some advice sooner than others, in order to stimulate them further. Some children stop working if they don't find the solution easily or if something doesn't work.'

The latter is very well illustrated in the following episode. And also below the other children interact as peers.

C1 begins to cut but it is going not to easy, he cuts above the eyes and horizontal. It is hard for him to get the scissors in the paper. C2 says 'No' and shows how he should do it. She does prick movements. C1 puts the scissors otherwise and the scissors are now standing perpendicularly from the paper.

However it does not work, and he looks around and watches the other children. He calls the teacher and indicates that it failed.

Teacher 'Do you have problems? How can you try otherwise?'

Child 4 'With a spike or something else.' Child 1 looks with the scissor in his hand to the paper. The teacher is sitting beside him.

Teacher 'How could you try it differently? How can you make a hole in there?' He points towards the bins which are near the table.

Teacher 'Have a look in the bins. Can you use something from there? Go and have a look.' Child 1 goes to the cabinet with the bins and looks in a number of bins (taking 1 or 2 minutes). He doesn't seem to find anything.

The teacher, who comes over, encourages him to take something out of the bin that pricks. He has found a stick. The teacher puts a mat on the table (where he was working).



The teacher also uses the questions to enhance the evaluation of the children's work, based on the criteria they set by themselves. In the episode, one of the girls is making a sprout. So, the teacher interacts and asks.

Child 2 'I can't do a hole.'

Teacher 'Say Mrs. Sprout, how does a sprout looks like? Do you know sprouts?'

Child 2 'Yes.'

Teacher 'How?'

Child 2 'Green'

Teacher 'Green, and what is the format of a sprout?'

Child 2 'round'

Teacher 'Do we have now a round already?' The teacher takes the mask and shows it to C2.

Teacher 'Look.'

Child 2 'No'

Teacher 'What do we have now?'

Child 2 'Rectangle.'

Teacher 'We have a rectangle, very good.'

Teacher 'But how can we make a round of it?'



- **Opportunities for mathematics/science learning**

In this episode mathematics and science are integrated in an art and craft activity. As you have noticed in the small episode with the girl, mathematics is integrated very naturally, initiated by the evaluation of the mask.

The design of the masks also enhances the knowledge of the girl concerning sprouts. She and the teacher searched for sprouts on the internet and together they have observed the sprouts and the leaves of the sprouts. Based on this observation she made her mask more around, using separate leaves. By encouraging the girl to observe real sprouts, the teacher uses the interests and the imagination of the girl to increase her knowledge about vegetables (nature).

The problem solving skills of the boy are fostered starting from this art activity. The teacher encourages him to search for the right tools to make the eyes in the mask.

For this teacher, art and craft activities are ideal activities to foster the creativity, the problem solving and the inquiry attitude of children. *'In the process of design, the product has to be evaluated artistically and scientifically. So design is not only art but also science.'*

Although this activity is an art and craft activity, several developmental aims in the domain of science and mathematics can be obtained.

World orientation (nature and technology)

- 1.2. The children show an exploring and experimenting approach to find out more about nature.
- 1.3. The children can handle sources, with the help of an adult, to learn more about nature.

Mathematics

- 2.1. Acting, the children can compare and articulate two things on their qualitative properties.
- 2.4. In concrete situations the children can perform actions with shapes, magnitudes and

figures, in function of a qualitative characteristic.

- 3.1. The children can use, acting in concrete situations, the terms "in, on, above, below, beside, in front of, behind, first, last, between, oblique, on each other, far away, close to, inside, outside, up and down" in their proper meaning. They can use icons related to "directions" as symbols.

- **Opportunities for Creativity**

Although this activity is linked to the project 'Belgium in Europe and beyond' and the teacher already made some designs of masks, the children are allowed to design their own idea. Their creativity is also promoted by the materials on and near the table. If the children want to select other materials, they are allowed to search for them in the bins. They are also allowed to try out their own solutions – the boy uses a scissor first, however reflection is necessary (did it work?).

As mentioned by the teacher, she finds it very important to evaluate the process and the design scientifically. She also encourages the children to design their mask as realistic as possible (in the episode, connections with real nature are made). By doing so she encourages the creative thinking of the children but also their conceptual understanding of nature. For example: How can we make the sprout around? The girl watches sprouts on the internet and then decides to work with little leaves, to make her mask around.

g) **The episode of the pirates**

One of the suggested activities for the children is to create a pirate for their Pirate boat. The children are working in small groups and in this specific corner a number of 4 children are allowed to build their pirate. During the activity several children come and go to work on their pirate, however in the episode below we focus on the interaction between two of the children.

The teacher comes and goes during the activity and takes time to observe the children. The children may use all the materials in the classroom to make their personal pirate. Sometimes the teacher interacts by placing some additional materials at the table; as such she is making suggestions without steering the children. At the end of the activity the children have their own personal pirate and have learned a lot about the concepts 'bigger' and 'smaller', about several materials, about connections between materials and about finding solutions for technical problems.



- **Pedagogical Framing**

In this episode the focus is on the capabilities of the children to carry out an activity by making own choices. Peer learning and interaction between children is also fostered during this activity. The activity is prepared in advance; this means that the teacher has planned an activity about creating a pirate. However there are still some uncertainties. The teacher doesn't know in advance which kind of materials the children will use and the processes they will follow; this will depend on the children

and on their capabilities. So, the teacher has to adapt her coaching to the zone of proximal development of the children who choose for the activity.

The main goal of the teacher in these kinds of activities is to enhance insights into different strategies to connect materials, to enhance knowledge about the use of different tools, and to enhance problem solving skills.

- **Pedagogical Interactions**

The teacher goes in interaction with the children in order to foster their critical thinking and to help them to find solutions for the problems they are facing. The teacher observes the children very often and she only asks questions when it is necessary in order to help the children in their own learning process. The teacher encourages the agency of the children, they have to select the materials themselves and find for solutions themselves. However, she also encourages collaboration and peer learning for example at a certain moment the teacher encourages one of the children, who has already done a part of the activity, to explain the activity to the children who want to start with it.

- **Opportunities for Mathematics/Science Learning**

In this episode the teacher sees the opportunities for science and maths, when the children experience the problem of placing a bigger box up on a smaller box and the other way around. Learning opportunities in the domain of science are created when the children are exploring the materials and are building knowledge about the properties of these materials. The children also need to reflect upon their choices and evaluate their results, in order to be able to adjust.

Sarah: 'As a teacher you don't have to reveal everything too quickly. You have to keep asking questions, so children can give the answer or solution themselves. The children have to experience themselves and have to do investigations on the materials. Some children may need some advice sooner than others, in order to stimulate them further. Some children stop working if they don't find the solution easily or if something doesn't work.'

An evaluation of the child's work is important, did it work or not. Below you find one of the moments in which this is happening.

Teacher: "Is this then the body you want to use?" ... "Can you try to use this?"

The child places the box above a cardboard roll.

Child 2: "No, it's too big" ... "I will use this one" And the child points at the materials next to the table.

Teacher: "Can you try it once?"

The child is looking at the different materials

Teacher: "What do you need then?"

Child 2: "A smaller box"

Teacher: "Can you look for something smaller than this one" and she show the big one the child selected at first.

Child 2 is looking for a smaller box.

By constructing their own pirates there are also opportunities to learn something about the human body, because they are making a link between their own body and their pirate.

Child 1 grabs the box and holds it below the cardboard roll.

Teacher: "Ah, his feet! Are your feet at your head?" and she point at the feet of the child

Child 1: "Here are my feet" While she is pointing at her feet.

Teacher: "Are this two feet or one foot?"

Child 1: "One foot!"

Teacher: "Oke, you may try!"

Child 1: "It doesn't work."

Teacher: "How many legs do you have?"

Child 1 shows with her fingers she has 2 legs.

Child 2: "And how many feet?"

Child 1: "Two!"



In this activity the teacher works on following governmental goals.

Mathematics

- 2.2 The children are able to compare things quality and pooling on the basis of one or two common characteristics.
- 3.3 The children are able to find solutions in concrete situations for a spatial problem.

World orientation

- 2.5 The children are able to choose appropriate material and tools for the realisation of a simple technical system.
- 2.9 The children show an experimental and exploring approach in order to find out more about technology.
- 6.1 The children are able to draw a human figure with the most important body parts (the head, the body, the legs, the arms, the ears, the eyes, the nose, the mouth) at the right place.

Opportunities for Creativity

In this episode the children are given the opportunity to be creative with the materials and find solutions for their own individual wishes. The children can be creative in choosing materials and tools to reach their goals. Apart from that, their designs creates several opportunities for creativity, it are their own ideas, solutions and adjustments.

A final important aspect in this activity is the dialogue between the children in order to help each other. By sharing information all children are given the change to be creative in their own designing process.



The teacher is observing the actions of the children.

Child 2 is explaining to the other children where he has found all the materials.

Sarah: 'Children are strong in helping each other, however they don't copy, and they have to have some individuality. By watching and hearing other children, some children are going a step further, Especially the children who pick up things very easily.'

3.1.3 Summary and conclusions

RQ2: Probing practice

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

The pedagogical vision of the participating teachers, Maaïke and Sarah, is strongly influenced by the pedagogical project of the school – which focuses on **inquiry learning, experiential education** and enhancing the **talents of children**. In their vision there is an emphasis on children's **agency, ownership** and **initiative**. Or as Maaïke formulates it '*Ownership or agency are encouraged tremendously here. It may seem somewhat chaotic.*'

Since these teachers value the **initiative, interests, talents, theories** or **questions** of the children very much, projects and activities are developed together with the children and/or initiated by the children. As a consequence it is impossible for the teachers to plan specific scientific or mathematical activities. Moreover, these teachers don't see these learning domains as separate areas. According to them, during every activity there is a focus on the world. Language, mathematics, science, physical and art education have to be integrated in it. Throughout every activity these teachers try to promote the **problem solving** and **inquiry skills** of the children. They also promote **reflection and reasoning** of the children in order to enhance their conceptual understanding of the world. In order to do so **play, exploration, dialogue, questions** are valued as well as **evaluation** (for example the flashback moments) and the input of peers (**peer-learning**). Every child is encouraged according to their **own strengths and possibilities**; children are seen as **individuals** – which are very well illustrated in the episodes of the pizza and the mask. In conclusion we could say that these teachers focus on cognitive as well as on the social dimension of science and mathematics learning.

During the observations we also noticed that an emphasis on the child's **initiative, strengths** and **ownership** as well as the focus on the **children's world, fantasy** and **imagination**, enhances the wellbeing and engagement of the children tremendously, it also promotes their creativity. The children have very interesting theories, solutions and designs - young children are often underestimated according to these teachers. So, the children are encouraged to communicate their theories, solutions and designs, and to work further with them. As the teachers stated, the children's creativity is even more encouraged if they have to consider restrictions – for example they can use all of the materials in the classroom and the corridor except for the adhesive tape.

In these combined classes, 'kring' moments are altered with corner activities. During these 'kring' moments **discussions** takes place, based on stories (stories of the children or story books), actuality, experiences of the children, observations, ... Interesting discussion can be found in the episodes of

the giant, the crooks and the waterfall. These 'kring' moments are also used as 'flash back moments' to **assess the design process and products** of the children. These teachers have a specific assessment strategy, based on the concept of the school. Emphasis is put on the process and on specific criteria formulated by the child and/or the teachers. For example I want to have a boat that floats. Photographs, images, drawings of the process and the product are sampled in the digital portfolio of the children, which is managed by the children themselves (ownership of their own progress). If children are interested in a specific issue; information or YouTube films about this issue can also be placed in the portfolio by the child.

According to Maaïke 'The product is not always that beautiful but the process is important. Usually we have the following approach: we explore the material (it is in fact inquiry), then we design (with evaluation), then we make it more esthetic and then we look at the different properties of what we created. So, working like this, you can really see which talents the children have, which strengths they have and which weaknesses.'

During corner activities children can choose between several corners inside and outside the classroom, some of them are specific and linked to projects, others are more general such as the construction corner, the art corner, the book corner, ... Depending on the specific activities in the corners the teachers **stand back or interact**. For example with cooking activities or carpenter activities the teachers are more present, because of handling saws, knives...

RQ3: Probing practice

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

As mentioned before, the emphasis on the children's world (imaginary and physical), experiences, theories, strengths and interests enhances wellbeing and engagement. The approaches are also very tight linked to the everyday live and the natural eager of children to explore, invent, experiment, design and communicate. As such the conceptual understanding and the reasoning, the fundamental learning and problem solving and inquiry skills of the children are encouraged/enhanced, which is noticed in the amazing theories and solutions they have, in the answers they give and the things they are doing and create.

How do teachers perceive their role in doing so?

To foster children's learning, interest and motivation in the world as a whole (including science and mathematics) the teachers focus on

- **listing to and observing** children, or as Carlina Rinaldi mentioned it: 'If we know how to listen to children, children can give back to us the pleasure of amazement, of marvel, of doubt ... the pleasure of the 'why'.'
- **asking questions** at the right moment. However, it is not that easy, which is also illustrated by a quote of Sarah 'As a teacher, it is important to ask questions at the right time. You are continuously thinking about that, it is an art to do or say as little as possible yourself. Depending on the child you have to adapt. Many or few questions or additional help. You also

have to make use of the peers.'

- allowing **children to discuss and interact**
- creating or selecting a **rich environment**, which contain rich materials: If you want to encourage children to develop creative and innovative solutions, children need to have the opportunity to gain knowledge about the properties of materials. Maaïke and Sarah offer the children a wide variety of materials (especially every day materials) and they make sure the children can explore and discover. If the children have gained sufficient material knowledge then restrictions can be introduced, see earlier. **Rough materials such as sand, water, wood ...** are also valued. In spring and summer, the children can play, discover and experiment with water. Maaïke and Sarah have a very large water box. Children are allowed to spill water on the floor. However, they also have the responsibility to clean up things.
- **peers**
- **resources.** For example children's theories and solutions are brought together and evaluated using resources such as books, experts, and the internet. Even if the teachers know the answer, they encourage the children to compare answers or solutions (episode of the mask – sprouts)
It is also no problem if you don't know the answer: *'As a teacher it should be possible to say that you don't know it and that you have to look it up. And then you have to exchange the knowledge with the children. During a discussion, you have to discuss first all the possibilities and then look it up afterwards.'* See the episodes of the waterfall and the crooks.
- allowing **time and space** to children. Children need to have time; as such no school bell is used. Children can have as much time as they want to finish an activity. Some children need more time than others, others are very fast in their ideas. The teachers try to interact to all these individual needs, by giving the children space to work in groups or alone if needed.
- **evaluating the process and the product** (in terms of criteria)
- being equally excited, curious, amazed, innovative, inquiring as the children

As a consequence of their very experiential approach, these teachers have to be creative in interacting to unexpected moments and they have to have confidence in their teaching skills and expertise, which is illustrated in several of the episodes. As such, no textbooks or other teacher manuals are used, Maaïke puts it like this *'Everything is in our head and in that of the children.'* These teachers make as much as possible use of what the children say or do. Since last year they also started **team teaching**. According to Sarah the added value of working together is *'Complementing each other. You pick up more things in the kring. It also offers some ease because you have a back-up.'*

3.2 Case 3 – Katrien – Exploration

3.2.1 Context

Where?	Country	Belgium
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	Setting name	AUC3					
	Location within setting	Pre-school					
Who? (children)	Year group/age of children	Reception; 2.5-3years old					
	Number of children in class	11					
Who? (adults)	Number of adults	1					
	Role of adults	1 teacher					
	Case teacher role	Co-ordinator					
When?		1	2	3	4	5	6
	Dates of visits (2013)	09/01	29/01	20/02	26/02	05/03	25/03
	Times of visits		8h45 -12h15		8h45 -12h15	8h45 -10h35	
	Goal of visit	Intake	Observation informal interview teacher	Informal interview teacher	Observation, informal interview teacher	Learning walk children, informal interview teacher	Informal interview teacher

a) AUC3: a catholic school

AUC3 is a school which belongs to the publically funded education, ruled by a private organisation, and more specifically the Flemish secretary of catholic education.



However, being a Catholic setting the school is open to all children, whatever the ideological or cultural background of the parents. So, the children aren't obliged to follow the religious moments.



The school organizes education from the age of 2,5 years up till the ages of 12 years. The school has two locations, both with classes for all age groups. The distance between the two school buildings is approximately 1,5km. The school building we focus on is located in a rural area at about 25 km from a Flemish provincial head town (Ghent). Close to the school the river 'De Schelde' passes and in the neighborhood of the school there are

several large and wide fields. In the environment of the school live a mix of young people and elderly people.



According to the school and the school team, the goal objectives are: To educate children in a protected environment, in which the development of children is fostered using a lot of experiential situations. In addition they want to give children the time and space to grow and to develop according to their own rhythm. Consequently they offer a lovely and fair care for each child, in a warm context and in a green

environment.

The core vision of the school is: The school is a community of many people. Everyone is involved, however based on their own talents and capabilities but always with responsibilities to all the others. In that way the school becomes a community. Therefore the school team has to start from a positive attitude in order to have collaboration in the best way possible.

The specific pedagogical project is built up around 5 core subjects. These are:

1. The school as community and organisation
2. The development of each child embedded in a wide range of care
3. An educational climate with a focus on fostering and on reaching goals
4. A sound and coherent educational offer
5. The school's own catholic identity.

The school works with year themes, the theme of this year is titled: "There is music in". However, in this specific case the teacher is working around several other themes which blend, she and the children started with art, went to stones and then started to work around bear hunting. These themes are the focus during the weeks and are based on the interests of the children at that moment.

b) Katrien: the teacher



The teacher, Katrien, has a large background in early childhood education. As a student teacher she was influenced by the first concepts of experiential education, as such she studied this profoundly in practice and theory. During her whole professional career she has been teaching children from the ages 2,5 up till the ages 6 years. At the moment she is working with a group of children from 2,5 to 4 years, and with a group of 4 year old.



Her viewpoint towards science and mathematics is a very open one. She believes that in the child's world there are a lot of things and events which can bring them a step further in understanding the world of science and mathematics. She also believes that mathematics is present in every daily moment in the practice of a teacher, such as the moments in which she organizes the eating of the children, the end of the day... Concerning science, she feels that education in science has to be about fostering and developing an inquiry attitude.

According to her, to develop scientists, is not the main goal of science.

She also shows a very involved attitude towards young children and believes in space for exploration and for relaxation (rest). In order to enhance exploration and relaxation, she offers structure. Her

teaching approaches are also focused on the zone of proximal development of every individual child.

Her classroom is located at the ground floor of the building, with a play ground on both sides. The classroom consists of two rooms, a main room and a little room at the back of the classroom. One of the playgrounds contains a large sand box, grass and trees, flowers and other natural materials.

As a teacher Katrien has a strong pedagogical vision which is based on the pedagogical project of the school. She focuses on:

- **Giving freedom to children to experiment**

A key element in the practice of Katrien is that she believes in the opportunities of allowing children to make some mess. This doesn't mean that she and the children won't clean up. However, she isn't afraid of polluting the space in order to offer learning opportunities for the children.

- **Experiences, interests, questions and theories of children**

The practice of Katrien is strongly influenced by the principles of experiential education, and she is a strong believer in building forward on the input of the children.

The children have been given the opportunity to build a wall with large bricks. During this activity the children showed great interest in how these bricks could be connected to each other. In order to reflect (interview of the researchers) and build further on that experience the children were offered some little bricks, sand, water, ... Only by showing them those materials the children could explain how a wall was build and they could describe the procedure, the product and different possibilities. Based on their explanations we (researchers) went on to make some new constructions with the bricks.



- **Ownership, initiative, agency of children**

According to Katrien it is important for the youngest to guide their own learning process, meaning they, themselves, have to be able to do what they want to do or explore. As a coach, it is crucial to be there, however that doesn't mean you have to do everything for them.

An important factor of ownership for the young children is the importance of appreciating the actions of the children and the results they reach. Katrien: *'That is why I always try to use the results of an activity to build upon during the day or week. As such, I can go a step further instead of only saying they did a nice job. When we reflect and we use what they have learned in another and different context they experience that their actions and learning processes were useful. This might motivate them to go a step further the following time.'* In this case the narrative of the bags illustrates how the results of an activity are used to initiate the concepts of heavy and light in a following, more classical activity.

- **Time and Space**

As a teacher, Katrien wants to be there at the right time, meaning she wants to interact when it is necessary, but she also wants to stand back if this is needed. She believes in being the observer, the

participant, and the questioner in order to be able to encourage the curiosity of the children in their inquisitive attitude.

She is a teacher who wants to be prepared by means of materials and offering changes to children, however she also succeeds in giving each child the space and time he or she needs to get to the next level of the zone of approximately.

- **Transfer of content**

As a teacher Katrien always takes into account the aspect of transfer and enhancing conceptual knowledge. She believes in the following principle: repeating something in different contexts results in context-free knowledge which facilitates transfer. Meanwhile the children are given the opportunity to rebuilt previous knowledge.

Sometimes Katrien uses drawings to capture the things/knowledge the children have picked up from a play, a story, an activity... After the child has made his or her drawing, she always asks what they have been drawing and she notes it on the drawing, in order to be able to reflect upon it later on.



In the episodes you will find some example of transfer and reflection on activities. One of the examples is given below. These moments are important to motivate, to foster and to assess.

The teacher calls all the children to come and look to the slings.

She asks which one is the longest.

The children answer; the right one.

The she ask if this one is shorter.

The children answer with yes.

In the short episode above a conversation with the whole class group is visualised, however this conversation is based on a group activity. The teacher also uses other strategies, such as bringing in the results or content of one activity (stones) into another activity (heavy/light). In this fragment you may also notice the use of movement in order to capture concepts.

The teacher brings in the 2 bags into the circle and closes them.

Teacher: "I will pass on the bags, and you will feel the two bags"

The teacher gives it to the first child in the circle/

Teacher: "You hold one bag in this hand, and the other one in the other hand."

Teacher: "You all may stand up."

Teacher: "Do you feel it?"

The child nods.

The bags are given to the next child.

Child: "Here there are stones, and in the other one not."

Teacher: "Hmm, I think there are stones in both bags." And she shakes with the bags so you

can hear the noise.

Teacher: "I feel like a balance" and she moves her body by letting her arms go up and down.

The children are also doing the movements.

The bags are given to the following child.

Teacher: "What do you feel?"

Child: "stones"

Teacher: "And what do you feel? Is it much? Little? Heavy? Light?"

- **Outside school learning**

The teacher often goes outside with the children, even on a rainy day the youngest children are used to be outside in the nature around the school to discover the world.

The teacher also goes with the children to the theater, to reading sessions, and movies... For example, the central theme during the final observation in the classroom was "on bear hunt!" based on this the children visited a

concert about a bear

hunt. In the same month she went to a cartoon festival with the children.



- **Participation of parents**

In the daily practice of Katrien, the involvement of the (grand)parents is very important, although it has to be balanced properly. At the beginning of the day, the (grand)parents are allowed to enter the classroom and to talk to the teacher. As such informal talks with each other are possible. Katrien is also very keen on involving the parents, without pressuring them to do a lot of work and she doesn't ask them only for practical reasons. A nice example of involving parents is the treasure box. She has a box for each child, and sometimes the children are asked to take their box with them and they have to bring it back with something in it from home. However the thing in the box has to remind them about the theme they are working with in the class.

c) The children

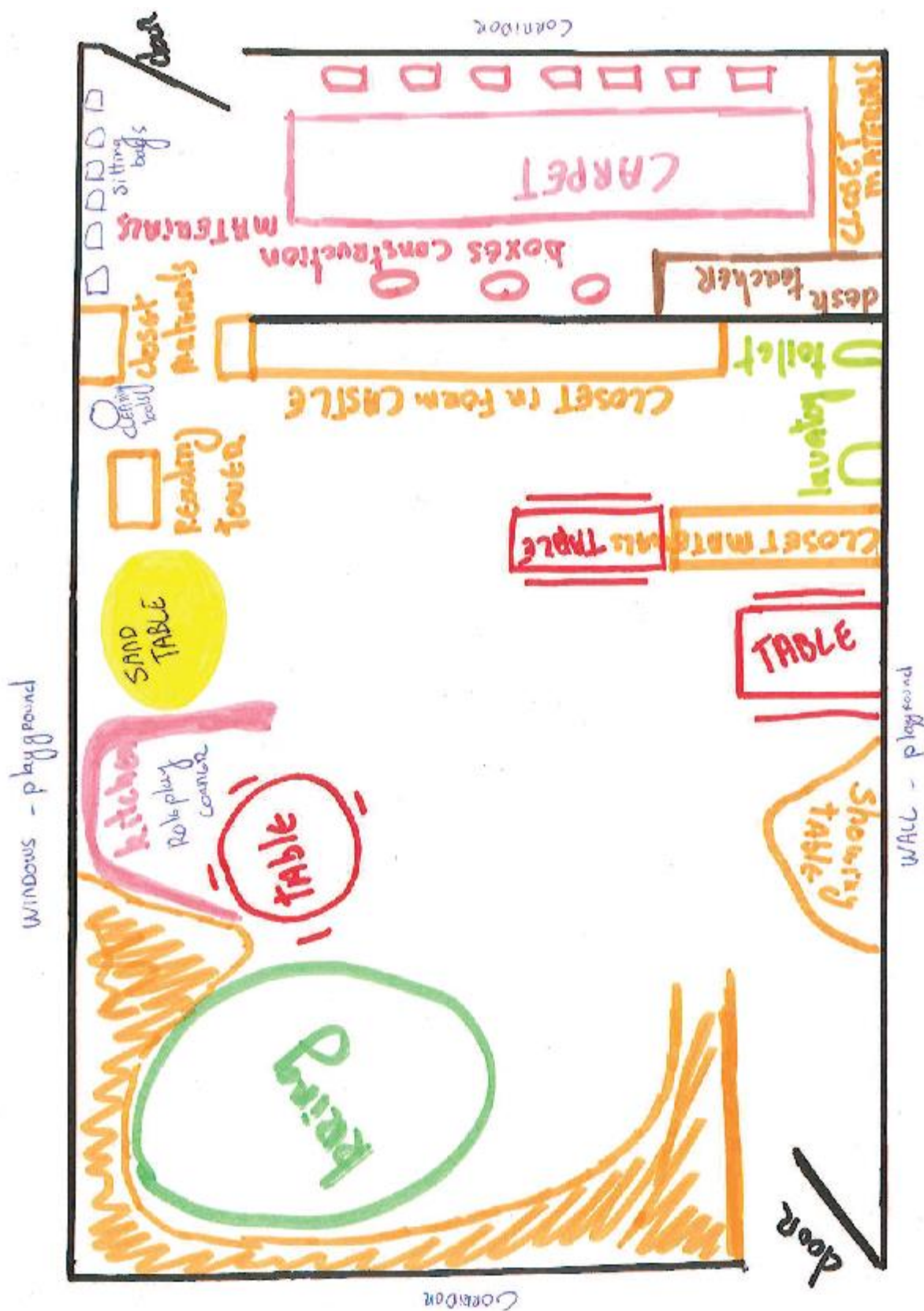
The children in the classroom of Katrien are active, lively and curious. They are aged between 2,5 and 3 years old. In this classroom there are 11 children. Even though they are very young, they are able to handle digital media like a video camera or a tablet. They also have a high degree of independency and a caring approach towards each other.



The episodes below are used to exemplify the actions of young children. They visualize the day to day opportunities created by the teacher in the domains of mathematics, science and creativity.

d) The classroom

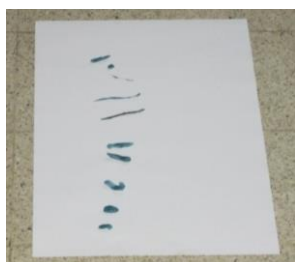




3.2.2 Episodes

a) The episode of modeling wax

The children are working on the theme “Art”, the result of a cascade of other themes; amongst them a theme about lights, one about colors, followed by a theme about selecting objects with specific colors, followed by a theme about painters, more specific Mondrian, ending in art. When the children were working about the painter Mondrian, they came across different forms and lines. They copied some of his works, using paint, stitch beads; they made them in the sandbox ... Based on these experiences the teacher thought of how she could do something about short lines. She created several activities with similar goals; these are described in the episode below.



The teacher asks: “What do we see now?”

Children: “all different”

The teacher asks: “What kind of differences do you see?”

Child 1: these ones are bigger

child 2: These ones are longer.

The teacher says that it's so and brings in slings of paper.

The teacher hands out slings of different length to the children. Once the children have received their sling they start to compare with each other. As notice the children are moving with the sling, she decides to bring in music and she let the children dance with the slings, after a while she brings in another sling for each child. After this phase the teachers brings in the materials for the corners. The children may choose with which materials they will play, but all the activities are linked to the concept of large and short lines. The teacher has foreseen 7 activities, so not all the activities will be chosen by the children. After the choices have been made they are allowed to go to the different corners.



In all the corners there were chances for the children to experiment with the materials, in order to gain insights in long and short lines. In each corner the children started to compare spontaneously. If necessary the teacher acted as guide or coach, she went from one corner to the other.

- Pedagogical Framing

In the corner of the modeling wax, there were 4 children actively busy with the construction of the

slings.

The objective of this activity was described as followed by the teacher, exploration of the concepts long/short throughout manipulation and the development of conceptual knowledge about long/short. The teacher had also chosen to transfer these goals towards the other corner activities during this session. Those other activities were:

1. Sand box: in the sand box, the children weren't offered any material but were given the assignment of making lines by making little holes in the sand with their fingers.
2. bottle closures: in this activity it was meant for the children to make lines of different length.
3. stitch beads: with the stitch beads the children could make lines of different length and placing them right below each other.
4. pearl necklace: with the pearl necklace the children could make a long and short necklace.
5. doll corners: making spaghetti: in the doll corner the children were cooking spaghetti, French fries, long sausages. In the conversation of the children you notice they were experimenting with the concepts of long and short.
6. building with boxes: in this corner there were two rows of boxes placed next to each other and the child was building by selecting the right box for each tower.
7. making slings with modeling wax: in this corner several children were making slings with the modeling wax, and so experimenting with long, short, big, thin, After a while they could start comparing their slings ...



Another important factor of this approach was that the teacher had foreseen other activities after the play time; these were also building on the same goals. In that way, she offered opportunities for the children to transfer their constructed knowledge to another context. So the children could make long and short door ribbons, paint slings on paper, make painting with lines, making lines on a mirror that was covered with shaving foam.

- Pedagogical Interactions

During the activities the teacher was present in the classroom and she went in every corner and made conversations with several children. For example she was involved in a role play where she ordered long spaghetti; she went to the beauty salon where she wanted to buy a short neck less...

After the activities the teacher called the children together to look at the processes and products of the different corners. For example in the short episode below the reflection about building with boxes is described.

The teacher goes with the children to the corner with the boxes. There she steps on the boxes using her fingers, first on the short one and then on the long one.

During this action she says: 'oh this goes fast and oh, this takes a while.'

Afterwards she asks one of the children to this and then she asks which one is the shortest.

Afterwards you see the children trying to walk with their finger on to the boxes themselves.

In the fragment above, you might notice that the children are given the opportunity to evaluate themselves. During these feedback moments (or flash back moments) the children are involved actively.

- **Opportunities for Mathematics/Science Learning**

During this activity the children got the opportunity to learn about the concepts long and short, and how they could reform the wax by using their own forces. During the activity the children are given the opportunity to enhance their conceptual knowledge about conservation.

However the richness of this episode, is not only the activity as such, it is about giving children the opportunity to experience a few concepts, short and large, in several activities and contexts. Each child in this classroom has got the opportunity to experience these concepts in at least two different contexts or activities. As such the conceptual knowledge of these children is promoted or fundamental learning is encouraged. Apart from this, the activity isn't a traditional mathematics activity; the children are manipulating materials and/ or are engaged in role play. For them it feels like playing and in this way they learn about mathematical concepts.

The teacher also worked with the governmental attainment goals, namely:
Mathematics

- 2.1 The children are able to act and compare with words two things on their qualitative properties.
- 2.3 The children are able to sort things by increasing or decreasing the level of a particular qualitative characteristic.
- 2.4 The children are able to act in concrete situation with forms, quantities and figures, in as a function of a qualitative characteristic.

- **Opportunities for Creativity**

In this episode (the whole episode with the different activities) is fostered by offering materials to children, by creating different activities based on similar concepts, by allowing children to play with these materials and concepts. Children are given the opportunity to transfer their gained experiences towards a new context. These children used the concepts in other contexts, which mean that these younger children are able to make transfer and are able to reflect and reason about mathematical concepts. The enhancement of conceptual understanding can also be noticed in the following: Tree

days after the activities, the children used the concepts, short and long, during a fruit moment. They were comparing the length of their fruits.

During the activity the children are given the opportunity to communicate with each other. By doing so, they could express their creative taught about the lines.

b) The episode of the sand box

This episode has to be situated in a theme about stones. In the sand corner the teacher had placed materials to build with real bricks. First, the two children who have chosen for this activity are working separately in order to make their wall. However, after some time they start working together towards one wall. During the activity they decide what they want to build. The teacher is guiding the process; she interacts mainly to ask what they have done so far or what has happened. At the end of the activity the wall falls down, and then the teacher interacts in order to find out the reason of the falling down. All children are involved now. The discussion ends with a comparison with the world around us and the bricks of the school building itself. After playtime the activity could be chosen again, however examples of walls (using the tablet) are shown by the teachers to new children.



- Pedagogical Framing

This is an activity for two children; they could work on their own and could also cooperate. They both have a different starting point concerning the content of the activity. Next to that you might notice in the episode that they both have a different way of interacting with the materials in order to learn.

They have both the same materials to work with and they both start by filling their bucket with sand.

Child 1 is filling the bucket with a shovel until it's completely full.

Child 2 is filling the bucket until it's semi-full.

The objectives of this episode were 1) using a combination of ground (rough) materials to design or create and 2) the exploration of several possibilities to build a wall.

- Pedagogical Interactions

In this activity the learning process of the children is characterized by the ownership of the children, who are learning by doing and by observing the effects of their actions. This is visualised in the example below, where the child is pouring out the water when she notices that the sand isn't mixing enough with the great amount of water.

Child 2 is putting some more water in her bucket and starts stirring again. After a while she notices there is too much water and she is pouring out some water.

Child 1 is putting a little bit of water on the sand in the bucket.

The self regulated learning and construction of their play is also enhanced by the space they get from

the teacher. The teacher is present in the classroom and is observing the children, but it takes more than 10 minutes before she comes in the corner to interact with the children. The few times she interferes with the children the main focus is on appreciating what they are doing and on supporting them to go to a next step. In the example bellow you might notice she offers learning opportunities just by making the suggestion to place the bricks next to each other, so this remark will offer new possibilities in the play of the children.

The teacher comes in the group and asks what they are doing.

Teacher: "What are you doing?"

Child 2: "We are building a wall!"

Teacher: "Perhaps we can place your bricks next to each other.

Child 1 is placing his brick next to the brick of **Child 2**.

And the end of the activity she takes time to reflect and to bring in a new question for the whole class group. So, what is learned by a few children can be shared with the other children, and the activity may grow further when other children are in the corner.

Teacher: "I have an assignment for you all, can you look at the bricks in the wall when you are playing outdoors. Are placed in the same way as here?"

During the activity the children are interacting with each other by observing at first, but at the end they are working together towards the same goal.

- **Opportunities for Mathematics/Science learning**

During the activity the children have learned a lot about the effect of combining sand and water, and how to use this combination in order to build a wall (and to fix bricks). During their play they also came across different strategies to balance their bricks, and the importance of placing them in a balanced way. They also got the opportunity of using different materials in order to construct their wall.



While playing the children came across some mathematical numbers, so they learned to use the numbers in a natural and contexted way.

Child 1 is adding water to his bucket filled with sand.

Child 2: "We need 2 more bricks!"

Child 1: "I will make them."

During the activity the children needed to use and select special technical tools. They explored these tools and experimented with them. As such they learned more about the tools and about manipulating them.

In this episode the following governmental goals could be observed:

Mathematics

- 3.1 The children are able To act, in concrete situations with the concepts “in, on, above, under, next, before, behind, First, last, between, oblique, on each other, far away, close by, inside, outside, upwards, downwards” in their correct meaning. They can use pictograms linked with “directions” as symbols.

World orientation

- 2.3 The children are able to investigate in a simple situation which technical system fits best for their need
- 2.5 The children are able to choose appropriate material and tools for the realisation of a simple technical system.
- 2.6 The children are able to construct a simple technical system, with or without a plan of steps.
- 2.7 The children are able check if a self-made technical system achieves his goal
- 2.8 The children are prepared to work hygienic, safe and caring.
- 2.9 The children show an experimental and exploring approach in order to find out more about technology.

- **Opportunities for Creativity**

In this episode the children are working very independently. They are facing several problems and are given the opportunity to solve those problems themselves. This episode also contains opportunities for collaboration between children. In their play, they are helping each other to construct a wall.

At this point the wall falls down.

Child 1 keeps preparing his brick.

Child 2 is trying to rebuilt the wall by replacing the brick up on each other, but she fails to lift them up to be able to place them up on each other. After a few tries, she places one brick on top of the two bricks next to her side of bricks.

Then she grabs the stone below and places that one on top of that side of the wall.

Child 1 is finished with preparing his brick and is looking at the actions of child 2. Child 2 is trying to place her 2 resting bricks on top of the tower, but doesn't succeed"

Child 2: "C1, can you make this?"

Child 1 is grabbing the bricks and places them one by one on top of the wall.

Child 1: "Please!"

Child 2: "I will place some more wet sand on top, so the next one will be fixed in a proper way."

Then she places some sand on top. Child 1 is preparing a new brick and she is also going to prepare a new brick.



At the end of the activity the teacher intervenes, in order to foster reflection and reasoning, however

she also makes connections with the everyday context, such as the buildings in the street. This reflection of flash back moment helps to assess the strategies the children used to build their wall.

Teacher: "Oh, look what happens?" and she lets the stone lose and they fall.

Teacher: "How is this possible?"

Child 2: "Because he wobbles." ... "I will take some wet sand"

Teacher: "Can you place the sand on the brick?"

Child 2 places the sand on top of the brick.

Teacher: "Can you make it completely flat?"

Child 1 is handing over the plaster trowel. **Child 2** is making it flat with the plaster trowel.

Teacher: "Can you place the next brick on it now?"

Child 2 is placing the brick on top of it.

Teacher: "Can you use your spirit level to see if the bricks are in balance?"

Child 2 is placing the spirit level on the bricks and sees they are in balance.

Teacher: "I have an assignment for you all, can you look at the bricks in the wall when you are playing outdoors. Are placed in the same way as here?"



c) The episode of the bags

During the morning the children were active with stones, based on this the children were getting the opportunity to experiment further with stones and additional materials for example they could fill bags with stones. The teacher offered them a variety of materials.

In this episode we will focus on the two children who were working for about 50 minutes with the stones and the bags.

During the activity the teacher was visiting this corner to ask questions and to make suggestions for the use of the materials; however the children determined the course of the activity. In this activity the importance of repeated play is also very strongly presented. These young children stayed involved when they repeated their proceedings. At the end of the activity the bags are used to bring in the concepts of heavy and light for the whole group of children. Both participating children were allowed to present their findings to the group; their work was appraised by the teacher. Using their experiences she was able to bring some mathematical concepts to the whole group.

- Pedagogical Framing

This was an activity for two children who were allowed to register their own activity; however they didn't need each other. This didn't mean they couldn't interact, but they didn't need each other to be active.



In the morning there had been children playing in the corner with the stones and bottles, so this activity was building further on that one. For one of the children it was actually really building further on her own learning experiences before the playtime, but for the other child it was building further on elements she picked up in another corner and during the reflection moment of the class group before play time.

As main objectives in this episode, the teacher mentioned: enhancing knowledge about strategies to fill objects and enhancing conceptual knowledge about the concepts 'light and heavy'.

As mentioned before, the findings made by the two children were also used in the reflection moment with the whole class group.

- Pedagogical Interactions

The main focus of this activity is learning by exploring and experimenting. The children are learning based on their experiences, and on the construction process following up on that. Below you will find a fragment which gives an illustration.

Child 2 is grabbing a bottle and starts filling the bottle with stones by using a spoon.

Child 1 is filling her bag with one scoop.

Child 2 is grabbing a smaller scoop to fill the bottle.

Child 2 is grabbing a small glass to fill her bottle.



In the example above you see that the child noticed that there were falling a lot of stones next to the bottle when using a spoon. Then she noticed that she could put a lot of stones into a scoop and then she tried the glass, which has the same opening as the scoop but can contain more stones.

During the activity the teacher was very focussed on allowing the children to play on their own. She only interfered when she observed she could foster the children to take a step further in their play. In the example below the teacher makes a connection between the individual play of two children. By asking the question if she also wants to try, she opens a learning opportunity for the child, based on the action of the other child. She sees children as experts which are able to foster the development of other children.

Child 2 is using her small glass to put stones into the funnel.

Teacher: "C1, do you also want to do this?"

Child 1 is nodding.

- **Opportunities for Mathematics/Science Learning**

In this episode the children are learning a lot by experimenting with different filling objects. They get experiences of the link between the speediness, the usability and the amount that can be put into a volume in order to be able to select the most efficient filling tool in a given circumstance.

In addition, they are exploring the characteristics of stones and the working principles of filling materials such as funnels. They experience that the stone can only pass when there is some air between the funnel and the object to fill.



Child 2 is pushing with her glass on the stones and then pulls up her filling material.

Child 2: “look, they are gone!”

Child 1 is adding stones to her bag, but places the filling material again outside the bag.

Child 2 is repeating the action but she doesn't lift the funnel as high as before and she does it after every time she brings in stones with her glass.

At the end of the activity the teacher offers all the children the opportunity to pick up some things about heavy and light, by bringing them into a circle and letting the children feel the differences between the bags.

Teacher: “And what do you feel? Is it much? Little? Heavy? Light?”

The child does the movement with his arms and pulls up the heaviest bag when the teacher asks which one is heavy. Then the bags are given trough to the next child.

Children: “This one is heavy and this one is light” and she holds the lighter bag high up.

In this episode the following governmental goals can be linked:

Mathematics

- 1.1 The children are able to compare by acting and putting in words one specific amount of things with another amount of things. In articulating they use the appropriate quantity concepts. (equal / not equal things, many / few things, too much / too little things, things about / things too short, more / fewer things, most / least things).
- 1.4 The children are able to perform in concrete situations calculation acts relating to the number and quantity. They can articulate these operations by applying the appropriate concepts (making the same amount, adding, putting away, aggregate, increase, decrease, divide).
- 3.1 The children are able to act, in concrete situations with the concepts “in, on, above, under, next, before, behind, First, last, between, oblique, on each other, far away, close by, inside, outside, upwards, downwards” in their correct meaning. They can use pictograms

linked with “directions” as symbols.

World orientation

- 2.3 The children are able to investigate in a simple situation which technical system fits best for their need
- 2.8 The children are prepared to work hygienic, safe and caring.
- 2.9 The children show an experimental and exploring approach in order to find out more about technology.

- **Opportunities for Creativity**

In their exploration play, these children are offered the opportunity to select materials and to construct their own strategies to fill their bags. They also got the opportunity of trial and error, and redoing their actions. They are offered space and time in order to think about their actions and assess themselves.

The teacher also uses the activity to appreciate their work, just by using their bags into the next classical activity, in order to motivate them to go and explore even more the next time. This action also offers possibilities for the children to link their actions with the concepts of heavy and light.

3.2.3 Summary and conclusions

RQ2: Probing practice

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

Katrien is a teacher who believes strongly in the potential of very young children, and she always starts from what they already can (which is according to her much more than people say). Her vision on teaching and learning is strongly enriched by **the theories of experiential education**. Based on this, she is a very strong believer of learning chances in the everyday context of the children. Throughout the learning process of children, she states that encouraging **the inquiry attitude in all domains** will help them to develop and to have confidence. As she believes that learning about science isn't always trying to develop scientists, but fostering the inquisitive attitude of children there are no activities that only focus on science or maths.

Although Katrien is the teacher of a class with very young children, she is convinced of the importance of **detecting the interest of children, always**. So, a planned theme can change according to the input of these young children. For example, Katrien had planned a theme around the early spring but after an excursion in the fields the theme was changed to tracks in the mud (the children were more interested in the tracks in the mud than in the young leaves on the trees or the early flowers). So, in all aspects of her teaching practice, the children must have the feeling they are **involved and have ownership**. In that way they will feel respected and motivated during the day.

The theme is also the framework for the **integrated approach** that the teacher uses in her daily practice. In her corners she sometimes foresees activities with different goals, but she also values the corners with different materials but build around the same main goal. As such you offer children the

opportunity to choose for those materials which they are most attracted to at that moment. And the children are constructing the same knowledge however with other materials which enhance **transfer and insights**, especially when they share their findings.

Katrien isn't organizing deliberately activities that only focus on maths or science. This means that Katrien is **offering materials** that have the potential to make the **play, exploration, experimenting** of the children **rich and useful**. Sometimes she will make some **concepts explicit** or **make connections** between certain elements.

In order to build forward on the learning experiences of the children, Katrien states that it's important **to observe and listen** to them. According to her, when you do this in a proper way, you will be able to bring in new materials and suggestion for activities which engages the children. Because these young children are experimenting and exploring a lot, it's important to see if they make **transfers** between contexts in order to be able to enhance their development further and to keep their **well-being** at a high level.

It's also a main strategy of Katrien to use the **curiosity of the children** and to encourage it even more, because she believes this can guide them towards new discoveries and learning chances. In their **play, communication, collaboration** it's also important to allow them to ask questions and to be wondered about things. Even in **assessment** moments (the reflection moments), it's sometimes better to end in an open way with a **new question which wonders or fascinates the child**.

RQ3: Probing practice

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

In these approaches there are opportunities for children to explore and experiment with materials, in order to trigger their interest in science and maths. By being offered a variety of choices within the same context, their autonomous motivation is triggered.

As they are given the opportunity to transfer a concept into other contexts, they are offered great opportunities to integrate new concepts in their daily life. Because of that they will value the content more and will get motivated to learn more about it. As an example of the spontaneously usability of a learned concept, Katrien told the story of the children who were comparing the pieces of fruit based on their length a week after they had been working around the concepts 'long, short, medium'.

How do teachers perceive their role in doing so?

To foster the interest and motivation during the learning process, Katrien perceives her role as follows:

- Using **everyday moments** to make the knowledge useful
- It's important to grab opportunities that are available in the everyday life. For example, Katrien says that you can integrate learning opportunities when you go with the children to the dining

hall. For example, you can make groups based on the color of the shirts. The children have to arrange themselves based on these criteria.

- **Time and space for experimenting and exploration** is crucial
It's important to find a balance between saying something about an activity (experiment) and letting the children experience at first. She doesn't like to steer the process of an activity, children have to have the opportunity to construct their own learning process with the materials given.
- **Questioning and coaching**
When working with young children, it is also important to guide them in their inquiry process, but they should always feel the ownership of the activity. You might do this by making a suggestion, talking about what another child is doing, asking a good question, pointing out a problem.
- **Enhancing conceptual understanding by reflecting and transfer**
When working with young children it is important to reflect upon what they have done during the activity, as such new learning experiences are secured immediately. This doesn't mean that reflecting afterwards can't be valuable for the children themselves and for the other children. In order to have sufficient transfer it can be important to offer repetition of the content and concepts in different contexts and at different times, for example, working around "short and long" in several different contexts.
- **Enhancing communication and explanation**
It is important to allow the children to articulate what they do or experience, whether as a teacher to express it yourself if they can't do it themselves. In that way, you enhance the children to think about and search words. However, if it is too difficult to articulate what they have discovered, they can show it. Also a short showing moment at the discovery table can be very useful; in addition you can also work with drawings or movement. Meaning the children can draw what they have experienced/learned or they can express it by making movements (for example how birds fly).
- **Allowing children to collaborate, interact and discuss**
- **Allowing children to observe and don't be active**
Sometimes young children only have a need to observe other children, just give them the opportunity to learn from other children and give them the time to do so.
- **Creating or selecting a rich environment**, which contains rich materials
If you want to encourage children to construct creative and innovative solutions, children need to have the opportunity to gain knowledge about the properties of materials. Katrien offers the children a wide variety of materials, from theme materials towards day to day materials and rough materials like sand, water, wax, corn, stones, bricks, ... The environment outside the classroom is also seen as a very rich and useful learning environment by the teacher, as the children go outside quite regularly.

3.3 Case 4 – Lies -Discovery

3.3.1 Context

Where?	Country	Belgium					
	Setting name	AUC4					
	Location within setting	Pre-school					
Who? (children)	Year group/age of children	Reception; 5-6 year olds					
	Number of children in class	24					
Who? (adults)	Number of adults	1					
	Role of adults	1 teacher					
	Case teacher role	Co-ordinator					
When?		1	2	3	4	5	6
	Dates of visits (2013)	13/02	18/02	20/02	22/02	27/02	25/03
	Times of visits		8h30 – 13h		8h30 – 10h30	8h30 – 13h	
	Goal of visit	Intake	Observation and informal interview	Informal interview	Observation and informal interview	Observation and informal interview	Informal interview

a) AUC4: a catholic school

AUC 4 is a school which belongs to the free subsidised education, and is more specifically organized by the Flemish secretary of catholic education.

The school organizes education from the age of 2,5 years up till the ages of 12 years. The school has one location. The school is located between Ghent and Antwerp, about 30km away from both Provincial head towns. The school is situated at 5km from the border with the Netherlands in a rural and wooded area. The “Moervaart” is a river passing at 100 meters of the school. The people living in the neighborhood of the school are a mix of young and elderly people.

In their vision the school team brings the following elements forward as crucial and characterizing for them; to be a Modern Catholic school with an open view towards the future. They present themselves as a school which want to give children, large and small, the needed support to grow in their discover process according to their own rhythm. They want to be a place where children are allowed to discover and try again, a place where children’s wellbeing is valued.

The central aspects on which the school, based on their catholic vision, wants to focus are:

1. Being a school of quality
2. Being a school of Modern times
3. Being a school which cares

4. Being a school which moves
5. Being a school that cares about the environment

The school team translates the vision of the school into an approachable theme of the year that forms the central line throughout the working of the school on a daily basis. The theme for this year is titled: "Mirror, mirror... show me your strongest side!"

b) Lies: the teacher

Despite her young age, Lies is experienced in teaching multigrade groups, all age groups up till 6 year olds. Currently she is the teacher of a class of 5-6 year old children.

Concerning mathematics and science she has a broad vision, and an open minded approach. She believes in creating environments for children to discover interesting concepts and content. She sees opportunities in daily events and situations that occur during the day. In the informal interview she also said something important, that gives an idea of her commitment to the children: *'Sometimes I observe some things that I only use a week later. I know it's sometimes better to respond immediately, but sometimes I don't have materials, inspiration, background ... and then I wait for a moment.'*



In this case the teacher was working around a theme about Indians which was chosen by the children, with attention for the integration of several development areas. When the theme was chosen, the children also made a brainstorm about the things they wanted to learn about

(see picture). This school year she also works around a year theme based on the book 'Pluk van de Petteflet'. In the beginning of the year the children have made their own class 'petteflet' (see picture).



Her classroom is located at the ground floor of the building, with a play ground on both sides. She has one large room with a lot of windows. One playground has a play park and a garden with a large sand box, grass and trees, flowers and other natural materials.

As a teacher Lies has developed a strong pedagogical vision about her daily practice in relation to the pedagogical project of the school. She focuses on:

- **Working with interests of the children**

Lies believes that the children can be the creators of activities, their inspiration and interests have to be used in activities during the day. Consequently, the children will be motivated and engaged. As

such she involves the children in the theme choosing process, as described above.

In addition, she also uses the first day of a theme period to observe and listen to the children. As such she knows in which new materials they are interested in and she also knows their theories and ideas about it. This knowledge is very important to her, based on it she tries to create activities. However these planned activities can also be tailored by the children.

- **Integrative approach of several learning domains within the theme of the moment**

In her teaching styles, she always tries to work integrated by combining several developmental domains. She also tries to make the theme visual throughout the different corners and activities. In order to make this statement concrete you find an example below.

The children are working collaboratively on a headdress for each one of them. In order to make them fitted they also have to measure them, to cut the paper, to fix the feathers on them, to draw and cut the feathers, ... As you see, they have to combine their motoric, mathematics, art, social and reasoning skills in order to make proper headdresses.

In addition, they also have to find their own solutions about how to fix the headdress. As such the teacher not only encourages collaboration but also agency.



- **Working with concrete materials**

This teacher strongly believes in the benefits of working with concrete materials. She works a lot with the rich and undeveloped materials water and sand, because of their great opportunities concerning discovery and play. According to this teacher concrete materials are also ideal when you want to focus on a more abstract content.



For example, she is using homemade materials to encourage children to understand the mathematical logical concept of conjunction. In this activity for instance the children get two dices (one with numbers, and one with colors on it), a picture of an Indian, and some colored and marked with nerved feathers. In order to know

which kind of feathers should be placed on the headdress of the Indian, they have to make the connection between the color of the dice, the number on the other dice and the characteristics of the feather.



In the classroom there is for example also a "technical closet" where the children can find materials. For example to create technical objects such as a magical periscope. In order to do this,

they have to explore a lot of materials.

- **Outside school learning**



Lies likes to go outside with the children, these excursions can be planned or not. She believes in the learning opportunities outside the classroom. For example, she goes with her children to the park across the school to find some more materials to color water, she plans a visit to a building place, to a natural park...

- **Cooperation with (grand)parents and other experts**

In the day to day practice of this teacher the cooperation with other experts is common. For example, when Lies and her children went to a natural park she invited an expert to assist her during the exploring activity in the park.



As a teacher, Lies puts a lot of emphasis on the cooperation with (grand)parents. Consequently they, for example provide her spontaneously with materials to use in the class; they assist her in making clothes for the school show, they invite her and the children in their garden (picture) and so on.

She also tries to make use of the talents and strengths of the parents and grandparents. So for example, she organized an evening for the children and their parents. At this evening the special guest and expert was one of the parents, he was expert in the topic of the week.

c) **The children**

The children are aged between 5 and 6 years old. There are 24 children in total in this classroom. They have a natural curiosity and they have confidence in asking questions, in speaking, in explaining and in communicating. For example, during the observation in a corner in which they were experimenting with a limestone to make a slide, the children are explaining spontaneously what they are doing and why.



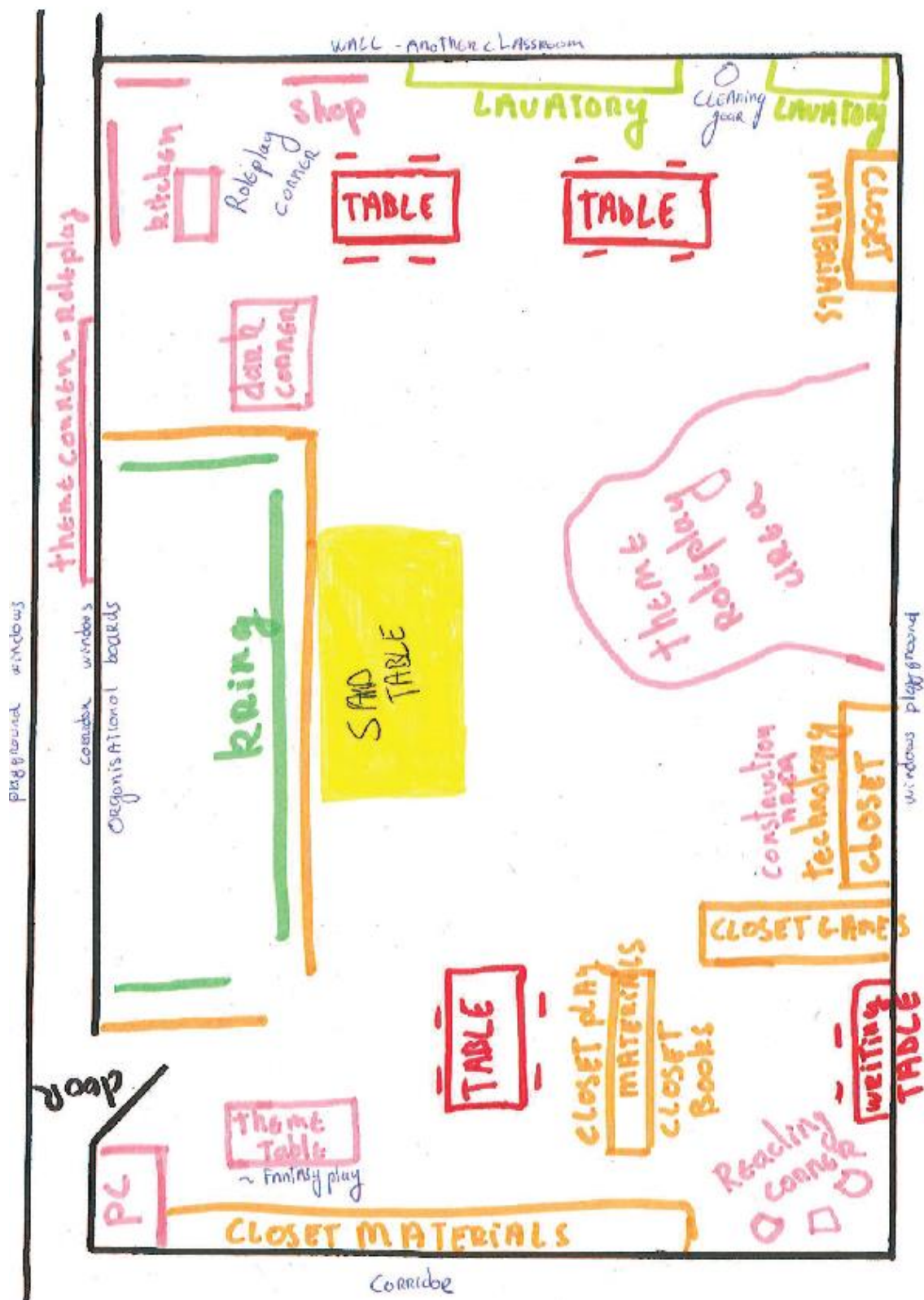
These children are also responsible for cleaning the classroom.

There are cleaning moments at the end of an activity however during the activities they are allowed to create chaos.

The episodes below are used to exemplify the specific activities and the approaches of the teacher as well as of what the children are capable of.

d) The classroom





3.3.2 Episodes

a) The episode of the tipi

This activity is building further on previous play in the sand box, during which they have used sand to create a tipi. At the beginning of that day, the children had collected twigs in the surroundings of the play ground. They asked the teacher if they could use the twigs in the classroom to build their tipi. At first the children decided to place the twigs on the sand tipi. However, when the teacher asked them if their Indian wouldn't like a tipi for themselves, they started to build a smaller tipi. During the activity they used different kinds of suture material, and were collaborating very intensively. At the end of the activity the children played with the Indian figures and their tipi construction(s).



- Pedagogical Framing

The teacher had foreseen that the children could play in the sand box, in order to build their Indian villages. Although the teacher had planned this corner activity, it's mainly because of the fact that the children were engaged in the subject (Indians and tipi's) that they collected twigs before school time. In this episode the ownership of the children was encouraged by the teacher, the children are the creators of this corner activity.

In order to encourage the learning process, there is already a lot of material into the sand box, but the teacher is bringing in gradually other materials. This gives the children the opportunity to look for different solutions and offers chances to explore materials brought in by the teacher.

C1 is placing the rope around the twigs and makes a knot. C2 and C3 are watching how C1 is doing this. C2 and C3 are grabbing some cloths to place on the twigs.

T comes in and offers some pieces wire (iron wire).

C3 places the cloths on the sand mountain, while C2 and C1 are working together to cut off some pieces of iron wire using scissors.

It's an activity with a small group of children playing in the sand box. The objectives the teacher had planned are: experimenting with materials to build a tipi and promoting understanding of conceptual knowledge about connecting materials and stable constructions.

- Pedagogical Interactions

During this activity the interaction between the children and the positive effect of their collaboration is placed central. In addition the ownership of the children is encouraged, which creates opportunities to learn from each other in a very natural way.

The role of the teacher is mainly characterized by coaching the children, she doesn't bring in the answer, however she intervenes a few times to make the learning process even richer.

Teacher comes in and asks: “Do your Indians want a tipi for their own?” *She takes tree twigs and places them together in a piece of sand and she asks the question: “How can we fix them now?”*

Child 3 keeps working on the mountain of sand.

Child 1: “We can use a rope” *and he goes to the other side of the sand box to grab a rope. The teacher leaves the group.*

Child 1 and Child 2 are working together to fix the tipi. One child holds the twigs, and the other one makes a knot.

The role of play comes also forward in this fragment. The children’s play in this episode is the motivational factor to realise their construction. In three following fragments you will notice that the children are evaluating their work during their role play in the sand box.

1. **C2:** “Now, the Mowi’s can be in there. Look, the horses can also enter.”
2. **C1 and C4** are playing with the horses in the sand tipi (mountain).
3. **C1, C2 and C4** are placing animals in the sand tipi, and are passing through with the cano.



- **Opportunities for Mathematics/Science Learning**

In this episode the focus is on adhesive materials and on the stability of a construction – for example the children have to construct a tipi with tree twigs, they have to make a passage into the sand mountain. They also have the opportunity to get to know the material sand and his characteristics. They also experience the influence of wind on a surface (see also the episode of the wind), and the need of fixing those surfaces properly.

In this specific episode the teacher also works on the following governmental goals in the domain of maths and science:

Mathematics

- 3.1. The children are able to act, in concrete situations with the concepts “in, on, above, under, next, before, behind, First, last, between, oblique, on each other, far away, close by, inside, outside, upwards, downwards” in their correct meaning. They can use pictograms linked with “directions” as symbols.
- 3.3 The children are able to find solutions into a concrete situation for a spatial problem.

World orientation

- 2.5 The children are able to choose appropriate material and tools for the realisation of a simple technical system.
- 2.9 The children are able to show an experimental and exploring approach in order to find out more about technology.

- 6.7 The children are able to set a space in use for their play.

- Opportunities for Creativity

In this activity the children are intrinsically motivated to build their own tipis. During their play, they are using their imagination to construct an environment in which they can play with their Indians, animals and so on. The teacher created several opportunities, for instance by providing materials, especially adhesive materials.



During the activity the collaboration of the children opens more possibilities to find creative solutions. In the example below it is clear that they needed each other to fix the tipi in this way.

Child 1 and Child 2 are working together to fix the tipi. One child holds the twigs, and the other one makes a knot.

The way of coaching by the teacher, by adding a question into the play of the children can also create opportunities for creativity. In the example below, you notice that the children are obliged to find a new solution for their problem.

Teacher: “What will happen if it aerates?” and she blows in the tipi. The children see the clothe move.

Child 1 blows also into the tipi, and they look for materials to fix the cloth. They use more clothespins and Child 2 asks at Child 4 to help her with cutting a piece of iron wire.

Child 4 places the iron wire around the tipi and Child 2 makes a knot.

Child 2 tries to blow again and sees that the tipi doesn’t move anymore.

b) Coloring with natural materials episode context and data and analysis

The day starts in the ‘kring’, the children and the teacher are working about Indians (a project which originates from the children). The children may choose between different corners. In one of the corners the children are allowed to experiment with natural colors on cotton. The Indians used natural dyes to color their cloths, so the children will first experiment how to dye clothes and will then, later on, make their own Indian clothes. Four girls choose to work in the corner of the natural colors. On the table in this corner, there are a lot of materials. The children and the teacher start by exploring what is on the table. Then an instruction card (technique) card is given to the children. On the card is visualized how the children have to work, how they have to handle the natural materials and how they have to separate these materials from the colored water. The children themselves choose the materials with which they want to color. During the corner work,



which lasted about an hour, the girls work quit autonomously. The teacher acts as a facilitator, she guides all corners and interacts if she notices children need some instruction or advice, or if she is called by the children.

- **Pedagogical Framing**

This episode takes place during corner work, there are several corners, amongst them is the craft corner about experimenting with natural colors in order to dye cotton. This corner is situated near the sink. The teacher has put a lot of materials on the table, natural materials (such as oranges, grass, herbs amongst others curry, coffee, tea (also rose hip tea), funnels, sieves (in different forms), cutting boards, scissors, cups, knives. The children are also allowed to go outside, for example two girls go outside to collect more grass, and they also went outside to collect mud. In order to bring in even more natural materials, the teacher decides to go to the park with the children after playtime, most probably they can find more natural materials in the park.

This specific activity is created by the teacher because the children are interested in Indians and the clothing of Indians, as mentioned before. The specific aims of the teacher for this corner are:

- *Accurately observing and naming of materials and steps.*
- *Knowing more about natural colors and the process to extract colors from natural materials*
- *Identifying factors which are necessary to dye cloths with natural materials for example time, warm water, ...*
- *Encouraging collaboration and autonomous learning*

In order to encourage independent work, the teacher introduces a technique card. This card promotes also communication and dialogue between the children (and the teacher).

The teacher chooses explicitly to work with mixed ability groupings, peers can learn a lot from each other. They also have to learn to collaborate and to respect each other weaknesses and strengths. In this particular episode four girls are allowed to work in the craft corner. One of these girls is a perfect instructor and leader, although she is shy in the presence of an adult. Lucky for her, the teacher knows her children very well and also their specific strengths.

The two girls (girl 1 and 3), who went outside to collect more grass, are back in the class. One of the girls says: 'We went for more grass.' The girls (girl 2 and 4) who stayed in the classroom interact. The first one says 'You may pour water in your cup.' However the second girl (girl 4), who is taking the lead now, gives the two girls some more instructions. 'If you want to bring in the new grass, you first have to put this grass in your cup. And if you want to have water in your cup, then you have to ask her (she means C3) in this way: Is it possible to take my cup with your hands and then you yourself have to pour the water in the cup, but you have to pay attention because it is very warm water.'

The teacher finds it necessary and important to reflect with the children on what they have done during corner work. These reflections take place in the 'kring' after group work, as such the results and the process is communicated to all the children in the classroom. So, other children can profit

and work further on the obtained results. For example in the episode one of the girls predicts that it is necessary to have the cotton longer in the colored water.

Girl 1 is back in the 'kring' and the teacher shows the mixture of rose hip to the children. The teacher is taking the cloth out of the cup and asks what happened. The cloth is pink now.

Girl 1 'It turned pink.'

Teacher to girl 3 'You worked amongst others with orange peels and you said, I don't want to take out the piece of cloth yet. Why?'

Girl 3 'Because it hasn't enough color.'

Teacher 'So you think that if the cloths stay longer in the colored water, then it is even are more colored? That it gets darker.' C3 nods yes.



- Pedagogical Interactions

The teacher is only interacting when she feels it is necessary or when the girls explicitly ask her help. She encourages autonomous learning, agency and peer learning. In order to reach these goals she introduces a technique card and she also coordinates the group composition.



During playtime we, as researchers, discussed the technique card with the teacher, because we noticed the following: *First the children looked to the card, however after the second time they knew what to do. However, one of the girls wanted to add several different materials in her cup, she also put the cotton in the mixture without filtering it. Lies is agreeing about this, she knows that this girl needs more instruction, that's why this girl is next to a girl who is very structured and even very scientific. It is remarkable for a girl of 5 years. She noticed, for example, that her water wasn't that colored and she investigated how she could deepen the color.*

Based on the conversations between the girls it is also clear that the teacher encourages collaboration and dialogue. Also in the other groups there is a lot of collaboration and discussion between the children. Although this results in some noise in the class, it also creates some very interesting conversations.

Girl 1 is still cutting with her tongue out of her mouth. **Girl 3** is saying 'Little pieces' to her. **Girl 1** to Girl 3 'But my fingers are almost broken.' Girl 1 and Girl 3 are cutting further.

Girl 1 'I'm curious what color this is going to be.'

Girl 2 'I'm also curious.'

Girl 1 'With you, it will turn yellow.' She is pointing to girl 2 who is working with the curry.

Girl 2 'That really stinks.' Girl 2 is giving her cup to girl 1 who smells. .

Girl 3 'And soon we are going to put a little water in it.' She looks at the instruction card.

Girl 1 'Later on we will bring water in it.'

When the teacher is interacting, most of the time she uses questions and she encourages the children to try out a lot.

Teacher 'How are you going to remove the pieces of peel out of the water?' Immediately girl 2 takes a tea egg.

Teacher 'Are you going to try it with that, you may.'

However, girl 2 decides to use the other sieve, with which she already worked with.

- Opportunities for Mathematics/Science Learning

There are a lot of opportunities for science learning in this episode. The motivation and affect of the children is promoted by using the interests of the children and by relating science to everyday life. All of the materials used can be found in the garden and the kitchen. The children are also allowed to collect materials outside, e.g. grass, mud.

During the whole activity collaboration and discussions between children are encouraged. The children have the freedom to make their own predictions. Based on the conversations, it is clear that the children are used to work independently and they are used to inquire and explore. During this inquiry they are guided by the technique card in order to have some notice of how to extract colors from natural materials. However the children are given the freedom to select the materials themselves, to investigate which sieve is the best to use and to predict how the water will color or how long the cotton needs to be in the water. They are allowed to plan their own investigations, for example one of the girls wants to have her piece of cotton longer in the water because she thinks the cotton will be colored deeper.



The teacher is a real facilitator, she is present when the children need some advice, however these interactions are very short. During these interactions she fosters exploration or reflection by using

questions.



After corner work, the findings are communicated to the other children. These reflections are also necessary to evaluate the process.

In the week that follows on this activity the children are checking regularly if the cotton is colored more intense or not.

In relation to the national curriculum this activity fits in the vision of the government. The government puts emphasis on some fundamental elements in the development of a child. For example self-esteem, motivation and initiative are woven as a thread through the whole of the national curriculum. Science is not a separate learning area; but part of the learning area world orientation. Children have to be oriented to the world in a broad way since the world is no compartmentalized reality. So one of the core goals is children have to develop basic competences that enable them to explore with trust themselves and their environment each time further and more profound.

In this specific episode the teacher also works with the goals of the government, namely

World orientation

- 1.1 The children are able to distinguish differences in sound, smell, color, taste and feeling.
- 1.2 The children to show an experimental and exploring approach to know more about nature.
- 1.4 The children are able to arrange organisms, and conventional materials to arrange based on simple, self found criteria.
- 2.3 The children are able to investigate in a simple situation which technical system fits best for their need
- 2.8 The children are prepared to work hygienic, safe and caring.

- **Opportunities for Creativity**

The teacher creates opportunities for creativity by encouraging the initiative of the children. As mentioned above the children are allowed to select their own natural materials, they are allowed to choose the sieves they want to work with. During the activity a lot of materials are explored by the children. The teacher provided different natural materials but also different working materials such as sieves, funnels ... Some of the children also experiment with two or more different natural materials. As they are in control of their own investigations, they are curious about the results and they are of course very motivated to work further and to explore other materials which aren't present on the table, such as mud.

c) The episode of the wind

This activity is prepared by the teacher and is presented to the children by using the story of the class doll, 'Dancing Leave'. This is one of the activities that is presented in the morning circle. During the activity the children are allowed to experiment with different materials in front of a fan, to see if they move with the wind. After a while the teacher introduced boxes, the children had to arrange the objects in the boxes based on their reaction in the wind (before the fan). Later on they did a recheck and had to fill in an assignment card on which the objects were visualised. Then the children were also allowed to experiment with materials they found in the classroom. During the activity the teacher asked questions and encouraged the thinking process of the children. At the end of the activity they discovered that the cano made a strange movement when placed in front of the fan.



- Pedagogical Framing

The teacher prepared this activity based on the experiences of the children in the weeks before. In this case it was a question of one of the children. Namely, after the story of the birth of 'dancing leave' one of the children had asked if it was because of the wind she moved when born.

This activity was planned for about four children, in a mixed setting. The other children were allowed to come and interact with the participating children for a certain period of the activity. The teacher used this strategy in order to make the activity also relevant for other children and to motivate them to listen to the result in the 'kring' at the end of the day. Another advantage is that because of the open atmosphere children are encouraged to try it the next time themselves.

The teacher had formulated the following goals: understanding the effect of wind on different objects, understanding the link between the concepts 'heavy or light' and movement caused by the wind, and understanding of the link with a large or small object surface.

- Pedagogical Interactions

In this activity the main focus of the teacher was encouraging children to observe and explain. She tried to make them check their observations by using different strategies (the boxes, the assignment card) and encouraged them to reflect on the things that were happening, such as in the fragment below.

At this point one of the children brings in a cano from the Indians.

Child 4: "Teacher, the cano doesn't move!"

And at that moment the cano goes sideways.

Teacher: "Oh, C4 look what's happening."

Child 4: "it moves sideways."

Teacher: "And if we place it in the other direction, will it move



too?"

Child 4 places the cano in the different direction and notices it doesn't move.

Teacher: "how should this come?"



In this activity the children's curiosity is encouraged by the goals of the activity, or by the research questions. The children are eager to know if an object will move. However, also in her coaching the teacher tries to foster the discovery urge and she herself is also excited. As such, she becomes an inquirer herself.

Child 4 is placing the sheet of paper in front of the fan.

Teacher: "Oh, should the paper always fly away?"

Child 4 places the paper folded in two on the table in front of the fan.

Teacher: "Look, does the paper fly away now?"

All the 4 children are looking at the sheet of paper.

Teacher: "How did it come it flew away before?"

Child 2 is opening the sheet of paper and sees that it is flying away then.

Teacher: "What did you do with the paper?"

Child 2: "I have opened it!"

Teacher: "You had opened it

Child 4 is picking up the paper and places it open in front of the fan, but pushes it completely against the table.

The children and the teacher are all looking what will happen. The paper stays at his places.

Child 1 is picking up the paper and places it a little bit further on the table, and then it flies away.

Child 3 is picking the paper up and places it back together with C1 on the table completely flat and then it doesn't fly away, until they pick it up a bit.

- Opportunities for Mathematics/Science Learning

During the activity the children are given the opportunity to sort the object according to their reaction in the wind (before the fan). Because they are given the opportunity to do this in several ways or through different procedural strategies, they experienced a wide range of different experiments and strategies.

Teacher: "You may put all the things back in the great box"

The children are putting them back in the great box

The teacher takes a basket with cards with the image of some of the objects on it and a matrix with the 4 categories on it.

Teacher: "Can you place the objects in the right place?"

Additionally, the children were obliged to use their numeral knowledge to communicate about objects that didn't have a place on the card. Because their only could be 4 objects on the card, but they had 6 possible objects.

This form of formative self-assessment was also very useful to stimulate their inquiry attitude.

In the domain of sciences they learned a lot about the effect of wind on objects, for example they had to investigate the link between the mass of the objects and the movement cause by the force of the wind. They also got challenged to try and find an explanation for the rotating movement of the cano. As such they learned about the relation between the surface or mass of the object, the force and the direction of the wind.



During their play, they also discovered the possibilities of the fan, so they learned how handle this technical system in order to make it blow fast and slow, to change the direction of blowing,... So they got the opportunity to handle this technical system in a proper way.

The children discovered they could make the wind blow hard and soft, and this made them experiment with the other materials.

Teacher: “C1, you wanted to know if the isomo still flew, if the wind blows softer.”

In this specific episode the teacher also worked towards the following government goals:

Mathematics

- 1.1 The children are able to act and compare with words one specific amount of things with a different amount of things. In articulating they use the appropriate quantity concepts. (equal / not equal things, many / few things, too much / too little things, things about / things too short, more / fewer things, most / least things).
- 1.2 The children are able to designate five things correctly (simultaneous) count and then say how many things there are numbered (resultative).
- 2.1 The children are able to act and compare with words two things on their qualitative properties.
- 2.2 The children are able to compare things quality and pooling on the basis of one or two common characteristics.
- 2.3 The children are able to sort things by increasing or decreasing the level of a particular qualitative characteristic.
- 2.7 The children are able to put in word the exchange, movement (speed) they experience with their own body or that they articulate with objects, phenomena or other people perceive.
- 2.8 The children are able to when comparing two known activities for them and sufficiently clear differences articulate any activity which takes the longest and the shortest.



World orientation

- 1.2 The children to show an experimental and exploring approach to know more about nature.
- The children are able to arrange organisms, and conventional materials based on simple, self found criteria.
- 2.9 The children show an experimental and exploring approach in order to find out more about technology.

- **Opportunities for Creativity**

In this activity the children's curiosity and questioning is fostered very intensively. They are offered the opportunity to develop their questioning by handling the objects and by the scaffolding of the teacher. She fosters the curiosity of the children by asking them regularly questions about the things she observes. Using this strategy, she also offers children the possibility to build up an explanation for the phenomena, which is demonstrated in the episode below.

At this point one of the children brings in a cano from the Indians.

Child 4: "Teacher, the cano doesn't move!"

And at that moment the cano goes sideways.

Teacher: "Oh, C4 look what's happening."

Child 4: "it moves sideways."

Teacher: "And if we place it in the other direction, will it move too?"

Child 4 places the cano in the different direction and notices it doesn't move.

Teacher: "how should this come?"

From this point the children are testing this with different materials, like the small fan.

Adding a matrix card in order to sort a part of the objects as a form of self-assessment was also a great opportunity to foster their inquiry attitude.

Teacher: "Oh, we will have to try again."

The children go to look in the great box and are placing the objects in front of the fan.

Afterwards they are placing the card into the right place in the matrix.

After a while they start discussing about the right place and start investigating again.

During the activity the children were given the opportunity to learn creatively from each other, just because of the open attitude and room for dialogue and collaboration; sometimes happening spontaneous, sometimes encouraged by the teachers, such as bellow.

Teacher: "Oh, If it doesn't move at all... C2, can you show at C4 what we have to do then?"

Child 4 goes to show at Child 2 where the sponge should be put.

3.4.3 Summary and conclusions

RQ2: Probing practice

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

The main focus of the teacher, Lies, is that she wants **to build further upon the experiences and questions of the children**. Concerning her vision on teaching and learning, she is greatly influenced by the concepts of **experiential education and developmental education**. Based on this she is a strong believer of the importance of **fostering an inquisitive attitude**. She is also convinced that learning should start from the children's own topics, questions or ideas as such learning will be more profound than when she brings them in from her point of view. As such the class themes are created **together with the children** and the activities are based upon their interests, talents, questions and needs. How does she do this? She plans the class themes together with the children. In the early stages of a theme she also **listens** to the children's ideas and questions, **and she observes** them during their play with new 'theme' materials. Based on this she brings in other materials and she creates activities in order to guide them **in finding answers to their question or in creating new questions and ideas**. This means that Lies only plans main broad goals, and the children determine with which materials they want to play or which materials they want to explore.

Because of that the teacher isn't focussing on a mathematics or science activity as such, she always tries to **work integrated** and she always creates several corners with different exciting materials, which can guide the children to reach **different goals**. Depending on the corner, and learning activity happening in it, the teacher observes and tries to find a balance between **standing back and interacting**. She puts a lot of emphasis on **the ownership** of the children, and on the opportunities to develop and show their **agency**. During the observations, we have noticed that these were important values in the approach of the teacher, for example in one of the corners, the children were offered the opportunity to develop their own ideas with the limestone.

She believes in the power of **questions**, as such her teaching practice is built upon questioning. Throughout the activities, **fostering curiosity and motivation** in order to discover and find out, are the main pedagogical goals of this teacher. During this process she creates time and space for **play, exploration, collaboration, communication, questioning, and fantasy**. She also tries to encourage the **reflection and reasoning** of the children during or after an activity. Her objective is always to offer growing possibilities to children. Children may not be afraid to ask questions or to give their opinion.

Another important element, which the teacher brings in during activities, is assessment. This is done in a formative way, by building in possibilities for **self-assessment** during the activity and **reflection moments** at the end of an activity, for example when the children present the findings of a certain activity to the whole classroom.

In this case you might also see that during the learning activities the teacher also puts emphasis on **the social dimension and wellbeing** of and individual child, by appreciating their individual strengths.

The teacher stresses on the importance of going into the world of the children, in order to construct an environment in which they feel confident in and to explore and find the learning possibilities that come forward from their fantasy and imagination.

RQ3: Probing practice

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

The opportunity to be involved in the construction process of the activities opens possibilities to **connect with the questions the children have about their interests**. By doing so, the self-confidence of the children will grow, and as such they will be more involved in the learning process.

By doing inquiry activities, together with the children, the teacher is showing her **appreciation** about their ideas and strategies to the children. As such she creates opportunities which motivate them to go deeper into the subjects of science and mathematics. Children are encouraged to discover the pleasure of finding possible explanations or new questions.

How do teachers perceive their role in doing so?

In order to encourage the learning process of children and to foster their interests and motivation, this teacher puts forward the following aspects:

- Giving the children **time and space to learn**
The children need time to explore and experiment with the materials. In addition, even when you are short in time, you don't have to give them the answers, but the opportunity to discover which solutions may work.
- Providing **opportunity to communicate and listen to each other**.
It's important that children are offered the possibility to talk about their findings. Herewith it's also important to foster the interaction with children who weren't active in the same corner; as such children can learn from each other and are encouraged to explore the activity in the corner also.
- Allowing **children to collaborate, interact and discuss**
During an activity the interaction between children can bring the activity to a next level.
- Encourage the children to **reflect critically**
Children can make mistakes, but they can also learn from it by self-assessment. As a teacher you can foster this by asking them to evaluate their outcomes, like the teacher did with the tipi or cano.
- **Interact and ask questions** when needed.
Sometimes it's important to bring in new materials, like the iron wire or to point out that something is happening, for example when the cano made a strange movement.
In addition questioning can help the children to think further or to encourage their curiosity.

- Appreciate the children by **observing them and listening to them**

As a teacher, when you observe and listen to the children actively, you will notice a lot of opportunities to foster their learning process. In this case, the children wanted to learn more about the Indians; as such it opened the opportunity to introduce them to the construction of tipis.

- Creating or selecting a **rich environment**, which contains rich materials: If you want to encourage children to develop creative and innovative solutions, children need to have the opportunity to gain knowledge about the properties of materials.

Lies offers the children a wide variety of materials, such as theme materials, day to day materials and rough materials like sand, water, twigs, stones ...

The environment outside the classroom is also seen as a very rich and useful learning environment.

In order to make the learning progress of the children visible for others Lies is using her goals to evaluate the learning of the children on a daily basis.

3.4 Case 5 – Els – A case of living materials and active independent learning

3.4.1 Context

Where?	Country	Belgium				
	Setting name	AUC1				
	Location within setting	School				
Who? (children)	Year group/age of children	8 years				
	Number of children in class	22				
Who? (adults)	Number of adults	1				
	Role of adults	School teacher				
	Case teacher role	teacher				
When?		1	2	3	4	5
	Dates of visits (2013)	13/11	28/01	01/02	04/02	08/02
	Times of visits	10h30-11h	8h30-10h30	10h30-11h	8h30-10u30	10h30-11h
	Goal of visit	Intake	Observation and informal interview	Informal interview	Observation and informal interview	Informal interview

a) AUC1: a school with a specific pedagogical project

The school is located just outside the ring of Antwerp, the biggest city of Flanders. Both single family homes and apartment buildings are located in the immediate environment of the school. Near the

school are living also many senior citizens. Most of the children live in a radius of 5 km around the school and come by foot, by bike or public transport.

'AUC1' belongs to the publicly funded, publicly run education. The school board is the city of Antwerp. As a public setting, the school is open to all children, whatever the ideological or cultural background of the parents. As such the school has currently 11 different nationalities.

Flemish schools enjoy a high degree of autonomy and are free to develop their own educational policies, including curriculum, assessment, certification and any self-evaluation activities. However, in order to be able to award official qualifications or to receive funding, schools must meet certain conditions set by the Flemish authorities, including: following a core curriculum (attainment of targets or developmental objectives according to the stage or type of education); and allowing the Flemish authorities to assure their quality (this is done via the Inspectorate). It is the 'organising body' that draws up a curriculum (curricular objectives, pedagogical project ...) based on the core national curriculum.

'AUC1' has its own pedagogical vision and project, approved by the city of Antwerp. The school only exists 2 years. In the school year 2011-2012 two existing school were put together and a new school 'AUC1' was implemented with a specific pedagogical project:

- The school believes in talent-oriented education: the school appreciates the individual talent of each child.
- The school believes in active independent learning: the school appreciates the individual learning pace of every child.
- The school believes in encouraging an inquiry attitude: the school appreciates the curious and critical attitude of every child.

To achieve this vision all members of the school team work to the same purpose and certain approaches are general. This means that these approaches are also visible in the practices of the participating teachers of the school, Els and Ilse.

Some exemplary approaches which are interesting for this case:

- Talent-oriented education: the report for the parents consists of two parts: a part about the learning process and another part about handsome works.

In each group there is a pupil of the day or the week. Special attention is given to these children and their talents are magnified.

There are exhibitions in and out the classroom at the end of a class or school project. For example during the period of the observations the project 'Start to art' ran. This is a project where art is combined with mathematics. At the end of the project (8/2/2013) the parents were invited to come and see what their children had done and created. So, at that day during the observations, parents came in the classrooms.

- Active independent learning: in all classes corners are created, these encourage the children

to try out different learning styles. In the classroom of Ilse there is a computer corner, a book corner, an art corner, ...

In the primary school an assignment letter is used so children can work independently. Els uses the whiteboard to note the different assignments during groups work.

The team chooses to work with as many daily life activities as possible. This can range from planting flower bulbs, weather observing, making fat cakes for birds to building castles and experiencing excursions. For example during the groups work about measuring, the children of Els use the doors, windows ... in the classroom and the corridor. Els uses experiments with eggs to learn more about 'zout', 'lauw' ... and other 'ou' and 'au' words.

- Fostering the inquiry attitude: In each class group there is a talking and discussion 'kring'. Every morning, a conversation is held in the 'kring', during these 'kring' moments questions are asked by the teachers and the children. Together they search for answers. In one of the episodes in the classroom of Els the morning starts with a conversation about the Flemish painter (Raveel) who died in that week. A talk about dying and health is initiated.

The teachers promote the creative thinking of the children by viewing different possible solutions for a particular problem.

At school there are several sources of information that children can consult. The school prefers to work with life-like materials. As such, children can often better adjust their research question and they dare to go further in their experimenting. For example in the episode beneath Els uses eggs and salt, the painting of Arcombaldi, the paintings in the school, a string of beads, elements in the classroom, ... during the observed activities.

b) Els: the teacher of the first grade

Els is the teacher of the first grade; however she is not a primary school teacher but a preschool teacher. She graduated in 1997. Because of her background, expert in experiential education, the principal has asked her to coach the children of the first grade. Since it is only the second year, Els is still searching and experimenting to find the best or a good pedagogical approach, combining the principles of experiential education (and the vision/general approach of the school) with the goals for primary education (especially learning to read, write and count). She finds it very important to practice the reading and language of the children by using real life materials (in combination with science, art, mathematics or a combination of them all). She is experienced in observing children, and knows how children react when they are



working with each other.

There are separate mathematics activities and language activities during the week however she uses also the principles of corner work and group work – so, she encourages active independent learning in mixed ability groups. Several groups of children work on different activities (language, mathematics, science ... activities). Worksheets are used to guide the activities. Els doesn't evaluate these worksheets one by one (meaning correcting them in red), however she reflects on the activities and the results with the children during 'kring' moments. Children have to experience and inquire the curriculum themselves during group work or individual work. Els finds it also very important to repeat activities and concepts, so children can have the opportunity to learn and to make transfers. Through experiences and repetition, the children can internalize the curriculum. She says that you could get the impression that her class is sometimes chaotic because of all children working on different things and because of the ownership they have. Play and exploration is valued as well as choices of children and collaboration. Examples of group work and corner work can be seen in the episode of measuring and ...

Els is confident in mathematics and science teaching. She is a teacher who makes a lot of connections with earlier activities, which supports the transfer for the children. Els is a lifelong learner, open for a lot of experiences. She is ICT skilled, in her classroom there is a digital board.

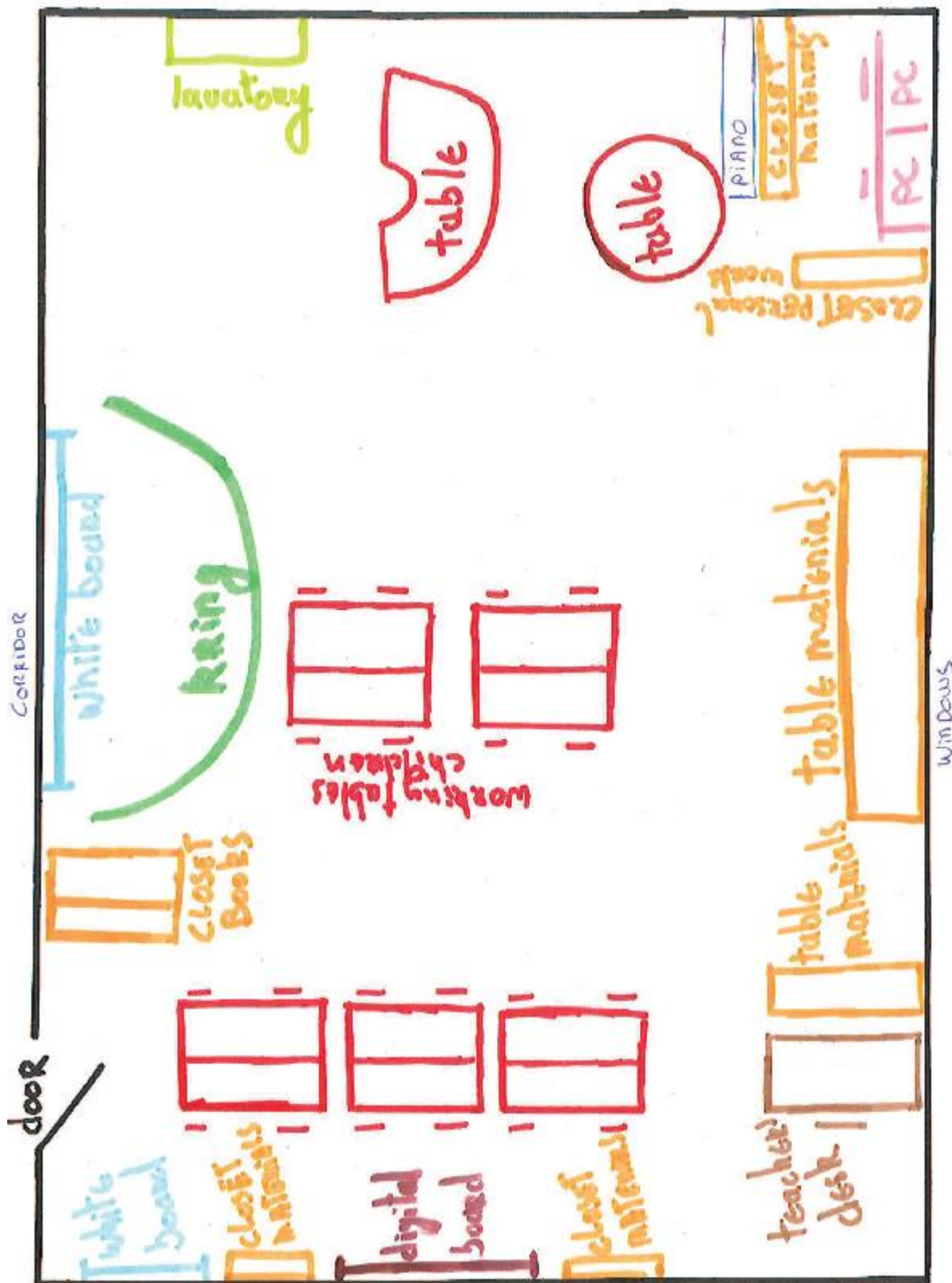
According to her the link between creativity, science and mathematics is: to give children the possibility to think first, to bring in their own theories, to work together in heterogeneous groups (mixed ability), to encourage cooperative forms of working, a teacher who gives children the opportunity to discover and explore things themselves, to listen to each other (as a teacher we have to listen to children, we have to extract what is usable and we have to build further on this).

c) The children

As mentioned before the school is an example of a multicultural group setting. In the school there are more than 11 nationalities. The number of children in the classroom of Els is 19. They are aged between six and seven years.

d) The classroom





3.4.2 Episodes

In the next episodes three activities of EIs are illustrated. One is an example of working independent on several activities (language, mathematics and science activities). A second is an example of group work during a mathematics activity. The third one, the episode of reflecting on an egg experiment, illustrates how this teacher reflects on earlier activities with the children during 'kring' moments. This third episode is also an example of combining science in a language activity or using real life materials and experiences to practice language.

b) Episode of estimating and measuring

In this episode the children are first in the kring and the teacher is presenting the different activities which the children are going to do in groups of 4. The teacher is very patient, she talks very clear and she has a friendly voice. First she reflects on two experiments with eggs (see the episode above). Then she presents the three other activities, in the episode we focus on the measuring and estimating activity. During the kring moment the teacher is repeating earlier knowledge, which is necessary for the children to fulfill the assignment about measuring and estimating.

After presenting the different activities the children take their places at the different tables. They are used to work in groups of four. They have 15 minutes to do the assignment at that table (which is on worksheets) and then they have to switch tables. The children are allowed to go outside the classroom (the door is open).

Four girls are working on the measuring and estimating assignment. They have a meter and a string of beads with a length of 1 meter. They all have a worksheet. On the worksheet two columns are drawn. In the first column several objects are visualized, they have to select a similar object (in reality) in the classroom or in the corridor and then they have to estimate the length of these objects. After they have estimated the object, they have to measure it. They may choose themselves the real objects, so they have to select a door, a window, a corridor, a board ... They have to search for these objects in and outside the classroom.



- Pedagogical Framing

In this episode the focus is on the measuring and estimating activity. The **aims** of the assignment are clear, estimating the length of objects and learning to measure them with a meter in order to check.

The teacher likes to use **real life materials**. This is also shown in this specific episode. She provides a

meter but also a string of beads. She wants the children to know that if you know the length of an object, you can use it also as measuring rod. The children have to choose themselves the real objects in the classroom and the corridor outside the classroom.

Teacher 'I have put there something new. Beads. And there is something very special about the beads. You can wear them if you go to a party.'

Child 'You can also measure with them.'

Teacher 'Oh, show me.' The boy takes the beads. Another boy says that you can lay them near the meter and it is longer than the meter. Meanwhile the first boy is laying the beads next to the meter.

The teacher repeats the knowledge and the measuring skills in order to make transfers and to encourage reflection – it is also a form of assessment: What do the children still know about measuring the length of objects and about a meter?

Teacher 'Which unit do we use to measure?'

Child 'Estimate'

Teacher 'First we have estimate but after that we measured with a ...'

Child 'Measuring rod'

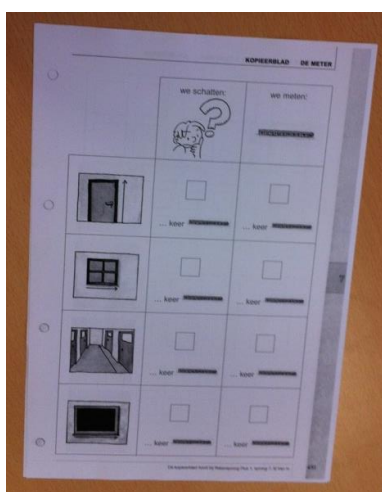
Teacher 'Ok, I will show you my measuring rod' The teacher is leaving the circle and is searching for her measuring rod.

Teacher 'This is my measuring rod. Did you measure with this?' The teacher has taken a measuring rod of 30 cm.

Children 'No'

Teacher 'No, but this is also a measuring rod'

Children 'Yes'



Teacher 'One large people step was?' The teacher is doing it for the children.

Children '1 meter'

Teacher '1 meter. Very good.'

Teacher 'You have measured with a meter.' The teacher shows the measuring rod of 1 m.

Teacher 'Two little people steps are?'

Children '2 meter?' - '1 meter' Some children know the answer and some don't. The teacher takes her meter and shows that one large people step is a very large step. She takes a large step over the meter. A little people step is half of a meter. She takes 2 smaller steps next to the meter.

During corner work – **small ability group settings** - the teacher prefers to work with **worksheets** in order to guide the children and to encourage their **agency**. Some worksheets are very visual, like the worksheet about measuring and estimating. On other worksheets there are sentences or questions.

The children read the worksheets to each other. The teacher finds these worksheets interesting to practice the reading of the children. They are interested in actively doing things, such as experimenting with eggs. However, in order to know what to do, they have to read the instructions. Since the children work together, the assignments are done within 15 minutes. Then children switch to another corner/table, so there is a lot of variation.

By using real life materials, collaboration and by enhancing the ownership of the children, they are excited to do the assignment and to learn more about mathematics.

- **Pedagogical Interactions**

In the episodes two parts can be distinguished: the instruction part and the small group part. During the instruction part, the teacher is guiding the children by using **questions**, encouraging **reflection**, **reasoning and collaboration**. The other children are observing. She wants to refresh what the children have learned and did before (see also the short episode above).

Child 'It is longer.' Teacher asks the help of another child to measure how much longer. They have to use a finger to measure. Several children are saying two meters.

Teacher 'Two meter?'

Child 'No'

Teacher 'Just not enough for 2 meters.'

Teacher 'OK, I will do something with it. I'm going to give you a string of beads of 1 meter. What should I do then?' She repeats the question and every child has to think. Who has a solution for the problem?

Child 'Cut'

Teacher 'Where do I have to cut?' One of the girls points where she has to cut.

Teacher 'There at the end?' Some girls are pointing to the middle of the string. Then the teacher says to the children, she wants to make a deal with them. Only one string shall be cut.

However, during this reflection there is also time for some **playful interactions**, for example the idea of the little horns and the interaction about the giant squid.

Teacher 'Can you promise that you will not cut? How do you promise something?'

Child 'So with the little horns against each other.' One of the girls is showing little horns. The teacher doesn't understand it quiet well and the girl explains that it is from an exhibition. There were little devils and they promised something to each other by using their little horns.

Teacher 'Ah Ok, but I have no little horns.'

Child 'But you can do it' The girl shows how. The teacher is also making little horns with her fingers, together with the other children and they promise that they not will cut in the string.

During the small group part, the children are instructing and guiding each other. There is room and time for collaboration and **agency**, the teacher is standing back. One of the girls is taking the lead. They are also checking each other's process and results – form of **peer assessment**.



Girl 1 is putting the meter on the ground, just in front of the door.

Girl 1 'The other meter (the string of beads)'
Girl 2 is bringing the string of beads next to the meter.

Girl 1 'No, not there.' She sees the girl isn't replacing the meter.

Girl 1 'Yes, ah so.' **Girl 1** is replacing the meter she is holding and brings it on top of the other meter.

Girl 3 '2 meter'

Girl 2 replaces the string of beads, and brings it next to the other meter. She says '2 meter'. She gives the string of beads to **girl 3**.

Girl 1 'Yes, 2 meter. I'm writing down 2 meter.'

They all are writing down the length on the worksheet.

Girl 4 'I have 2 meter.' She is watching her worksheet.

Girl 1 'Oh, it was right, the door was right.' She is pointing to the estimated length on her worksheet. She looks at the worksheet of **girl 2** and says.

Girl 1 'You have to blot it out.'

Girl 2 is doubting.

Girl 4 'That is noo ..ot'

Girl 1 'No, you have to blot this out and write the length here' **Girl 1** herself is blotting out the estimated length on the worksheet of **girl 2**. **Girl 2** and **girl 4** are watching.

Girl 3 has measured the frame of the door alone and says to **girl 2** 'Two meter' while pointing at the frame.

- Opportunities for Mathematics/Science Learning

This specific episode provides several opportunities for mathematics learning. It is an episode about to estimate and measure, and about using a meter. Some concepts and skills are refreshed before starting the corner work. Then children are given the time to practice their mathematical skills in group. In fact the assignment could be seen as a short guided inquiry. They have to plan an investigation, they have to estimate, then they have to measure and observe, finally they have to communicate the results. During and after the investigation the peers are assessing the process and the product, as shown in the small episode above.

The assignment is an open assignment because the children themselves have chosen the objects in reality. Collaboration, agency and real materials are used to enhance their attitudes in science



learning. The girls are excited when they have the good answer.

Girl 4 'Yes, we are right, 3 meter.' ... 'Yes, we are right'

Girl 4 'I have already written 3.' Girl 1 is also writing 3 on her worksheet as well as girl 2. They are sitting down in the corridor; the worksheet is on the ground.

National curriculum - Mathematics – measuring

2.1 The pupils know the main quantities and units of measure with regard to content, length, area, weight (mass), time, speed, temperature and angular size and they can make the relation between the quantity and the unit of measure.

2.7 The pupils can perform meaningful retracements with the used units of measure.

2.8 The pupils are capable of estimating using reference points

- **Opportunities for Creativity**

Based on the pedagogical project of the school and the interaction of the teacher in this specific episode it can be stated that several opportunities for creativity are provided in this classroom. Motivation, initiative and affect are enhanced by playful interactions, by encouraging ownership of the children, by listening to what they are saying. There is room and time for dialogue and collaboration, the teacher is guiding however she also stands back (scaffolding). She knows the children in her class and knows what their strengths are. She also knows where to look at. For example in the episode she is looking for girl 3, a girl who is measuring other objects.

In the other groups, children get also the opportunity to explore, as you will notice in the picture, one of the eggs crushed and the water has a yellow color. So, although the children have worksheets, initiative and creating thinking of children is valued.

As for assessment, emphasis is put on formative assessment and less on summative assessment. Strengths of children are important.



b) The episode of the parallel lines



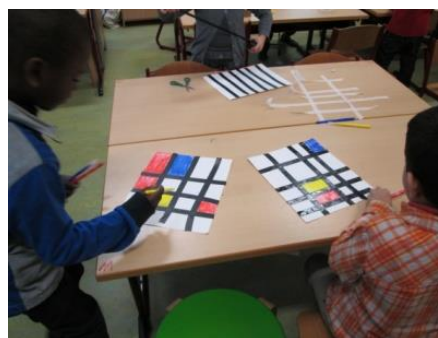
This activity is building further on previous content knowledge about parallel lines, in other terms they had already worked with the concept of parallel lines. As an introduction to the group work, the teacher reactivates the pre-knowledge in the 'kring'. She starts off with a sort of reconstruction of parallel lines using tape placed on the ground, she allows the children to make parallel lines using their body, and allows them search for parallel lines in the classroom. During these actions she is asking

questions to promote reasoning and reflecting. Then she brings in a Mondrian painting by using the digital and she reconstructs the drawing with tape on the floor. In addition, she shows one of the works of one of the little children of the other classroom. In order to give a more diverse image of the work of Mondrian, she shows several paintings on the digital board and notes on the white board the term "parallel" as common characteristic. After this introduction, the children are allowed to try and construct parallel lines themselves in groups of 4 with tape, and individually on paper. In this episode we focus on the learning activity with the tape in one of the small groups.



- Pedagogical Framing

The children are divided in small groups of four and all groups have the same assignment. During the activity some of the children are working faster and can work individually on paper. By doing so the teacher can differentiate based on the level of the individual child, without given others the feeling they can't do it. Everyone is allowed to work on his own pace and also the value of observing is validated.



The teacher had foreseen in specific materials and her classroom was set up in groups of 4 to make the group work possible in a natural way. All the materials in the class could be used, however most of the materials have a fixed place in the classroom where everyone has access to. As you will notice in the fragment below, the teacher hands out the materials and then observes what the children are doing.

The teacher hands out the materials after giving the assignment in the 'kring'.

[starting the activity]

Child 1 takes the tape and starts to place a taped line on the table by ripping the tape.

Child 2 is helping **Child 1** to keep the tape in place.

Child 3 is watching

Child 4 is watching

The main goal of the teacher was to iterate the conceptual knowledge of parallel lines, in order to give the children the opportunity to transfer these concepts to another context.

- Pedagogical Interactions

During the activity the teacher is the person who focuses on facilitating the learning process, by giving some guidelines in advance and by offering materials at given times.

Another role of the teacher in this episode is the aspect of assessing the outcomes of the children. The teacher stresses on this strategy, because she finds it important to be sure that no misconceptions are created by allowing the children work on their own without guidance. Therefore she believes it's important to seek for opportunities to obviate the misconceptions, like illustrated in the example below.

The teacher comes back after one minute and says: "These are interesting lines!" and she calls all the children of the classroom to give some explanation.

Teacher: "What happens with two straight lines that aren't parallel?"

Child 1: "they cross"

Teacher: "Can you make those lines a bit longer"

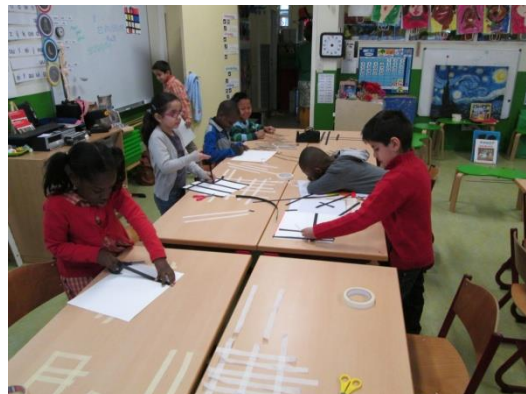
Child 3: "They cross each other!"

Teacher: "So if we make them longer we can see if they are parallel or not"

- Opportunities for Mathematics/Science Learning

This activity contains opportunities to construct conceptual knowledge about parallel lines. There are several opportunities for the children to learn, they listen to the teacher, they find out with their own body, they search for parallel in the environment, they construct them themselves with materials or by making a piece of art.

In this specific episode the teacher also works on the governmental goals, namely:



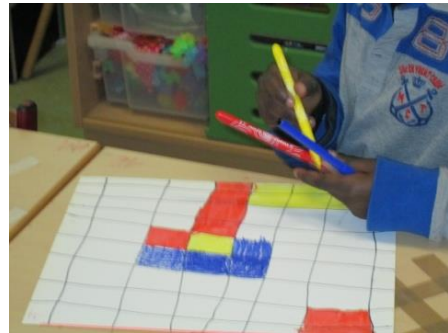
Mathematics

- 3.2 The children are able to recognize the following geometric objects based on the following properties and name:
 - o in the plane: points, lines, angles and plane figures (triangles, squares, circles)
 - o in space: polyhedra (cube, bar, pyramid) and sphere and cylinder
- 3.3 The children are able to read and write the symbols of the perpendicularity and parallelism.
- 3.6 The children are able to discover the concepts of symmetry, similarity and equality in reality. They can create simple geometric figures themselves.

- Opportunities for Creativity

In this activity the diversity of activities building further on the same goal are opening possibilities for keeping the motivation at a high level, because of the diversity there are challenges for all children.

The teacher states it as follow: *'I find it important to foresee a wide range of differentiation in order to reach children at the place they are able to learn the most, at their own individual level.'*



As you can see in the picture one of the children is making a "Mondrian" on paper by using lines he draw himself, but he still has the challenge left of drawing them straight with the use of the tool, a lath.

In the example above the teacher can also scaffold on an individual level and foster the creativity of each child separately.



Also the involvement of other classes offers possibilities for creativity through collaboration, motivation and appreciating. By letting other children visiting the class, you are giving the messages to your children they have done something that is worth showing to other people. But in the meantime you offer the change for those other children to be encouraged to think and reflect up on what they have been seeing. You reach the same goal by using some work of another class into your own practice, like the teacher did here in the

beginning of the day.

c) Episode of reflecting on an egg experiment

All children are sitting in a circle; the teacher is in the middle of the circle. The day starts with a little talk about the Belgian painter who died that week. The children are learning about painters (there is an art project running in the school), so the teacher says to the children that she finds it important that they know something more about a modern painter, who was living in Flanders and just died. It is Roger Raveel. There is a little discussion about the age of Roger Raveel and why he died. Next week, the teacher says, they will work further with Raveel. Today they are going to do some other exercises, amongst them corner work with 5 separate activities. One of these activities is the experiment with an egg, only a few groups have already done this experiment. As such the teacher wants to repeat it for the other groups. She wants to know from the children –who have done the experiment – what they did. So, peers are used to instruct and guide the groups who didn't do the experiment.



As such the teacher wants to repeat it for the other groups. She wants to know from the children –who have done the experiment – what they did. So, peers are used to instruct and guide the groups who didn't do the experiment.

- **Pedagogical Framing**

The episode takes place in the kring with the whole class group. It is a **mixed ability group**. Several of the children are no native speakers. The teacher puts a lot of emphasis on learning the Dutch language and on reading and writing. In Flanders, children learn to read in the first grade. The teacher finds it important to use **real life experiences** and **materials** during language activities. The activities with the eggs are in fact activities in which the two sounds 'ou' and 'au' are practiced (aim of the egg activities). Science experiments are used to encourage reading and writing, especially the Dutch words 'rauw', 'lauw', 'zout' are used in the experiments.

The episode is selected because of the **evaluation strategy** of the teacher; she uses the 'kring' moments to assess what the children learned during group activities.

During these group activities the children use worksheets to guide them; however these worksheets are not evaluated by the teacher. Instead she uses kring moments to assess what the children learned. As such, **formative assessment** is very much emphasized in this class group, which is supported by the pedagogical project of the school. In this specific episode, a reflection about the

egg experiments takes place.

Teacher 'Who has done the experiments with eggs?' Several children raise their hands. The teachers picks one of the children and asks which experiment they did (they work with 4 children in a group – the tables in the classroom are arranged in order to work in groups of 4).

Child 'With an egg and with salt' The child (no native speaker) has some problems with the word salt and the teacher repeats the word.

Other Child 'And with water'

Teacher 'Do you still know with what kind of water?'

Child 'Warm water'

Teacher 'Do you still know why we needed warm water?'

Child 'To let sink or float the egg' This child has also some problems with the Dutch words and sentences.

- Pedagogical Interactions

As mentioned before, the focus in this episode is on **reflection** and **assessing** what children learned before. This information is used to instruct other children, in the episode some groups have done the experiment with the egg, others haven't.

The teacher uses **questions, reflection and reasoning** to promote the prior knowledge and the earlier experiences of the children. She is also making explicit connections with earlier experiences, in the episode below, she asks 'Who was in the kitchen and watched?'

Child 'Not boiled egg'

Teacher 'Not boiled is ...'

Child 'Raw'

Teacher 'Raw is not boiled' 'Another question: How do you make boiled eggs? Wait, first think' The teachers points her finger to her head and she watches if every child is thinking. She is asking it to several children

A child says 'With water'

Teacher 'warm water, lukewarm water, cold water?'

Child 'Lukewarm water'

Teacher 'Lukewarm water, can you boil eggs in lukewarm water?'

Some children are saying hot water. But the teacher asks 'Who was in the kitchen and watched?' The children confirm that every child watched.

Teacher 'What happened to the water that boiled? How did it look like?'

Child 'With bells.'

Teacher 'With bells, with bubbles. That's boiling water.'

Child 'Like a bubble bad'

Teacher 'Can you feel at hot water?'

Child 'No'

Teacher 'What was lukewarm last week? Everyone has to think.'

Child 'The tea'

- Opportunities for Mathematics/Science Learning

Although the focus in this activity is on language, there are some opportunities for science learning. First of all the children are encouraged to think about earlier experiences which took place in the classroom. By recalling and reflecting on what happened the teacher not only evaluates what children (the children who have done the experiment already) learned about boiling water, about raw and boiled eggs, about sinking and floating in salt water and about dissolving salt in water, she also enhances their scientific understanding. According to the teacher, repetition and making connections is very important for children to learn.

She uses questions and reasoning to activate the knowledge of the children and she interacts to what the children are saying, it is not a guess what I am thinking dialogue. According to her this is also important for creating opportunities for creativity - listening to children, extracting what is usable and building further on this.

- Opportunities for Creativity

Using formative assessment the teacher create some opportunities for creativity, for example by using questions and encouraging reflection, the **reasoning skills** of the children are enhanced as well as their understanding of some scientific issues – dissolving salt in water. In addition, attention is given to **connections with experiences in their daily life**, for example a link is made between the dissolution of salt and sugar. The teacher uses visual expression to visualize the connection - stirring in a cup of coffee - which is necessary in this mixed ability group.

Teacher 'When will the salt melt?'

Other Child. 'If it is warm.'

Teacher 'If it is warm.'

Teacher 'Who knows the same, what are you doing in your cup, in warm water and then it melts.'

Child 'Sugar'

Teacher 'Sugar. OK, we have a cup of coffee, if you bring in a spoon of sugar. What happens with the sugar?' Meanwhile she is demonstrating with her hands what she means. She forms a cup with her hand and she brings in a spoon of sugar and then she is stirring.

Children 'Melting'

Teacher 'It melts, it will dissolve. Melting, we say it about ice and snow. The sugar will dissolve. So the experiment is with warm water.'

3.4.3 Summary and conclusions

RQ2: Probing practice

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

The approaches used by EIs are strongly influenced by the vision or the pedagogical project of the

school – talent-oriented education, active independent learning and encouraging an inquiry attitude. In order to achieve this vision, the school team agreed on some general approaches (all learning areas), such as

- creating corners in each classroom (in preschool as well as in primary education) in which children can work **independently or in group**. During this individual or group work **agency** of children is promoted, which can be noticed in the episode of estimating and measuring.
- planning activities linked to the **everyday life/world** of children – Ilse is very experienced and talented to work with **theories and interests** of the children, by using questions she connects them with other concepts.
- installing a talking or discussion 'kring' in which **dialogue/questioning/theories/reflection** are encouraged. A nice example is the episode of reflecting on an egg experiment.
- promoting **creative thinking** by comparing all different solutions of children of a particular problem (could be a mathematical problem or a world oriented problem). Els is paying special attention to the thinking of children, she creates time and space for all children to think.
- working with life-like materials – For example during the groups work about measuring, the children of Els uses the doors, windows, ... in the classroom and the corridor. Els uses experiments with eggs to learn more about 'zout', 'lauw' ... and other 'ou' and 'au' words.
- facilitating the access to **resources**.

Based on the vision of the school and the general approaches, group work and corner work are altered with 'kring' moments. Although the teacher **plans and structures** the activities, children are allowed to bring in their **own ideas, solutions and theories**. Especially during group work, **active independent learning** is encouraged. Children have to **experience and inquire** the content themselves during group work or individual work (see episode of measuring and episode of ...). During these moments **exploration, play, collaboration and dialogue** is encouraged, there is a focus on the cognitive and social dimension of learning science and mathematics. She says that you could get the impression that her class is sometimes chaotic because of all children working on different things and because of the **ownership** they have.

During group work, Els uses worksheets or oral instructions to guide the children – guided inquiry or investigations. She doesn't **evaluate** these worksheets separately, however she **reflects** on them during 'kring' moments by using **questions** and making connections (see the episode of reflecting on egg experiments). During group work **peer assessment** is valued, that's why Els works with mixed ability groupings (see episode of measuring). Els finds it also very important to repeat activities and concepts, so children can have the opportunity **to learn and to make transfers**. According to her, through experiences and repetition, the children can internalize the curriculum.

The approaches Els uses are based on the principles **of experiential education**. As a preschool

teacher she knows these very well.

According to her the **link between creativity, science and mathematics** is: to give children the possibility to **think** first, to bring in their **own theories**, to work together in **heterogeneous groups** (mixed ability), to encourage **cooperative forms of working**, a teacher who gives children the opportunity to discover and explore things themselves, to listen to each other (as a teacher we have to listen to children, we have to extract what is usable and we have to build further on this).

RQ3: Probing practice

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

As mentioned in the previous section, **active independent learning** is encouraged by creating corners and using group work. During these activities the children have to **experience** and **inquire** themselves the content. In order to enhance understanding and to make transfers, **peer assessment** is valued as well as **reflection** on the group activities during 'kring' moments. Group activities and concepts are **repeated/recalled** to enhance learning.

The interests and motivation of the children are enhanced because they have ownership on their own learning and they are active engaged.

How do teachers perceive their role in doing so?

To foster children's learning, interest and motivation in the world as a whole (including science and mathematics) the teacher – and the school - focuses on

- **listing to and observing** children,
- **building further on what children do or say by asking questions** and making **connections**
- allowing **children to discuss and interact**
- **working with every day world of the children (including actuality) and with life-like materials**
- interaction with **parents** – for example the exhibition during the 'Start with art' project
- using **resources** and **ICT** – digital board in the classroom
- repeating activities and concepts to foster transfer and understanding
- being equally excited, curious, amazed, innovative, inquiring as the children

3.5 Case 6 – Ilse – A case of encouraging conceptual thinking

3.5.1 Context

Where?	Country	Belgium				
	Setting name	AUC1				
	Location within setting	Pre-school				
Who? (children)	Year group/age of children	7 years				
	Number of children in class	22				
Who? (adults)	Number of adults	1				
	Role of adults	School teacher				
	Case teacher role	teacher				
When?		1	2	3	4	5
	Dates of visits (2013)	13/11	28/01	01/02	04/02	08/02
	Times of visits	10h30-11u	10h30-11h	8h30-10h30	10h30-11h	8h30-10h30
	Goal of visit	Intake	Informal interview	Observation and informal interview	Informal interview	Observation and informal interview

a) AUC1: a school with a specific pedagogical project

The school is located just outside the ring of Antwerp, the biggest city of Flanders. Both single family homes and apartment buildings are located in the immediate environment of the school. Most of the children live in a radius of 5 km around the school and come by foot, by bike or public transport. However, near the school there are also a lot of senior citizens.

‘AUC1’ belongs to the publicly funded, publicly run education. The school board is the city of Antwerp. As a public setting, the school is open to all children, whatever the ideological or cultural background of the parents. As such the school has currently 11 different nationalities.

Flemish schools enjoy a high degree of autonomy and are free to develop their own educational policies, including curriculum, assessment, certification and any self-evaluation activities. However, in order to be able to award official qualifications or to receive funding, schools must meet certain conditions set by the Flemish authorities, including: following a core curriculum (attainment of targets or developmental objectives according to the stage or type of education); and allowing the Flemish authorities to assure their quality (this is done via the Inspectorate). It is the ‘organising body’ that draws up a curriculum (curricular objectives, pedagogical project ...) based on the core national curriculum.

‘AUC1’ has its own pedagogical vision and project, approved by the city of Antwerp. The school only exists 2 years. In the school year 2011-2012 two existing school were put together and a new school

‘AUC1’ was implemented with a specific pedagogical project:

- The school believes in talent-oriented education: the school appreciates the individual talent of each child.
- The school believes in active independent learning: the school appreciates the individual learning pace of every child.
- The school believes in encouraging an inquiry attitude: the school appreciates the curious and critical attitude of every child.

To achieve this vision all members of the school team work to the same purpose and certain approaches are general. This means that these approaches are also visible in the practices of the participating teachers of the school, Els and Ilse.

Some exemplary approaches which are interesting for this case:

- Talent-oriented education: the report for the parents consists of two parts: a part about the learning process and another part about handsome works.

In each group there is a pupil of the day or the week. Special attention is given to these children and their talents are magnified.

There are exhibitions in and out the classroom at the end of a class or school project. For example during the period of the observations the project ‘Start with art’ ran. This is a project where art is combined with mathematics. At the end of the project (8/2/2013) the parents were invited to come and see what their children had done and had created. So, at that day during the observations, parents came in the classrooms.

The principal of the school about the ‘Start with art’ project: *It is the first time that the school is doing such a project. They will work on this school project for about two weeks. The purpose is that the art project will be integrated by the different teachers in their daily practice. Today it is the first day of the project.*

The organizer of this ‘Start with art’ initiative has put the paintings on the walls in the school in the weekend. Since there are a lot children of other cultures in the school, the principal hopes this project will have an impact on the different parents (there are not used the have projects in the school). Every day, the parents are entering the school through a small corridor, so they also will notice the paintings on the walls in this corridor.

At the end of the project weeks there will also be a demonstration activity. The parents will



have the opportunity to visit the school and the observer about what their children have done during the project. www.startwithart.org.

- Active independent learning: in all classes corners are created, these encourage the children to try out different learning styles. In the classroom of Ilse there is a computer corner, a book corner, an art corner, ...

In the primary school an assignment letter is used so children can work independently.

The team chooses to work with as many daily life activities as possible. This can range from planting flower bulbs, weather observing, making fat cakes for birds to building castles and experiencing excursions. For example in the activity about the circles and ovals, Ilse uses paintings to gain insights into geometric figures such as circles and ovals.

- Fostering the inquiry attitude: In each class group there is a talking and discussion 'kring'. Every morning, a conversation is held in the 'kring', during these 'kring' moments the teachers and children ask questions. Together they search for answers. In two of the episodes, a 'kring' moment is selected. In first episode a discussion about hail is initiated by the snow during the weekend, in the second episode an inquiry about ovals and circles is initiated by working around geometric figures.

The teachers promote the creative thinking of the children by viewing different possible solutions for a particular problem.

At school there are several sources of information that children can consult. The school prefers to work with life-like materials. As such, children can often better adjust their research question and they dare to go further in their experimenting.

In one of the episodes the children are the painters themselves, they create paintings with all kind of circles and other geometric figures, they also learn to use a passer.

b) Ilse: the teacher of the second grade



Ilse is the teacher of the second grade, however she is not a primary school teacher but a preschool teacher, and she has a bachelor in early childhood education. Because of her background, expert in experiential education, the principal has asked her to coach the children of the second grade. Since it is only the second year, Ilse is still searching and experimenting to find the best or a good pedagogical approach, combining the principles of experiential education with the goals of primary education. She also wants to focus on

understanding the world; therefore children have to be stimulated to think. Since she works with a multicultural group, language is an important factor. Discussions in group about several world issues

are important for her, in order to stimulate language and conceptual understanding.

As Ilse is experienced in experiential education, she is used to work in corners and to have 'kring' moments for reflection, start of the day, important issues of children, actuality ... She is used to observe children and to listen to children.

Ilse is confident in mathematics and science teaching. She is a teacher who makes a lot of connections, which supports the transfer for the children. Ilse is a lifelong learner, open for a lot of experiences. She is ICT skilled, in her classroom there is a digital board.

She is proud of her children; they amaze her with their theories and concepts. For example: Because of the 'Start to art'- project, there are paintings of Monet hanging near the classroom of Ilse. She likes this painter, she loves the blurred colors. The paintings are also discussed with the children, at a certain moment these children say to the teacher, you can see when the painter has made is drawing. When you look at the painting, you see the light of the sun but you don't see any shadow. It has to be around midday. The Sun was perpendicular.

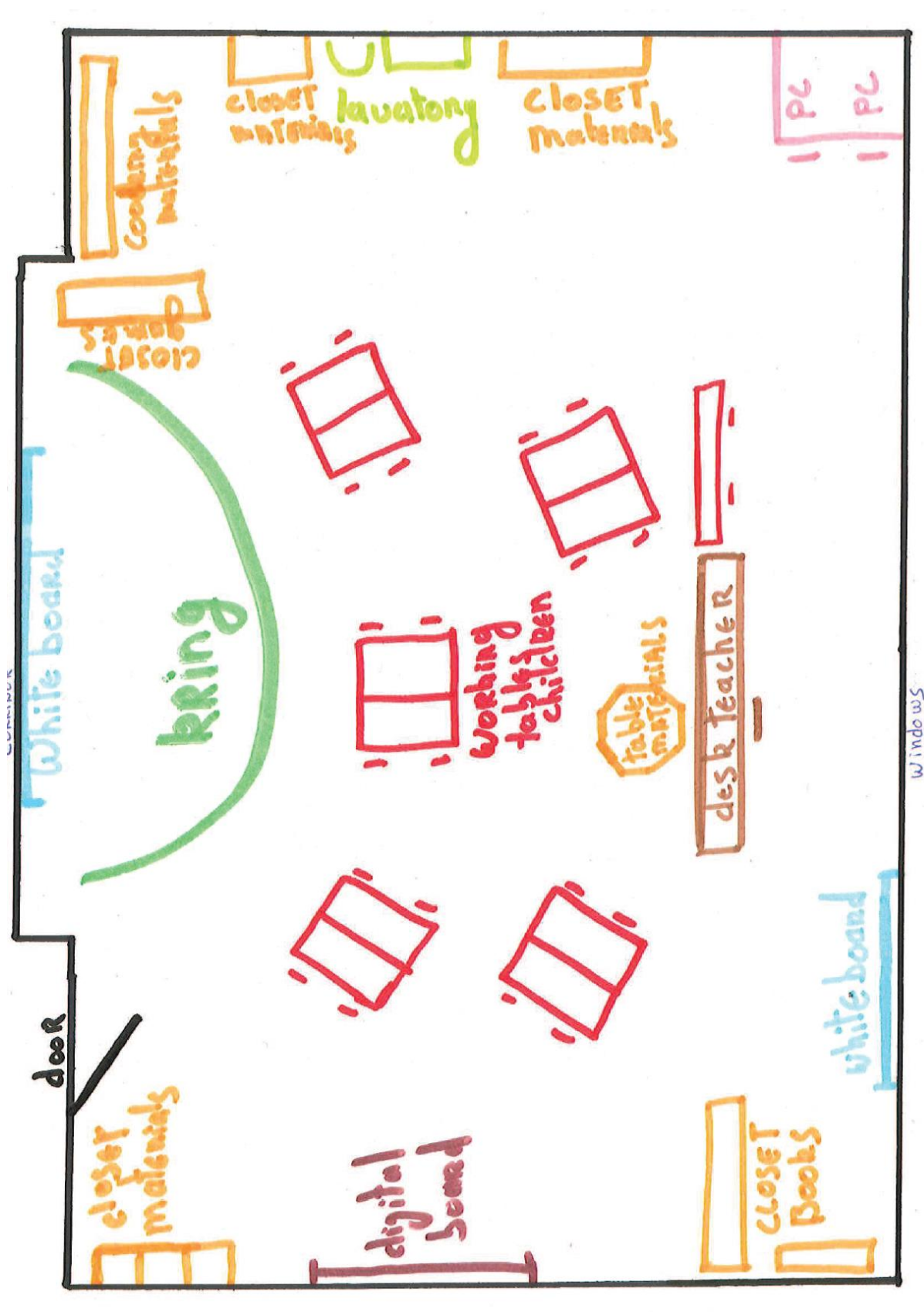
c) The children



The children in this classroom are between the age seven and eight and they all have a multicultural background. In the school there are more than 11 nationalities. The number of children in the classroom of Ilse is 22.

d) The classroom





3.5.2 Episodes

a) The episode of the 'hail' discussion

This episode is situated in the 'kring'. All children are sitting in a circle; the teacher is in the middle of the circle. The day starts with a talk about the weather during the weekend. It snowed the days before and the children have created snow mans during the weekend. It is not that cold anymore and the snow mans are melting. At a certain moment one of the children says that there was ice coming down from above. From that moment on a whole discussion about hail, about the Earth, about the air and about breath starts. All these issues are linked to each other and they are discussed because the teacher is continuously interacting on what children say or do.

- Pedagogical Framing

The teacher works with an agenda and she plans several of the activities, especially the specific activities such as mathematic lessons. However, during the interview she admits that most of the time she does things she hasn't planned, because of the issues raised by the children. She says 'You can't plan them, so I leave space in my agenda to do this.' She finds it very important to stimulate the thinking of the children and to interact on what they are interested in. Most of these unexpected conversations and activities are linked with the immediate environment and daily living of the children, which covers most of the time science or world orientation.

Although the teacher doesn't plan these specific activities, like the conversation about hail, she knows very well which goals she want to reach by creating these unexpected activities. During her work with the children, during every activity she wants to stimulate the thinking, the conceptual understanding, the problem solving and inquiry attitude of children (see also vision of the school). She also wants to appreciate the different talents of children. She encourages collaboration and is open for discussion and interaction between the children.

The teacher is working with a mixed ability group. Several of the children are no native speakers. Although they don't always express themselves in a proper way, they are used to interact and be engaged in the process of conceptual understanding and thinking. The concepts are not that simple however the children are very engaged.

The teacher is repeating the words and concepts because of the non native speakers in her classroom. She also is visualizing the content by creating drawings on the whiteboard.



- **Pedagogical Interactions**

The teacher is using a lot of humor and expression in her work with the children. Although she has some rules, the children are allowed to give their own opinions and theories. She listens to the preconceptions or ideas of the children and she works further on them. She is an expert in observing what children say or do and interacting to them. When she hears a good or an interesting answer, she is repeating the answer or rephrasing the answer. Otherwise she brings in a new idea or suggestion or activity to stimulate the understanding of the children, this is illustrated in the short episode beneath with the Earth and the form of the Earth. At the end of this short episode, the teacher encourages the imagination and prior experiences of the children. She is creating for them the beach and the sea.

It is a pity the digital board is broken otherwise she could visualize what they have recalled in their head and imagination with real pictures and videos (so with richer data).

Teacher 'May I First draw the Earth. How the Earth looks like?'

Children 'Round.'

Teacher 'Round, the Earth is round' She draws a circle on the white board.

Child 'Miss, you do not see that it is round here, because here everything is right.'

Teacher 'I was going to say exactly ... because if the Earth is round then ... ' The teacher is pretending that she falls off the Earth.

Child '.. Then you can fall off.'

Child 'The Earth is straight.'

Teacher 'Is the Earth straight?'

Child 'No, the Earth is round however you can't see that she is round.'

Teacher 'There is a place where you can see that the Earth is round.'

Child 'Miss, I know.' The teacher interrupts because she wants that every child gets the opportunity to reply.

Other child 'With a telescope.' The other children have some comments on this.

Teacher 'Do you look to the Earth with a telescope or ...?'

Children 'To the stars.'

Teacher 'With it you look to the stars.' There is some buzz among the children, they have another proposal to use the telescope, they are also making some gestures. The teacher says that there proposal is rather difficult.

Teacher 'Who of you has been to the sea before?' Several fingers are going up. The teacher reacts to a child she didn't hear yet. She asks to the child if she has been to the beach.

Teacher 'You stand on the beach and you see the sea before you.' The teacher demonstrates where the sea is located. The children need to close their eyes and think of the sea before them. And then they have to look and look and look, until they see the spot where the air touches the sea.

Although the teacher didn't plan the activity nor the answers and the actions, she is able to make connections with earlier knowledge and experiences and to create transfer. For example she

encourages the children to recall what they have learned about the nose in order to search for an answer to the remark of a child *'If we not do like that (blowing with your mouth), then we have no breath.'* This remark is rephrased by the teacher *'C says that if you breathe through your nose, you don't have it.'* This remark results in a search for explaining this fact, by using the knowledge they have obtained in the beginning of the year and which is now recalled. As mentioned earlier, there are several non native speakers in the group, so rephrasing words and recalling words is very important for these children.

Teacher *'C says that if you breathe through your nose, you don't have it.'*

Teacher *'Who knows yet what is the function of our nose? We have learned that in the beginning of the school year.'*

Child *'Smell'*

Teacher *'You smell with your nose. What does your nose also and is important to your body?'*

Child *'Breathe.'*

Teacher *'To breathe.'*

During the conversation the teacher makes also a connection between the stripes in the air from airplanes and the white breathing out of our mouth when it is cold (this connection is new for the children). The talk about the stripes in the air leads to some misconceptions, on which the teacher immediately interacts leading to a humoristic talk.

Teacher *'And you can see that, if you see a plane, you see that the air is much colder there.'*

Child *'so on the smoke.'*

Teacher *'you say smoke.'*

Teacher *'Where there is smoke there is ...'*

Child *'Grey'*

Other children *'Fire'*

Teacher *'Amaai, I wouldn't like to be in that plane. You?'* Several children are laughing.

Teacher *'But you are right, it looks like smoke.'*

Teacher *'Last week, when it was cold. Did we all have smoke?'* Several children say yes.

Teacher *'Everyone, everyone got smoke?'*

Teacher *'When we did like this, what was coming out of our mouth?'* She blows.

Children *'Smoke'* **other children** *'White'*.

Teacher *'Do you know what it is?'*

Child *'Breath'*

Teacher *'That is your breath.'*

- **Opportunities for Mathematics/Science Learning**

Although this is an unexpected moment there are several opportunities for science learning. In fact the whole discussion is a good example of using questions and dialogue to promote conceptual understanding of children. In this specific episode their conceptual understanding of hail, breath and the Air around the Earth is enhanced. During the conversation, preconceptions and pre knowledge of

children are used to work with. The teacher also makes connections and transfers with earlier activities, for example the lessons about the nose. As such, she is evaluating what children learned in a very natural way. During the discussion she pays attention to reflection and reasoning.

Since the teacher works with the experiences of the children and listens very well to their ideas and opinions, efforts are made to enhance the children's attitudes in science and mathematics. The role of humor and different forms of expression are also valued.

This teacher is perfectly doing what is advised in the national curriculum. Children have to be oriented to the world in a broad way since the world is no compartmentalized reality. More specifically:

World orientation (living and non-living nature)

- 1.8. The pupils can simply explain the function of the senses, the skeleton and muscles;
- 1.15 The pupils can illustrate that the state of a substance can change.

However, in Flanders, schools or the organising bodies of the school, make their own curriculum based on the national curriculum. 'AUC1' has a specific approach and pedagogical concept which is illustrated in the first part of this case. One of the goals is to stimulate the inquiry attitude of the children, for example by using the 'kring' moment at the start of the day and by using the experiences and questions of the children. This approach is very well illustrated by the teacher.

- **Opportunities for creativity**

In this episode opportunities for creativity are created by providing children opportunities to bring in their own experiences during the weekend, their own opinions and ideas about the discussed scientific concepts. The teacher listens to what children are saying, she also uses questions, humor and imagination to engage them and to enhance their attitude for scientific learning. In order to encourage their learning she also interacts, she is searching a balance between interaction and standing back (meaning encouraging dialogue and explanations of children). Reflection and reasoning are promoted and all reasoning is valued equally.

Since she is not following a specific book or tight curriculum, she has no problem to quit a prepared activity – in the episode she interacts on a specific remark of a child about hail and creates together with the children a whole new activity. According to this teacher 'goals' are key issues and not the lesson plan. It is very well possible to reach a specific goal following the experiences and interests of the children. As a teacher you are a pedagogical-didactical expert, as such it is possible to interact to the children without writing everything out. 'Guess what I'm thinking dialogues' have to be abandoned.

b) Episode of the oval and circle

All children are sitting in a circle; the teacher is in the middle of the circle. They have a talk about the painters they have learned about last week. A lot of children have talked about the painters at home. You can clearly see they are very interested in the different painters, they were also engaged in the activities of the past week. A painter came in their classroom and there were 4 groups working around 4 different painters, linked with 4 different art forms. Each child made a drawing conform the painter of his/her group. They also worked with information boxes about the painters and the art forms and they explored a lot.



The teacher reflects with the children on what they have learned about the different painters and art forms. These painters were in fact also inquirers, since they developed their own art form. At the end of this reflection moment the teacher links painters to mathematics and cubism to geometric figures.

'That's crazy, hey. Each artist has made his painting with a little mathematics. A lot of fantasy, many colors and a drop of mathematics.'

'Because Cubism, that is all geometric figures. That is a difficult word; I'm going to write it down on the white board.'

The teacher points towards the classroom and encourages the children to find geometric figures in the classroom. During the conversation which follows she is categorizing the figures on the white board. At a certain moment all known figures are on the board and one of the children is saying 'oval'. This is the start of a real inquiry about circles and ovals. Both are round and have no angles, but what is the difference between both. As the children are that curious, the teacher learns them more about radius and ovals in a very humoristic and expressive way, using tools to measure and to draw.

- Pedagogical Framing

The teacher has planned a mathematics activity with her group of children. Based on the paintings, especially the paintings about cubism, they are going to work with geometric figures in order to enhance their understanding about geometric figures and about the properties of different geometric figures. Although the teacher has planned this activity she is open for interests of children linked with the topic and the goal she wants to reach.

'I normally work with a brief agenda (teacher journal); I certainly don't write everything out. I create a calendar schedule for the week. The main objectives are important, how to reach them differs. The key for me is to work with and build upon the experiences and interests of

the children. As a teacher you have to dare to let go if the activity (or the practice you have developed) doesn't work at that moment. Together with the children you must probably find a solution which does work. So, it is possible that an activity completely changes because of the interests of the children (what they say or do). This does not alter the fact that I do reach my goals with the children.'

In the episode, at a certain moment one of the boys says 'Oval'. The teacher interacts on this and a real inquiry activity follows about the difference between an oval and a circle, which wasn't prepared.

Boy 'Oval'

Teacher 'Where are the angles in an oval? But an oval ... is that with points?'

Children 'no'

Boy 'Round is like this but an oval is like that.' The boy is drawing both forms in the air.

Teacher 'Come, draw.' The boy is drawing something on the board.

Teacher 'Is that an oval?' Some of the children say no.

Teacher 'Could you draw a circle?'



The teacher is working with a mixed ability group. Several of the children are no native speakers. Although they don't always express themselves in a proper way, they are used and engaged in the process of encouraging conceptual understanding and thinking. The concepts are not that simple however the children are very engaged.

The teacher is repeating the words and concepts because of the non native speakers in her classroom. She also is visualizing the content by creating drawings on the whiteboard. Or by asking the children to draw.

- **Pedagogical Interactions**

The focus in this episode is on the cognitive dimension as well as on the social dimension. The conceptual understanding of the children about circles, ovals and radius is enhanced using questioning, the planning of an investigation, gathering evidence and making connections. The findings are explained and communicated as well as their earlier experiences and pre-knowledge. During these conversations and investigations collaboration and dialogue is encouraged as well as reasoning and reflection.

Teacher 'Suppose I would put a point in my oval.' She gives the pen to a boy. He places a point in the oval. The other children have helped him to search the oval on the board.

Teacher 'Is it in the middle? We shall see.'

The teacher chooses a girl and instructs her to measure the oval. It is a shy girl and the teacher asks if she wants to do it together with her. Another girl must read the sizes.

Child '11'

Child '3'

Child '10'

Child '3'

The teacher takes over the pen and writes the sizes near the lines. In fact she uses 2 colors, red for the horizontal lines and blue for the vertical lines.

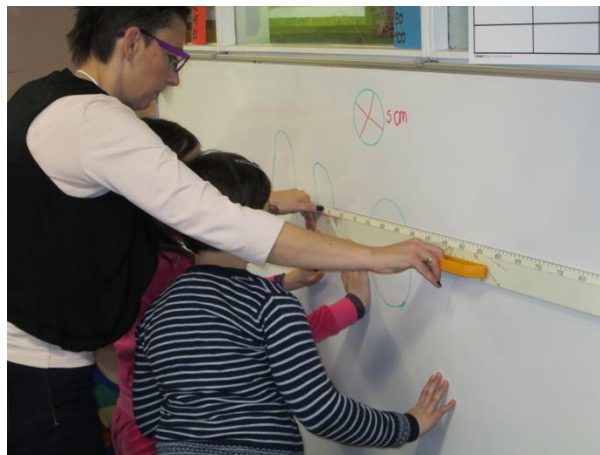
Teacher 'What is now the difference between an oval and a circle?'

Child 'With the circle it is round and with the oval it is straighter.'

Teacher 'With the circle the radius is always the same and with the oval it is not always the same, but the oval is round because the oval has no?'

Child 'rectangles, squares ...'

Teacher 'No, what is this?' She is showing an angle.



The teacher is able to enhance the children's attitude towards mathematics by using humor, by interacting on their interests, experiences, opinions and preconceptions and by creating mystery (see opportunities for creativity). In the short episode below you will notice the playful interaction between the teacher and the children.

The teacher is drawing a circle on the board and she is using a tool, a round lid.

Child 'That is not fair.'

Teacher 'And why it is not fair?'

Child 'Because we may not use that and you are using it.'

Teacher 'I have thought about it. Did I say that you couldn't use a tool?'

Meanwhile there is a circle on the board.

Teacher 'Is this a circle?'

Children 'Yes'

Teacher 'How can you say 'Yes that is a circle'?'

Child 'Because it is round and it is thick.'

Teacher 'Yes, could be.' She asks a girl to say why she thinks that is a circle and the other form (oval) isn't.

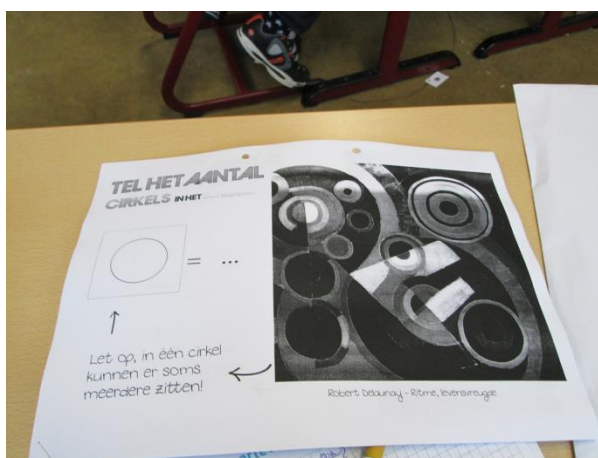
Child 'It is not the same.'

- Opportunities for Mathematics/Science Learning

In this episode the teacher has planned a mathematics activity which she combines with the art-project which is running in the school. As such the children are very interested; they are fascinated by the painters which combine mathematics with art. Their motivation towards mathematics

learning is even more encouraged by using the interests of one of the children (ovals), by encouraging the opinions and ideas (drawings) of the children and by creating some mystery and curiosity - the knowledge about radius is for the older children.

At the end of the episode the children are encouraged to work in groups on an assignment about three paintings: a painting with circles, a painting with the Eiffel tower and a painting with squares. The children are practicing the geometric figures which they have discussed about during the 'kring' moment.



The objectives (attainment goals at the end of primary education) in the national curriculum for the learning area mathematics, which are covered in this episode, are:

3. Mathematics – geometry

Understanding – mathematics language-facts knowledge

- 3.1 The pupils can explain, by using examples, concepts and notations concerning the geometric determination of space.
- 3.2 The pupils can, based on of following properties, recognize and name the following geometric objects: in the plane: points, lines, angles and flat figures (triangles, quadrangles, circles)

Procedures

- 3.4. The pupils can classify the different types of corners and the different types of quadrangles on the basis of sides and angles. They can also shape them.
- 3.6. The pupils can discover the concepts of symmetry, uniformity and equality in reality. They can make themselves simple geometric figures.

5. Mathematics - attitudes

- 5.1. The pupils have appreciation for mathematics as a dimension of human inventiveness
- 5.2. The pupils experience that engagement in mathematics is an active and constructive process that can grow and expand as a result of own thinking and learning activities; as a result, they develop the following view - all pupils can acquire mathematical ability which can

lead to studies and professions in which mathematics are addressed.

However, in Flanders, schools or the organising bodies of the school, make their own curriculum based on the national curriculum. 'AUC1' has a specific approach and pedagogical concept which is illustrated in the first part of this case. One of the goals is to stimulate the inquiry attitude of the children, for example by using the 'kring' moment at the start of the day and by using the experiences and questions of the children.

In order to have a learning line throughout the various grades, they are following the curriculum of OVSG for the different learning areas. That is why the teacher says that 'radius' is content for the older children. However it is no problem to interact and learn about 'radius' since questions and interests of children are appreciated in this school and are seen as starting material for further learning and activities.

- **Opportunities for Creativity**

Also in this episode the teacher creates opportunities for creativity by interacting to the experiences, opinions, ideas of the children, for example through the use of questions and humor which is also mentioned in the first episode. She promotes collaboration, dialogue and the motivation and attitude of children towards mathematics learning. In this specific episode she encourages the curiosity of the children by creating a sphere of mystery around the radius of a circle. The children are motivated to learn more about a concept – radius - which isn't a goal for the second grade. However, the teacher doesn't find this a problem, the children are interested in the subject, they learn more about geometric figures and the properties of geometric figures and they are engaged.

Teacher 'If you put in the middle of the circle a point and you measure from the middle to the end of the circle.' She measures several times and the children are saying the length.

Child 'That is equal round.' He shows it with his hands.

'The radius, actually we don't have to know it yet. But do you want to know?' She is whispering it and saying sstt. She is saying it is content for the older children. The others may not hear this or know this.

Children 'Yes'

Teacher 'Look this that they call in mathematics, the radius.' She draws a line from the middle point of the circle to the edge of the circle.

Teacher 'And the radius of the circle is equal everywhere.'

Teacher 'How much was it here?'

Child '5'

Teacher 'And this stick is 1 meter and a little piece of this stick is 1 cm, so how much is it then.'

Child '5 cm'

c) The episode of the circle



them together to show them a new tool, a pair of compasses. the children may experiment on in the week, they may use their own piece of art with see in the picture.

This activity is integrated in the central theme of art. The children had been introduced to a painting with a lot of circles on it. More specifically the children had been doing an exercise on counting geometric figures in paintings, after they had been offered classical information about the circle and the oval in the “kring” (see also the episode of the circle and the oval). They also had been active by coloring and counting for themselves on their work sheet. At a given moment the teachers calls something new, they may use After an instruction moment, with pairs of compasses. Later the pair of compasses to make geometric figures as you can



- Pedagogical Framing

This activity contained a classical instruction moment, and afterwards the children were able to practice in their small groups of four, in which the class is set up to make the transition between different grouping styles very smoothly.

The teacher has prepared the activity and knows very well which materials she needs, however she leaves space for children to interact en be involved in the knowledge building process. In order to introduce the new tool and knowledge she tries to build up on the input of the children, such as in the example bellow.

The teacher calls the children to the middle of the classroom, where they gather around the table of one group.

Teacher: “Now, You have seen... if we want to draw a circle it isn’t easy? How comes that?”

Child 1: “Because its round”

Child 2: “Because I need something else”

Teacher: “So, I need an aid ... an aid” ...
“Now, there are a lot of aids possible. So, you can take a round figure and draw around it. But there is also ... How is this called?”

Child 3: “There is a pencil on it”

Child 4: “You have to turn with it”

Child 5: “This is also so with Piet Piraat”

Child 6: “Yes, when he looks on his maps”



Teacher: “Because, in former times they used this to measure” and she shows how this can be done first on the table, then to measure a sheet.

The main goal of the teacher during this activity was to introduce the pair of compasses and teach to the children how they can use it, next to the construction of conceptual knowledge about the radius of a circle.

- Pedagogical Interactions

During the instructional moment the involvement of the children was very high. In order to build up her instruction, the teacher used the knowledge and the answers of the children to move forward.

The teacher grabs a ruler and she places the ruler in different directions on the circle.

Teacher: “Look, How do I have to place this?”

Child: “Like this” and he shows it with his hands and arms.

Different children try to put their hand on the ruler when they think the ruler is positioned in a good way.

Teacher: “Ok, when I draw my line now, it will not be in the middle”

Child: “You have to place the ruler in the point and then draw the line.”

Teacher: “Can you do it?”

The child gets the pencil and draws the line.



During the process there is also space for reasoning and reflecting. The children are given the opportunity to think about problems that occur and are allowed to search together for a solution. The enthusiasm of the children is high leveled and they all want to find the solution. In the example below one of the children is explaining by using movement instead of words, which on his turn is also a relevant form of communication that is valued by the teacher.

Teacher: “But, on that painting there’re also circles who didn’t fit on the canvas. How were those made?”

The children are negotiating on how this could be.

Teacher: “how smaller the circle, how closer the legs of the pair of compasses are. How larger the circle, how...”

Child: “... how closer.”

Teacher: “What do you have to do when you want a larger circle?”

Child: One child show it with his arms, by making the movement of spreading his arms and says: “Moving it to the outside”

The teacher does the movement with the pair of compasses. “Moving it to the outside”

- **Opportunities for Mathematics/Science Learning**

In this episode the children are offered the opportunity to learn about the technical way of using a pair of compasses, but also about the conceptual reasoning behind the tool.

In this conceptual reasoning for example, the teacher also sees an opportunity to build in some content about multiplying.

Teacher: "Actually, we don't know, because..."

And she grabs a ruler, where she places the pair of compasses next to.

Teacher: "It's 3, and how many times was he able to walk?"

Child: "7"

Teacher: "7 times 3 are..."

Child: "21"

Teacher: "How long is the sheet in cm?"

Child: "21 cm"

Teacher: "Have we measured this with a ruler?"

Child: "No"

Teacher: "We have measured this with a pair of compasses, a pair of compasses. But actually we use this for something else... to make nice circles."



In addition, they come across some conceptual elements of a circle like radius, middle point ... and so on.

In this specific episode the teacher also works on the attainment goals of the government, namely:

Mathematics

- 1.3 The children are able to know the meaning of addition, subtraction, multiplication, division, multiple, divisor, common denominator, greatest common divisor, least common multiple, percent, sum, difference, product, quotient and remainder. They can correct examples and can articulate in what situation they can use it useful.
- 3.2 The children are able to recognize the following geometric objects based on the following properties and name:
 - o in the plane: points, lines, angles and plane figures (triangles, squares, circles)
 - o in space: polyhedra (cube, bar, pyramid) and sphere and cylinder
- 3.5 The children are able to draw a circle with a pair of compasses.
- 3.6 The children are able to discover the concepts of symmetry, similarity and equality in reality. They can create simple geometric figures themselves.

- **Opportunities for Creativity**

During the activity the teacher offers a lot of possibilities for reflection and reasoning, by involving them in the process intensively. So the children are challenged to find creative solutions for drawing a semi-circle and they come up with several options like: covering with your hand, drawing a straight

line through it ...

In the activity following the classical instruction the children are given the opportunity to experiment themselves and help each other in order to make some circles. By giving them the opportunity to do so, you give the ownership about the content to the children and they are enthusiastic to explore the possibilities.

During the activity itself the teacher tries to trigger the children also by promoting their inquiry attitude.



T: “But, on that painting there’re also circles who didn’t fit on the canvas. How were those made?”

The short episode of one of the children explaining himself by using movement instead of words, is also very important in fostering children’s creativity. This way of appreciating the children’s answer is beneficial for their development and wellbeing, and because of that may give them the opportunity to grow, especially when they aren’t able yet to express themselves in words.

3.5.3 Summary and conclusions

RQ2: Probing practice

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

The approaches used by Ilse are strongly influenced by the vision or the pedagogical project of the school – talent-oriented education, active independent learning and encouraging an inquiry attitude. In order to achieve this vision, the school team agreed on some general approaches (all learning areas), such as

- creating corners in each classroom (in preschool as well as in primary education) in which children can work **independently or in group**, during this individual or group work **agency** of children is promoted.
- planning activities linked to the **everyday life/world** of children – Ilse is very experienced and talented to work with **theories and interests** of the children, by using questions she connects them with other concepts.
- installing a talking or discussion ‘kring’ in which **dialogue/questioning/theories** are encouraged.
- promoting **creative thinking** by comparing all different solutions of children of a particular problem (could be a mathematical problem or a world oriented problem)
- working with life-like materials – The paintings are connected with mathematics, each painter was in fact also a researcher and mathematician.

- facilitating the access to **resources**

Based on the vision of the school and the general approaches, the activities in the classroom of Ilse are **teacher-initiated** and **child-initiated**. And even when she planned an activity, such as the mathematic lesson about the geometric figures, she confirms that the **children's ideas or interests** can change the activity. In the episode of the circle and the oval, some new concepts, such as radius or oval, are introduced without being planned. The competency of the teacher to interact on what children say or do and to link it with the goals she wants to reach, is based on her training as a preschool teacher, in which she learned the principles of **experiential education**. However, she is also an expert in making **connections and in facilitating transfer**, even with very scientific concepts.

According to Ilse you have to leave space in your teacher's journal to interact to unexpected moments 'You can't plan them, so I leave space in my agenda to do this.' Although several of the activities or parts of activities aren't planned, Ilse knows very well which goals she wants to reach. During her work with the children, during every activity she wants to stimulate the thinking, the conceptual understanding, the problem solving and inquiry attitude of children. In order to do so she also encourages **collaboration**, open discussion and interaction between the children. During group work play and exploration are valued, for example in one of the mathematics activities the children were allowed to act as painters and were encouraged to explore geometric figures.

Typical in her approach is also the **humor** and her talent to enhance the **curiosity** of the children.

In conclusion you could say that Ilse focuses on the **cognitive** dimension as well as on the **social** dimension of mathematics and science learning. By valuing the ideas, theories, concepts, talents, initiative of the children, Ilse also promotes their creativity.

RQ3: Probing practice

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

The emphasis on the children's every day world, experiences, theories, talents and interests enhances **wellbeing and engagement**. By promoting transfer, reflection, dialogue, problem solving and inquiry, Ilse tries to enhance the **conceptual understanding** of the children as well as their language skills. Even if the children can't express themselves properly, it is noticed that they are able to make connections and that they have insights in several scientific and mathematical concepts. The teacher is very proud of her children. For example she was very pleased about the theory they had concerning the painting of Monet – according to them Monet made his painting around midday, because of the absence of shadow.

The children's interests and motivation in science and mathematics is clearly enhanced by the teacher who **responds** to the **unexpected moments, ideas, experiences and interests** of the children, who uses **humor** and a lot of **expression**, who enhances the curiosity of the children, for example she creates some **mystery** about the radius of a circle (see episode of the circle and the oval).



How do teachers perceive their role in doing so?

To foster children's learning, interest and motivation in the world as a whole (including science and mathematics) the teacher – and the school - focuses on

- **listening to and observing** children,
- **asking questions** and making **connections**
- allowing **children to discuss and interact**
- **working with every day world of the children (including actuality) and with life-like materials**
- interaction with **parents** – for example the exhibition during the 'Start with art' project
- using **resources** and **ICT** – digital board in the classroom
- allowing **time and space** to respond to unexpected moments, ideas, theories, experiences.
- **evaluating the process and the product** – **with special attention for talents/strengths of children** being equally excited, curious, amazed, innovative, inquiring as the children

4. Discussion of findings

4.1 Enabling Factors or Barriers at Contextual Level

Based on our findings in the researched cases we can say that there are a number of contextual factors which may enable creativity through science and mathematics in preschool and first years of primary education. In the section below we elaborate on each of these factors and if possible, differences between preschool and primary school or between mathematics and science are indicated.

4.1.1 Freedom of education – national policy

The schools and teachers which participate in the project have strong visions and own teaching, learning and assessment approaches. They also have their own curricular objectives based on the national curriculum. In Flanders, because of the principle of freedom of education (Belgian constitution, article 24), schools are totally free in how the Flemish core curriculum has to be reached. There is room for diversity and difference in approach.

In fact, the Flemish education system does not impose a curriculum, but sets out attainment levels and development aims. In early childhood education as well as in primary education the emphasis is laid on a) a broad core curriculum in which the child's personal development takes centre stage, on b) active learning, on c) care for every pupil and on d) coherence. The attainment levels describe a minimum content of knowledge, skills and attitudes that students should demonstrate by the end of primary education, however they do not detail different levels of student proficiency or mastery of these different areas. It are the 'organising bodies' - school boards or the educational umbrella organisations - that draw up a curriculum (curricular objectives, pedagogical project, ...) based on the core curriculum. The government monitors the implementation of attainment levels and development aims via the Inspectorate's evaluation of schools' curricula (pedagogical project, curricular objectives ...) and their results. The government, by way of the Inspectorate, will not make any judgment about the attainment levels of individual pupils.

However, in Flanders most schools belong to an educational network - GO! Education; the publicly funded publicly run education; the publicly funded privately run education - and they most frequently choose to use the curricular objectives developed by the different umbrella organizations within these networks. The pedagogical project however is school specific as well as the quality assessment strategy and the specific school policy. As such there is a big variety in schools and school curricula.

So, based on these data **it is possible to have a school curriculum in which creativity, science, mathematics or approaches to foster creativity are valued significantly**, which is noticed in **the pedagogical projects and approaches (learning activities, pedagogy and assessment strategies) of the selected schools**.

Two schools belong to the publicly funded, privately run schools (more specifically catholic education); both schools use the curricular objectives of VSKO - Flemish Secretariat for Catholic

Education. However they still have a lot of freedom and these objectives promote explicitly exploration, independent play, development supportive learning and socializing.

'AUC1' and 'AUC2' belong to publicly funded publicly run education (more specifically municipal education), they use the curricular objectives developed by OVSG - Educational Secretariat of the Association of Flemish Cities and Municipalities. The preschool teachers of 'AUC2', however, have the permission of the Pedagogical Advisory Service of the city of Ghent to deviate from the specific objectives and to work with broad goals (as in the national core curriculum). As such these teachers have even more freedom in their approaches.

Freedom of education could also be a barrier. As a school (principal and school team) you need to have a strong policy capacity (beleidsvoerend vermogen), a strong educational project and vision, especially if you want to enable creativity in a good way through science and mathematics.

4.1.2 A strong school and/or teacher philosophy

In the selected settings we noticed very **strong teacher visions** based on the pedagogical concept of the school and on earlier experiences. For example, several of the teachers participated in research or development projects in which they worked in close collaboration with researchers and developed strong visions. Several of these projects were situated in the domain of **inquiry based education** and/or **experiential education**. For example Maaïke of 'AUC2' worked with Ferre Laevers. Together with Katrien and Lies, she also participated in the educational design research 'Eureka' (Van Houtte et al., 2012) in which a vision about enhancing an **inquisitive attitude** in preschool was developed as well as a professional development trajectory. Currently, Maaïke, Sarah, Katrien and Lies belong to a professional development community which focuses on **Education 3.0**, education which is child-centred. Not all selected teachers participated in educational research projects, however they are all experts in experiential education (4.1.3) and they all belong to schools who have an **open vision about innovative pedagogical concepts and approaches** – which is illustrated in their pedagogical project (see cases) and in the policy of the schools. For example the principal of 'AUC1' finds it very important to participate in innovative projects linked with the vision of the school, she encourages her teachers to engage in professional development courses, to read books and to have discussions about pedagogical visions.

The influence of inquiry based education (amongst them problem based education) and experiential education as well as talent-oriented education can be noticed in the pedagogical concepts of the selected schools (see cases). Moreover, in two schools 'AUC1' and 'AUC2' some general approaches are implemented to promote and enhance an inquisitive attitude and to promote the strengths and agency of the children. In 'AUC2' for example they implemented atelier work, based on the Reggio Emilia philosophy. As noticed during informal talks with the teachers of both schools and with the principal of 'AUC1', these approaches are also discussed within the school team and are ameliorated.

A whole school philosophy in which the school team discusses approaches, assessment strategies and the learning process of children is very valuable when you want to enhance children's agency, when you want to work with their experiences and prior knowledge, talents and skills (creative,

problem solving, inquiry, ...), when you want to come to deep level learning...

In the selected schools there were no differences between preschool and primary school. In 'AUC1' the whole school philosophy applies for the elementary school as a whole, preschool and primary.

4.1.3 The teacher: an expert in experiential education

In the selected schools the participating teachers are very experienced in experiential education, due to their training in initial teacher education – the teachers are preschool teachers – and/or collaboration with Ferre Laevers. As such, the differences between the participating preschools and primary school are less than they are in general in Flanders.

The link between experiential education and understanding and exploring the physical environment (science in a broad sense) is very narrow, it was Ferre Laevers (2002a) who stated that *'It is not by seeding mathematics that one will harvest better engineers, but by putting them in a firm background of experience on which they can inoculate abstract ideas'*. Indeed, exploration and inquiry are key elements in approaches such as 'Reggio Emilia', experiential education and High Scope (Brouwers, 2010). These approaches are characterized by an **"open framework"** approach or a **"child-centred approach"**. This means that the child has the **freedom** to think, experience, explore, question and search for answers. The role of the adult is characterized by **active listening** and **observation**. In these approaches **communication, interaction and a rich environment** are essential. In this respect, young children have the opportunity to develop a strong basis for later abstract learning. Children get time to develop an intuitive understanding of the properties of the material world around them, of spatial relations and of quantities (Laevers, 2005). According to Ferre Laevers (2002b), education has to take into account the **intuitive layer of cognition** which is anchored in the basic schemes and has to develop this further to the level of scientific intuitions. Intuition, as such, can be defined as the faculty to mentally represent reality by the use of **imagination**, in such a way that the (re)produced meanings are sensed in a concrete and intense way so that one gets a 'feel' of the real thing. In this view logico-mathematical competence is seen as an aid to, rather than the essence of, real understanding of the physical and social world. As such Laevers (2002b, p.84) concludes 'To do so teachers have to realise that the knowledge that is transferred is only really assimilated when it is endorsed by the deeper level of cognition we call 'intuition'. If we want that kind of teaching, we need teachers that themselves have well developed basic schemes about their field of expertise: helping persons develop fully. This demands in turn teacher training that is doing more than inserting new ideas and methods, leaving the **initial intuitions of the trainee** untouched.'

In order to help teachers to realise experiential education, ten action points are offered (Laevers, 2002). However, nonetheless these advices it is up to the teachers, they need to have insights in deep level learning and the expertise to take the perspective of the child. Competencies which are present in the teachers we observed. In addition, especially the participating teachers of the preschools combine them with the principles of encouraging an inquiry attitude (Van Houtte et al., 2012).

Ten action points:

- rearrange the classroom in appealing corners*
- check the content of the corners and replace unattractive materials by more appealing ones*
- introduce new and unconventional materials and activities*
- observe children, discover their interests and find activities that meet these orientations*
- support ongoing activities through stimulating impulses and enriching interventions*
- widen the possibilities for free initiative and support them with sound rules and agreements*
- explore the relation with each of the children and between children and try to improve it*
- introduce activities that help children to explore the world of behaviour, feelings and values*
- identify children with emotional problems and work out sustaining interventions*

4.1.4 Team teaching

In one of the schools - 'AUC2' - team teaching is tried out and is found very interesting in an experiential and inquisitive approach. Moreover, in Flanders team teaching is an innovative practice which is gaining interest of the government and the pedagogical advisory services. Reason: In the near future there will be too few classrooms in proportion to the number of children. Team teaching, in which classes are combined, could be a solution. However, based on our observations and literature, we could say that team teaching is much more than a practical solution.

- interests, ideas, theories, questions ... of children are picked up faster – necessary in promoting a child's initiative and to have an idea about the basic schemes of children – conversations and discussions with the children can become richer (if children are allowed to discuss and bring in their own opinions and ideas);

Sarah, teacher of 'AUC2: *'The children may also think further and react on each other, integrating fantasy. So children are then discussing and leading the kring 'talk'. At those moments, as a teacher, you have to let go. Children should be able to talk to each other and to discuss. Because you're with two teachers, you can much easier hear what all the children say and you can easily interact at the right time.'*

- you have a back up and you can share knowledge, ideas and experiences, so the teachers feel more confident – interesting in the areas of science and mathematics;
- critical reflection is enhanced – observations can be shared and discussed (wider view on children);
- more opportunities for differentiation – two teachers who are observing (and interacting

with) children during activities in corners;

- combination of strengths and competencies of teachers – form of professional development.

4.1.5 Rich materials and resources

Based on the observations we noticed that certain materials are particularly interesting to enhance the curiosity of the children, to encourage them in their creative ideas and to challenge them in their natural inquisitive attitude. In the participating classes life-like materials or the so called 'household' materials are available for the children. On the other hand, sand and water and other unformed materials also offer a lot of possibilities.

Sand and water

Sand and water are unformed materials, which offer children many opportunities. They are relatively inexpensive, can be put in the class, but can also be found in nature. During the observations, Katrien went outside with her children with different boxes and shovels to collect sand.

Big sandboxes are also present on the school yards of the participating schools. Children are used to play in those during play time.



As noticed in the schools, it is important for the teacher to add various additional materials in order to increase the investigative behavior of the children and their problem solving and creative thinking. For example, in the episode of the tipi, Lies added branches, iron wire, clothespins, textiles, dolls, ropes, ... to the sand table which resulted in an investigation how tipi's best can be built. Both the older children and the youngest children can be challenged. For example, in the classroom of Katrien the youngest children experimented with sand, bricks, water, spatula, shovel, level.

The teachers of the preschool confirm that children also like to play and experiment with water. During spring and summer there are big water boxes in their classrooms or on the playground. Additional materials in these water boxes are funnels, sieves, buckets, tubes ... The teachers provided some pictures of children in action with water and/or sand.





Life-like materials – great variety

The different teachers work with their children with real materials, they also ensure that different types of materials are present. By offering a wide variety of materials the children get the opportunity to build up fundamental experiences and basic schemes. For example in the episode of the Carpenter corner, the girl and the boy experience the difference between all kinds of saws. In the episode of coloring with natural colors, the children can choose between different sieves, they can choose themselves and try out what works the best. In the episode of the pizzas the children experience the difference for example between tomatoes in cans and fresh tomatoes.

In the pedagogical project of 'AUC1' the necessity of life-like materials is stressed as follows *'The school prefers to work with life-like materials. As such, children can often better adjust their research question and they dare to go further in their experimenting.'*

The more children acquire knowledge about different materials, the easier it is for them to find creative and innovative solutions. Materials that are not common to children can't be used for their solutions. Although Sarah and Maaïke of 'AUC2' have some interesting additional thoughts about providing materials. *'The children can take a lot of things themselves but sometimes there is a restriction. Because we want children to think, so the drawers with adhesive tape are closed. Adhesive tape for instance is too easy; children are not encouraged to think. Other times they get only a few things in order to promote their creative thinking even more. For example: In the week before Eastern, creating Easter baskets, the children were not allowed to use glue, tape or iron wire. The Eastern baskets also had to have a close link with nature. The children visited the nature education centre 'De Kaaihoeve'. The children decided to use weaving as technique. Of course I offered them the technique, and I showed how they had to weave. However, the children had to figure out how they had to create the form of the basket.'*

Books and photographs



In order to encourage the learning process, the teachers also provide visual stimuli and books. This can help to foster creativity and encourage inquisitiveness.

4.1.6 Time

Time is an important factor in activities in which children are really engaged and; their agency and initiative are encouraged. For example to experience that a certain glue doesn't work, children need time. In the episode of the mask time was given to the girl to experience herself how the mask could be made more around. In the episode of the pizza time was provided to the boy to think how he could divide the mushroom without using scissors or a knife.

In 'AUC2' no school bell is used, the teachers observe the children very well and if they notice that the children like to go outside or need a break, they stop the activities. Also Katrien is used to look at her children, so playtime can vary.

However, also in the other schools teachers are used to interact to their children and to make time for unexpected moments, to plan more time if activities are not finished or if individual children need to have additional time to understand a certain topic or to train a particular skill, which is possible during corner work.

4.1.7 Mixed ability groups – peer learning

Based on the data, peer learning is a potential factor to enable creativity in mathematics and science for all children. In the participating classrooms, teachers are experienced to work with mixed ability groups; they are also experienced in observing children and in using the strengths of children. In all

the classrooms children with high creative and problem solving capacities are placed together with other children in order to enhance learning from each other. Some children are good in their role as leader; for others it is necessary to have an example in order to make their own designs or to hear from peers which steps they have to take. Examples can be found in the episode of the carpenter corner, in the episode of coloring with natural colors, in the episode of the mask, in the episode of measuring.

4.1.8 Partnerships (parents, organisations)

Parent involvement is encouraged in several of the participating schools (preschool as well as primary schools). For these schools it is important to interact with the parents. Parents need to know the vision of the school and need to know what children are doing and how they are learning. Parents are invited in the schools and they even participate. Some of them are experts in a certain area or can provide materials and resources.

An interesting example of how an organisation can enrich the approaches of a school is seen in 'AUC1'. Based on the 'Start with Art' materials and activities, the teachers were encouraged to link mathematics to art. The environment of the school changed, in every room and every corridor there were paintings, which enhanced the curiosity of the children and of the parents.

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

4.2.1 Aims and Objectives

4.2.1.1 Differences between preschool and primary school

Although there are some differences between the preschools and the primary school, there are also a lot of similarities especially in the domain of inquiring and exploring the world or about problem solving skills in mathematics. As mentioned in the national policy report, in Flanders, the essence of elementary education - early childhood and primary education - is to prepare pupils for critical and **creative functioning** in society and for the development of their personal life. The children's diversity in personality, talents and background have to be taken into account. Emphasis is put on some fundamental elements in development of a child.

- The **development of the personal core**. Basic characteristics such as self-esteem, motivation and initiative are woven as a thread through the whole of the core curriculum.
- The **general development** through goals aimed at learning to communicate and collaborate; the acquisition of independence; **creativity and problem solving** interaction with the world and self directed learning. These goals can be found in all learning areas as well as in the cross-curricular themes, implicitly or explicitly.
- The **specific goals**: specific learning area goals: *Development aims* (pre-primary education) and *attainment levels* (primary education). Development aims are formulated for the end of pre-primary education and attainment levels are formulated for the end of primary

education (12 years). No specific levels are indicated for young pupils (8 year, 10 year); this is the domain of the organising bodies.

As noticed during interviews, informal talks and observations, the participating teachers know very well what is written in the national curriculum – especially about the core goals. This is also seen in their practices and in the broad objectives and aims they have, which are tightly linked to the visions of the schools. All of the participating schools or teachers have very strong visions concerning the education of children. Several of these broad goals are interesting in the light of this project.

4.2.1.2 Differences between science and mathematics

Concerning the broad goals and objectives there are no differences between science and mathematics. However, due to the specific curricular objectives (provided by the Pedagogical Advisory Boards) there are differences between science and mathematics especially on the level of content.

4.2.1.3 Opportunities and challenges for creative learning and teaching

The emphasis on broad goals and fundamental development of children, creates several opportunities for creative learning and teaching. The participating teachers know very well what is written in the core curriculum, their pedagogical project and objectives are closely linked to the broad goals of the core curriculum. In 'AUC2' for example, teachers are allowed to work with broad goals, as such they can be very creative in their approaches and the agency and ownership of the children is extremely encouraged.

4.2.2 Learning Activities

4.2.2.1 Differences between preschool and primary school

In both the preschools and primary school the children are encouraged to observe, to plan, to gather evidence, to make connections, to communicate. As such in both there is a **focus on the cognitive dimensions of science and mathematics as well as on the social dimensions**. Most probably this is also linked to the vision of the schools and the experience and training of the teachers (experiential education). In the preschools no textbooks are used, in the primary school the teachers use no textbooks/method for world orientation, however, to have some guidance they use textbooks and manuals for mathematics and Dutch. Yet, even in these domains, they still are searching for good practices and approaches linked to the vision of the school. As the school only exists 2 years the principal has confidence that in about 5 years they will have their own practices for all the areas based on this vision. Currently they are looking at the 'Singapore method for mathematics'. Although they have these textbooks and worksheets, they do not follow them very strictly and their practices are similar to the practices used in preschool.

In both preschool and primary school '**kring**' moments are altered with **corner activities** or **group work**. During 'kring' moments communication, discussions as well as reflection are encouraged, teachers are interacting with the children. **Ideas, interests, questions and theories** of children are valued in all cases. It was interesting to note that children have amazing theories and ideas. Teachers

are experienced to listen to them and to work further on them, even if they had planned other things. Ilse, teacher of the second grade *'You can't plan them, so I leave space in my agenda to do this.'* Some of the teachers plan **whole projects based on the interests or ideas of the children**, for example Lies developed together with the children a project about Indians. In 'AUC2' **atelier work** is created and find very powerful. Since it is based on the talents of the teachers, teachers are very confident in guiding these ateliers.

During corner work and group work the focus is more on the agency of the children and on peer learning/collaboration. The teachers are guiding all the corners and activities, so they aren't always present. Some interesting conversations between children could be heard. The children have a lot of freedom in constructing their own activities even if worksheets (for example in the case study of Els) are provided or instruction cards (for example in the case study of Lies).

Two of the teachers, Ilse from the first grade and Katrien of the youngest, stressed on the importance of repetition in order to promote transfer and learning. Moreover, if activities are repeated with time intervals, so during other themes or projects, the transfer is even better. Although not all the teachers did mention it, activities in corners are repeated so children are able to experience the activity or the materials for more than one time.

4.2.2.2 Differences between science and mathematics

In the participating preschools there is an integrated approach. Mathematics and science are not seen as separate areas.

Although in primary school there are specific science and mathematics activities, or are named as such, in reality there is no difference between both. During each mathematic or science activity the teachers try to bring in life-like materials, try to make connections and to enhance understanding.

4.2.2.3 Opportunities and challenges for creative learning and teaching

In all of the cases teacher **listen actively** to children and allow children to take the **initiative**. As such discussions are created which are **very child-led**, sometimes these discussions are **very imaginary**, for example the episode of the crooks.

Corner work in which children can take **agency** very easily have a lot of opportunities for creative learning. So do the 'kring' moments in which children are encouraged to **communicate and to express their own ideas and theories**. During these moments children's reasoning and reflection is enhanced.

4.2.3 Pedagogy

4.2.3.1 Differences between preschool and primary school

As both primary teacher are experienced in experiential education and have in fact a bachelor in early childhood education, there are some differences in pedagogy (in comparison to the preschool practice) however they are not that pronounced. The differences could be due to the fact that all other participating preschool teachers are and were involved in earlier research projects and

participate in a community which is focused on 3D education and creating powerful learning environments to encourage and enhance an inquisitive (problem solving) attitude.

A brief overview of interesting pedagogical approaches is provided below. More details can be found in the different cases. The approaches are linked with approaches such as experiential education and 'Reggio Emilia'.

- **listing to and observing** children, or as Carlina Rinaldi mentioned it: 'If we know how to listen to children, children can give back to us the pleasure of amazement, of marvel, of doubt ... the pleasure of the 'why'.' – this means also detecting the interests of children, their ideas, preknowledge, theories, ...
- **asking questions** at the right moment. However, it is not that easy, which is also illustrated by a quote of Sarah *'As a teacher, it is important to ask questions at the right time. You are continuously thinking about that, it is an art to do or say as little as possible yourself. Depending on the child you have to adapt. Many or few questions or additional help. You also have to make use of the peers.'*
- **Building further on** children's knowledge, interests, ideas, ... by engaging children in different kind of activities with rich materials, fantasy, ...
- **Allowing children to take their own materials - agency**
- **Allowing fantasy and humor**
- **Valuing imagination**, by encouraging fantasy and humor
- Using **everyday moments** to make the knowledge useful or to create activities based what children observe or find interesting in their environment – to make use of the **unexpected moments**
- allowing **children to discuss and interact** during 'kring' moments and during corner work
- allowing children **to communicate what they have experienced**, this could be by using words, but drawings, gestures, movements, ... are also possible
- **valuing peer learning (collaboration)**
- creating or selecting **a rich environment**, which contain rich materials
- **evaluating the process and the product**
- **team teaching**
- **Providing time and space** necessary for experimentations, explorations, however also for observing other children.
- being equally excited, curious, amazed, innovative, inquiring as the children

4.2.3.2 Differences between science and mathematics

No differences could be detected between science and mathematics. In fact, in preschool these are

not seen as separate areas.

4.2.3.3 Opportunities and challenges for creative learning and teaching

Several of the approaches above encourage not only the agency and initiative of children but also their problem solving, creative and innovative thinking as such these approaches can be seen as opportunities for creative learning and teaching.

4.2.4 Assessment

4.2.4.1 Differences between preschool and primary school

In preschool as well as in primary school formative assessment is valued. All of the teachers (and schools) have specific strategies concerning assessment (digital portfolio, flash back moments, work sheets, ...), however they all focus on the strengths and capabilities of children and on the processes they go through as well as on the products they design and create. Special attention is also given to transfer and conceptual understanding, as such reflection moments are used, worksheets are discussed, creations are evaluated ...

- *Maaïke: 'The product is not always that beautiful but the process is important. Usually we have the following approach: we explore the material (it is in fact inquiry), then we design (with evaluation), then we make it more esthetic and then we look at the different properties of what we created. So, working like this, you can really see which talents the children have, which strengths they have and which weaknesses.'*

4.2.4.2 Differences between science and mathematics

No differences between science and mathematics are observed or noticed in the preschools. In the participating primary school, however, they are struggling with the fact that parents want to have tests and scores, especially for mathematics. They are examining how they can present the capabilities of the children in all domains. For example, they also notice that children are capable of multiplying in concrete situations but they can't do it on paper. They want to honor this also.

4.2.4.3 Opportunities and challenges for creative learning and teaching

All the presented assessment strategies in the cases try to enhance deep level learning. These strategies value the capabilities of a child and not the work of the teacher nor what parents want. These strategies enhance the agency of the children and their self confidence. However, the role of the teacher is the most important one. These strategies don't mean anything if the teacher doesn't actively listen to and observe children, without judging them.

By using these assessment strategies, the conceptual understanding and the reasoning, the fundamental learning and problem solving and inquiry skills of the children are encouraged/enhanced, which is noticed in the amazing theories and solutions they have, in the answers they give and the things they are doing and create.

5. Implications

5.1 Implications for teacher training

Based on the findings at the contextual and pedagogical level, the following implications for teacher education could be extracted. It would be interesting

- to take in account educational approaches such as experiential education, principles of Reggio Emilia.
- to train (student)teachers in actively listen to children and actively observing children; in order to have insights in the (pre)conceptions, the (pre) knowledge of children, teachers need to have an idea about the children's theories and ideas. In order to enhance deep level learning they also need to know the interests of the children and their questions.
- to train (student)teachers in reflection and discussions with children, in the domains of science and mathematics. As a consequence it is important to train teachers in asking questions; however they have to be the right questions at the right time. If not, the process could be blocked or teachers are leading the activity instead of the children.
- to train (student)teachers to interact on unexpected moments
- to train (student) teachers in creating rich environments or selecting rich environments. This includes selecting and choosing rich materials such as or bringing in exciting materials, creating rich corners such as the carpenter or art and craft corner with several different sorts of materials in boxes and bins, ...
- to train (student) teachers in seeing the potentials present in the school environment
- to train (student) teachers in using humor and fantasy
- to train (student) teachers in searching for information together with children and discussing this information.
- to train (student) teachers in standing back but even then they still need to create opportunities by adding things or asking questions at the right moment
- to train (student) teachers in enhancing transfer by offering them strategies in order to do so.
- to train (student) teacher in working as a team and in participating in each other's classrooms, such as team teaching

Based on the research methods and instruments, the following implications for teacher education could be expressed.

- Video recall is an interesting method to be used with (student) teachers, reflection of the (student) teacher is much more enhanced when he/she watches her/his own approach or interactions.
- The template with factors, used to analyse the video data is an interesting instrument to

analyse (student) teacher practices (we used the template with factors to start and guide the discussions and interviews with the teachers)

- Participation in a research project = professional development – it would be interesting to encourage (student) teachers to engage in a research or development project.

5.2 Implications for policy development

Based on the value of practice with attention for creativity in the domain of science and mathematics, there could be some suggestion for policy development at governmental and local level.

Governmental policy

- Clear regulations about the use of text books into an educational setting. There should be more influence on the content, vision and didactics present in text books published by a commercial company. Or policy should advice to not use textbooks.
- They can encourage schools to use the environment as learning environment by fostering the local communities to participate in school life.
- Making profound choices when they give funds to school in order to build up their accommodation. They should have criteria that also take into account the school as learning environment, and not only the classrooms.
- They can have great influence on the image parents have about education, by putting less emphasis on grades and more on the fundamental learning processes of children and young people.
- If there is freedom of education, there should be more emphasis on a strong school philosophy and on school team which reflects upon his approaches and has a strong professional development program based on the philosophy and the main goals.

Local policy

- A combination of freedom of education with a strong school philosophy based on principles of creative and inquiry education and team work can lift a school to a higher level.
- Schools can make fundamental choices about the timing aspects.
 - They can question if a school bell is necessary.
 - They can think about gaining time by working in projects.
- Schools can choose to use several manuals and resources (also digital ones) as background, instead of one handbook that offers a suggested learning path.
- Schools can choose to make their school a place with countless resources for development; they can construct a rich environment, playgrounds and school buildings which foster the fascination of children.



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- In the selection of learning materials there should be enough attention for unformed materials, because of their amazing learning potential.
- Schools can value the different compositions within their team, for example in this research we observed the value of more teachers in one classroom.



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