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

D4.3 Country Reports

Report 3 of 9:

Country Report on in-depth field work in France

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1. Aims of this Report

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

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

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

The French National Report

The fieldwork in France was undertaken from January 14th until March 19th, 2013, and was completed by phone calls in April, 2013. Before that, in November 2012 schools were contacted and encountered by the researcher. At this occasion, an observations' schedule has been made, and specific authorizations have been asked. Because, we have used video to collect the data, a specific attention has been provided to the authorizations' forms.

Six classes called cases have been under the focus of this national report. The cases come from 5 different schools also called settings. 'Good practice' sites' selection has been done through:

- the questionnaire (WP3) where responders could specify if they would like to take part at the 'second phase of the research, collaborating with researchers through classroom observations and interviews (January-April 2013)'. This is the case of 3 out of 6 of the present cases (FRA3, FRA4, and FRA5);
- other have been recommended by national inspectors of education (FRA1 and FRA6), and ;
- FRA2 has been selected because of the specific approach proposed in that school (Montessori's school).

In preschool, 4 cases have been selected from the reception and the pre-kindergarten levels (FRA1, FRA3, FRA5, and FRA6). In primary school, 2 cases have been selected in grade 1 and 2 (FRA2, and FRA4). Only one of these schools is private (FRA2), the others are public schools. All the teachers, from public schools, who participate to the fieldwork, are training teachers.

18 narrative episodes have been identified (3 narrative episodes for each case). Most of them focus on adults' interactions with children but also on children's collaborations or on children autonomous activities. Approaches which foster children's free exploration, manipulation of rich material, democratic discussion and decision making, collaboration into proximal zone of development, construction of their own/common understanding have been observed and are presented in the next sections.

Before that, in the methodological part, the research questions, the research instruments, the data collection and analysis are presented. Then, a detailed analysis of the six cases studies is proposed. This national report ends on a discussion of the findings and their

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implications of teachers training and policy development.

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2. Methodology

As it has been explained in the WP 4.1 Methodology for in-depth fieldwork, WP4 research's approach takes place in an interpretive paradigm which follows a phenomenological approach. This national report seeks to document practices resulting in a series of unique cases stories. For that we do not 'scale' but try to 'characterize' French exemplify practices.

The methodology was intensively developed over the period September to November 2012 although preliminary discussions were held from July 2012. The methodology was conceived by a team led by the OU comprising OU, BG, IoE, AUC and EA. Other partners contributed to specific elements and Professor Derek Bell attended an early meeting offering his perspectives on the team's thinking.

The main goals of the methodology are to allow to make a deep analysis of implications of mapped and compared approaches revealing details of current practice in early years science and mathematics education and insights into whether/how:

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

In the next part, the research questions and instruments and the data collection and analysis are presented.

2.1 Research Questions

Four research questions organized the CLS project. The objectives, the data and the analyses presented in this document mainly answer to the second and to the third question.

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

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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

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

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

2.2 Research Instruments

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

1. **WIDER SITE CONTEXT**: encompassing data from existing Deliverables D3.2, D3.3, and D3.4.
2. **CASE PEDAGOGICAL CONTEXT**: the setting's teaching and learning policies and planning documents as appropriate, assessment records if they exist, overview of resources and a map of the space.

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3. **CASE OBSERVATION OF PEDAGOGICAL INTERACTION AND OUTCOMES** (episodes of learning involving children and teachers):

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

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

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

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

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

As can be seen above, ten core instruments have been defined for use. In addition, three repertoire instruments can be used depending on the opportunity and the research competencies. In other words, repertoire instruments should be used depending on each partner experiences. Each of the core and repertoire instruments serves to inform and reinforce the data collected by the others. The aim of the data collection process is to produce a vivid and, of course, coherent picture of classroom practice in the cases visited.

In the French context we favor the use of video to collect the data. This specific technology allows capturing at the same time:

- Fieldnotes: include speech acts, non-verbal communications, children's interactions, contextual data such as resources, classroom layout, class numbers, (etc.);
- Audio recording: e.g. recording children's discussions during work, teacher's interaction with children;
- Sequential digital photos: to collect vivid a picture of classroom activity;
- Timeline: to make sure that as many of the key events are noted as possible;

<u>Two cameras have been used:</u>

- One camera was recording, at a specific place of the classroom. Most of the time, it focuses on the teacher and a part of a classroom. Because the classrooms are not

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so big, this camera was quite close to a specific group of children. It was frequently forgotten by the children and the teacher's so rich data has been recorded thanks to it.

- The second camera was used by the researcher. It was used to focus on specific interactions, discussions, artifact making, or to record interesting part of the teaching and the learning processes which occur in the class.

Open and/or semi-structured individual interviews with the teachers have been done. Most of the time, they were recorded through the camera microphone.

Children interviews and learning walks have been done when it was possible. Most of the time, the researcher asks children to comment their own work, or to explain the school organization. Nevertheless, because of time constrain it was quite difficult to realize them.

Classroom plan has been drawn when the researcher was in the school.

Teacher's journal and more precisely teacher's preparations of their teaching have been collected when it was possible.

2.3 Data Collection

According to the Methodology for in-depth fieldwork (D 4.1), 'For the fieldwork each partner works in a minimum of four sites, researching classes of children aged 3 to 8 years old in both pre-school and school, with a minimum of six cases, each case comprises of one practitioner and the children they work with'.

For the French data collection 6 cases or classrooms have been selected. They come from 5 different sites or schools (2 primary schools and 3 preschools) located in three different French areas.

2.3.1 Sampling principles

2.3.1.1 Site and case selection

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,

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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.

The French class's selection has been done in three waves.

- First wave: Class' selection was driven by teachers' answer to the questionnaire proposed in June 2012 (WP3). Some teachers accept to participate in the second phase of the research, by collaborating with researchers through classroom observations and interviews. It was the case of the teacher in the cases FRA3 and FRA4. The teacher in the case FRA5 is a colleague of the teacher in FRA3. She accepts to participate to the fieldwork. Both cases FRA3/FRA5 come from the same preschool which is situated in a city at the north of Paris. The case, FRA4, comes from a big primary school which is close to the capital.
- Second wave: the case, FRA2, has been selected because of the specificity of the pedagogical approach proposed to children. Indeed the Montessori's approach focuses on children's experimentations, manipulations and autonomy. Moreover, FRA2 has been picked up from a small primary school located in a village.
- Third wave: The last to class (FRA1 and FRA6) have been recommended by two national inspectors of education already encounter for FRA3/FRA4 and FRA5 consents form.

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Overview of the sample

Fieldwork Sites		1	2	3	4	5	6
General Selection Criteria		Recommendation from the national inspector of the academy	School with a Montessori's approach	Teacher who has reponded positively to the questionnaire to take part of the observation phase	Teacher who has reponded positively to the questionnaire to take part of the observation phase	Colleagues from FRA3	Recommendation from the national inspector of the academy
Phase	Prescho ol	X		X		X	X
	Primary School		X		X		
Governance	Non-fee paying	X		X	X	X	X
	Fee paying		X				
Age(s) of children	3			X		X	
	4	X					X
	5						
	6		X				
	7		X			X	
	8		X			X	
Mixed age groups		X	X				
Special school							
High Diversity	SEN						X
	Non-native speakers	X		X		X	
	Socio-economic disadvantage			X		X	
Location	Urban	X			X		
	Suburban			X		X	X
	Rural		X				

2.3.1.2 Narrative episodes' selection

To address the main research questions of the consortium, it has been acknowledged that each partner has to identify at least 6 cases. Each case has been recorded in a consistent way. Individual cases are built on the identification of at least three narrative episodes.

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Each of them should focus on mathematics or/and science creative activities.

2.3.2 Ethical issues

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

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

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

The specific attention, on the consent form, required by the CLS project is quite coherent with the French rules to encounter children and teachers at school. Moreover, because we use video the attention has been even more enhanced. Particular attention has been provided to the consent form. In France, the rule depends on the statue of the school:

- In public pre- and primary schools, the national inspector of education, the school director, the teacher and children's parents have to give their agreement for a researcher to be able to collect data.
- In private schools in France, the school director, the teacher, and children's parents have to give their agreement for the researcher to be able to collect data.

Authorizations forms have been also proposed to teaching assistants, volunteers, and more broadly to any person in the class during the time of the data collection.

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2.4 Data Analysis

A qualitative enhanced analysis has been realized on the fieldwork's data collection. For that, dependability and deductive coding analysis has been ensured through the factors identified in the Conceptual Framework (D2.2, March 2012). Then, an inductive analysis follows the deductive analysis. Other collective behaviors have been organized between partners to ensure the confirmability.

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.

The narrative episode selection in France has been realized in three waves:

- 1st wave: during the fieldwork, the researcher tries to identify interesting episode compared to CLS' objectives. This first wave allows making an implicit pre-selection of the videos. Here, the researcher has in mind, four main criterions to process to the episodes' selection:
    - practice in teaching
    - practice in learning
    - activities in science
    - activities in mathematics.
- 2nd wave: all videos from each case are viewed as many times is required to select

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the three best episodes. Here, the researcher has a broader view of the data collection, and enlarges the selection's criterions by the following key aspects:

- children's collaboration
- individual activities.

- 3rd wave:
  - when the data were too rich (i.e. more than 3 episodes can be identified): selection have been made in order to keep the episodes which represent teacher's approach, or children's learning in science or/and in mathematics the best.
  - when data were poor (i.e. less than 3 episodes can be identified): narrative episodes' selection has been made in order to illustrate teacher's main goals in their teaching or children's main goals' in their learning.

Narrative episodes' transcription tries to avoid the transcription of whole conversation and to propose enough details to be able to construct a clear representation of what happens. Notes were added to make clearer the transcription. The coding was realized at the same time as the picture's selection. The coding is a deductive coding analysis system which utilizes the framework as developed by Siraj-Blatchford et al. (2002) setting pedagogical interventions in context (D4.1 Methodology in-depth fieldwork, see Appendix 6) and the factors identified in the Conceptual Framework (D2.2, March 2012). The picture's selection tries to illustrate key aspects of the narrative episodes.

Then, the *description* of each narrative episode was written up step by step:

- First step: description of each narrative episode from each case was written up. For each narrative episode, a description of teacher's or children's main goals in teaching or learning was written up, as well as key aspects of creative collaborative/individual work in science/mathematics. This first draft was organized into four sections: 1) introduction, 2) mathematics/science aspects, 3) creative aspects, and 4) conclusion.
- Second step: the previous drafts were enriched and boostered through the use of the "Codes for Deductive Analysis November 2012 ».
- Third step: the structure of the narrative episodes has been modified to fit to the CLS guidance and organized in five parts:
  - introductory comments
  - Pedagogical Framing
  - Pedagogical interactions
  - Opportunities for mathematics
  - Opportunities for Creativity.

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2.4.2 Final sample

6 cases from 5 settings have been identified. 3 narrative episodes have been selected for each case.

- FRA1: 3 narrative episodes associated to *science* teaching and learning.
- FRA2: 3 narrative episodes associated to teaching, learning and children's autonomy in *mathematics.*
- FRA3: 3 narrative episodes associated to *science* teaching and learning.
- FRA4: 3 narrative episodes associated to teaching, learning and assessment in *mathematics*
- FRA5: 3 narrative episodes associated to teaching and learning in *mathematics* and one to *science*
- FRA6: 3 narrative episodes associated to teaching and learning in *mathematics*.

2.4.3 Limitations

More time in order to do the observations would have provided richer data and maybe more precise information on children's and teacher's representation of their own activities.

Moreover, because the researcher in charge of making the data collection, analysis and redaction of the national report is not used into such qualitative research, each part of the fieldwork has taken more time. Nevertheless, she tried to do her best to fit to the CLS objectives and constrains. Furthermore, she benefited from a great help from all partners.

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3. Case Studies

Heighten narrative episodes from six cases from 5 French schools will be presented in the next section.

3.1 Case 1 – 'Ivette': How to balance explorations and collective discussions to construct a common understanding

3.1.1 Context

Where?	Country	France			
	Setting name	FRA1			
	Location within setting	Pre-school			
Who? (children)	Year group/age of children	Reception and pre-kindergartens 3-4 and 4-5 years old			
	Number of children in class	26			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher and 1 teaching assistant			
	Case teacher role	Coordinator			
When?		1	2	3	4
	Dates of visits	05/02/13	08/02/13	08/02/13	08/02/13
	Times of visits	Morning	Morning	Morning	Afternoon

3.1.1.1 School/setting

FRA1 is a public pre-school in Châtillon, a city closed to Paris (c.f. Map of the city's location in France).

Map of the city's location in France

Seven classes compose the school where 183 children from 2 to 6 years old evolved. It is located in an area where most of the population has a high socio-cultural level. In each class of the preschool, teachers receive the help from a teaching assistant. Because of parents' job, more than half of the children go to the childcare center in the morning and in the

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evening. In other words, children spent a lot of time at school. This specificity explains why language acquisition and mastering constitute the main objective of the school and of Ivette's teaching. In FRA1 there is 1 director (released from teachings), 8 teachers (one is replacing the trainings teachers when they are outside of the school) and 7 teaching assistants.

School hours are: Monday, Tuesday, Thursday and Friday: 9:00-12:00/13:30-16:30.

3.1.1.2 Teacher

The teacher, Ivette, is confident in her knowledge and her competencies. She works as a teacher more than 20 years. She explains that for a few years now, she feels more comfortable in her class. She manages to engage herself and children themselves into dialogues, collaborative time, and explorations. This kind of teaching and learning approach was difficult for her when she started to teach. At this time, she was focused on the curriculum demands and on the best way to lead her class. Moreover, at the beginning of her career she thought that a 'quiet class' was the main characteristic of a 'working class'. Progressively, she has changed her view. Indeed, year after year, because she became familiar with the content of the curriculum, she opened her way to teaching and introduced more frequently collective and collaborative times. The next three narrative episodes are linked to science. To prepare her teaching, specifically in science, Ivette uses books where sessions are proposed.

For our coming, the Ivette has prepared sessions linked to magnet, math, and water. She is used to do this kind of teaching but she feels more comfortable when she does biology (e.g. wheat, avocado germination) and mathematics.

Biological corner from Ivette's classroom

3.1.1.3 Classroom

There are 26 children in Ivette's classroom. Two age groups of children composed the entire group of the classroom. Indeed, 13 children out of 26 are 3-4 years and 13 are 4-5 years old. The teacher is really pleased to have a double level class this year. She can prepare dedicated workshops for each group. She does specific workshops with the older children when the younger are sleeping after lunch time, and realize specific activities for the youngest when the oldest are in autonomy. So, most of the time, she feels to have a

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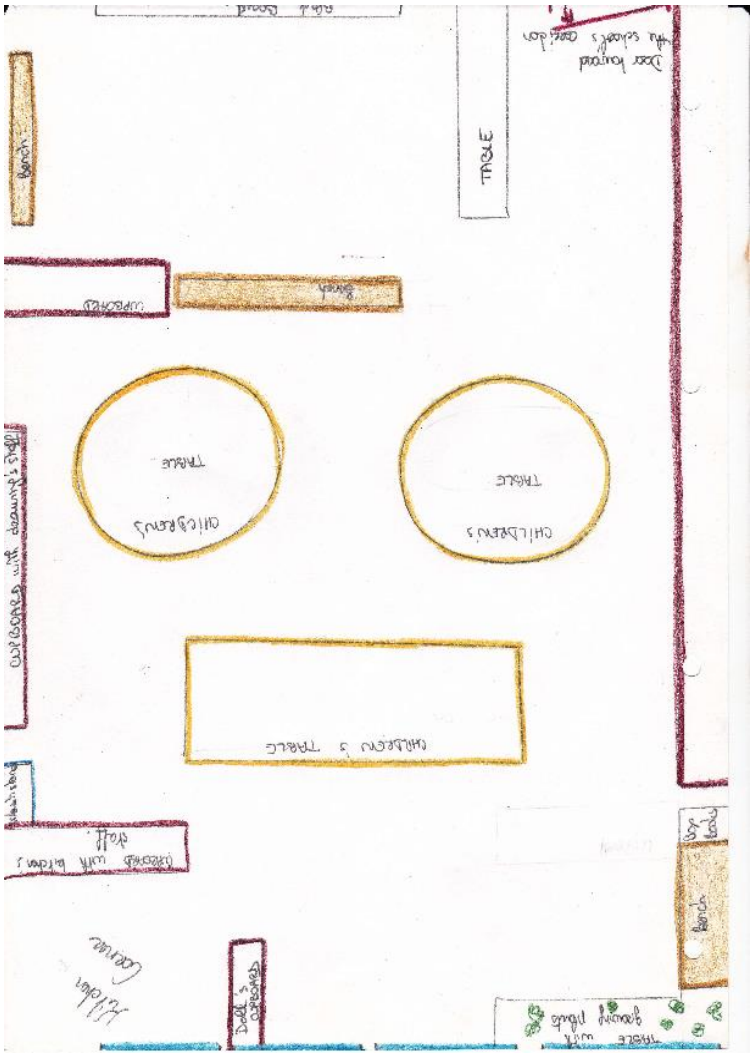
class where there are only 13 children! Moreover, she has noticed that children in double levels develop new attitudes such as collaboration, and mutual assistance (e.g. to help younger children to put their clothes, to take care of them).

Two child in her class have another mother tongue language (one child is Portuguese, the other is Turkish). The classroom is organized into different corners (a discussion corner, a nursery corner, a kitchen corner, a drawing space and a science corner; c.f. map of Ivette's Classroom).



Map of Ivette's classroom

3.1.2 Episodes

The next three narrative episodes are linked to 4-5 years old children's discovery of magnets. All the narrative episodes are realized with the same children (N=13). They are located in Ivette's classroom. Children are invited to discover and conceptualize magnets' properties and then to use their knowledge to solve problems (or *'challenges'* as Ivette calls

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them).

- In the first narrative episode, magnets are given to the children. They have to explore them in the classroom. Then, the teacher asks children to share their own observations.
- In the second narrative episode, the teacher proposed to the children to test and to categorize different objects depending on their attraction or not by the magnet. Then, they are invited to share and to conceptualize what they have observed.
- In the third narrative episode, a problem is given to the children: *'How can you pick up a trombone, in a pot full of flour, without touching it?'*

3.1.2.1 'Magnet Discovery': FRA1Ivette_Pre_Sch_FiedNotes_Video_MagnetDiscovery

Introductory comments

This activity, from which this episode is drawn, focuses on magnet's exploration. Magnet is one of the traditional activities realized by preschool teachers in science. So, the activity fits to curriculum expectations. Moreover, this topic, as any other in science, allows children language's acquisition and mastering to be foster. The activity has been initiated by teacher, and involved children working in entire group at two tables (n=5-6) and in entire group (n=13).

The first narrative episode can be divided into two phases: an exploration phase (4-5 minutes) and a sharing phase (6-7 minutes). During the exploration phase, children explore the new object. They evolve in the classroom to test it. Few interactions occur between them, or with the teacher. Then, during the sharing's phase, children are invited to express their own observations to the whole-group, in the discussion corner. According to Ivette this activity is already a little assessment of the children's knowledge. It allows her to know if children know the object and to have an access to their knowledge and believes about the object. She wanted children to make the observation that magnet attract some objects.

The whole-group interactions are under the focus of the first episode.

Pedagogical framing

This activity is framed as a whole-class exploration of a new object followed by a whole-class discussion dedicated to share individuals' observations. During the second phase, the teacher writes down, on a big sheet of paper, all children's experiences without making any selection between appropriated and erroneous observations.

During the exploration phase, children are asked to be quiet, to make their own experiences with the new object (FRA1Ivette_Pre_Sch_Image_1_MagnetDiscovery). Then during the sharing phase, children have to express themselves, and to pay attention to the

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observations made by other children. This approach is usual in the teacher's approach.

FRA1Ivette_Pre_Sch_Image_1_MagnetDiscovery

Pedagogical interactions

During the exploration phase, the teacher encourages children exploration by using their senses:

- **T:** What does it smells? I see that you smell!

Then, during the sharing phase, the teacher takes into account all children observations, without making selection between 'scientific' versus 'nonscientific' observations:

- **Fé**: it tilts a little
- **T**: It tilts a little?! Ok, **Vi**?
- **Vi**: It smells the chocolate
- **T**: Ah, it smell the chocolate
- **A Child**: No, I did smell anything
- **T**: At the moment, I write everything, we will see after. **Ax**?
- **Ax**: It rests on tables

During the sharing phase, the teacher makes some tests to check critical observations:

- **Ti**: It sticks under the chairs
- **T:** It sticks under the chairs, I agree. I can see one of them under a chair! Wait, we will see if it is stick. *[The teacher takes the chair and shakes it, FRA1Ivette_Pre_Sch_Image_1_MagnetDiscovery].* You are true, it doesn't fall.

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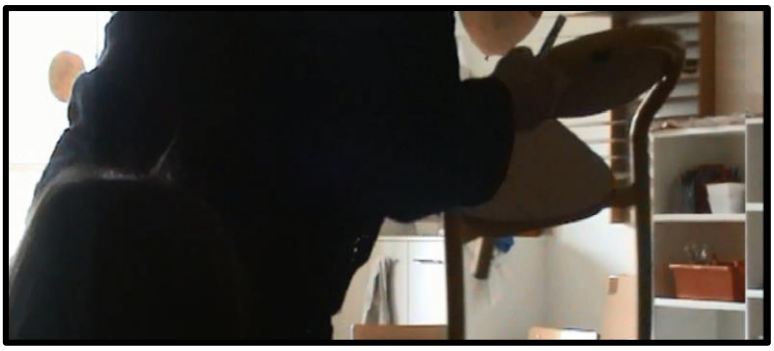

FRA1Ivette_Pre_Sch_Image_1_MagnetDiscovery

- **T:** There is on one that furniture. Do you think it is glue?
- **Some children**: Yes
- **Some children**: No
- **T**: No, you are true *[The magnet is on a wooden table*].

Opportunities for science learning

Children's free explorations, free experiments, and free tests of the new object constitute an important time for them to construct and imagine their own understanding of the magnet. Children can follow their own assumptions because the teacher doesn't provide much information about the object, even its name.

During the second phase of the activity, children own experiences have been shared. This collective time, allow children to confront their point of view and to get awareness of different experiences:

- **T:** There is on one that furniture. Do you think it is glue?
- **Some children**: Yes
- **Some children**: No

This way to organize the lesson allows children to construct their own representation about the object and to be aware of it.

Opportunities for creativity

Because, the teacher starts her activity with a mystery, she enhances children curiosity. Indeed, she doesn't provide the name of the object. Different assumptions arise, such as it is *'chocolate',* and children smell the object… The teacher encourages this kind of attitude. She doesn't constrain the exploration toward the magnet properties. In other words, she motivates children's creative dispositions toward their understanding of the object. As soon as one of them observes that objects can stick on iron, communications and discussions began. This discovery fosters affective factors of science learning.

After a while, the teacher asks children to go back to the discussion corner. There, children are invited to share their own experiences with each other. They do it with their own words

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and with their own understanding (e.g. *'it wriggles a little when we putted them', 'it rests on tables', and 'It smells the chocolate'*).

Conclusion

To conclude, the first narrative episode presents a learning activity focuses on cognitive and social dimensions. Children's explorations and sharing observations constitute the key goals of the activity. To achieve them, the teacher fosters play and exploration, motivation, curiosity and dialogue. Importance is provided to children experiences. Affective factors of science learning are reinforced because of the time taken by the teacher to write down children comments.

This teaching approach may provide an appropriated context for children to develop general skills and dispositions for learning.

3.1.2.2 FRA1Ivette_Pre_Sch_FiedNotes_Video_MagnetAttractionOrNot

Introductory comments

This activity, from which this episode is drawn, focuses on magnet's conceptualization. Magnet is one of the traditional activities realized by pre-school teachers and fits to curriculum expectations in science. Moreover, this topic allows fostering children language's acquisition and mastering. Teaching on magnet is a usual topic for the teacher during the school year, but she has scheduled it for our venue. The activity has been initiated by teacher, and involves children working in small group (n=5-6), then in entire group (n=13).

The second narrative episode can be divided into two phases: a categorization phase (11 minutes), then, a conceptualization phase (22 minutes). During the categorization phase, children at tables in small groups with their own magnet, group different objects in two groups (objects which are attracted by magnet or not). Many exchanges and discussions occur between children during this phase. The teacher discusses with both groups about children discoveries, and their way to manage the activity. Then, during the conceptualization phase, the teacher checks with children their categorization and fosters their reasoning to achieve to a general comprehension of magnets' properties.

A few children, from whole-group interactions during the conceptualization phase, are under the focus of the second episode.

Pedagogical framing

This activity is framed as a whole-class conceptualization after small groups work on the categorization of different familiars objects (FRA1Ivette_Pre_Sch_Image_1_MagnetAttractionOrNot).

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FRA1Ivette_Pre_Sch_Image_1_MagnetAttractionOrNot

The teacher emphases the importance of children making tests and experimentations during the first phase in order to be able to justify their own categorization.

In addition, during the sharing's and conceptualization's phase, she insists on the importance to test again objects if necessary to be sure of their categorization. Here too, children ability to express themselves and to listen to the others is foster. Moreover, the teacher uses a paper sheet to organize the collective and common categorization. This allows creating a trace of their work. At the end of the activity, the teacher asks the children to formulate a general definition of magnets properties.

Here, Ivette's main goal is that children understand that magnet attract or is attracted by iron objects.

Pedagogical interactions

During the second phase, the teacher firstly checks with the children their categorizations (categorization phase). Objects can go in the red or in the green boxes depending on their attraction or not by the magnet.

In the next extract, the teacher emphasizes the difficulty associated to the categorization of ambiguous object such as the scissors. Moreover, in this exchange the name of the magnet is given by a child.

- **T:** So, I have a look on what you have done… the red container. The red containers are all at the same place, the green are also together. Nobody has said to me « I don't know »… You did know, it sticks or it don't. **Ax** told me the scissors sticks ***[T** takes the scissors].* Ah! They are in the box where it doesn't stick!
- **A Child**: I've tried and it didn't stick!
- **T:** Ah... Ah… Ah…. Come **Ax**, we will try, if we don't know *[**T** is sitting, near her is **Ax**].* I've heard many children who said the name of the object... No? Don't you know the object's name?
- **Children:** No
- **T: Fé** you told it! **Ma**?
- **Ma:** A magnet

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- **T:** Yes! Magnet! I've heard many children who have said it!

The teacher and the children are still talking about the ambiguous object. Some children have already tested it and known that magnets stick on scissors. Other children have already tested it and known that magnets don't stick on scissors. So, the discussion is running on. The teacher tries to foster them to explain why scissors can stick or not. A child tries to explain that magnet sticks on iron (FRA1Ivette_Pre_Sch_Image_3_MagnetAttractionOrNot), but because of language difficulties he takes time to express what he has in mind.

- **T:** We can place it in both containers… So why in a side, it sticks and not on the other side? Yes, the red, what do you want to say **Ca?**
- **Ca:** The red, because it is scissors.
- **T**: Yes, it is scissors you are right, **Ma**?
- **Ma**: Because it is big.
- **T:** because it's big. **Ax**?
- **Ax:** It doesn't stick because it only sticks on the green.
- **T:** On the…? *[in French, glass, green, and iron have closed spelling]*
- **Ax:** Only on green, as green… you know, green
- **T:** Wait, are you talking to me about glass *[**T** shows to the child a pot in glass]*
- **Ax**: Yes, *[**Ax** scrubs his head]* no, in iron *[**Ax** shows the iron part of the scissors]*

FRA1Ivette_Pre_Sch_Image_3_MagnetAttractionOrNot

In the next extract, the teacher proposes children to realize a collective categorization of the objects on a big sheet of paper. She draws two columns on the paper sheet: one for the attracted object sand one for the objects which are not attracted by magnet. By testing each time a single object, a common and collective categorization is progressively created. Finally the question of the scissors is still confusing children:

- **T:** Yes, it doesn't stick on the orange side! **Ax**, do you remember that? Looks, on this side it sticks and on this side it doesn't *[**T** tries with the magnet on both sides of the scissors].*Where will we place the scissors*? [**Ax** shows the column where it doesn't stick]*
- **Ca:** We will stick it on the line!
- **T:** Come and show me, that is a good idea. How do you place it? Show me *[**Ca** places de*

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scissors on the line, the iron part on the stick column and the plastic part in the column where objects do not stick on the magnet]. That is a great idea **Ca**!

A creative solution is proposed by one of the children. The solution might be to place scissors on the line of the paper sheet.

FRA1Ivette_Pre_Sch_Image_4_MagnetAttractionOrNot

Opportunities for science learning

Children are sitting around two tables and explore with their magnet the material in the boxes. They try, share, manipulate, and place the objects in two different boxes: one is dedicated to objects which are attracted by the magnets. The other box is dedicated to objects which cannot be attracted by the magnet. This activity constitutes a first step toward science processes acquisitions:

- experimentation
- testing
- differentiation depending on specific properties
- categorization, and
- discussion.

When children on each table have classified all the objects, the teacher asks them to go back to the discussion corner. There, they are invited to share their observations and to agree on a common categorization. During the second phase of the activity, the focus is given to conceptualization by collective: reflection, reasoning, and collective conceptualization. Indeed, children have to decide if one object is attracted by the magnet or not, then they have to fix it on a sheet of paper on the wall. For each object, the teacher encourages children to make predictions (e.g. *'Come on **Ga**, you try also?', 'It doesn't stick in there? Why it does stick?'*) and to make tests.

To let children make their own categorization, and then to foster collective categorization constitutes an interesting pedagogical choice. Indeed, it allows children to construct their own understanding and then, to make adjustment following collaborative and collective

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discussions. This way to process allows going from subjective conceptualizations toward objective and so, scientific, a conceptualization of magnet's properties. The example of *'scissors'* can illustrate this aspect. The scissors are half of plastic and half of iron. Children's categorization depends on which side of the scissors they have texted. Here, the ambiguity of the object's categorization arises because children are sharing their observations. In other words, children get the awareness of the scissors double categorization because some of them have classified them differently. This collective discussion seems to be critical for children to go ahead from their own experience toward an objective and scientific understanding.

Finally language acquisition in sciences is also foster. During this narrative episode, scientific content has been provided. Children identified the new object as a *'magnet'*.

Opportunities for creativity

In the second narrative episode, many creative aspects can be identified. Firstly, collaboration and discussions may have supported creative understanding of the magnet's properties (e.g. its action on other objects). It might be the case when children were exploring them in small groups (e.g. for the scissors: the idea that the color can be the reason why they are attracted by the magnet, FRA1Ivette_Pre_Sch_Image_2_MagnetAttractionOrNot).

FRA1Ivette_Pre_Sch_Image_2_MagnetAttractionOrNot

Two other events could illustrate the creativity of the activity. During the collective discussion, a child tries to say that iron objects are attracted by magnet. In French *'iron'* (fer) spelling is closed to *'green'* (vert) which is similar to *'glass'* (verre). So, at first the teacher doesn't understand the child's explanation because of his enunciation's difficulties, and because of the word spelling. This language's problem is really frequent in pre-school. Nevertheless, instead of guessing what the child wants to say and to suggest 'iron', the teacher shows him a glass and asks: *'Do you mean glass ('verre')?*'. The child thinks and says *'no, I mean iron ('fer')'* and shows the iron part of the scissors. Sometimes, because of this kind of difficulties children cannot express what they know. Here the teacher strategy is pertinent because she doesn't provide the expected word, but allow the child to use

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different forms of expression in order to be understood.

A great and creative idea emerges at the end of the workshop. It has been proposed by a girl to solve the problem of the scissors' categorization. In which category do they go? Many discussions and assumptions are developed by the children and the teacher on this topic. None of the children manage to say that the scissors can go in both categories. Nevertheless, at last, a girl suggests placing them 'on the line' between both categories.

Finally, the whole-narrative episode is creative in its structure. In fact, the teacher is only here to scaffold children interaction and to guide them. Children's productions are used by the teacher to foster their own reasoning.

Conclusion

To conclude, knowledge/understanding of the science content, science process skills, social and affective factors of science learning and creative dispositions constitute competencies which have been foster during this narrative episode. The cognitive and the social dimensions of the activity are present. Dialogue and collaboration, question and curiosity, scaffolding and involvement constitute key aspects of the teacher's pedagogy.

It can be stressed that ambiguous material (e.g. scissors) fosters creative attitudes.

3.1.2.3 'Magnet Attraction through Flour': FRA1Ivette_Pre_Sch_FiedNotes_Video_MagnetAttractionThroughFlour

Introductory comments

This activity from which this episode is drawn focuses on solving a problem which involves magnet's properties understanding. Magnet is one of the traditional activities realized by pre-school teachers and fits to curriculum expectations in science. It is a usual topic for the teacher during the school year, but she has scheduled it for our venue. The activity has been initiated by teacher. It involves children working in entire group (n=13) then in small group at two tables (n=5-6).

The third narrative episode can be divided into three phases: a reminder phase (4-5 minutes; FRA1Ivette_Pre_Sch_Image_1_MagnetAttractionThroughFlour), a solving phase (10 minutes), and conceptualization phase (2 minutes). During the reminder phase, children discuss and explain what they have done few days ago with magnets in whole-group in the discussion corner. Then, in small groups they try to collaborate and to exchange to find a solution to a problem. The teacher discusses with both groups of children. During the conceptualization phase, she mainly rephrases children explanations of their observation in the previous phase.

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FRA1Ivette_Pre_Sch_Image_1_MagnetAttractionThroughFlour

A few children from whole-group interactions during the conceptualization phase are under the focus of the second episode.

Pedagogical framing

In the third narrative episode, the teacher changes her way to teach compared to the attitude she had during the previous ones.

Children cannot longer explore, and then share their observations together to find common solutions. Here, they have to think in order to find a solution to the teacher's challenge and then, they are able to manipulate. In other words, they have to produce assumptions based on what they know and ideas first. The teacher explains it clearly 'make your head working'. For that, she starts the activity by making some reminders on magnet's properties. Indeed, the third narrative episode occurs a few days after the previous ones. She uses an already known support to do that: the categorization's paper sheet (see, second narrative episode). During the manipulation phase the teacher fosters children curiosity about the phenomenon. Moreover, the teacher insists on children's ability to provide sense to their own experiences as she enhances them to provide some general conclusions at the end of the activity. In her pedagogical approach the role of problem solving and agency is central to develop children capabilities to carry out scientific inquiry, and problem-based approaches.

Here, Ivette's goal is that children understand that magnet attract objects trough other material.

Pedagogical interactions

During the solving phase, teacher's way to present the activity is interesting because she fosters children curiosity, and enhances the role of their reasoning and capacities to make assumptions.

- **T:** I've hidden something. I've hidden a trombone in the flour pot. Make your head working.

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You have to find the trombone with no help from your fingers.

- **A child:** What?
- **T:** Think… I might help you a little. How could you find the trombone which is hidden in the flour without your fingers? **Fé**, you have an idea?

In the next extract, it can be observed that even if the idea 'to pick up the trombone with the magnet' is found quite quickly; the way to do it is not obvious (FRA1Ivette_Pre_Sch_Image_2_MagnetAttractionThroughFlour).

FRA1Ivette_Pre_Sch_Image_2_MagnetAttractionThroughFlour

- **Ax:** With magnet we could catch the trombone without touch it.
- **T:** With a magnet you could catch the magnet without touch the trombone *[Laugh].* What do you think about that?
- **A child:** It is a really good idea
- **T:** Do you think it can work?
- **Many children**: Yes
- …
- **T:** So do you have any idea **Ax**? Come on, we are looking! *[**Ax** places the magnet above the flour, and the trombone is attracted by the magnet]* Oh! *[laugh]* It has worked! [*Laugh*]. Did it works, or not? **Ax?** *[Laugh].* Did your idea was a good one? *[Looking at the teacher, **Ax** says yes with his head]…* Give the pot of flour to your friend…

Before moving to the next challenge, during the conceptualization phase, the teacher asks to children to explain what they have done and observed. The use of appropriated language is foster by her.

- **Fé**: It did go up
- **T**: What did go up?
- **Many children**: The trombone
- **T:** Where did it go up? On the ceiling?
- **Fé** *[shows with his finger the magnet in the teacher hand]* toward this thing
- **T:** What is the name of this thing? Yes, **Ti.**
- **Ti:** A magnet
- **T:** So, it went up to the magnet. Where was the trombone **Mo?**

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- **Mo**: In the flour
- **T:** So what did the magnet do? It…
- **Mo:** It did fly
- **T:** The magnet did fly? No?
- **Al:** The magnet did attracted
- **T:** Well done **Al**, the magnet did attract the trombone. But, the last time we also have seem that it attracts *[The teacher attracts the trombone on her hand]*. This time, what did it do? Where was it?
- **Al:** In the flour
- **T:** So, it did attract the trombone through the flour! The magnet did attract the trombone through the flour. Ok?

Opportunities for science learning

The teacher begins the class by reminding the children what they have done few days ago. She shows the sheet of paper where objects where categorized as attracted by the magnet or not. This first phase is quite important it allows children to remind what they have done, to ask questions if they don't have understood something etc.

Teacher's presentation of the activity enhances the importance of children's reasoning and making assumptions to find a solution to her challenge. The solution is found quickly by a child (FRA1Ivette_Pre_Sch_Image_3_MagnetAttractionThroughFlour)

FRA1Ivette_Pre_Sch_Image_3_MagnetAttractionThroughFlour

Then, children experiment the phenomenon: the trombone attracted by the magnet through to the flour. After a while, the teacher takes the time to put into appropriated words children's observations. She helps them to build a scientific knowledge/understanding of what happened. Later, she proposes to them another challenge: 'H*ow to pick up a trombone located in a full glass of water*'. Her way to structure the lesson allows children to learn from science content and process.

Opportunities for creativity

The way to present to the children the activity as a challenge, the material proposed, and

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the fact that solution has to be found in group make the narrative episode creative. Indeed, to solve the challenge children need to elaborate a new idea '*I may attract trombone trough flour through a magnet*'. Moreover, the material, pots full of flour with a hidden trombone constitute for young children a familiar, interesting and attractive support for reasoning.

Conclusion

To conclude, in the third narrative episode, cognitive and affective dimensions are fostered. More precisely, children's capacities to use previous learning (e.g. 1. magnets attract iron, 2. a trombone is in iron), to reason in order to find an original solution and to conceptualize their experiences into language (e.g. magnet can attract a trombone through flour) are fostered.

3.1.3 Case summary and conclusions

3.1.3.1 Learning in science

Teacher's approach fosters children learning in science and mathematics because she gives children the time to make their own explorations of new material and so to construct their own representation. Then, to go ahead from children's first understanding, the teacher proposes to share collectively their own representations. The sharing time allows children to confront their ideas and to construct more objective understanding. By doing that, the teacher just fosters play and exploration, then discussion and collaboration.

She also helps children to build clear and coherent representations of the world (e.g. categorization of the objects), to solve problem by their own and so to take up challenges.

3.1.3.2 Interest and motivation in science

The teacher fosters children's interest and motivation by proposing to them new objects such as magnet, and by letting they discover its properties.

Interest and motivation are enhanced because the teacher uses appropriately the balance between individual and collective times. This change in the structure of the group (entire group-13 children/small groups of 5-6 children) provides a rhythm and facilitates to maintain the workshop's main objective. Indeed, children know that they have to be attentive in individual time, because they have to explain their observations during sharing time. Children curiosity is fostered by this approach because children discover what other children have found.

Moreover, the teacher knows how to foster her activity. She uses to make jokes and proposes to the children challenges!

At last and in a general way, material is attractive and the teacher takes into account

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children's speech (e.g. she uses to write their observations on the blackboard).

3.1.3.3 How do teachers perceive their role in doing so?

According to the teacher, to do what she does is not obvious when a teacher starts to teach, as she says*: 'You need to accept that children talks and move freely in the classroom'*. Moreover, teachers have to develop competencies in leading a class: to know how to get children back to work, how to go from free play or free exploration to more constrained times. Indeed, constrained times allow children to share their own experiences, and to listen other children's experiences. This balance between less constrained and more constrained times is progressively built with the group of children, week after weeks during the school year.

According to Ivette, the most important point is to foster children curiosity and to take into account their ideas.

According to her, her role is:

- « I have to create a peaceful ambiance in the classroom. This year is easy because I've only 13 children in the afternoon. With the whole-group, as it is usually, I like to isolate the group from the other children. It is possible because of the classroom configuration, with the banks, or in another room when it is possible. The teaching assistant role is here important to take care about the rest of the group of children.
- To organize and prepare all the necessary material I will need for an activity. To do that i make mental simulation of the activity and I make a list of the necessary material.
- To foster creative and motivating learning, I foster children questioning in order to enhance their curiosity. I take into account children's answers which are coming from their own knowledge or believe, then I invite them to experiment and to manipulate to verify or to modify what they think at start.
- I'm just there to guide them in their observations, and to help them to formulate their thought by providing them vocabulary to allow them to express their experiences. I remind them regularly what we have already seemed in order to help them to use that knowledge to go ahead.
- The goal is to help children to build more objective thought by confronting children ideas. That is why I organize discussion, schema, and writings.
- To prepare my teaching, I need to have in mind my goals, my material, and the experiences I will have to use. Nevertheless, there are many ways to achieve the goals, so I adapt myself to children's knowledge. »

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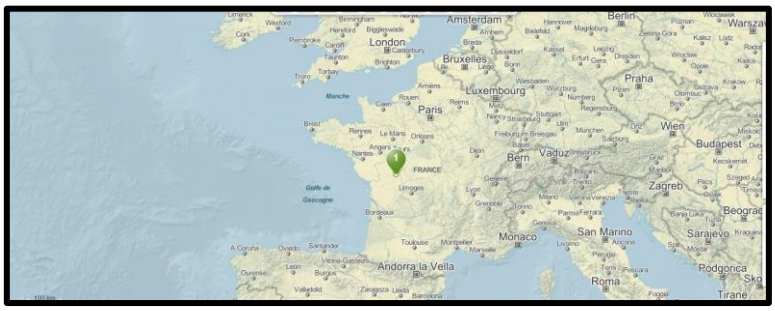
3.2 Case 2 – 'Robert': How to foster children's construction and autonomy

3.2.1 Context

Where?	Country	France			
	Setting name	FRA2			
	Location within setting	Primary school			
Who? (children)	Year group/age of children	1st to 5th grade 6-7 to 11-12 years old			
	Number of children in class	23			
Who? (adults)	Number of adults	4			
	Role of adults	2 teachers, 1 person for a child with specific needs and 1 volunteer			
	Case teacher role	Co-coordinators			
When?		1	2	3	4
	Dates of visits	21/01/13	22/01/13	23/01/13	23/01/13
	Times of visits	Morning	Morning	Morning	All day

3.2.1.1 School/setting

FRA2 is a private school in a village closed to Poitiers (c.f. Map of the city's location in France). The specificity of this school consists in using the Montessori approach of learning and teaching.



Map of the city's location in France

FRA2 is composed by 2 classes, where children from 3 to 12 years old evolved. One class is dedicated to pre-school children and the other one to primary school children. FRA2 is a 2 years old school. Teachers have experimented in teaching and they follow specific trainings linked to the Montessori approach each year and are visited by specialist of the approach

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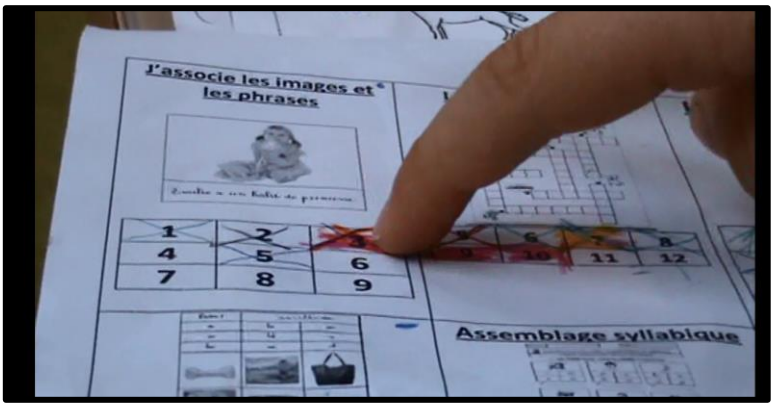
regularly. In that school, many activities are realized outside of the class. For example, there is a farm closes to the school. Children have they lunch (organic food) there, and use to make workshops with the farmers. Moreover, the school is close to a river where children have built wooden houses and use to make bird's observations. In FRA2 there is one director which is also a teacher and two other teachers, one person for a child with specific needs, one teaching assistant (ATSEM), and one volunteer.

School hours are: Monday, Tuesday, Thursday and Friday: 9:00-12:20/14:00-16:30; Wednesday: 9:00 12:15.

3.2.1.2 Teacher

The teacher, Robert, which is also the school's director, is confident in his knowledge and his competencies. He works as a teacher for many years now. He started in pre-school. In traditional schools, teaching's goal is to help children to become a citizen. In Montessori's schools the goal is to help children to construct themselves. Teachers and materials are there to help them to be autonomous and to take pleasure in learning. The teacher stresses the importance of the educative relationship with the children. For example, he has done a formation on 'nonviolent speech' which is really helpful to manage with conflicts at schools. The learning and the relationship with each child are specific when the rules of the class running are common. For example, each child received each month his/her work's plan (c.f. Children work's plan). The learning activities which have to be done, during the month by the child, are represented and listed there. Those work plans are conceived in order to fit to children own development, learning abilities.



Child's work plan

3.2.1.3 Classroom

In FRA2 primary school there is only one class, it is a multi-levels' class composed by 23 children. The teacher really appreciates this specificity because it allows him to know and to follow each child's progression and development. According to him *'It constitutes a great advantage when you take into account each child's specificities'*. Two teachers make collaborating teaching in this class. Furthermore, one person helps one child with specific

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needs, and a volunteer helps the class running half of the day. The classroom is organized into different corners (music, computer, grammar, mathematics, science, tea and breakfast, drawings, c.f. Map of Robert's classroom).

Mathematics' corner

Science' corner

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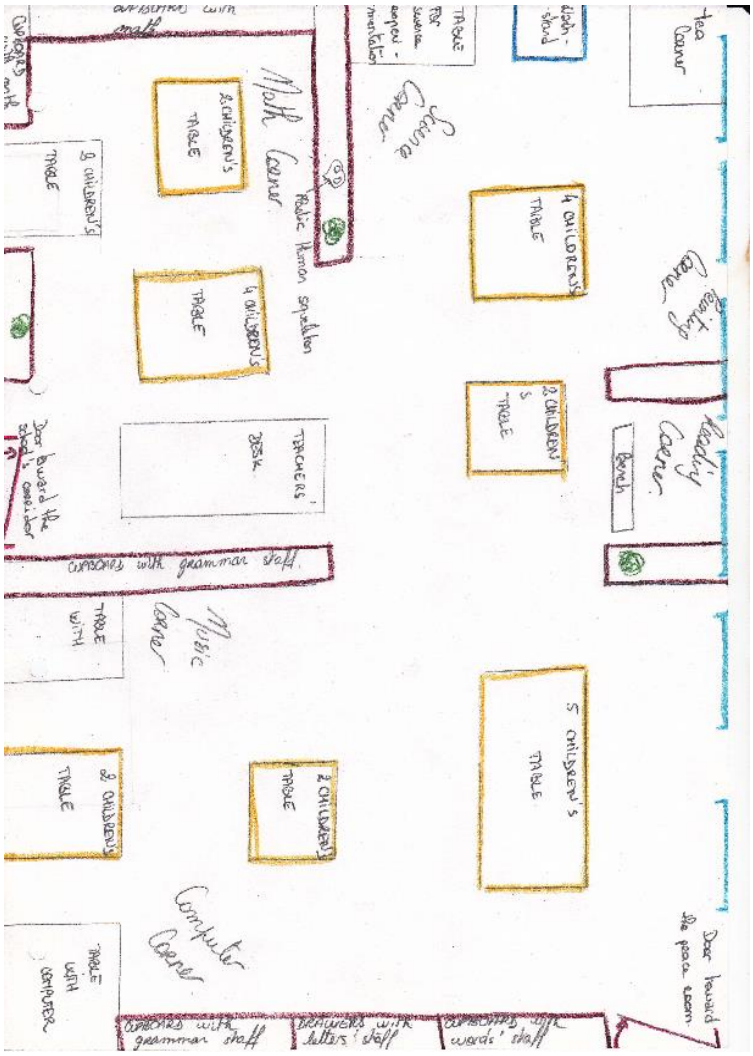

Map of Robert's classroom

The children in FRA2 are there for different raisons. 'Children with high potential' have been oriented there by specialists (e.g. psychologist). Some children are there because their parents desire to offer them a specific pedagogical approach of learning. The school also welcomes children with deviant behaviors. The school is a partner of different associations such as: the "l'association Montessori de France" (French Montessori association); "l'enfant et la vie, le magazine des parents chercheurs" (child and life, the parents' researchers magazine); "movement pédagogique Pierre Faure" (Pedagogical motion Pierre Faure) etc.

3.2.2 Episodes

The next three narrative episodes are linked to 6-8 years old children's activities in mathematics. Because it is a multi-level classroom, older children (8 to 13 years old) can interact with younger children to help them to solve problems.

- In the first narrative episode, a child wants to show to the researcher a cards game

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but doesn't know the rule. So, the child asks and receives some help from older friends.

- The second narrative episode presents usual way to scaffold children learning in the class. An adult (a volunteer) helps a child to make addition by using wooden material.
- The third narrative episode presents the difficulties encounter by a young girl to make the addition table of 5 because she doesn't use carefully the material.

3.2.2.1 'Children Collaboration Card Game Rule': FRA2Robert_Pri_Sch_FiedNotes_Video_ChildrenCollaborationCardGameRule

Introductory comments

This activity from which this episode is drawn focuses on children's collaboration. This kind of attitudes occurs frequently in this FRA2 as children's autonomy is one of the key objectives of the Montessori's learning and teaching approach. Children's collaboration goal is about the rule of a cards game in mathematics. This activity fits to the curriculum expectations in mathematics for a 6 years old child (**Ma**). The cards game is a usual material used by the teachers in charge of the class to make children progress in their autonomous learning in mathematics. The activity has been initiated by **Ma**, who wants to show to the researcher this material.

The next episode involves mainly two children. **Ma** is at her table with the cards game and the researcher. When she understands that she doesn't know the rules of the game, she left the researcher to ask for some help. She comes back with a friend, then another one (**Vi**) explains her entire rules. **Vi** is older than **Ma,** and he knows much more in mathematics. Indeed, he already knows how to do subtractions and times.

The whole-episode takes place on **Ma's** table (7 minutes). Teachers aren't involved in this narrative episode. Here, only children are interacting. Episode duration is around 7 minutes.

The main focus of the episode offers here become two children, **Ma** and **Vi** who try to make sense to the game.

Pedagogical framing

The card game is an activity conceived as an autonomous one where children can train themselves to do additions.

This activity is frame as a two children exploration and construction sense to a mathematical card game play (FRA2Robert_Pri_Sch_Image_1_ChildrenCollaborationCardGameRule;

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FRA2Robert_Pri_Sch_Image_2_ChildrenCollaborationCardGameRule)

FRA2Robert_Pri_Sch_Image_1_ChildrenCollaborationCardGameRule

FRA2Robert_Pri_Sch_Image_2_ChildrenCollaborationCardGameRule

Vi has the role of the expert and **Ma** the role of the novice.

Pedagogical interactions

Ma starts by showing to the researcher the material, and progressively gets the awareness that she doesn't know the rule of the game.

- **Me**: There is a six on this one *[**Ma** is still looking at the different cards].* What is the goal of this play?
- **Ma**: I don't know
- **Me**: Ok…
- **Ma**: I have to ask to **To** *[the teacher],* I will come back.

Ma comes back with a friend **Fo**. **Fo** starts to explain to **Ma** how to do the cards game. It can be stressed that her way to explain it quite clear. **Fo** is a beat older than **Ma**, so she knows the game.

> **Fo**: You see **Ma**, your cards are placed, you have to found the results, it mean what it do, that means the results has to be above of the cards *[in the play there is two types of cards, cards with a number and cards with an addition, the goal is to make the addition*

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and to identify the associated results and to place both cards together; FRA2Robert_Pri_Sch_Image_3_ChildrenCollaborationCardGameRule].

FRA2Robert_Pri_Sch_Image_3_ChildrenCollaborationCardGameRule

Ma doesn't feel comfortable yet with additions, she is still using her fingers. But now with big number it isn't working anymore. **Vi** notices it and suggests her a strategy to add big numbers by using fingers in another way.

- **Vi**: It is working like this, looks, for example, 5 plus 8 how does it do?
- **Ma**: Oh, no, but…
- **Vi**: 5 plus 8 how does it do?
- **Ma**: *[Showing on her fingers]* 5 and we put 8 *[then, she starts to count her height fingers].* One, two, three, four, five, six, seven and height *[she looks at her friend and laugh. It seems strange for her that 5 plus 8 makes 8].*
- **Vi**: Plus 5!
- **Ma**: No! I don't know how to do it yet!
- **Vi**: You do 5 plus 8 *[**Vi** looks at **Ma**].* You do 8 plus 5 [***Vi** shows 5 fingers*]. It does, 9, 10, 11, 12, and 13. [***Ma** starts to count the dots on the card where 5 plus 8 is represented; FRA2Robert_Pri_Sch_Image_4_ChildrenCollaborationCardGameRule]*

FRA2Robert_Pri_Sch_Image_4_ChildrenCollaborationCardGameRule

Opportunities for science learning

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This narrative episode enhances how the proximal zone of development (Vygotsky) can run naturally without any adults' scaffolding in multi-level Montessori's classroom, through children's collaboration.

A child wants to play to a mathematical game but doesn't know the rules. The rule of the game consists in grouping different cards. Those with additions have to be placed with the cards where the associated result is represented by dots (FRA2Robert_Pri_Sch_Image_3_ChildrenCollaborationCardGameRule). So each time, two cards go together. Children have here to identify a card where there is an addition, to make it, and to find the appropriated result on another card.

Two main aspects linked to mathematics can be stress in the first narrative episode. Firstly, children are able to provide clear and simple explanations in mathematics (**Fo'**s explanations). Moreover, they can explain the rule of a mathematical game (**Vi'**s explanations) without any help from the adults. Two children (**Fo** and **Vi**) help a child (**Ma**). Those capacities reflect children deep understanding of additions and of the materials.

The second important aspect linked to mathematics, in the first narrative episode, is children's strategies to count. The youngest child (**Ma**) is still using her finger to make additions, but **Vi** doesn't need them anymore. **Ma** is counting by her fingers, but when she makes 5 plus 8, she found 8. Indeed, **Ma** counts five fingers with one hand. Then, she starts to count height, but forgets to add both numbers! **Vi** shows her another way to do. He suggests to say 8, then to add 5 fingers to find 13. This proposition is really interesting because it could be in the ZDP of **Ma**. Nevertheless, **Ma** finds another and easier way to do the addition, through the material, by counting the dots on the card, and finds also 13.

Here, children learn and explain new strategies to make additions.

Opportunities for creativity

Creativity can be identified here through children's collaboration. Children know where to find support to go ahead in their learning, and they are competent in providing scaffolding.

Moreover, children reassure each other. For example, in the present narrative example: *'**Vi:** … after is the blue card game (subtractions), the blue cards are even easier'.* **Ma** can go on the activity as it is not so difficult, and even after, she will discover easier one.

Vi suggests to **Ma** appropriated and new strategies for her to go ahead in her mathematical understanding and mastering.

The rich material is rich. It allows **Ma** to find her way to make additions by counting the dots on the card! The material constitutes in this case a really good support to foster children's mathematical and creative use of it.

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Conclusion

To conclude, this narrative episode is coherent with the main pedagogical goal of the teacher *'to make the children autonomous'*. Moreover, it constitutes a good illustration of how the Montessori's pedagogy allows children to construct themselves. For example, **Vi** is usually boisterous, but he is also really competent in scaffolding **Ma,** and here the context allows him to explore this kind of attitude. Mathematics education constitutes, in this narrative episode, a context for the development of: general skills', positives attitudes for learning and autonomy. Understanding about scientific inquiry, science process, capabilities to carry out scientific inquiry or problem-based approaches, social factors of science learning and creative dispositions are enhanced by those children. Moreover, the activity initially conceived to focus on the cognitive dimension has been the source of more complex exchanges which involved social dimension.

Creativity seems to be foster by the context in which children evolved. In fact, children can and are encouraged to help each other. In a way, the material in itself fosters the natural emergency of the proximal zone of development.

3.2.2.2 'Scaffolding Math Activities': FRA2Robert_Pri_Sch_FiedNotes_Video_ScaffoldingMathActivities

Introductory comments

This activity from which this episode is drawn focuses on the volunteer's scaffolding of a child which is making additions with dedicated material. Adults' scaffolding or teaching to one or a few children constitutes the usual practice in this Montessori's school. Because children's autonomy is one of the key objectives of the Montessori's learning and teaching approach, children have to know how to use material in order to benefit from its help. The present activity fits to the curriculum expectations in mathematics according to the 6 years old child (**Ma**, same girl as in the previous narrative episode) who is provided help. The wooden material used here is usual. Teachers propose it to children to facilitate their progresses to make additions and subtractions. The activity has been initiated by **Ma**. Indeed, this activity is one of those she has to realize that day (c.f. work plan).

Ma is at her table with the volunteer (**VO**). On the table there is a sheet of paper with additions written on it. Moreover, there are two boxes with wooden materials. One if full of wooden bars which represent the dozens (composed by ten glued wooden cubes). The other box is full of wooden cubes which represent units (FRA2Robert_Pri_Sch_Image_2_ScaffoldingMathActivities).

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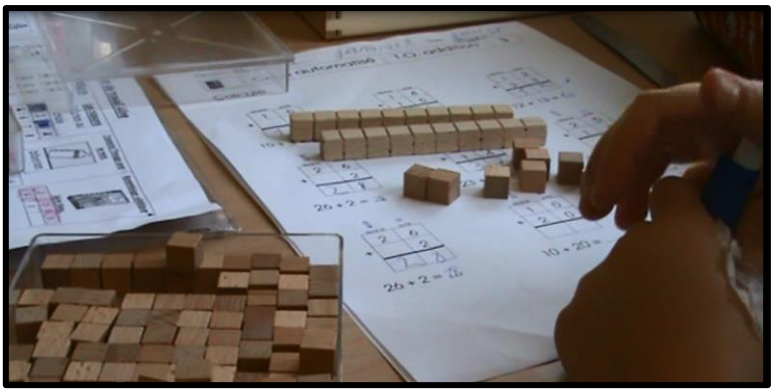

FRA2Robert_Pri_Sch_Image_2_ScaffoldingMathActivities

Here all interactions occur between the volunteer and the child. The researcher is recording the scene. Episode duration is around 5 minutes.

The main focus of the episode offers here become two children, **Ma** and **VO. VO** scaffolds **Ma** who is making additions.

Pedagogical framing

Actually, there is no blackboard in the class, traditional teaching (teacher teaches to the entire group, never happen). Most of the time, the teacher asks 3 or 4 children to come to his table and explains the way to use specific material. Then, children are free to use it in an autonomous way. Here the volunteer scaffolds the children to acquire the appropriated way to use and make additions.

The main role of the volunteer is here to scaffold Ma, and to check with her progression in solving additions: 1) her correct identification of the numbers dozens, and units; 2) that she picks up the appropriated numbers of bars and cubes; 3) that she adds correctly the numbers of bars and cubes; 4) that she writes at the right place that information on the paper sheet.

Pedagogical interactions

The interaction between **VO** and **Ma** stresses how **VO** helps **Ma** to manage her additions with the material. Indeed, **Ma** is far from having acquired an autonomous way to solve additions. Material is really rich. The wooden bars and cubes help children. Moreover, on the sheet of paper it can be viewed that dozen (bars) and units (cubes) are also drawing.

- **VO**: So, how many dozen there is?
- **Ma**: One!
- **VO**: Look, the dozen are here. How many dozen there is here *[**VO** points the* 2; FRA2Robert_Pri_Sch_Image_1_ScaffoldingMathActivities*]*.

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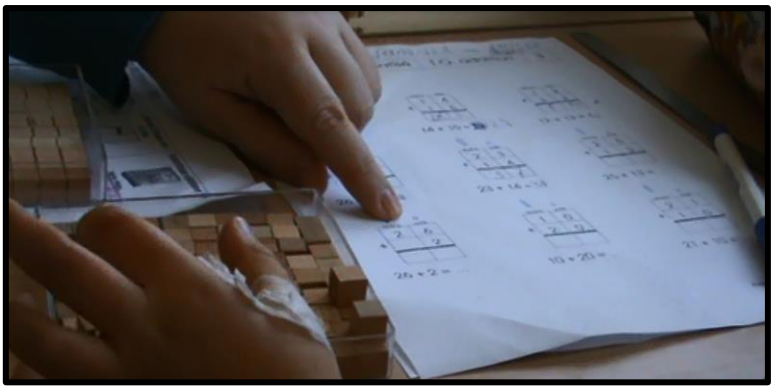

FRA2Robert_Pri_Sch_Image_1_ScaffoldingMathActivities

- **Ma**: Plus?
- **VO**: So, here is the column of the dozen *[**VO** shows with her finger all the column]*
- **Ma**: It is there
- **VO**: Yes. So, how many dozen there is?
- **Ma**: 2, 2 dozens *[**Ma** takes 2 dozens in the appropriated box].*

Here, **VO** encourages **Ma** to solve additions 'Nice', and helps her to focus her attention on the appropriated elements of the addition.

- **VO**: So, in this one, how many dozen there is? *[**Ta** shows the dozen column*]
- **Ma**: 10?
- **VO**: No, looks, the dozen are only in this column
- **Ma**: 2, 10, 1, 1.
- **VO**: One dozen *[**Ma** takes one dozen in the dozen box].* How many units there are?
- **Ma**: Zero
- **VO**: Do we take little cubes?
- **Ma**: Nothing *[**Ma** shows her empty hands]*
- **VO**: Nice, and in this one how many dozen there is?
- **Ma**: 2 *[she points the number with her finger at the same time; then she takes two dozen in wood]*
- **VO**: And how many units?
- **Ma**: zero
- **VO**: So, shall we calculate? *[**Ma** writes 20]* Are sure of your results?
- **Ma**: No
- **VO**: Look carefully, how many dozen do you have?
- **Ma**: Ah, 3 and 0 *[for the units]*
- **VO**: How many does it make?
- **Ma**: It makes, 30 *[FRA2Robert_Pri_Sch_Image_3_ScaffoldingMathActivities]*

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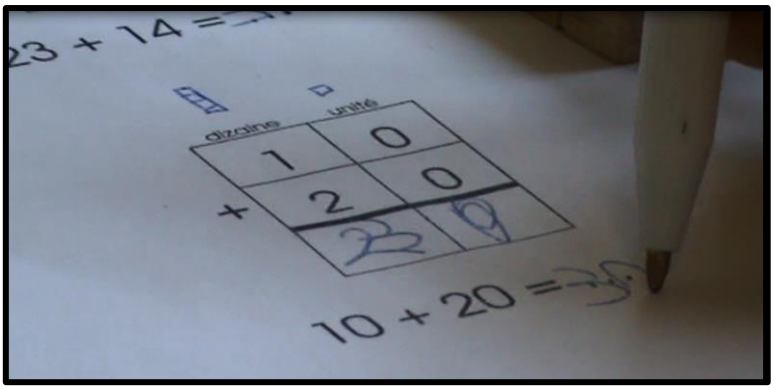

FRA2Robert_Pri_Sch_Image_3_ScaffoldingMathActivities

Opportunities for science learning

This narrative episode stresses how the proximal zone of development (Vygotsky) can be established between:

- an adult, who does not have received any specific training to teach as she is a volunteer,
- a child, **Ma** which is far from to be able to make additions by her own, and
- the material (FRA2Robert_Pri_Sch_Image_2_ScaffoldingMathActivities). The next activity is linked to addition.

The volunteer helps the child to focus her attention on each step of the procedure to succeed additions, for example: to identify correctly dozens and units in numbers. In this episode, even if appropriated material is provided to the child, **Ma** needs to learn how to use it. For example, the child has to pick up the appropriate number of wooden cubes and bars. But frequently, the child makes mistakes. When she sums up the cubes, for example, she counts more than one time or forget cubes (they have the same shape and color). A solution suggested by the adult is to put away the cubes already counted. Progressively, the child will be able to do the required steps to make additions alone and to understand deeply how it works. The wooden material allows the child to become progressively autonomous. Latter, the same material is used for subtractions.

Opportunities for creativity

The second narrative episode is creative in the sense that the child manipulates a rich material and because an adult scaffolds her and discusses with her. Nevertheless, the most creative use of the material appears as soon as the child has acquired the ability to use it in an autonomous way.

Conclusion

To conclude, the objective of the volunteer is here to foster **Ma**'s mathematical processes skills. A consequence of the activity is also to foster social and affective factors of

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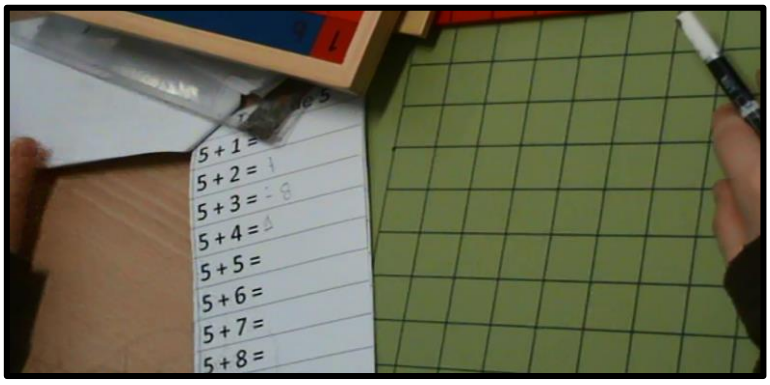
mathematical learning through the volunteer scaffolding. As in the first narrative episode, the activity is conceived to foster cognitive dimension nevertheless, it fosters learning social dimension. By using dialogue and collaboration, the volunteer tries to motivate the child. She helps her to solve problems when she has no specific training to do that. It can be supposed that the material helps her to produce appropriating scaffolding. Indeed, as in the first narrative episode, the material provides to the children is rich and help them to construct progressively abstract knowledge and processes. Nevertheless, the second narrative episode stresses that the material by itself does not allow children to be autonomous, and knowledgeable. Explanations and habits have to be developed to use it appropriately.

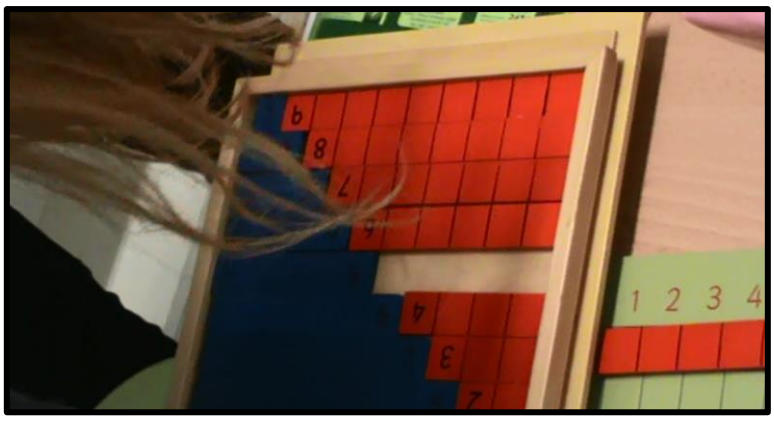
3.2.2.3 'Addition': FRA2Robert_Pri_Sch_FiedNotes_Video_Addition

Introductory comments

This activity is usual in Montessori's school. A child has to complete a sheet of paper where the addition table of 5 is written without the results (FRA2Robert_Pri_Sch_Image_3_Addition), to do that she has at her disposition some material (FRA2Robert_Pri_Sch_Image_1_Addition). The next episode involves mainly one child. Episode duration is 4 minutes.



FRA2Robert_Pri_Sch_Image_3_Addition



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FRA2Robert_Pri_Sch_Image_1_Addition

The material is composed by a slim box where each number is represented by blue wooden bars (1 to 9, where each unit which composed the number is delimited) and red wooden bars (1 to 9, where each unit which composed the number is delimited). The material is interesting and allows to see that the 'one' blue bar associated to 'nine' red bar make ten (etc.). Moreover, there is a green 10X10 cases piece of wood where children can place the blue and red bars to solve additions.

The activity initiated by the child (one of her exercise of the day, c.f. work plan) is realized in autonomy even if on adult comes to remind her how the material work at the beginning of the narrative episode.

Pedagogical framing

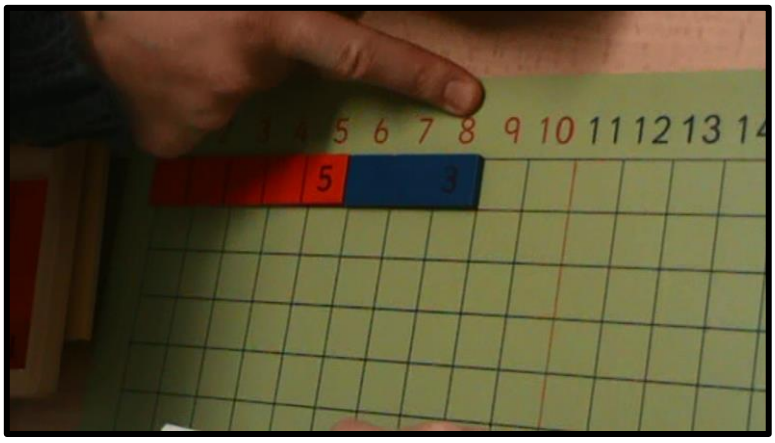
This kind of activity is a usual one to introduce addition tables to children. It allows children to get familiar with them.

Material constitutes the pedagogical framing for the child to manage to complete the 5 addition table. Moreover, in her case, teachers try to foster her autonomy because she depends a lot from adults.

Pedagogical interactions

One of the adults is there for a child with specific needs. She reminds to **Em** how to use the material (FRA2Robert_Pri_Sch_Image_2_Addition).

- **Pe**: You place the 5, the 3 you look above and you find the result. 5+3 make 8. Then, you put back the 3 and you follow with the 4.



FRA2Robert_Pri_Sch_Image_2_Addition

Then, **Em** follows the exercise. Nevertheless, each time she places a new blue bar, she pushes the red one. This unexpected use of the material entails progressively wrong results

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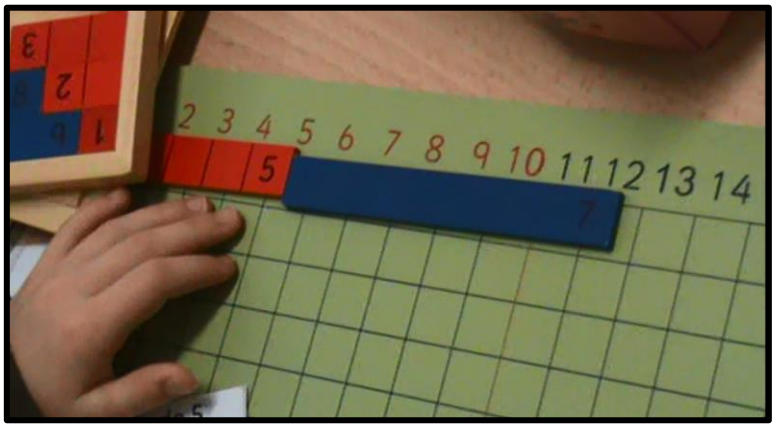
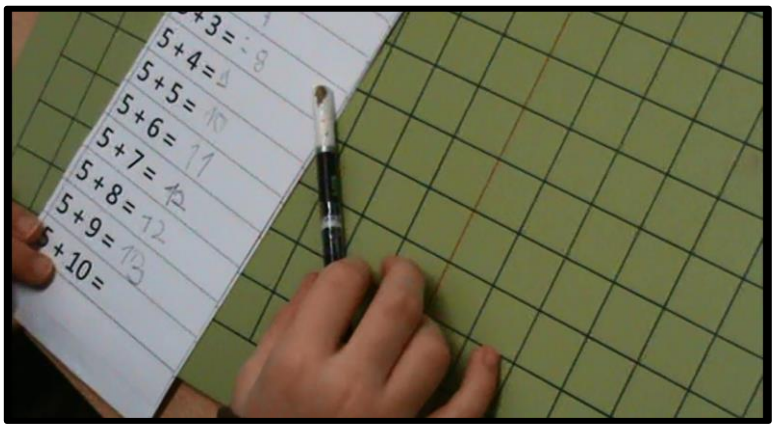
to the addition.

- *When **Em**, tries to add 7 to 5, she starts to have difficulties, because she has pushed the bar of five so the bar of seven do not fit to the 12 case (*FRA2Robert_Pri_Sch_Image_4_Addition***)**.*



FRA2Robert_Pri_Sch_Image_4_Addition

- *When she will add 8 to 5 she will find also 12, then the mistake will be reported on the next addition 5 plus 9 will make 13* (FRA2Robert_Pri_Sch_Image_5_Addition).



FRA2Robert_Pri_Sch_Image_5_Addition

Opportunities for science learning

In the third narrative episode a young child makes the addition table of 5. Because she doesn't use appropriately the material she makes mistakes. Her work will be check latter by the teachers and new scaffolding will propose to her.

Here too the material is really interesting because it helps children to construct a deep and concrete understanding of additions and of number composition. The material is conceived to allow the child to represent in a concrete way how does 5+3 make, for example.

It can be supposed that the child is not so familiar with the material. In a way, she is still

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exploring it. Indeed, she doesn't paid attention that she is pushing progressively the bar of five out of its initial case. So, the observed result became wrong when the child add 5 + 8. Because the child doesn't understand that she has made a mistake, she needs some help from adults or from older friend to go ahead.

Conclusion

To conclude, material on its own is not sufficient for children to discover and to build scientific or mathematical content or processes. Adults or experimented children scaffolding allow children to understand material use. Nevertheless, rich material and appropriated scaffolding lead to autonomous development.

3.2.3 Summary and conclusions

3.2.3.1 Learning

The teacher's approach and more globally Montessori's main goal is to allow children to construct themselves. In this context learning activities is one of the mean to achieve this goal. Leaning in science allows children to understand and to get familiar with their environment. For example, a great importance is given to children surrounding ecosystem. The river, the farm, the trees, the birds, and the plants constitute elements of reflection and of knowledge contents regularly enhanced. Questioning and reasoning are foster during informal time, when the class is group at the end of the afternoon. The material plays a crucial role in this approach. It is conceived, in mathematics and in science, to help children to go step by step from concrete observations to abstract constructions.

Moreover, children seem to be aware of their level and competencies and are able to explain it.

3.2.3.2 Interest and motivation

Children's self-confidence and self-construction are enhanced each day by the context in which their evolved, and by adults' scaffolding. Because children's work has been conceived to fit to their own progression and their own capacities, their interest and their motivation are fostered. The time children spend on specific activity depend on their capacities. In other words, if a child is good in mathematics and not in science, he/she is able to spend more time in science than in mathematics. The consequence is that:

- Children own rhythm of learning is respected, and
- Children fell to be good in their job and enjoy it!

Finally, interest and motivation are also enhanced because concrete examples are picking up from their environment. For example, in science children were working on the water cycle and they were invited to go to the river to make experiments and observations.

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3.2.3.3 How do teachers perceive their role in doing so?

Teacher's role is to provide each child specific scaffolding depending on what he/she needs. For example, high potential children require specific attention because their relationship to their work is linked to their relationship with adults. Teacher needs also to provide specific attention to children to help them to go into work. For some children it is not obvious nevertheless, they are peaceful when they do it. To manage to offer those moments to children is one of the goals of the teachers. Finally, teachers in the Montessori's school seem to be 'next to' and not 'in front of' the children. In other words, teachers seem to guide children into their learning and their own construction more through teaches them scientific or mathematic contents. This specific position is allowed by the rich material available to the children.

Finally, according to Robert his role is:

- 'to leave notions marks in children's imagination by allowing them to reproduce experiences, to present their own works. It is also to provide children opportunities to participate to different actions and to situations.'
- 'to dramatize the way to realized workshops, to make them more attractive: for example to light on candles, to speak in a low voice or with another tone, to inspire passion and wonderment'.

3.3 Case 3 – 'Rollande': How to scaffold children's experimentation

3.3.1 Context

Where?	Country	France			
	Setting name	FRA3			
	Location within setting	Pre-school			
Who? (children)	Year group/age of children	Reception 3-4 years old			
	Number of children in class	26			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher and 1 teaching assistant			
	Case teacher role	Coordinator			
When?		1	2	3	4
	Dates of visits	17/01/13	24/01/13	07/02/13	14/02/13
	Times of visits	Morning	All day	Morning	All day

3.3.1.1 School/setting

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FRA3 is a public pre-school in Beauvais, a city at 83 km in the North of Paris (c.f. Map of the city's location in France).

Map of the city's location in France

Six classes compose the school where 150 children from 2 to 6 years old evolve. It is located in a specific area called "ÉCLAIR" since 2011. For that, the school receives more funds and can employ more persons compared to other schools. This school is engaged in the initial formation of future teachers as most of the teachers are training teachers. Because of the specific location of the school, the language is the main objective of this kindergarten school. In FRA3, there is 1 director (released from teachings), 3 teachers and 4 training teachers, 5 teaching assistants, and one person for a child with specific needs. In FRA3, most the children don't go at the childcare center in the morning or in the evening.

School hours are: Monday, Tuesday, Thursday and Friday: 8:20-11:20/13:20-16:20

3.3.1.2 Teacher

The teacher, Rollande, is experienced. She used to participate in researches on human sciences (in psychology and in didactic of science). She is familiar with her job as she teaches for more than 20 years. She is a training teacher who likes science. Her last project with a researcher was about the running of a vacuum cleaner.

For our venue, Rollande has decided to work on "slides". She has divided the progression in four workshops. The first one was dedicated to body testing, in the gymnasium (the entire class of 26 pupils, about 30 minutes, repeated 4 times, c.f. trying to slide into the gymnasium).

Trying to slide into the gymnasium

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The second workshop was dedicated to test different objects chosen by the children in the classroom on cardboard plank (workshop with 6 children, around 20 minutes, c.f. objects testing on cardboard planks).

Objects testing on cardboard planks

The third workshop was more experimental as the teacher construct objects with different texture for children to test them on cardboard plank (workshop with 6 children, around 20 minutes, c.f. Material).

Material

During the fourth workshop, pictures of the previous workshops were proposed to children to help them remember what they have done and to write down in their science book why and how to slide (workshop with 6 children, around 20 minutes, c.f. example of the content of the science book).

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Example of the content of the science book

3.3.1.3 Classroom

There are 26 children of 3-4 years old in Rollande's classroom. Five or 6 of the children have another mother tongue language. The classroom is organized into different corners (nursery, kitchen, garage, library, drawings space, and a collective space, c.f. garage and drawing corners, and c.f. map of Rollande's classroom). Each day, children participated into different workshops: two in the morning and one during the afternoon. The teacher is helped by a teaching assistant.

Garage and drawing corners

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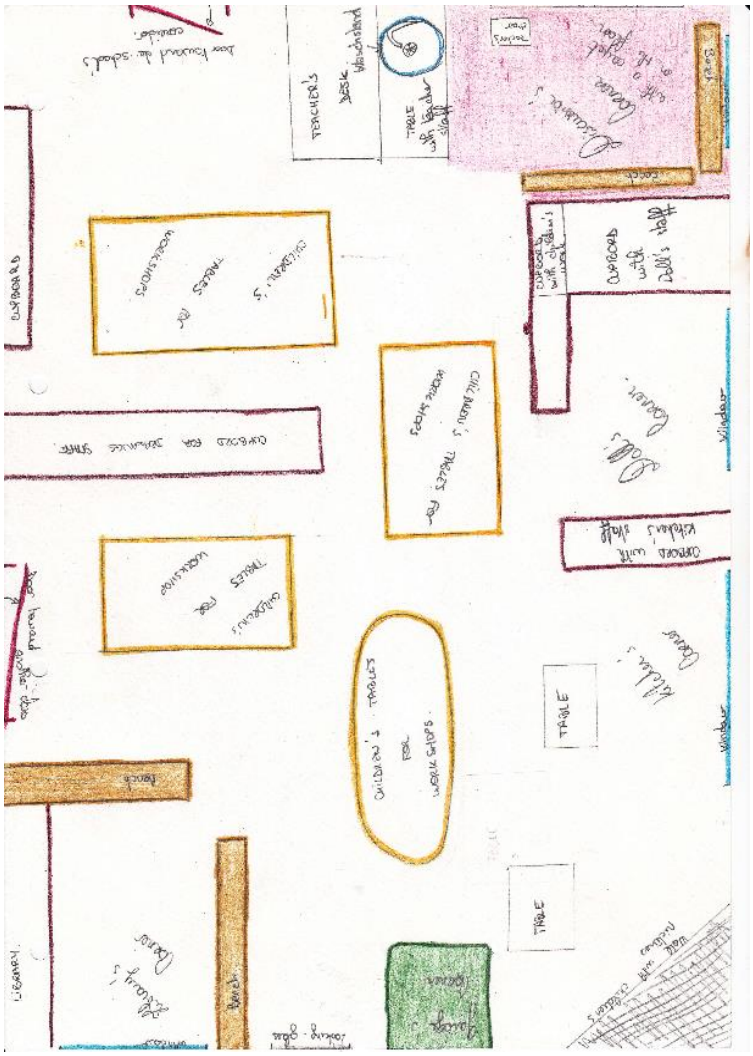

Map of Rollande's classroom

3.3.2 Episodes

The next three narrative episodes are linked to 3-4 years old children's discovery of slide in little groups (5-6 children). Each narrative episode comes from the second workshop dedicated to test different objects chosen by the children in the classroom or prepared by the teacher on cardboard planks.

- In the first narrative episode, children try to make objects slide during a free playing time. Teacher's observations of children's interactions provide to her the opportunity to stress one of the most important aspects of slide, plank's tilted.
- In the second narrative episode, the children and the teacher make slide objects on one tilted plank, and encounter difficulties with an ambiguous object: a wad half in plastic and half in moss.
- In the third narrative episode, the teacher asks children to predict and to categorize

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into two different boxes objects depending on their capacity to slide or not.

Before those three narrative episodes, the teacher spent a long time in the gymnasium to make children slide, to make them feel how to slide, and to make them think about how to slide. At the end of each workshop, in the discussion corner, children share their experiences and present their work to their friend. This moment constitutes the opportunity for the teacher to precise appropriate words linked to slide for example.

3.3.2.1 'Providing Scientific Words':
FRA3Rollande_Pre_Sch_FiedNotes_Video_ProvidingScientific

Introductory comments

This activity, from which this episode is drawn, focuses on objects' slide. Objects' slide is not a traditional activity realized by pre-school teachers, but the way to process fit to curriculum expectations in science. 'Slide' is a new topic for the teacher. The activity has been initiated by the teacher, and involved children working in a small group in the garage's corner (n=5-6 children).

The first narrative episode duration is around 2 minutes. Children are exploring sliding of objects on planks of cardboard, each child has a plank. They are free in their objects choices. Interactions occur between them, and with the teacher. Teacher's role is mainly to keep children into the main objective of the activity: to make slide objects, and not roll.

The main focus of the episode offered here is two children, **Bo** and **Gi**, who discover that the tilt of the plank has an influence on object's slide.

Pedagogical framing

Teacher's approach is similar across the three episodes. Rollande values inquiry-based science education and tries to encourage children to investigate their own hypotheses. She has a clear idea about her goal, but the way to achieve this goal is mainly determined by children. This is even more obvious here because slide constitutes a new and unusual topic for her.

This activity was framed as a workshop time dedicated to a few children each time. The teacher emphasizes to the group the importance of testing and experimenting objects on the plank. She encourages original ideas as to place upside down cars to make them slide and not roll. She also focuses language mastering as it is one of the principal goal of her pre-school.

At the beginning of the workshop, the children were sitting at a table but encounter difficulties to hold up the plank and to drop on it objects. In fact, they were too small to do it, so the teacher suggests going to the garage's corner in order to have more place.

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During the episode **Gi, Bo** and the **teacher** are mainly involved in the interaction.

Pedagogical interactions

Bo and **Gi** play together. **Bo** tries to make a tractor slide, and **Gi** plays with the tilt of the cardboard plank. The teacher interferes because children are arguing. **Bo** explains with his own words that **Gi** prevents him to make slide the tractor, because she holds up the plank.

- **Bo:** *[**Bo** starts to grumble against the **Gi** when she holds the plank horizontal]* No! Not that! *[He moves the plank].*
- **Gi:** Hey! *[She holds horizontal the plank].*
- **T**: *[Seeing what happen]* "**Gi**, don't break the plank… *[**Bo** starts again to push the tractor on the horizontal plan.]*
- **T:** No, **Bo** we want it slides… Becarefull!
- ***Bo**: [**Bo** answers something incomprehensible and touch the plank]*
- **T:** What ? The plank is up ? Yes, what happen ?
- **Bo:** Holding *[**Bo** points at the same time **Gi's** hand on the plank]*
- **T:** Is it sliding ? Show me…
- ***Bo**: [**Bo** pointing at **Gi**]* **Gi** is holding… **Gi**!

Then, the teacher encourages children to continue their experimentation. She allows and sustains them in order to explain, with their own words, the influence of the plank's tilt on object's slide.

- **T: Gi** holds it… and what? What is happening? Go on…
- *[**Bo** puts the tractor on the horizontal plank and nothing happen.]*
- **T:** Does the tractor slide?
- **Bo:** No.
- **T:** No?
- ***Bo**: [Both children think]* **Gi** is holding.
- **T: Gi** holds it that is why! What can we do?
- ***Bo**: [**Gi** and **Bo** move oblique the plank]* Like this.
- **T:** Yes, you have to tilt it!

Opportunities for science learning

Children play freely and teacher tries to remind them that objects have to slides. What is interesting is that children can try the objects they want to. This way to process allows them to test their own ideas, and to build their proper comprehension of object's slide. The boy and the girl on the left side of the picture play together (FRA3Rollande_Pre_Sch_Image_1_ProvidingScientific). Trough they play and trough the teacher's observation, they discover and express that the plank's inclination has a great influence on objects' slide.

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FRA3Rollande_Pre_Sch_Image_1_ProvidingScientific

This awareness is foster by the teacher scaffolding. She asks questions to **Bo** and **Gi,** and she fosters their reasoning and reflections. In order to help children to express that the tilt of the plank influence objects' slide, she uses evidences gather by observation and by using equipment.

Opportunities for creativity

The creative aspects of this narrative episode are linked to the rich physical environment in which children make their explorations, their testing, and their manipulations. Here teacher's scaffolding allows children's awareness through their interactions.

Moreover, children actions and interactions constitute the resource for the teacher to achieve the goal of the workshop.

In FRA3, language mastering is the first goal of the school because many children have poor language or other mother tongue language. So, according to the teacher *'science' activities constitute a good opportunity to introduce new words'* (e.g. tilt, roll, moss, etc.).

Conclusion

To conclude, young children's exploration of the material seems to be a crucial step when a new one is provided to them. It allows them to become familiar with objects. Moreover, free playing constitutes a rich context for creative dispositions and understandings.

This first narrative episode shows that free playing constitutes an opportunity for children to explore interesting phenomenon, such as the inclination of the plank, but also to make links between language and actions (tilt versus roll).

In this narrative episode, the teacher's pedagogy focuses on play and exploration, dialogue and collaboration, and scaffolding.

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3.3.2.2 'Scaffolding Children's Experiences': FRA3Rollande_Pre_Sch_FiedNotes_Video_ScaffoldingChildrenExperiences

Introductory comments

This activity, from which this episode is drawn, focuses on objects' slide. More precisely, children discover here the influence of the objects' material on their capacity to slide. Objects' slide is not a traditional activity realized by pre-school teachers but the way to process fit to curriculum expectations in science. Slide is a new topic for the teacher. She has conceived those workshops for our venue. The activity has been initiated by the teacher, and involves children working in a small group in the garage's corner (n=5-6 children).

The second narrative episode's duration is around 1.30 minutes. Children are testing objects' slide on one a tilt plank of cardboard in the garage corner. They attention is focused on an ambiguous object, a wap.

Pedagogical framing

Teacher's approach is similar across the three episodes. She has a clear idea about her goal in the activity, but the way to achieve this goal is mainly determined by children's actions and interactions. This is even more obvious for teaching slide which constitutes an unusual topic for the teacher.

The second narrative episode follows the previous one. The group organization has changed, one plank of cardboard is placed in a tilt position, the children and the teacher are in front of the plank to test objects. In the second narrative episode, children are interested by an ambiguous object: a wad which is half in moss and half in plastic. This material slides, or not, depending on which side is placed on the plank. Through this example, children discover that the material in which an object is made influences its way to slide.

Moreover, teacher has brought some material in two boxes. In one of them objects slide well, while in the other one they don't slide. Teacher fosters children's reasoning, encourages them to touch the objects to make predictions about those objects. The teacher scaffolds children's reasoning (**Bo** and the wad) to help them to express what their have in mind.

During the episode **Gi, Bo** and the **teacher** are mainly involved in the interaction.

Pedagogical interactions

The teacher tries to help children to make predictions before to test the object on the plank.

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- *[The teacher shows a black box to the children. In this box there are different objects, some slide really well others not. Those objects have been identified before the workshop by the teacher]*
- **T**: Which one slides the best? Which one slides good? Go one, try…
- ***T**: [**Bo** picks up an object in wood and he drops it from the top of the plank. At the same time, the teacher asks to the children to look what is happening]* Is it a good slide?
- **Children**: Yes!
- **T:** Yes, it slides good…

Children are interested in a specific and ambiguous object a wad. It is half in plastic and half in moss. So it slides well on a side but not on the other side. In the next extract, it can be supposed that **Bo** has already in his mind this idea but do not manage to prove it with the material.

- **T**: [*Then, **T** asks to **Gi**, which object she wants to try. **Gi** shows the wad which is half in plastic and half in moss].* The wad, what will happen with the wad?" *[**Bo** moves his head]*
- **T**: Paul thinks that it will not slide?
- **Gi***: [lets go of the wad on the plank, looks at the teacher]* Yes! *[For, yes it slides].*
- **T**: **Bo** shows us why you think the wad will not slide.
- **Bo**: No, like this *[**Bo** looks at the mossy surface and drops the wad on the side which is half in plastic and half in moss. The wad slides.]*
- **T**: Like this, does it slide?
- **Children**: Yes!
- *[During this time, **Bo** tries another side of the wad, but chooses the face full of plastic.]*
- **T:** And like this?
- **Children**: Yes *[**Bo** gives the wad to **Gi**]*

Then, the teacher asks to make good slide with the wad. **Bo** places it appropriately on the plastic side. When, she asks children to predict what happens on the other side of the wad, **Bo** explains clearly that it doesn't slide.

- **T**: Like this, it makes a good slide… and on the other face, what happens?
- **Bo**: It doesn't slide. *[**Gi** takes the wad and drops it on the plank on the mossy surface. The wad stays.]*
- **T**: Why it doesn't slide?
- **Bo**: Because, there… [He shows the mossy surface with his hand and looking at the teacher; FRA3Rollande_Pre_Sch_Image_1_ScaffoldingChildrenExperiences]

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FRA3Rollande_Pre_Sch_Image_1_ScaffoldingChildrenExperiences

- **T**: What is it?
- *[**Bo** answers something difficult to understand]*
- **T***: [**T** interprets]* It is something to efface… It is like moss, it called moss I think.

Moreover, children touch with their hand object's material:

- ***Gi** looks at the wad and puts it on her cheek*

Opportunities for science learning

In this second narrative episode children discover that depending on the material of the object, it slides or not. Indeed, plastic slides well on cardboard, but moss doesn't. This awareness is relevant to objects' slide. The teacher fosters children reasoning to make them understand that depending on the object's surface the object slides differently. Moreover, she asks them to make prediction, and make links with language acquisition (e.g. moss).

Opportunities for creativity

The wad is, as the scissors in FRA1, an ambiguous object which is at the sources of a complex reasoning. The wad fosters children's interest and curiosity. Indeed, depending on which side is placed on the plank it slides or not. The main creative aspect in this second narrative episode appears in the interaction between **Bo** and the teacher when she scaffolds him because she has notice that **Bo** has something in mind, and tries to help him to explain it progressively.

Conclusion

To conclude, to foster children's reflection and reasoning the teacher uses one set of material: objects are tested one by one, on one plank of cardboard. It can be supposed that, because in the first narrative episode children have time to explore the material, they can concentrate themselves now on one set of material. Problem solving and agency are at

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the center of the teacher's pedagogy. She provides comments and explanations about children experiments. Here, she scaffolds their explorations of the material by providing some rules: children have to look at what happen, and try to understand why an object slides or not. With her attitude, the teacher manages step by step to provide children new knowledge and to foster their understanding of scientific content. In this context children can develop general skills and attitudes for learning, and understand the process of the scientific inquiry.

3.3.2.3 'Predictions and Categorization': FRA3Rollande_Pre_Sch_FiedNotes_Video_PredictionsandCategorizations

Introduction and comments

This activity from which this episode is drawn focuses on objects' slide. More precisely, children are encouraged to categorize objects' depending on their ability to slide or not. Objects' slide is not a traditional activity realized by pre-school teachers but the way to process fit to curriculum expectations in science. Slide is a new topic for the teacher. She has conceived those workshops for our venue. The activity has been initiated by teacher, and involved children working in a small group in the garage's corner (n=5-6 children).

The third narrative episode's duration is around half past 4 minutes. Children are exploring sliding of objects a plank of cardboard. They have to predict and explain why a specific object slides or not. Interactions occur between them, and with the teacher. Teacher's role is to encourage children to make predictions, to explain their own point of view and to rephrase their explanations when it is necessary.

The main focus of the episode offered here become children and the teacher who try to categorized in two boxes objects depending on their ability to slide or not.

Pedagogical framing

Teacher's approach is similar across the three episodes. She has a clear idea about her goal in the activity, but the way to achieve this goal is mainly determined by children. This is even more obvious for teaching about slide which constitutes an unusual topic compared to magnet for example.

This activity is framed as a small-group activity with discussions between children and scaffolds by the teachers. The small-group and the teacher are sitting together on the garage corner. The goal of the activity is to categorize objects depending on one of their properties: to slide or not on the plank of cardboard. Rollande emphases and encourages the group to reason and to make assumptions before testing objects. It means to make a prediction and try to find a justification each time.

Pedagogical interactions

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In the next exchange it is the first time that children are encouraged to classify the objects depending on their capacity to slide or not. It can be stressed that firstly the teacher provides an example with the lady-fly. Then, she asks and so encourages the children to do the same with the sponge.

- ***T**:* So… What have we seemed…? The lady-bird makes good slides... We place it on this side. The sponge, will it slide? *[**T** gives the lady-bird to **Bo**]*
- **Bo:** Yes *[he feels it and says]* It is moss!
- **T:** It is moss, yes… *[**Bo** drops the sponge.]*
- **T:** Look! What happens?
- **Children:** It doesn't slide
- **T:** It doesn't slide… We will place in the blue box the objects which slide badly.

In the next exchange, children are looking for objects which slide well. They are interested by the wad (half in plasticine and half in moss). They just have categorized the mossy part of the wad in the box where objects badly slide. Now they are looking at the plasticized part of the wad, just by touching it they can categorize in the appropriated box. Then, children will try the gum which is a new objects compared to the wad.

- *[Children touch and try plasticine and place it in the appropriated box. Plastic bear, then they try other objects from the classroom.]*
- **T***:* What does the gum do?
- **Gi***:* It doesn't slide.
- **T**: Where does the gum go? *[**Gi** puts the gum is the appropriated box]* In that box!

Opportunities for science learning

Teacher's approach fosters children's reasoning and reflection. Free playing is not the context of this activity. Now, children have to anticipate what happens to specific objects. To manage to make predictions they can discuss and touch objects (FRA3Rollande_Pre_Sch_Image_1_PredictionsandCategorizations).

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FRA3Rollande_Pre_Sch_Image_1_PredictionsandCategorizations

Then, they can make the test, and choose in which box the object should go. The teacher enhances children's science process skills and their capacity to carry out scientific inquiry or problem-based approaches. Here, the focus is mainly on cognitive dimension as the teacher fosters questioning, gathering evidence, observing and running experiments, making connections. Nevertheless, the social dimension is also present as exchanges are running between children and with the teacher. As in the previous narrative episodes, the teacher encourages and fosters children to formulate their own explanations of their observations.

Opportunity for creativity

The creative aspects of the third narrative episode are linked to the pedagogical approach used by the teacher, and the context in which children evolve. Children can discuss. They play to drop object on the plank, at the end of the workshop children make races between different objects. They reason at the same time (does the object slide or not, why?). Moreover, the teacher mostly follows children experiences. She encourages them to build they own representation and to test it. Indeed, when children have tested all the objects she has prepared before, she asks them to go in the class to try other objects.

Conclusion

To conclude, with this last activity the teacher helps children conceptualize they experiences and to develop general skills and positive attitudes for learning. They also develop their capacity to carry out scientific inquiry or problem-based approaches. Here children understand that depending on the object's material it can slide or not.

3.3.3 Summary and conclusions

3.3.3.1 Learning in science

Teacher's learning activities in science are really well conceived and repeated. She provides the time to children to construct their own understanding. When the researcher comes, she observes one workshop each time, but the teacher make daily reflection during 4 or 5 weeks on slides!

Interestingly, the teacher has introduced the topic by making children slide in the gymnasium. Children have felt in their body the notion. Then, through free play and exploration they have discovered that the 'tilt' of the support, and the 'object's material' interfere the object's slide. Then, they were invited to test the same objects cover by different surfaces on a plank and finally to explain through pictures taken during previous workshops what they have done and to write it down their observations in the science book. This approach stresses teacher's experience for this kind of project.

Here, children are helped to construct progressively a complex notion. Scientific content is

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provided when occasion appears. Scientific processes are involved in children exploration, experimentation and play. Scientific learning is fostered because time is provided to explore deeply natural phenomenon in many contexts (e.g. children slide on the snow).

3.3.3.2 Interest and motivation in science

Because the teacher likes to do this kind of project, children's interest and motivation have been fostered. Children are happy to try new motion such as slide. They were working on roll a few months ago. Most of the time, the teacher has a main objective in her head, but children's interactions guide the workshop. She is able to pick up interesting discovers or results and to transform them as key elements of the workshop. In other words, even if the teacher has an idea of her goal, she is flexible and mainly focuses on children progression to provoke the entire group's progression. The consequence or the result of this attitude is to enhance the importance of children play, explorations and experimentation and so their motivation to do good job.

3.3.3.3 How do teachers perceive their role in doing so?

Rolland's role in science activities is to provide a context and material with which children can play, explore and make experiments. Then, her role is to enhance, to foster and to pick up appropriated behaviors, to recognized pertinent observations and to share them. Finally, she helps children to remember and to cogitate on their experiences in order to put them into words, to make sense on what their have done.

According to Rollande:

- Teaching has to be flexible, to scaffold and to answer to children own questions.
- The teaching attitude has to help children to listen to each other and to encourage them to express themselves.
- Situations have to be repeated several times with little change to be acquired by most of the children.
- Teachers have to suggest and not to impose their own point of view.

Moreover, according to her, her role is:

- To follow preschool curriculum's prescriptions in science, even if it is not really developed in this science. Then, she takes into account language as it constitutes the first learning domain in preschool. Then, she tries to take into consideration children needs: manipulations, actions, explorations, do something and do it again in order to understand.
- To achieve this goal, she offers rich and motivating situations, which are attractive for the youngest children. Those situations have to foster surprises and

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questionings. Her role here is to foster exchanges, to rephrase children's speech, to structure them in order to allow any children to share their own experiences and their own discovering.

3.4 Case 4 – 'Nani': How to foster children understanding of numbers

3.4.1 Context

Where?	Country	France			
	Setting name	FRA4			
	Location within setting	Primary school			
Who? (children)	Year group/age of children	Grade2 7-8 years old			
	Number of children in class	28			
Who? (adults)	Number of adults	1			
	Role of adults	1 teacher			
	Case teacher role	Lead teacher, sole responsibility for the class			
When?		1	2	3	4
	Dates of visits	14/01/13	15/01/13	05/02/13	19/02/13
	Times of visits	Morning	Morning	All day	All day

3.4.1.1 School/setting

FRA4 is a public school in Châtillon closed to Paris (c.f. Map of the city's location in France).

Map of the city's location in France

Fourteen classes receive children aged from 6 to 12 years. This school is old as it has opened its doors at the end of the XIX^{ème} century. FRA4 is a big school, with one room for the teachers, one for computers, one to make sport, one for children to eat (etc.). In the

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school there is 1 director (released from teachings); 10 teachers and 3 teachers' educators.

School hours are: Monday, Tuesday, Thursday and Friday: 9h-12h20 / 13h20-16h20

3.4.1.2 Teacher

The teacher, Nani, is confident in her knowledge and her competencies. She is teaching for many years, and she is a training teacher. Most of the time, she uses Ermel's method. It is mainly based on concrete problems solving and manipulation (e.g. examples of exercises and assessments in mathematics). Nani has had an interesting approach in her career. She has done her entire teaching at the same level (Grade 2). Year after year, she has made a deep analysis of each of the teaching's domain. For example, she has carefully analyzed the official documents proposed to the children. She notices some problems. For example, in French 'a' and 'à' are used differently depending on the context. When children have to complete sentences with 'a' or 'à', she notices that the answer 'à' is always placed before 'a'. According to her, children can understand the rule as: 'à' is always in first, instead of, 'à' or 'a' depends on the sentence. When she teaches, she tries to foster children's knowledge construction and avoids learning by heart (e.g. Examples of exercises and assessments in mathematics).

Examples of exercises and assessments in mathematics (on the right side: how much money did you spend for the Mary Christmas dinner?)

3.4.1.3 Classroom

In Nani's classroom, there are 28 children most of them are 7-8 years old, except 4 who are 6-7 years old. The classroom's organization is classical with children's tables in front of the blackboard (c.f. Map of Nani's classroom). Nevertheless, many staffs are in the classroom, teacher's colleagues use to say that her class is the cavern of Ali Baba. Some snails and insects are feed by the children each day. Some materials in mathematics are present. For example, the teacher used to make with children meter, with 3 strips where numbers can

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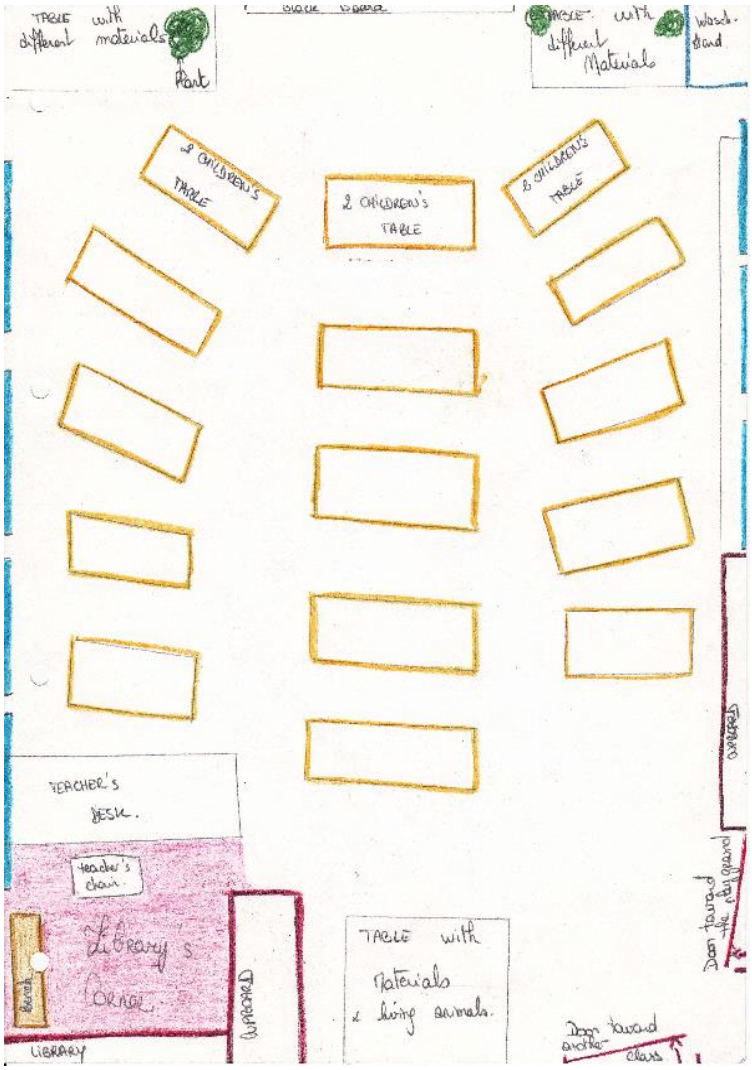
slide from 0 to 9. There is a corner with books where children can read. This corner is also used by children to go back on their work when they don't manage exercises. In the class, there are many plants any seeds bring by children.



Map of Nani's Classroom

3.4.2 Episodes

The next three narrative episodes are linked to 7-8 years old children's activities in mathematics in entire group.

- In the first narrative episode, children's goal is to count how many ice creams have been eaten by the teacher (FRA4Nani_Pri_Sch_ Image_1_IceCreamSticks). The entire narrative episode is based on this topic, i.e. how a group of children can count a big number of ice cream sticks. What are the possible strategies? How do children manage to agree on common solutions?

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FRA4Nani_Pri_Sch_ Image_1_IceCreamSticks

- In the second narrative episode, the children and the teacher come back on this previous work and try to use appropriately the new material constitute by the different groups of ice cream sticks. They count (groups of ten, groups of hundred and group of thousand ice cream sticks) and write in a mathematic way the number of ice cream sticks. Moreover, in this narrative episode a child asks an important question *'Why are there three zeros in one thousand*'. The teacher and the children try to find a solution.
- In the third narrative episode, we see how a little girl manages to count a five hundred of trees in a few minutes.

3.4.2.1 'Ice Cream Sticks': FRA4Nani_Pri_Sch_FiedNotes_Video_IceCreamSticks

Introductory comments

This activity from which this episode is drawn formed part of a classic topic on numbers' composition and decomposition. Mathematics is done regularly in Nani's classroom. But today, she proposes a specific kind of lessons to children called a 'lighthouse lesson'. Numbers' composition and decomposition incorporates different curriculum areas aside from mathematics: discussion, collective decision making, and citizenship behavior development. The activity initiated by the teacher involves children working in whole-group but also by pairs of two at tables.

The children work in whole-group to decide appropriate strategies to count the big number of ice cream sticks. Then, by pairs at table they manipulate the material. Lesson's duration is about one hour and a half. Children's job is to imagine a collective strategy to solve teacher's problem: how to count a big number of sticks. The collective strategy is build step by step through collective discussions. The teacher scaffolds and helps to organize a democratic discussion and decision making. Pairs of children put into practice collective decisions to count the ice cream sticks at tables.

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Pedagogical framing

Teacher's goal is to allow children to understand numeration functioning, i.e. the transition between units to dozens, then the transition between dozens to hundreds, and the transition between hundreds to thousands. According to Nani, it is an interesting activity for children who have difficulties because they can focus their attention on units and dozens and for gifted children because they can focus their attention on bigger numbers such as hundreds and thousands.

This activity is framed as a whole-class lesson with whole-class discussions alternation with manipulations by pairs of children's on their tables. Nani emphasizes the importance of thinking in order to find solutions to the problem. She also enhances the importance to listen each children's suggestion in order to make awareness decisions. She explains during the interview the importance of the *'democratic'* dimension of this activity. Moreover, one of the important aspects of Nani's pedagogy is to encourage children to explain their own view, or understanding. Indeed, if teachers cut down children's explanation, they may stop children's learning. Furthermore, she encourages collaborative work between gifted children and children with difficulties by placing them together for specific occasion (*'**T**: **Au** could you come to work with **Ma?')*.

The first narrative episode retraces the entire workshop. Teacher's goal is to let children explore the material, and find a strategy to count the ice cream sticks.

Pedagogical interactions

Nani's way to propose the problem:

- **A child**: You have eaten all of them? *[he is talking about the ice cream sticks]*
- **T**: Yes, I've eaten all of them, can you imagine it*?* According to you, how many are they?
- **Children**: 100, 2000… More than 100…
- **T**: That is what I want to know, how many ice cream I've eaten…

At first, a child suggests counting the ice cream sticks every two. It is an interesting idea, but it is not the one that Nani is expecting (every ten is more appropriated toward her goal). Nevertheless, because in her approach the best solution is collectively decided, she doesn't make any comment on this specific solution.

- **T**: So, how will we do to know how many ice cream sticks there is?
- **A child**: We will count them.
- **T**: To count them, yes… **Sh?**
- **Sh**: We will take them every two and count them.
- **T**: To take them every two… and count them…
- **Some children**: Every ten
- **A child**: Every twenty.

It is quite clear for children that democratic solution deciding is their way to do daily activity

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('***Sh**: The children on the tables, if they agree…'*). According to Nani, this kind of lesson can be proposed to the class only when this classroom functioning is accepted and acquired by children.

- **T**: Hey children, 10 seconds of attention. **Sh** has said that after we will count and see how many ice cream sticks there is.
- **A child**: Yes, but we have to agree on something
- **T**: We have to agree on something. And, we have to be able to check. If you say to me "they are 48", I have to be able to check that they are 48!
- **Hi**: We will count them again!
- **T**: Again?!
- **Sh**: The children on the tables, if they agree, will count every 10, when they will have the correct number and we can do 10, 20, 30 and it doesn't take a lot of time, and we will be able to know the number.
- **T**: Ok, it doesn't take a lot of time to do 10, 20, 30, 40… Do every bodies count every 10? Does someone count every two? Ah, why do you count every ten all?
- **Children**: Because it goes faster!

The teacher fosters children reasoning and expressions of their own solution and collective decision making. It can be noticed that children develop a large understanding of number through the activity. Numbers are not just representing ice cream sticks; they are useful to count faster (e.g. *'hundred is easier'*).

- **T**: Wait, wait, and listen, there is another idea which is arriving, listen, then we will choice the best idea, the easiest to count. **An** you say that we have to make?
- **An**: Hundreds.
- **T**: Packets of 100, because you have a lot of dozens…
- …
- **T**: So do we make packets of 100? Or, the other idea is to count all the dozens on the table the other idea is that we take all the units on the tables to make dozens. So what do we do?
- **Al**: If you count all the dozens on the table you can forget some… when hundred is easier.

Opportunity for science learning

During the first narrative episode, children try to make sense to number's composition and decomposition. Teacher's goal is to make them understand, for example that 10 units compose a dozen, or that 10 dozens compose one hundred, and so one. To manage that, she asks them to count more than 2 thousand of ice cream sticks (FRA4Nani_Pri_Sch_ Image_2_IceCreamSticks).

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FRA4Nani_Pri_Sch_ Image_2_IceCreamSticks

This kind of situation is relevant to the Ermel's approach. Children manipulate a lot, make assumptions, and try to find solutions collectively. Through this activity they manage to decompose big numbers. Moreover, children construct an interesting material for future activities. They replace a big amount of ice cream sticks by a clear and simple organization of ice cream sticks. More precisely, they organize them in different kind of groups: 10 units are held together through elastic string, 10 groups of 10 units are placed into plastic bags, and 10 plastic bags are placed into aquarium (FRA4Nani_Pri_Sch_ Image_3_IceCreamSticks).

FRA4Nani_Pri_Sch_ Image_3_IceCreamSticks

This material follows children for the entire school years. In the future, the teacher will send them to the ice cream sticks corner for any difficulty with numbers. Manipulation, reflection, reasoning, problem solving and agency constitute relevant aspect of this narrative episode.

Opportunity for creativity

Creativity is foster here at each step of the progression of the workshop. In fact children

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have to find by themselves the best strategy to count the big amount of ice cream sticks. Teacher's role is mainly to choreograph the discussion, to stress important ideas, and to ask children to make choices between different strategies. Children have to reason, to find solutions, but also to listen other suggestions and to decide democratically which solution is the most appropriated and why.

According to Nani '*this approach suits entirely with the idea of the curriculum to help children to become citizens*'. Furthermore, the presence of a challenge, counting such an amount of ice cream sticks, enhances children's curiosity and motivation. Moreover, collaboration and dialogue constitute key aspect of the process because children have to count by group of two, and the entire class's work allows them to succeed.

Conclusion

To conclude, cognitive and social dimensions during this learning activity are clearly foster by the teacher. For that, a rich physical and mathematical environment is proposed to the children. At each step of the collective strategy's construction toward the solution, Nani fosters dialogue and collaboration.

3.4.2.2 'Three 0 In Thousand': FRA4Nani_Pri_Sch_ FiedNotes_Video_Three0inThousand

Introductory comments

This activity from which this episode is drawn formed part of a classical topic on numbers' institutionalization. Mathematics is done regularly in Nani's classroom. This episode has been recorded the day after the previous one and it is linked to it. The institutionalization is initiated by the teacher, and involves children working in whole-group but also in pairs at their table.

The children worked in whole-group and by pairs in alternation. Children's job is to draw the number of ice cream sticks found the day before on their exercise's book, then to write it with appropriated number. At last, with the teacher, children are encouraged to find and explanation to a specific question "why is there three zeros to one thousand?" This question has been initiated by one of the children at the end of the lesson.

Pedagogical framing

Nani's main goal for this activity is to do the institutionalization linked to the previous 'lighthouse lesson'. The second unexpected goal is to help children to understand:

- What zero is useful for?
- What zero does mean?

This activity is framed as a whole-class lesson with whole-class discussions alternation with children's own works (e.g., drawings, complete a sheet of paper). Nani emphasizes the

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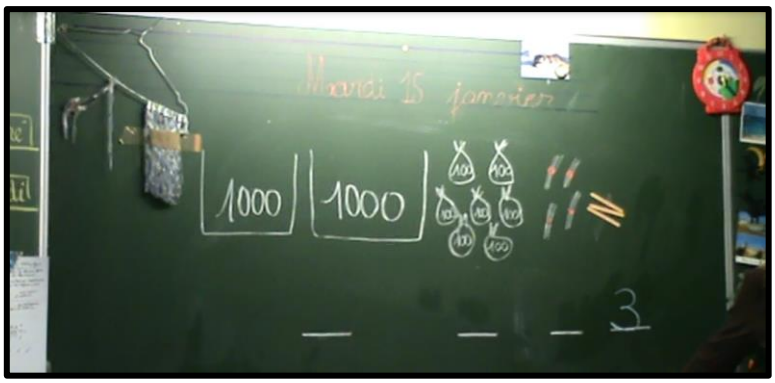
importance of understanding that each number, from a bigger one, represents a specific number of ice cream sticks. Nani makes links between the previous activity (i.e. to count a big number of ice cream sticks) and the way to write numbers in mathematics. For that, she has drawn on the blackboard the aquariums (thousand), the bags (those which cannot go in the aquariums), the dozens (those which cannot go in the plastic bags) and the units (those which cannot go in the dozen; FRA4Nani_Pri_Sch_Image_1_Three0inThousand). As she says, is what is *'writing'* what is *'heard'* (e.g., 200 and two hundred).



FRA4Nani_Pri_Sch_Image_1_Three0inThousand

She also encourages children to ask questions *'I cannot resist… Those questions are really interesting and important; they show that children are thinking on what we are doing in classes'*.

Pedagogical interactions

The next extract is an example of the institutionalization of the numbers (FRA4Nani_Pri_Sch_Image_2_Three0inThousand).

FRA4Nani_Pri_Sch_Image_2_Three0inThousand

- **T**: 4 dozen *[**T** writes below of the 4 packets of 10 sticks, the number 4*.] Does everybody understand? How many bags of hundred?

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- **Ad**: 7
- **T**: I don't hear you. 7 don't…
- **Ad**: 7 hundred
- **T**: 7 hundred, this is why we say 700. There is 7 hundred so 7 bags of hundred *[At the same time the teacher shows the 7 bags of hundred sticks on the blackboard and the number 7 written below].* So it does?
- **Children**: 700
- **T**: Seven hundred forty three… nevertheless, here we have, in more…
- **A child**: A two
- **T**: A two, and why a two?
- **A child**: Because two thousand, in the two boxes there is thousand, so it makes two thousands.
- **T**: That is it *[she writes the number 2 below the two drawing boxes on the blackboard]*. So it is placed this way, because it is thousand boxes. So, it as usual, as the number you did know in grade 1, it is what we hear, all right?

The teacher likes to provide little tricks to children to manage in mathematics...

- **T**: Be careful, more the packet is big more it goes which side?
- **A child**: More there is dozen
- **Another child**: More it goes on the thousand side
- **T**: On the left side, on the right side, on the left on the right? *[**T** shows directions with her hands].* By this way *[right hand up]* or by this way *[left hand up].*
- **Children**: the thousand!
- **T**: Bigger the bag is, more we go *[**T** moves toward the thousand side of the number writing on the blackboard].*
- **Children**: Thousand, trillion.
- **T**: We go on the left side. Ok? And the smaller, when there is few? When there is few, it is?
- **Children**: Units
- **T**: Units, yes

Nani uses to enhance children to ask questions to foster their reflection and their reasoning. Here, a child comes to her to ask a question:

- **T**: Ah! We have a great question *[a child has just come to the teacher to ask her something]…* It is quite complex, it is quite complex, but all right… So, we help **Hi** to answer to his question. His question is, why there is three zero for thousand?

To solve the problem, Nani uses the material and the blackboard. The child who has asked the question is invited to take an aquarium where there is one thousand. Then, the teacher asks him and the class how many hundreds, dozens and units are left? It takes a while, but children find that there is no more hundred, no more dozen or no more unit. In other words, there is zero hundred, zero dozen and zero unit. So three zero in one thousand!

- **T**: Comes and takes thousand here *[**T** asks to **Hi**, to take 1000 ice cream sticks].* Show to everybody what is 1000 *[**Hi** takes a box of sticks, **Picture3, 5.26***

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FRA4Nani_Pri_Sch_Image_3_Three0inThousand*].* Is that 1000?

FRA4Nani_Pri_Sch_Image_3_Three0inThousand

- **Children**: Yes
- **T**: Wait a minute *[**T** writes on the blackboard: units, dozen, hundred, thousand]* How many boxes of thousand do you have now?
- **Hi**: One
- **T**: Does everybody agree?
- **Children**: Yes
- **T**: **Lé** listen, **Au** be careful. There is one box of thousand, so I write 1 *[below thousand].* All right? And now, how many hundred do you have? *[*FRA4Nani_Pri_Sch_Image_4_Three0inThousand*]*.How many hundred do you have?

FRA4Nani_Pri_Sch_Image_4_Three0inThousand

- **Hi**: 10
- **T**: Are you sure?
- **Hi**: No
- **T**: How many hundred do you have in our hands? *[Looking at the class].* How many hundred have him, when the box is closed?
- **Children**: 10, 0, 10, 1000, 0…

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- **T** *[about the dozen]:* Yes but they are inside, they are in the 1000!
- …
- **Em**: Zero
- **T** *[looking at **Hi**]:* Do you agree? So, zero in the hundred *[**T** writes down the number 0 below of the hundred column. Then the teacher follows, for the dozen and the units, and count 1, 2, 3 zero]* Is *that ok?*

Opportunities for science learning

Children have to make the links between the number of thousands, hundreds, dozens and units found the day before and the mathematical way to write numbers, i.e. two aquariums of one thousand each means 2 000, 7 plastics bags of one hundred each means 700, 4 groups of ten ice cream sticks each means 40, and 3 ice cream sticks means 3. According to Nani, the institutionalization is one of her *'favorite moment'* when she does this topic.

Then, because of a child question, the whole-group tries to find a solution, so to make assumptions and to use the material to answer to the question. In a way it is the first time for the class that they use the material as a resource or a cognitive tool.

Opportunities for creativity

Nani's way to teach is really creative because children are invited to manipulate, to test on materials their own ideas, and to suggest them to the group. Children are encouraged to ask questions, to make comments and to construct with the teacher their learning. Here, as the teacher says, she uses children talks to feed her objectives. In her pedagogy, she uses play and exploration, motivation and affect, dialogue and collaboration, problem solving and agency, questioning and curiosity, reflection and reasoning, scaffolding and involvement. Moreover, she uses observation of concrete material to construct abstract knowledge.

To assess children, the teacher uses many different resources as children's drawing (e.g. she asks them to draw the number of ice cream sticks found the day before) or exercises (e.g. third narrative episode).

Conclusion

To conclude, cognitive and social dimensions are closely linked and fostered during this second narrative episode. Questioning, reasoning, reflection are attitudes regularly required by the teacher to feed her interactive lessons. Mathematical abstraction is build day by day and step-by-step.

3.4.2.3 'Children Strategy to Count': FRA4Nani_Pri_Sch_FiedNotes_Video_ChildrenStrategyToCount

Introductory comments

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

This activity from which this episode is drawn formed part of a classical topic on counting a big number of units. Mathematics is done regularly in Nani's classroom. This work has been initiated by the teacher. The children worked alone. Their job is to count the number of trees draw on their own sheet of paper.

Here children use their own strategy to solve the task. This work constitutes a relevant source of assessment for Nani.

Pedagogical framing

One of the official objectives in grade 2 is children to be able to know big numbers and to be able to decompose them. The next episode constitutes of a typical activity to achieve this goal. Moreover, it is framed as an individual assessment exercise realized by each child. During the episode involving **Es** below, there are in fact very little interactions between children or with the teacher. Interaction mainly occurs between **Es** and the researcher, when she has completed her work.

The third narrative episode focuses on **Es's** strategy to count a big number of trees drawn on a sheet of paper (FRA4Nani_Pri_Sch_Image_1_ChildrenStrategyToCount). According to the teacher, children strategy can be interpreted as a '*consequence*' or as a metaconceptual awareness of their understanding of previous activities (e.g. first and second narrative episodes).

FRA4Nani_Pri_Sch_Image_1_ChildrenStrategyToCount

Pedagogical interactions

On the picture (FRA4Nani_Pri_Sch_Image_2_ChildrenStrategyToCount) **Es** shows that she has stress 10 trees in line then, she has counted 10 trees in column and draw a line around the group of 100 trees. Then, she has counted the line by making 10, 20 (etc.) because on each lie there are ten trees…

- **'Es**: With a pen, I've count 10, and I've stress the trees [*she shows the 10 first trees from left to right, on the upper line on the sheet of paper*]. And, as I've ten, then I've just to do, 10,

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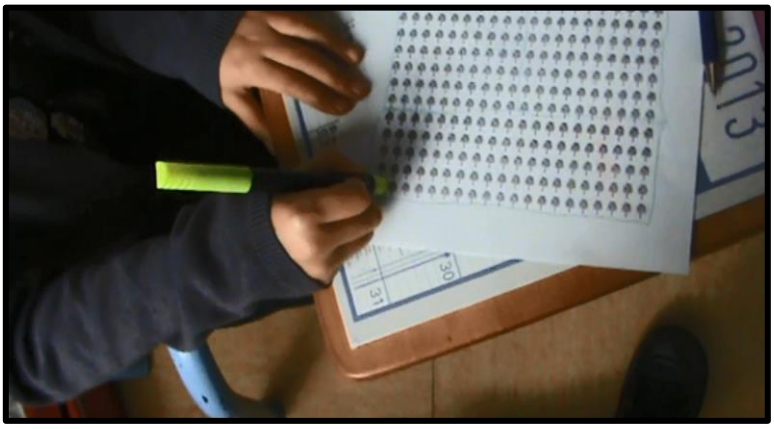
20, 30, 40, and that it [*she is counting the line bellow the stressing one*]'

FRA4Nani_Pri_Sch_Image_2_ChildrenStrategyToCount

Her difficulty was for the last group because there were only 50 trees at the bottom of the page. Nevertheless, because she has two times 50 trees, she manages to make another group of 100 trees (FRA4Nani_Pri_Sch_Image_3_ChildrenStrategyToCount; FRA4Nani_Pri_Sch_Image_4_ChildrenStrategyToCount).

- **'Es**: I've done the same think [*she shows me the next group of trees surrounded by a green line. Then, she shows another group of trees, which is quite flat compared to the other one*]. Here I didn't know how to do… Because here, it was 1, 2, 3, 4, 5 [*then, there is no more lines on the sheet of paper*]. It means that it is fifteen [*she shows the vertical line which makes the separation between the 20 trees in line*]. Because here it stop, I've send that there is fourteen here too [*she shows the other part on the sheet of paper*]. And fourteen add to fourteen make one hundred.'



FRA4SNani_Pri_Sch_Image_3_ChildrenStrategyToCount

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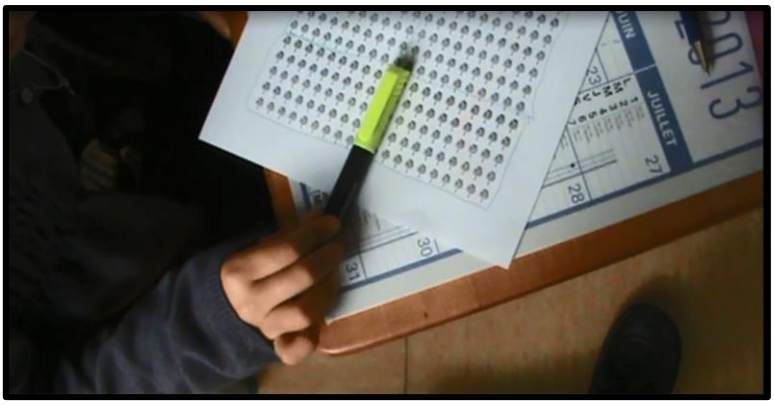

FRA4Nani_Pri_Sch_Image_4_ChildrenStrategyToCount

Then, she just has counted the groups of 100 trees in order to find the total number of trees in the sheep of paper.

- **Es**: So, I've counted things that I've surrounded with a green line. I've made *[she shows the one group of trees]*… I've said, 1, 2, 3, 4, 5 *[each time she shows me a group of trees].*
- **Me**: Yes…
- **Es**: So we have to write 5… and because they were no units or dozens, I've write two zero.
- **Me**: That is it, so strong! *[**Es** smiles]*

Her neighbor adopts another strategy. He has stressed 10 trees on each line and tries to count the number of lines. Because they are many lines in the column, he lost himself regularly (FRA4Nani_Pri_Sch_Image_5_ChildrenStrategyToCount). Another child, competent in mathematics, stresses groups of trees ten by ten with different colors. It can be suppose, that at the end she will count one by one each group of ten trees.

FRA4Nani_Pri_Sch_Image_5_ChildrenStrategyToCount

Opportunities for science learning

The proposed activity allows children to use already known process or knowledge associated to counting. For example, **Es** is able to do and to explain clearly her strategy to manage the activity. By solving the task as the child does, she shows that she has

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understood number's composition. It can be stressed, that the activity has been adjusted to children by providing a sheet of paper where the number of tress differs depending on their abilities.

Opportunities for creativity

In the third narrative episode, the main creative aspect is that children are allowed by the activity to explore their own strategy to solve it. They can see by themselves if their own strategy is efficient or not. Moreover, it is a really interesting support for the teacher to have an access to each child own development. Another important aspect of such exercises is that they allow the teacher to enlarge children competencies, and her understanding of their aptitudes in mathematics. Indeed, here, a gifted child in mathematics doesn't use the most appropriated strategy, contrary to the girl under focus in this narrative episode.

Conclusion

To conclude, Nani proposes to children short exercises which can be more or less difficult depending on each child level, and checks how children solve those specific tasks. Those individual works are even more interesting in the sense that, most of the time, the classroom is working collaboratively. Here the aim of the activity is for children to develop mathematical process skills and problem-based approaches. This kind of assessment is interesting because it contrasts with more usual evaluations which are frequently stressful and nerve-ranking times.

3.4.3 Summary and conclusions

3.4.3.1 Learning in mathematics

- Nani fosters children learning in mathematics by proposing to them: experimentations and concrete problems solving
- Progressive way to access to abstract contents and strategies.

Moreover, by their activity children construct material which constitutes an important and collective resource for future problems solving in mathematics. So by their activities children, learn contents, develop understanding and process in mathematics. Moreover they construct collective resources. Teacher fosters children learning also because she adapts her lessons and her exercises to children own development (e.g. counting the trees).

3.4.3.2 Interest and motivation in science

The teacher fosters children's interest as she proposes mathematical problems to them which are not traditional exercise in mathematics, for example: *'how many ice cream sticks do I have eaten?'* Here, collective and collaborative reflexion and reasoning in mathematics is required. So the social and the cognitive dimension are mixed. Moreover, Nani uses to make jokes, and suggests tricks to understand and remember contents or process. Interest

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and motivation are also foster because the teacher allows children during collective time to talk slowly. During those moments, children exchange on their misunderstanding, to find common solution. Here too, the material is rich and the teacher is really scaffolding.

3.4.3.3 How do teachers perceive their role in doing so?

Nani's role is to provide to children the best context, material and support she can. Nevertheless, depending on the year she has more or less efficient group. She likes dynamic group, where interactions, learning and teaching become natural. Her role is to foster interactions, collaborations, democratic discussions and choices. Her role is also to foster children affective dimension of learning. But most of all, she is there for children who have difficulties, as she says '*the other will be ok*'. To help children with difficulties she uses to place for specific activity which require reflection, reasoning or problem solving, gifted children who agree to help their friends. It constitutes an interesting dispositive for both kinds of children to develop social and cognitive attitudes.

Nani's thoughts:

- 'A child who learns has to question his/her own old believes, then he/she can manipulate, then he/she understand and then, he/she can use his/her new learning. '
- 'Children are like me when I receive a new washing machine; they try to use previous strategies. Sometimes it works, but most of the time new strategies are more efficient.'

3.5 Case 5 – 'Joelle': How to count during daily activities

3.5.1 Context

Where?	Country	France			
	Setting name	FRA5			
	Location within setting	Pre-school			
Who? (children)	Year group/age of children	Reception 3-4 years old			
	Number of children in class	26			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher and 1 teaching assistant			
	Case teacher role	Co-coordinator			
When?		1	2	3	4
	Dates of visits	17/01/13	24/01/13	07/02/13	14/02/13
	Times of visits	Morning	All day	All day	All day

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3.5.1.1 School/setting

FRA5 is a public pre-school in Beauvais, a city at 83 km in the North of Paris (c.f. Map of the city's location in France).

Map of the city's location in France

Six classes composed the school and received 150 children range from 2 to 6 years old. It is located in a specific area called "ÉCLAIR" since 2011, for that the school receives more funds and can employ more persons compared to other schools. This school is engaged in the initial formation of future teachers as most of the teachers are training teachers. Because of the specific location of the school, the language is the main objective of the kindergarten school. In the school there is 1 director (released from teachings), 3 teachers and 4 teachers' educator, 5 teaching assistants, one person for a child with specific needs. Most the children don't go at the childcare center in FRA5.

School hours are: Monday, Tuesday, Thursday and Friday: 8:20-11:20/13:20-16:20

Teacher

The teacher, Joelle, is experienced and she is a training teacher. She is found of craft workshops. Since few years (because of school's collective projects) she starts to do more activities in science and mathematics. According to her, teachers have few resources to do project linked to science and mathematics. For Joelle, mathematics as science need to have concrete echoes for children. For example, it is interesting for children to count until 4, because most of the children in her classroom have 3 years old and some have already 4 years old. When the teacher does activities in mathematics she uses books where the progression into learning is presented step by step. She is really interesting and paid attention to children own strategies development to solve problems. Because of our venue, those elements have been even more in her focus. This teacher has introduced, this year, Montessori drawers in her class. According to her, they constitute interesting times because they offer to each child an individual moment of concentration. This activity is proposed when children come back from the siesta, to bring them progressively into collective times.

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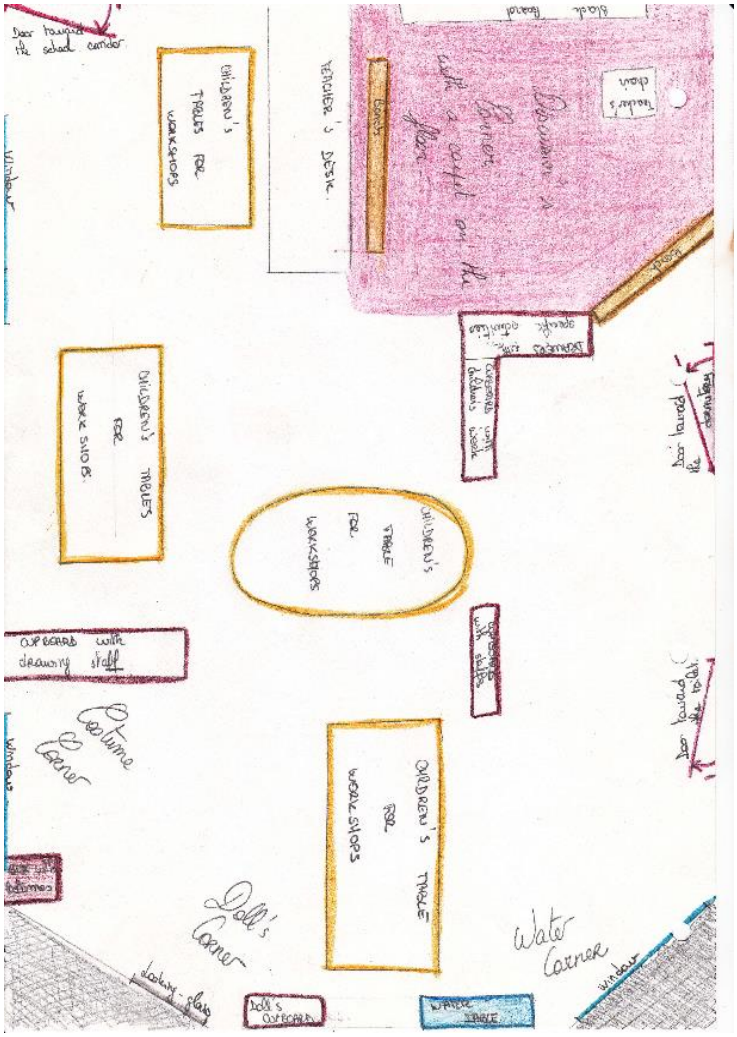
Classroom

There are 26 children of 3-4 years old in the classroom. Five or 6 of the children have another mother tongue language. The classroom is organized into different corners (doll's corner, costumes corner, water corner, Montessori's drawers, etc., c.f. Map of Joelle's Classroom). Each day, children participate to different workshops: two in the morning and one during the afternoon, and go to the gymnasium. The teacher is helped by a teaching assistant.

Costume corner



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Map of Joelle's classroom

3.5.2 Episodes

The next three narrative episodes are linked to 3-4 years old children.

- In the first narrative episode, we see how counting can be introduced in different daily activities proposed to children in pre-school.
- In the second narrative episode, the teacher leads an activity in the gymnasium linked to counting depending on different sounds she makes.
- In the third narrative episode, some examples of children exploration of Montessori's drawers are presented.

3.5.2.1 'Counting Absents': FRA5Joelle_Pre_Sch_FiedNotes_Video_CountingAbsents

Introductory comments

This activity from which this episode is drawn formed part of a daily ritual in the class. The ritual consists of presenting the date of the day, counting the children who are present and those who are absent. This activity incorporates a number of curriculum areas aside from mathematics indicates above: representing time and space, lecture (of the name), language (etc.). The activity initiated by the teacher, involves the whole-group of children in the discussion corner.

The children work as a whole-group and answer altogether to teacher's questions. The aim of this activity is to introduce the children to numbers.

Pedagogical framing

According to the teacher, "*at the beginning of the school year I say who is absent and who is present. Then, progressively, we count how many children are absents. Here, the goal is to allow them to acquire knowledge link to ordinal numbers (1, 2, 3, etc.). I use hand in paper to foster children understanding of constellations (on dice). I use them for children to know cardinal numbers as well. For example, when I show them a three fingers hand they have to say three, without counting 1, 2 and 3. In other activities we will place one counter on each finger to make something like constellations on a dice. At the end of the school year, I will introduce numbers. I use to talk about children age, because it constitutes an important source of counting for then. Even at home, parents show them their age with fingers. So children age, counting candles constitute important mean to teach and learn in mathematics as it is linked to children daily life".*

Pedagogical interactions

In the first interaction extract, the teacher and the children count the number of children who are absent. The teacher uses her finger to do it, child do the same. Then, she will use

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paper hand as another support for counting.

- **T**: With **Ea**, it makes?
- **Children**: One
- **T**: With **Da**, it makes?
- **Children**: Two
- **T**: And with **Am**, it makes? *[The teacher shows with her hand and add a finger for each child,* FRA5Joelle_Pre_Sch_Image_1_CountingAbsents*]*

FRA5Joelle_Pre_Sch_Image_1_CountingAbsents

- **Children**: Three
- **A child**: Three children are absent
- **T**: There are three children absent. So *[the teacher takes some hand represented in laminating paper].* Come one **Ga**, where is the three? *[The teacher shows **Ga**, three hands one represent "1", another "2", and the last one "3"/ **Ga** shows the appropriated hand, so the teacher shows them to the other children. Who show me also the appropriated hand?* FRA5Joelle_Pre_Sch_Image_2_CountingAbsents*].* This one? Yes, how is absent? We have said, **Ea**, **Am** and **Da** *[each time the teacher shows one finger of the represented hand with three fingers up].* Yes, it makes three.

FRA5Joelle_Pre_Sch_Image_2_CountingAbsents

The second extract stresses one of the main aspects of Joelle approach of teaching in mathematics or in science. According to her, the content which is teached to children has to

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be linked to children's daily life. For example, learning to count until 4 is coherent in the sense that children have 3-4 years old.

- **A child**: After I will have three years.
- **T**: You, you have 3 years, and **Ne** have got 4 years *[the teacher shows 4 fingers].* Everybody has 3 years, only **Ne** et **Vi** have 4 years

Opportunities for mathematical learning

In the first narrative episode, the teacher asks the children to count the number of absent children. Then, to enhance the counting aspect of the activity she presents to children the corresponding number of fingers and children imitate her gestures. According to Joelle, it is important that children learn not only the name of the number but deeply understand that two correspond to one plus one. So each time Joelle does counting with children, she uses to add a new finger with her second hand. Latter in the morning a little group of children make a workshop link to a mathematical activity. Their task is to make a birthday cake with material for the birthday of teddy bears. The objective of the activity is also to place the right number of candles on the cake depending on the age of the bear (1, 2 or 3).

To use a rich material which means the same thing (e.g. 1 can be represented by one finger or a paper hand with one finger up) constitute of helpto young children to develop their understanding of numbers. It is even more important for children who have another mother tongue language because of their difficulties with language. Nursery rhythm constitutes another way to introduce number to children in their daily routine.

Otherwise, in the narrative episode counting is used to know how many absents are in the class, but also to discuss about children age. According to the teachers, the knowledge content has to be presented in contexts which make sense for children.

Opportunities for creativity

The creative aspect of teaching in pre-school, and even for 3-4 years old children is to manage to use a same content with different contexts, in other words, to make links across domains.

Creative aspects of the teacher's lesson are to manage to introduce mathematical content into daily habits. It is also, to use different supports to sustain children's attention and reasoning.

Conclusion

To conclude, the aim of this activity is to start to develop general skills and dispositions for mathematical learning. Furthermore, the teacher's goal is to provide children's knowledge and understanding of the mathematical content. The activity is mainly focused on cognitive dimension even if social dimension is involved too. Teacher's pedagogy focused on the role

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of dialogue.

3.5.2.2 'Bodies counting': FRA5Joelle_Pre_Sch_FiedNotes_Video_BodiesCounting

Introductory comments

This activity from which this episode is drawn formed part of a class topic on mathematics lasting several weeks. The activity is initiated by the teacher, and involves children playing in whole-group in the gymnasium to investigate what would represent one and two. Depending on a noise made by the teacher children have to be alone or to group themselves by two.

The children work altogether and help each other when it is useful. The aim of the activity is for the children to investigate the different ways to count, here through their bodies' action.

Pedagogical framing

According to Joelle*: "As in the previous narrative episode, the goal is here to foster children number's construction. The idea is to allow children to fell in their body what is one and two. For some children it constitutes an interesting way to engage themselves into counting. I do the same when I ask then to line up in two or three. Those activities allow them to see that we count, not only to count, but because it is useful in daily life. It is the same when we play to the shopkeeper, we ask "one bread, please!" and children have to paid with one or two coins. It is really important to have real situations"*

Pedagogical interactions

Joelle encourages children's collaboration to succeed to the activity.

- *Children are walking/running around the houses [hoops] after a while the teacher makes the small bell ring. Children run in the room to find a house, when they do not move any more the teacher talks,* FRA5Joelle_Pre_Sch_Image_1_BodiesCounting

FRA5Joelle_Pre_Sch_Image_1_BodiesCounting

- **T**: So, are you all one by house?

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- **Children**: Yes, No
- **T**: Explain it to her **Sa**! *[**Sa** pushes her friend which is in the same house as her in another house*]. Good! **Ma** did you find a house? Go one that is it really nice. We said when the small bell ring it is one by house. Go one.

Because some children have another mother tongue language they can encounter difficulties:

- **T**: At the small bell we are one. *[Children adjust their place in the houses; some helps other to find a house,* FRA5Joelle_Pre_Sch_Image_3_BodiesCounting*].* **Ri**, when the small bell rings children have to be alone in each house. Well done **El**. *[One child is walking, and do not seem to know what happen].* **Ri** doesn't understand the language that is why. **Ri** you have to be alone in your house, one **Ri** *[teacher shows to **Ri** one finger].*

FRA5Joelle_Pre_Sch_Image_3_BodiesCounting

Teacher encourages children to evolve in the gymnasium to solve problem.

- **T**: How many are you?
- **Children**: Two
- **T**: What have we said *[the teacher shows one finger to the children]?*
- **Children**: Just one
- **T**: Yes, just one. So what do you have to do **Lé** and **Cé**? [***Lé** looks forward*] Yes, go one [***Lé** runs to another house, but where there is already a child*].
- **Children**: No
- **A child**: No, we have said one [*two other children come to help them*]
- **T**: That is nice.

Opportunities for mathematical learning

Children have been working on the numbers: 1, 2, and 3, for a few weeks now. They start to understand that one plus one composes the number two, and so one. Children go ahead compared to a simple learning by heart. In this narrative episode, the teacher asks them to group themselves as quickly as possible by two or to be alone depending on a noise she makes. This exercise is interesting as it provides the opportunity for children to play with

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their body on mathematical content. The number 'two' is no more an abstract number, it means in the activity, 'me and you'. Moreover, for the teacher, it constitutes a good source of assessment, which occurs in a playing context.

Opportunities for creativity

This activity is creative in the sense that it is unusual to make science or mathematics with our body. It constitutes an interesting to foster the interest of the children who have difficulties with abstract contents. Here, children who prefer to do things with their body can enter into mathematics learning. So, the activity constitutes a great opportunity to include more children into mathematical activities. Moreover, it allows children to consolidate they actual understanding by using it in different contexts. If the activity focuses apparently on cognitive dimensions, it also fosters social dimensions of the learning. Indeed, children exchange a lot and provide help to their friend which don't succeed. In other words, the activity fosters children collaboration (FRA5Joelle_Pre_Sch_Image_3_BodiesCounting).

FRA5Joelle_Pre_Sch_Image_2_BodiesCounting

Conclusion

To conclude, the main goal of the activity is to allow children to understand the difference between one and two. This knowledge/understanding of mathematical content is fostered by the teacher's pedagogy which is centered on play in the gymnasium. Children's motivation is foster because the activity is funny. Moreover, dialogue and collaboration, problem solving and agency are enhancing as children help each other to succeed. For those reasons it can be said that the learning activity focuses on cognitive and on social dimensions.

3.5.2.3 'Montessori's drawers':
FRA5Joelle_Pre_Sch_FiedNotes_Video_Montessori'sDrawers

Introductory comments

This activity from which this episode is drawn formed part of a class daily time. Joelle has

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decided this year to introduce Montessori's drawers. So, the teacher has introduced Montessori's drawers for children to engage themselves in peaceful time activities which foster many different developmental aspects (FRA5Joelle_Pre_Sch_Image_1_Montessori'sDrawers). Depending on the drawer chosen by the child the activities can be linked to science, to mathematics but also to any other domains. The activity involves children working alone in the class (at table, on the carpet in the discussion corner…).

FRA5Joelle_Pre_Sch_Image_1_Montessori'sDrawers

The children work alone on their own activity. When all of them are back in the classroom and awake the teacher stops the activity.

Pedagogical framing

According to Joelle, Montessori's drawers' goal is to: "focus children attention on to thread beads, to full up or empty containers (etc.). Most of the time, we have already done those activities in whole-group. With the drawers, children can do and do again those actions until they manage. For example, I've placed nest boxes in one of the drawers, I was sure that all children will manage, but it wasn't the case. You cannot make science with 26 children, but here children can by themselves explore material".

Pedagogical interactions

The teacher encourages children to explore the material and to let run their own imagination.

- *[**To** is the first child who comes back from the siesta. He tries to construct with the help of the teacher funny animals. In the drawer there is a cow, a horse, a giraffe and an elephant. Each animal can be separated in pieces: each time there is a body, 2 pairs of legs and a head. **T** suggests to the child to make funny animals. Nevertheless, **To** firstly constructs a giraffe.]*
- **T**: You have done a giraffe. Why don't you to mix them? *[**To** shakes his head to say no. So, **T** decides to make a funny animal].*

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- **T**: I will take the cow, the horse, elephant and… Giraffe's legs, that it! *[**To** laughs].* It is your turn makes a funny animal! Come one with the elephant, what can you do? *[**To** first behavior was to pick up the elephant's legs, but he changes his mind and pick up the horse's and the cow's legs and the giraffe's head].*
- **T**: Yes, they are so funny! Go one make another.

…

- **To** to **T**: Look how this one is funny *[*FRA5Joelle_Pre_Sch_Image_2_Montessori'sDrawers*]*

FRA5Joelle_Pre_Sch_Image_2_Montessori'sDrawers

- **T**: Yes it is funny. I don't know how we can call it? It is the half of an elephant with the half of a giraffe…
- **Me**: With a head instead of the legs
- **Teaching Assistant**: An "eraffle"?

Opportunities for science and mathematical learning

In the third narrative episode, the first child is playing with animals which can be deconstructed. The teacher asks him to construct funny animals. Interestingly, to achieve this goal the child has to know how to build a 'conventional animal' and to go ahead to construct funny animals. The second child has to place in three pots a specific measure of couscous. Through this activity, she is developing science process skills (FRA5Joelle_Pre_Sch_Image_3_Montessori'sDrawers). It is the same, for the third girl who is moving water with a syringe (FRA5Joelle_Pre_Sch_Image_4_Montessori'sDrawers). Here children can explore freely the material in this rich environment.

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FRA5Joelle_Pre_Sch_Image_3_Montessori'sDrawers

FRA5Joelle_Pre_Sch_Image_4_Montessori'sDrawers

The fourth child doesn't talk French language. He is exploring magnet (FRA5Joelle_Pre_Sch_Image_5_Montessori'sDrawers). According to Joelle, *'he really likes magnet, he takes this drawer each time!'* Those activities may enhance children's positives attitudes in science and mathematics.

FRA5Joelle_Pre_Sch_Image_5_Montessori'sDrawers

In the third narrative episode, the role according to play and exploration and the creative

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disposition offer to the children foster children creativity. Because, those activities are mainly individual they foster children agency. Nevertheless, children can discuss about their difficulties or explain each other what to do with a specific drawer when they have already made it. Furthermore, affective factors of science learning are foster.

Opportunities for creativity

Children positive attitude toward science and mathematics are here foster. Creative use of material is also possible and encouraged. Moreover, autonomy and agency are enhanced because of the specific pedagogical framing of the activities. This kind of dispositive is also creative for the teacher. Indeed, he/she can propose drawer's content in function of seasons or specific rituals depending on children's culture (e.g. to count, organized many fathers Christmas depending on their size).

Conclusion

To conclude, the third narrative episode stresses that Montessori's drawers can constitute an interesting tool to bring in 'classical' pre-school to help young children to come progressively from the siesta to collectives' times and to practices activities and develop children knowledge and positive attitudes toward science and mathematics. Moreover, those drawers help children to switch from individual time to collective time. Because the content of the drawers can change, the teacher can orient children's activities toward her objectives, moreover she can also propose to children specific activities to make them progress in precise domain.

3.5.3 Summary and conclusions

3.5.3.1 Learning in science and in mathematics

The teacher fosters children learning in science and mathematics by making links across domains. It seems important for young children (3-4 years old) to use a same knowledge in different domain to help them to construct an appropriate understanding of them. Moreover, she fosters learning by using different supports. It may allow children to understand what the focus of the teaching is (different representations of the number: words, fingers, sheet of paper representing numbers). Another important point is to link science or mathematics content to children's daily life (e.g. to learn 1, 2, 3, 4 when children have 3 years old). Finally, learning is foster because the teacher adapts the task to children actual level of understanding.

3.5.3.2 Interest and motivation in science

The teacher fosters children's interest and motivation by proposing to them regularly workshop linked to the same area of knowledge. This aspect allows children to progress week by week and to feel more comfortable to solve the activities proposed by the teacher. Moreover, she uses to make cakes, and use of that mathematical material.

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3.5.3.3 How do teachers perceive their role in doing so?

According to Joelle her role consists in:

- *I'm here to propose to children divers situations, then I focus on what they are doing to enrich and to prepare next activities. I can also proposed to them problem or challenges and help them to succeed. For example, I can provide them magnets or sticks for them to explore this material. Following my observations of their manipulations, I will realize a few workshops as making lines with sticks, or making square with sticks. Usually, I increase the number of constrains through the workshop progression until to achieve my initial goal (e.g. discovering of square).Yesterday, I've asked them to empty a tub full of san. They start to do it as they want, they can use spoons or buckets. Then, progressively I will ask them which one of both containers is the most efficient.*
- *I'm like an actor, or a conductor I think that the idea to focus on problematic situation at start can constitute a cross-domain approach also use in craft workshop, for example. You start from the larger then you reduce progressively your focus of teaching and learning.*
- *I think it is a great importance to provide time for learning, most of the time we forget that, even for future teachers we have to remember them that time is require and activities have to be repeated for children to construct deep understanding."*

3.6 Case 6 – 'Sandy and her dream team': How to foster children's exploration of their own world to create sense collaboratively

3.6.1 Context

Where?	Country	France			
	Setting name	FRA6			
	Location within setting	Pre-school			
Who? (children)	Year group/age of children	Pre-kindergartens 4-5 years old			
	Number of children in class	26			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher and 1 teaching assistant			
	Case teacher role	Coordinator			
When?		1	2	3	4
	Dates of visits	18/03/13	18/03/13	19/03/13	19/03/13

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	Times of visits	Morning	Afternoon	Morning	Afternoon

3.6.1.1 School/setting

FRA6 is a public pre-school in Beauvais, a city at 83 km in the North of Paris (c.f. Map of the city's location in France).

Map of the city's location in France

Five classes compose the school which receives 97 children range from 2 to 6 years old. FRA6's project is centered on children's capacity to speak, to browser a book and respect it, to relate, to understand, to create stories, to discover authors and illustrators, to listen adults' lectures, to read, to count collections and to play with mathematical nursery rhythm. In FRA6 there is 1 director (released from teachings), 2 teachers and 3 teachers' educator, 3 teaching assistants, three persons for children with specific needs.

School hours are: Monday, Tuesday, Thursday and Friday: 8:30-11:30/14:30-16:30

3.6.1.2 Teacher

The teacher, Sandy, is experienced and she is a training teacher. She has started her career in primary school. There, she realized that children have strong difficulties to solve problems in mathematics because the vocabulary is misunderstanding. She explains that when she asked the children to explain what they have understood, their explanations were far from the expected understanding. According to her, the comprehension of mathematics is a problem of language in pre-school. That explains why in her daily teaching practice, she takes a lot of time to help children to talk, and to express clearly what they have in mind. The teacher and the teaching assistant are close and have the same goals when they follow children. Children have to explore their own strategies, their own way to do things. Time is given for that. Moreover, collaboration between children is encouraged. This way to scaffold the children applied in all domains: when children want to talk, when they do mathematics activities (etc.).

3.6.1.3 Classroom

There are 26 children of 4-5 years old in Sandy classroom. Three children have another mother tongue language. One child with specific needs come each morning in the

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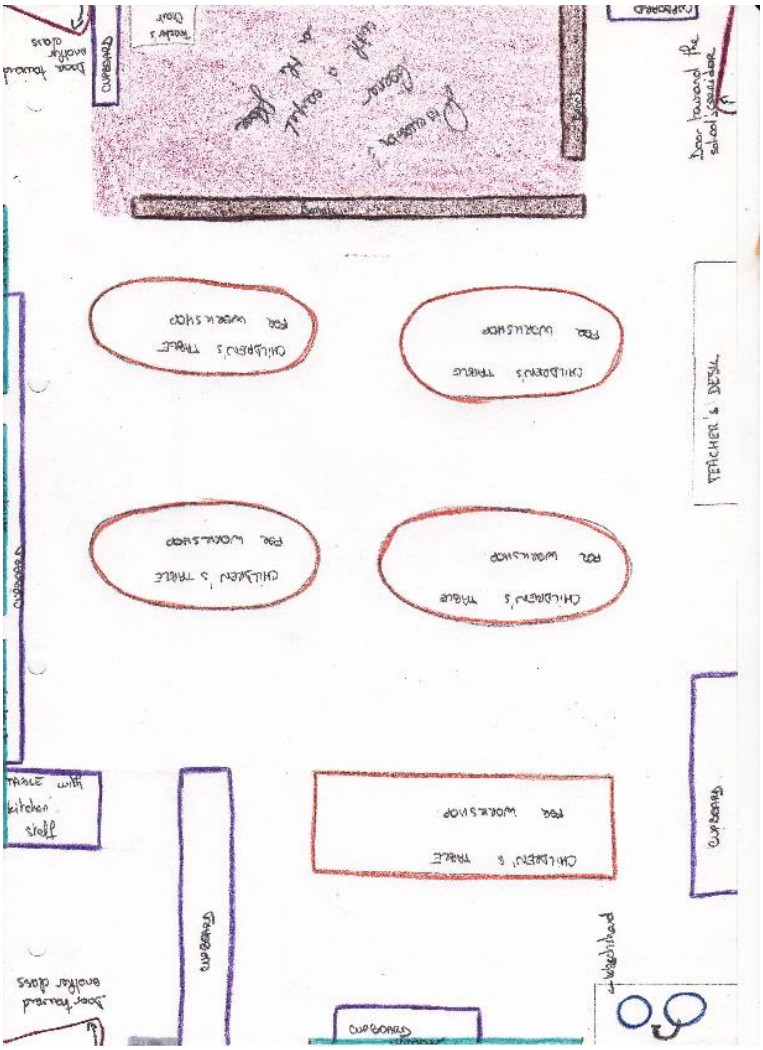
classroom. The classroom is organized into different corners (kitchen, garage, nursery, c.f. Map of Sandy's classroom).

Nursery and garage corners



Map of Sandy's classroom

Tables occupied most of the space where children make activities. Each day children participated to different workshops. Most of the time, they are linked to stories read in the

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class. For example, when the researcher went to make observations, the class was working for few weeks on the story of the three little pigs' house. Different versions of the story were presented to the children (cf. three pig's house story illustration in the classroom and in the school). Moreover, workshops in mathematics and in science were running around this story.

Three pig's house story illustration in the classroom and in the school

3.6.2 Episodes

The three narrative episodes are linked to 4-5 years old children's activities in mathematics and geometry.

- In the first narrative episode, the teaching assistant proposes to a small-group of children to share equally sweets which have been won by the three pigs at a concert.
- In the second narrative episode, the teacher introduces geometry during a daily activity. At this occasion, she makes a brief reminder of the square properties.
- In the third narrative episode, children are playing to a game involving a wolf against the three little pigs. For this activity, children have to use a dice and to count bricks to construct a wall to protect the three pigs.

3.6.2.1 'Share': FRA6Sandy_Pre_Sch_FiedNotes_Video_Share

Introductory comments

This activity from which this episode is drawn formed part of a classical topic on mathematics. This activity embraces different domains, as literacy and mathematics. The activity was initiated by the teaching assistant a week ago in small-groups at a table to investigate children capacities, and strategies to share equally pig's money.

The children work together, one of them tries to share equally a handful of sweets in salt dough. The others have to look at what is happening and at the end discuss about the child's strategy to share. Each child can explore his/her own strategy then discusses about

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it. The aim of this activity is for the children to explore their own strategies to share a handful of sweets in three equal numbers. Indeed, if children know how to share, they encounter difficulties to do it equally.

Pedagogical framing

It is a real common goal for the teacher and the teaching assistant to allow and encourage children to explore and to express their own strategies, ideas in different domain, such as language, and mathematics. As the teaching assistant says '*it is a real goal, we talk really frequently with* ***La*** *(the teacher) about that'.*

The activity has already occured the week before but with cardboard counters. This time **TA** (teaching assistant) has enhanced the complexity of the task. As she says '*I wanted to see if they have really understood fair sharing'*. To do that, she provides to children handful of sweets and not a number which is a multiple of three as she did the last time. Indeed, when children are provided a number which is multiple of three it is easier because there is not units less. With a handful of sweets children encounter a problem: for example they can have 2 sweets left and cannot share them between the three pigs. Some children encounter difficulties, but no failures because *"we do it again and again, with the help of the other children. It seems important that children can go until the end of their strategy".*

Pedagogical interactions

In the first extract, the teaching assistant and the small-group of children discuss about what 'equally' means. It can be notice that each child knows clearly what share mean but the notion of 'equality' is more difficult for them. Indeed, the notion's acquisition constitutes the central goal of the teaching assistant's activity. It can be stressed that for children color might be one of the criterions to share equally (e.g. '***Ro****: And the same color*!').

- **TA**: It is not sweets… My advice is not to eat them as they are in salt dough… So, we will share [*FRA6Sandy_Pre_Sch_Image_1_Share*]. To share we have to pay attention. If I share without paying attention, like this. Sweets for Henry, for Christopher, for Raphael. That is it. I've shared. According to you, is it just?

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FRA6Sandy_Pre_Sch_Image_1_Share

- **Children**: No
- **TA**: Why it is not just?
- **Fl**: Because it is not the same.
- …
- **TA**: So, we will try to share them just. That means… Who remind me what does it means? What will we have to do?
- **Fl**: To provide the same.
- **TA**: We will try to provide the same number of sweets in each plate. All right?
- **Ro**: And the same color!
- **TA**: No, the color is not important here. We will not take the color into account! Ok?
- **Ro**: All right.

As it can be driven from the next extract, it is not so easy for children to share equally the sweets in three equal parts.

- **TA**: So, **Ro** I will give you a handful of sweets. We will do it one after the other, we will work together. Here are the three plates, one for Henry, one for Christopher and one for Raphael. So, **Ro** starts the sharing ***[***FRA6Sandy_Pre_Sch_Image_2_Share***].*** We look carefully what **Ro** does, because if she makes mistakes we will have to help her. So how will we do? Follow, you have to give out all your sweets. [***Ro*** *starts to put one sweet in a Henri's plate, then two in Raphael plate, the one in Henri's plate….* ***Ro*** *shares the sweets between two plates only*]. Christopher?

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FRA6Sandy_Pre_Sch_Image_2_Share

- **Ro**: I don't have!
- **TA**: Why didn't you provide some sweets to Christopher?
- **Ro**: Oh!
- **TA**: Could you do something in order that Christopher has some sweets?
- **Ro**: I will remove some [*She picks up some sweets to put them in Christopher's plate*]
- **TA**: It has to be equitable… That means that everybody has to have the same number of sweets in his plate. Do you prefer to do it again?

When children encounter difficulties the teaching assistant do not provide solutions but fosters children's collaboration and own exploration of their strategies.

- [***Ro** starts again an put 4 sweets in a plate*]
- **Fl**: What is she doing?
- **TA**: She is trying.
- [***Ro** places 4 sweets in another plate and the last 2 sweets in the third plate*].
- **Ro**: I don't have enough sweets!
- **TA**: There is still a problem!
- **Fl**: She doesn't have enough!
- **TA**: Do you want to try **Fl**? [***Fl** shakes his head to say yes*]. You will all try, all right?

Opportunities for mathematical learning

The first narrative episode is leaded by the teaching assistant. She scaffolds children and allows them to explore their own strategy but also to collaborate. Sweets have to be shared between the three pigs: Henry, Raphael and Christopher. This activity has already been done by the children. This time, the teaching assistant enhances, on the one hand, on the complexity of the task, i.e. the number of sweets is not a multiple of three. On the other hand, she makes the choice to propose sweets in salt dough instead of cardboard counters to make the activity more attractive for children.

The activity is really rich and challenging as it is based on counting from 1 to approximately 20. Children have to find a strategy to share equally the handful of sweets between the

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three plates for the three pigs. It seems to be difficult for those children to share equally. They manage to share, to place sweets into each pig's plate but they encounter difficulties in placing the same number of sweets in each plate (FRA6Sandy_Pre_Sch_Image_3_Share; FRA6Sandy_Pre_Sch_Image_4_Share).

FRA6Sandy_Pre_Sch_Image_3_Share

FRA6Sandy_Pre_Sch_Image_4_Share

Opportunities for creativity

Creativity might be recognized through the material used in the activity, sweets, and pigs' name. Moreover, this activity is linked to a story which is read at the moment in the classroom but also at the school's level. Those elements allow children to fill more familiar with the mathematical activity. Moreover, the teaching assistant modifies the workshop by using sweets instead of cardboard counters "*because it is more attractive for them*". Moreover, she can modify the activity to test if its help children (e.g. '*try share them with your brother*'). This modification stresses her great involvement in scaffolding children's progression. The teaching assistant is also creative in her attitude towards children progression as she doesn't constrain then toward an expected strategy to share. She lets them try, and organizes collective checking. At the end of the workshop, most of the

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children manage to do an equal sharing by using different strategies.

Conclusion

To conclude, this mathematical activity provides to children a rich context to develop general skills and dispositions for learning. Through this activity, children acquire knowledge/understanding about mathematical content, they develop mathematical process skills, and capacities to carry out inquiry and problem based approaches. Moreover, creative dispositions and explorations of the material have been foster here, as reflections and reasoning. Finally, the teacher assistant is gifted in listening, and in scaffolding children and to foster dialogues and collaboration between children.

3.6.2.2 'The Square': FRA6Sören_Pre_Sch_FiedNotes_Video_TheSquare

Introductory comments

This activity from which this episode is drawn formed part of a class topic on geometry. The activity has been initiated by the teacher because a child was drawing a shape on the blackboard. The episode involves children working in whole-group to investigate the properties of the square with a ruler.

The children are sitting in the discussion corner and they listen to the teacher's explanations about squares. They have already seemed this shape with the other teacher (**So** which comes each Monday).

Pedagogical framing

Two teachers teach in the class, Sandy and **So**. Researcher has observed the class when Sandy was in charge. Sandy explains that she is pleased to work with **So**, they use to share the topics on which they work, Sandy explains *"it is important to make links and to promote **So** specific teachings"*. It is the case in the next episode. Sandy reminds children properties of the square which constitutes a topic mainly leads by **So**.

According to Sandy, with 3-4 years old children you can be vague, but not with 4-5 years old children. In this sense, a square has some specific and well defined properties. A square is not composed by 4 corners, but by 4 submits. Vocabulary aspects are important with 4-5 years old children. It is important to reminder the different aspects of the institutionalization of a square, with measures through ruler use for example. Moreover, *"when you use the ruler, you do not have to tell the children square properties, the ruler does!"* According to Sandy this attitude *"prepares a rich filed to defined geometry".*

Pedagogical interactions

Sandy and the children (entire group) are grouped in the discussion corner. They are checking who is present and who is absent (a child read the names). The child has to count the number of children who are present and absent. Then, he has to draw a house and

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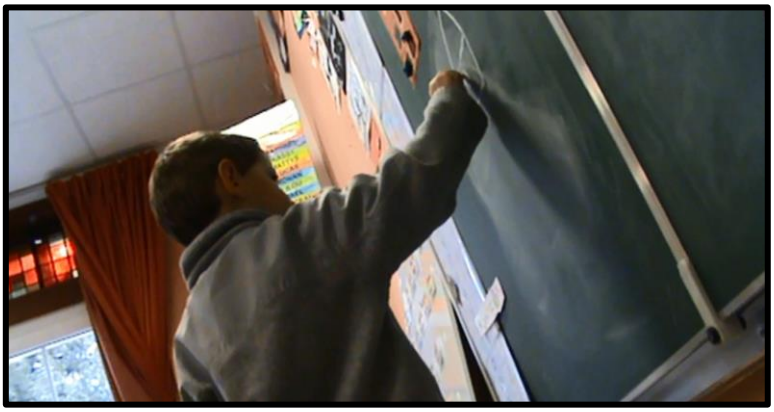
appropriated number dots representing the children which are at home (FRA6Sandy_Pre_Sch_Image_1_TheSquare). Here, Sandy makes links with **So's** lesson on square.

- **T**: Wait, it is an important moment. Thanks to **So**, in this class, we start to know the geometric shape properties *[**T** draws a square in the air. To the child at the blackboard]...* What is the geometric shape of your house? *[The boy starts to draw the house].* No, no before to draw it! Tell me. What shape do you want to give to your house?
- **The child**: In square



FRA6Sandy_Pre_Sch_Image_1_TheSquare

Here, the teacher tries to remind children the square's properties. Instead of explaining them, she uses the ruler.

- **T:** How many summits they are in a square? *[**T** points the different summits of a square].*
- **Children:** There are 4
- **T**: There are 4, and the sides. What is the specificity of the sides in a square? *[*FRA6Sandy_Pre_Sch_Image_2_TheSquare*]*

FRA6Sandy_Pre_Sch_Image_2_TheSquare

- **A child:** Lines
- **T:** Yes, they are lines, but their measures? If I measure them? You have seemed that with **So**

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[Another teacher which come each Monday. ***T*** *comes back to the square with a ruler to measure each side of the square]* Look, I've stop there in my measure ***[***FRA6Sandy_Pre_Sch_Image_3_TheSquare***].*** I will do the other side. Oh! Here again. Here also, it is the same, and there it is the same also. So the sides are all…?

FRA6Sandy_Pre_Sch_Image_3_TheSquare

- **Children:** Similar.
- **T:** They have the same measure. And the sides of the square did measure 10 cm. We will verify **Ma's** square.

At last, the teacher checks with the child the shape he has done on the blackboard. He said he does a square, but is it really a square?

- **T:** At the top… 10, and a little more. So it is not really a square, it is more a…
- **A child:** A rectangle
- **T:** A rectangle, because it has both sides longer than both opposite sides. Ok? So we have lengths and widths, but we don't have seemed the rectangle yet

FRA6Sandy_Pre_Sch_Image_4_TheSquare

Opportunities for leaning in mathematics

In this narrative episode the teacher reminds children the square's properties: there are 4

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summits, and each side has the same measure. For that, she takes the example made by her colleague, a square where each side is 10 cm. Instead of explaining to the children the properties of a square; she uses a ruler to make measures. She founds that each side has the same measure and shows the measure to the children each time. Then, she checks, with the ruler, the shape realized by the child who has to draw a house for the absent children. They observed that only two sides of his house have the same measure and conclude that it is a rectangular. Children can learn here how a tool such as a ruler can be useful for. Moreover, as Sandy says *'it might allow children who haven't understood yet the square properties to do it now'.*

The teacher here gathers and explains evidences from observations and through equipment. The aim of this episode is to foster children's knowledge and understanding of geometrical shape's properties but also science's process skills and capabilities to carry out scientific inquiry or problem-based activities.

Opportunities for creativity

This narrative episode is creative in the sense that the teacher makes links between different area of knowledge, and between geometry and classroom daily life. Interestingly, she makes links with children own production by checking the absent children house's shape. By doing that, she fosters children curiosity and motivation.

Conclusion

To conclude, the teacher reminds knowledge and understanding of geometry content. She provides creative dispositions to do it by using children's own production. Moreover, she uses equipment such as a ruler to do it. The activity focuses here on cognitive and social dimensions. Sandy's pedagogy mainly fosters questioning and curiosity.

3.6.2.3 'The Wolf': FRA6Sandy_Pre_Sch_FiedNotes_Vide_TheWoolf

Introductory comments

This activity from which this episode is drawn formed part of a classical topic in mathematics. This topic incorporates a number of curriculum areas aside from communications, mathematics, and literacy. The activity initiated by the teacher, involves a small-group of children working at a table to explore a game. For this play children need to use a dice where number from 1 to 5 are involved. Then, they have to pick up the appropriate number of paper bricks to build a pig's wall. Interestingly the paper bricks can groups 1, 2, 3, 4 or 5 bricks. So, in order to pick up 5 bricks, for example, children can choose a '2 paper bricks' and add a '3 paper bricks' or any other combination (FRA6Sandy_Pre_Sch_Image_2_TheWolf). This play allows children to identify, to construct and to deconstruct numbers.

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FRA6Sandy_Pre_Sch_Image_2_TheWolf

The children work together, one after the others. Episode length is 8 minutes.

Young children, 4-5 years old, can be more or less confident in mathematics. In this narrative episode **Li** is not confident contrary to **Fl**. During this episode, **Fl** helps **Li** to understand the rule of the game but also to succeed when it's her turn to play.

Pedagogical framing

According to the teacher: *"peer's talk has more repercussion on children compared to teacher's scaffolding."* When it is possible, it is useful to let some space for a child who knows how to explain his own procedure to solve a task to do it. Sandy likes to choose activities that foster children's collaboration. Collaboration is really important for the gifted children but also for the children who have some difficulties, because gifted children can help and be helped when they don't pay attention.

Teacher's job is also to be able to propose to gifted children attractive and challenging activities. This kind of children allows the whole-class to go ahead in learning activities.

Pedagogical interactions

In the next extract, the teacher encourages **Fl** to explain to **Li** the rules of the game as he already know it.

- **Li**: What is this play?
- **Fl**: I know this play!
- **T**: What is it? What do you see **Li**?
- **Li**: Three little pigs.
- **T**: Yes it is true *[three little pigs are drawn on the sheet of paper where the wall is]*
- **Fl**: We have to build the wall, and if it has been built before the wolf, he lost.
- **T**: All right, so what is that *[she shows the paper bricks]* It is bricks… *[**T** to **Li**]* Do you understand what **Fl** wants to say or not? *[**Li** shakes her head to say, no].* No? So, try to explain the play **Fl**.
- **Fl**: That is the dice. There, is the wolf *[on the dice]* and so you take a piece of the wolf. Then,

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you put it for the wolf.

- **T** [*to **Li***]: What did you think about that? *[**Li** shakes her head to say, yes].* Yes.

The teacher uses also different support to help children to manage the task. More precisely, she proposed different supports which represent numbers in order to be sure and to help children to construct a deeply understanding of them.

- **T**: How many it is **Li**?
- **Li**: I don't know…
- **T**: How can you do to know?
- **Fl**: 5, you have to take five bricks
- **Li***[**Li** counts the dots on the dice]* : 5
- **T**: Do you see five bricks somewhere? *[**T** presents to **Li** 5 pictures where 1, 2, 3, 4, or 5 bricks are represented. **Li** shows the appropriated card].* Yes, that is it!

Here too, different supports are proposed to help children's understanding of numbers: the dice, the paper bricks, and picture where 1, 2, 3, 4 and 5 bricks are represented. Moreover, the teacher adds a new support to help **Li** to understand: **Fl** and **Ra** fingers (FRA6Sandy_Pre_Sch_Image_3_TheWolf).

FRA6Sandy_Pre_Sch_Image_3_TheWolf

- **Li**: 3
- **T**: Does it make 3 **Fl**?
- **Fl**: No, 5
- **T**: Show me three fingers **Fl**, show me two fingers **Ra**. Three fingers in a side and two in the other, how many fingers there are?
- **Li**: 5
- **T:** Ok, next!

Opportunities for mathematical learning

The proposed activities allow children to manipulate numbers through a play. Indeed, they can compose and decompose them by using the paper bricks.

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To foster children's learning, the teacher asks question gathers and explains evidences from material and equipment. Her pedagogy center on play and exploration, dialogue and collaboration, problem solving and agency, she also values diverse forms of expressions and she scaffolds children progresses. Sandy proposes here a rich physical environment for children's exploration. The aim of the activity is to foster children knowledge and understanding of mathematical content.

Opportunities for creativity

Creativity is foster by the teacher. She encourages collaboration, and social dimension of learning. Moreover, she uses different support for children to build their reasoning. Collaboration, discussion, teacher and children scaffolding are involved in this narrative episode (FRA6Sandy_Pre_Sch_Image_4_TheWolf).

FRA6Sandy_Pre_Sch_Image_4_TheWolf

Conclusion

The third narrative episode shows how collaboration between children can be used to help a child to go ahead of his/her difficulties in mathematics. This narrative episode has been recording from 8:30 the time when children arrived in the class. That is why at first only two children are playing to the game then progressively they are 3 and 4 at the end (FRA6Sandy_Pre_Sch_Image_1_TheWolf).

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FRA6Sandy_Pre_Sch_Image_1_TheWolf

To conclude, in the third narrative episode, collaboration is present and fostered by the teacher. Moreover, children are encouraged to construct and to deconstruct numbers, to solve problem by their own. Teacher's pedagogy enhances children reflection and reasoning when the activity focuses on cognitive and social dimensions. Finally children should acquire knowledge and better understanding of mathematical content.

3.6.3 Summary and conclusions

3.6.3.1 Learning in science and in mathematics

The teacher and the teaching assistant foster children's learning in science and mathematics. For that they encourage children to explore their own strategies to solve problems, and by checking with them if it works or not. According to the teacher, mathematics is mainly a problem of meaning in pre- and also in primary school, children who don't succeed at this level, mainly fail because they don't understand the terms of a problem. This is why Sandy and the teaching assistant main goal is to help children to construct meaning. For that, they foster them to express their own idea, to explore their own strategies, to master language across domains.

3.6.3.2 Interest and motivation in science

The teacher and the teaching assistant foster children's interest and motivation by proposing to them activities in which there are deeply involved and they use to take children's own representation as starting point. Moreover, because workshops linked to the same area of knowledge are repeated, children are able to progress week by week and to feel more comfortable to solve the activities proposed by them (c.f. first narrative episode). Furthermore, activities are linked to other domains, for example, in the present case most of the activities are linked to the three pigs' house story here.

3.6.3.3 How do teachers perceive their role in doing so?

Finally, according to Sandy, to develop children's creativity is not her main objective. Even if, she founds that it constitutes an important aspect of children development. When she prepares teachings, she tries to identify activities:

- which foster children thinking
- which foster their reflection

When she can, she proposed problematic situations.

In sciences, creative activities seem to be difficult to realize because according to Sandy, she cannot provide to children all material they would like to have. Moreover, she is afraid to go in areas where she is not competent. According to her, it is easier in mathematics because most of the time material is already provided by the initial situation. Then, her role

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is to observe and foster children exploration of their proper strategies.

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4. Discussion of findings

4.1 Enabling Factors or Barriers at Contextual Level

Teachers' experience is one of the enabling factor stresses by most of the creative teachers. According to them, experience is required to feel confident with:

- the curriculum's expectations, and
- their capacity to regulate the classroom.

Indeed, curriculum's content is not obvious for young teacher, so it takes times to get familiar with it. Moreover, creative teachings require teachers to hold a representation of 'an efficient class' as a class where children can move, talk, discuss. This representation differ from a class conceived as a quiet area where children are working alone (etc.).To lead a group where children are moving, talking and discussing creatively required from teacher to have develop some well accepted rules in the class. For example, children have to understand that free playing time is itself a working time. According to primary school teachers (e.g. FRA4) most of the time, this kind of organization is efficient in December. It can be noticed that, multi-level's classroom, where children stay a few years with the same teacher, facilitates this kind of classroom functioning in primary school (FRA2).

Flexible attitude of teaching constitutes another enabling factor for creative teaching and learning. For example the teacher in FRA3, explain that she has in mind her main goal associated to the activity but focus on children's activities, interactions, own explorations and to transform children's key observations or experimentations as opportunities for teaching and learning.

The balance between individual activities (e.g. playing, exploration, experimentation) and collective sharing times (e.g. discussion, reflection, confrontation of ideas) constitute an interesting way for children to build scientific knowledge with adult's scaffolding. For example, the teacher in FRA1 guides children from their own subjective understanding toward collective objective understanding.

Multi-level classrooms with a large range of ages seem to foster creative attitudes, and collaborative support between children. For example, in FRA2 older children can explain the mathematical game's rules and propose appropriated strategies to younger children.

To focus and foster children explorations of their own world (strategies, ideas, knowledge etc.) enhances creative approach of teaching, learning and assess (FRA4 and FRA6). For example, in FRA6, the teaching assistants encourage children exploration of their own strategies to share sweets. Then, she organizes collective and collaborative checking between children.

Main barriers against creative teaching and learning emerge when teacher are focus on the

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expected content children have to achieve and not on children exploration of their own world first.

The principal contextual barriers consist in two mains aspects:

- Few materials are provided to preschool teachers in France to help them to develop activities in science and in mathematics.
- In addition preschool teachers have weak trainings in science and mathematics.

Moreover because language is the main goal of preschools, the consequence is that few preschool teachers involve themselves and their classroom in such activities. In primary schools curriculum constrains teaching/learning/assessment so teacher may have less time to engage themselves in creative approach.

4.1.1 Differences between preschool and primary school

Play, exploration, manipulation can be used in pre-school and in primary school in order to propose creative learning/teaching/assessment to children.

To make links: in pre-schools, it seems crucial to be able to use a same content across domains (e.g. FRA5, FRA6). The training teachers from FRA3 and FRA5 use to say that '*a good teacher is the one who knows how to make network of links with the same content across domains'*. This aspect seems to be less emphasis in primary school. The focus is there given to concrete observations to build progressively abstract and conventional understanding (e.g. FRA2, FRA4).

Assessment: even if, assessment is not obvious in primary school, it is more important there than in pre-school. An important effort is made by some French national inspectors of the education to facilitate and to homogenized children's assessment at the end of the pre-school. Nevertheless, because language is under focus in pre-school, few items concern mathematics and even less are dedicated to science. Nevertheless, in pre- and primary schools assessment is made on daily children's productions and behaviors.

Language: in pre-school the most important goal is language and language mastering. At this level, according to Sandy and her teaching assistant in FRA6 meaning's construction is the corollary of language acquisition. In their classroom, time is provided for children to express their own view. In primary schools, because of curriculum's constrains, it is not obvious that this time is still taken.

Activities' content: In preschools, teachers are free to choose the topic they want to explore compared to teachers from primary schools. Usually, preschool is conceived as an exploration time/are and primary school as a learning time/area. Nevertheless, creative approaches of teaching, learning and assessment show that both activities can be conceived coherently at the same time and at both levels.

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4.1.2 Differences between science and mathematics

More similarities than differences between science and mathematics: creative approaches in science and in mathematics take different shapes because content is not the same. Nevertheless play, exploration, manipulation, collaboration have been used in both topics. In other words, the approaches used for teaching/learning/assessment are quite similar in both domains.

4.1.3 Opportunities and challenges for creative learning and teaching

Teacher's knowledge of the curriculum expectations: This first point constitutes the main challenge, according to the teachers, to be creative. Teachers feel uncomfortable with the curriculum expectations during quite a long time when they began their career. According to them, they manage to become creative in their way to teach when they were comfortable with curriculum expectations.

Teachers' experiences of leading a classroom: teachers' capacity to manage a group of children, to switch from individual to collective times is not obvious for young teachers. Creative approaches take place in contexts where the teaching and the leaning are linked to open spaces, free playing, children's discussions and manipulations. This way to manage a class differs from classical class and need time to be built (FRA4, FRA2). It can be supposed that specific training can be proposed to teachers to manage it.

Teacher's representations: according to us teacher's representation of what is a good/efficient/working class might constitute a strong barrier for creative approaches to occur.

Material: even if creative approaches can occur with cardboard and cubes in moss, appropriated material is helpful (e.g. FR2). Many teachers ask for appropriated books and materials to help them in science and mathematics, where they have already few competencies (FRA6).

Multi-level classrooms: multi-level classrooms constitute opportunity to foster creativity because collaboration and children's scaffolding appear naturally in this context. (FRA2, FRA1). Moreover, multi-level classroom can help teachers to construct an appropriated organization for a few years with a group of children to put in practice creative approaches.

Context of the school: countryside schools (e.g. FRA2) foster project link to nature and help children to better understand their environment.

Challenge: Creative approaches are cross domain approaches. This specificity can constitute an open door for the teachers which don't feel comfortable with science and mathematics to come to those topics through painting, drama, etc. (FRA5).

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

4.2.1 Aims and Objectives

Toward which goals are children learning?

Teachers' conceptualizations of aims and objectives are important to map in relation to classroom practices. The corresponding factors are:

- knowledge/understanding of science content (e.g. ideas/concepts and processes)
- understanding about scientific inquiry (how scientists develop knowledge and understanding of the surrounding world)
- science process skills (e.g. predicting, observing, measuring, describing, classifying)
- capabilities to carry out scientific inquiry or problem-based activities (e.g. questioning, gathering evidence, interpreting evidence, communicating findings)
- social factors of science learning (e.g. collaborative and communal, engagement, communication, questioning/dialog/debate/arguing
- affective factors of science learning (e.g. attitudes to science, attitudes to learning science, attitudes to learning)
- creative dispositions (e.g. sense of initiative, motivation, innovative thinking, connections making, imagination, curiosity, creative thinking skills, problem solving skills, reasoning skills).

In our observations most of the time aims and objectives are focused on knowledge/understanding of science/mathematics content, capabilities to carry out scientific inquiry or problem-based activities, social factors of science/mathematics learning and creative dispositions. Affective factors of science learning rarely constitute the aim or the goal of the activities proposed to children. Nevertheless, they can constitute implicit or associated goal, e.g. to make creative science. Few observations enlighten children's understanding about scientific inquiry.

4.2.1.1 Differences between preschool and primary school

Most of the factors associated to the aims and the objectives are common to pre-school and primary school.

In pre-school, the topic in science depends on the teacher/children's choice. Indeed, French curriculum doesn't constrain science teaching/learning/assessment. This flexibility

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constitutes an opportunity for pre-school teachers to follow children reflection in order to introduce knowledge/understanding, concepts, or process depending on their progression. According to our observations, two main aspects should structure teaching and learning activities in preschool:

- to use the same content in as many contexts as possible (FRA3 and FRA5) and
- to allow children to construct meanings (FRA6).

In primary school, it is different in France. There, the curriculum is more precise. Teacher/children's possibility to choose on topic or another is reduced. Nevertheless, the way to teach depends on the teacher own choice. So, in primary school, teachers know what they have to teach/assess, but they are free in their way to do it, i.e. in their pedagogical approach.

4.2.1.2 Differences between science and mathematics

Science learning is less constrained than in mathematics.

Nevertheless, each factor has been observed, at least one time, in science and mathematics through our observations. So, they structures teachers' aims and objectives in science and mathematics.

4.2.1.3 Opportunities and challenges for creative learning and teaching

In France, understanding about scientific inquiry doesn't constitute an aim or an objective, when it could be introduced in pre-school. For example, in FRA5 there is a costumes corner, where children use to transform themselves into princess or monsters. It could be imagined, using those costumes, to retrace the main steps of the life of a researcher, for example.

Some pre-school teachers stress that it is a challenge for them to introduce science in teaching and learning activities, because of a lake of resources to help them to find ideas in areas where they do not feel comfortable.

4.2.2 Learning Activities: *How are children learning?*

The emphasis of the factors under this dimension is on whether learning activities in early years science focus equally on the cognitive development of children, often called a 'readiness for school' approach, and on their social development, that is follow a 'foundation for lifelong learning' approach (with a social pedagogy approach).

- focus on cognitive dimension (e.g. questioning, designing or, landing investigations, gathering evidence, observing, running experiments, making connections)
- focus on social dimension (e.g. explaining evidence, communicating

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explanations)

Both factors were present in nearly each of our observations. Most of the activities proposed at school are conceived to foster cognitive dimension, buts most of the time the social dimension is also present (FRA2, FRA2Robert_Pri_Sch_FiedNotes_Video_ChildrenCollaborationCardGameRule)

4.2.2.1 Differences between preschool and primary school

In preschool, the social dimension is achieved by the teacher, because of children's difficulties in language mastering. By doing so, teachers scaffold children language development (FRA1, FRA3). Then, progressively, children become more gifted to explain evidence, communicating explanations until to propose their own strategy to solve problems (FRA4).

In primary school, cognitive dimension is foster, but social dimension of teaching and learning is also foster by the context (FRA2) or the teacher (FRA4) in creative approaches.

So in France, both factors are present in pre-schools and in primary schools. In preschools, teachers use to interpret (FRA3) or to help children to explain their ideas (FRA1, FRA6). When children get older, both dimensions gain in complexity and enhance other possibilities.

4.2.2.2 Differences between science and mathematics

Both dimensions are present in science and in mathematics activities in French schools. For example, in science, the teacher proposes a challenge to the children: 'to pick up a trombone in a pot of flower without touching it' (FRA1). In mathematics, when the teaching assistant fosters children's collaboration to share equally a handful of sweets (FRA6).

4.2.2.3 Opportunities and challenges for creative learning and teaching

Hopefully, cognitive and social dimension of learning are present and foster in the visited French schools.

To foster cognitive and social dimensions may appear as time consuming for teachers, but it is a gain for latter teachings and children's learning.

4.2.3 Pedagogy: *How is the teacher facilitating learning?*

The factors under pedagogy refer to the pedagogical commonalities (or synergies) between inquiry-based science education (IBSE) approaches and creative approaches (CA), identified in the conceptual framework.

- role of play and exploration (e.g. open/unstructured play, role/pretend play, physical exploration, outdoor activities, use of digital technologies)

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- role of motivation and affect (e.g. use of drama, use of narrative, use of history, informal learning settings, cross-disciplinary context, incorporating children's prior experiences, relating science to everyday life)
- role of dialogue and collaboration (e.g. small group settings, collaborative approaches, classroom discussion)
- role of problem solving and agency (e.g. guided inquiry, open inquiry, structured inquiry, autonomous learning)
- fostering questioning and curiosity (e.g. questioning, imagination, multimodal expression)
- fostering reflection and reasoning (e.g. evaluation of alternative ideas)
- teacher scaffolding and involvement (e.g. explicit instruction, delayed instruction, teacher as facilitator, teacher as allower)

In the previous narrative episodes most of those factors are used by teachers.

During our observation few outdoors activities have been proposed to the children (except in FRA2). It might be because data collection takes place in winter. Nevertheless, in public school it is difficult to go outside of the school with children because. Indeed, teachers need to have authorizations from the national inspector of the education, the school director, and children's parents.

Drama and informal learning settings have not been clearly identified during our observations. This result is consistent with the French survey where most of the teachers answer that they don't use drama at school. It can be supposed that because teachers know that we were coming to observe their practice in science and mathematics, they don't make cross-disciplinary links with other areas.

4.2.3.1 Differences between preschool and primary school

Some factors seem to better characterized pre-schools' activities compared to those which are realized in primary schools.

In preschools, play and exploration, open/unstructured play, role/pretend play are frequently proposed to children for example.

Then, the other factors are used at both levels.

4.2.3.2 Differences between science and mathematics

According to our observations, teacher's pedagogy is coherently applied in all domains (FRA2, FRA6). So no specific differences have been identified in the pedagogy used by the

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teachers in science compared to mathematics.

4.2.3.3 Opportunities and challenges for creative learning and teaching

Drama and cross-disciplinary links are not used by French teachers, when it can constitute an open door for teacher's team to build collective project in order to introduce science in preschool.

4.2.4 Assessment: *What are the means to evaluate children progress during the learning process?*

The following factors express the objective/intention of the project, as this is formulated in its conceptual framework, to examine: the ways in which formative and summative assessment are used in science and mathematics teaching in early years; the involvement of children in assessment processes; the use of multimodal approaches to assessment; the role of context and authenticity of assessment tasks; the person/people considered to be responsible for making judgments in assessing science and mathematics.

Assessment function/purpose

- formative (e.g. assessment for learning, improvement of learning, improvement of teaching, improvement of curriculum)
- summative (e.g. evaluation of performance, comparative purpose)
- recipient of results (e.g. parents, children, authorities)

Assessment way/process

Strategy

- formative (e.g. self-assessment, peer assessment, ongoing)
- summative
- focus on product vs. process

Forms of evidence (e.g. multimodal, context-based, authentic problem-based, portfolios, tests, checklists, homework)

Locus Beneficiary of assessment judgment (e.g. teacher, child)

Assessment doesn't constitute an explicit main objective for pre-school teachers, even if they are checking all the time children progression. According to our observations, in primary school, in creative approach of teaching and learning, assessment occurs during daily activities because all children productions are sources of assessment. Most of the time, adults are the sources of assessment.

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4.2.4.1 Differences between preschool and primary school

In pre-school and in primary school, children's learning and teacher's teaching improvement is making day after day. When teacher or teaching assistant identifies problems or better solutions (FRA6, e.g. sweets instead of counters in cardboard), they use to make quickly the required modifications. Children can also suggest modifications for example, to change their place in the classroom because their do not manage to learn closed to a friend.

In primary schools, summative assessment is more present than in pre-school. Primary school teachers use children's productions to evaluate their performances (FRA4, FRA4Nani_Pri_Sch_FiedNotes_Video_ChildrenStrategyToCount and FRA2, FRA2Robert_Pri_Sch_FiedNotes_Video_Addition).

In pre-schools, summative assessment is done through teacher's observations of children and their productions. Depending on the academy, some French teachers have to complete a little book which follows pre-school children's progression. In that book different expected competencies and performances are listed. In this case, each teacher has to precise children own progress depending on the book items.

4.2.4.2 Differences between science and mathematics

In science, it seems to be more difficult to assess children understanding than mathematics. Indeed, in mathematics exercises can be provided to children when in sciences children have to use language to express their thoughts.

Nevertheless, in both topics adults use children's behaviors and productions to make their assessment.

4.2.4.3 Opportunities and challenges for creative learning and teaching

Many forms of assessment are described in the CLS project when few of them are explicitly used by teachers. Nevertheless, it can be supposed that they occur implicitly through teacher/children, children/children interactions.

4.2.5 Materials and Resources: *What are children using during the learning process?*

According to *Creative Little Scientists* conceptual framework a wide range of materials in the classroom, including digital technologies, can be motivating and offer different ways for young children to represent ideas and express their thinking. Research in science, mathematics and creativity also highlights the importance of a rich physical environment and the use of the outdoor environment in promoting opportunities for exploration in the early years.

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The following factors are therefore closely linked with the ones of the 'Learning Activities' and 'Pedagogy' dimensions and could be easily seen as belonging to the 'Teaching, Learning and Assessment' strand, as well as to the 'Contextual Factors' strand.

- rich physical environment for exploration
- sufficient space
- outdoor resources
- informal learning resources
- ICT and digital technologies available
- different kinds of resources
- sufficient human resources
- policy documents

Few outdoors activities have been observed during the data collection, except for FRA2. Children went to the river close to the school because of their big science project linked to the water over the world. As it has been stressed above, pre-school teachers asked for more resources in mathematics and in science (e.g. books, material). Human resources don't seem to be the bigger problem or an obvious request, even if specialists in teaching and learning in science and in mathematics are welcome in pre and primary schools as it was clear in the French survey (WP3). Digital technology are present in school (frequently in a dedicated room), but few use of them have been done during our observations.

4.2.5.1 Differences between preschool and primary school

In preschools, it can be supposed that because teachers' initial training doesn't focus on science and mathematics, and because the French curriculum doesn't precise specific contents in science, teachers don't feel to be qualified to make teaching in science. It is less obvious in mathematics. Many teachers during our observation stress that books and dedicated material are missing in science.

In primary school, it is usual to make science and mathematics teachings so the previous points are less salient.

4.2.5.2 Differences between science and mathematics

In mathematics, more material is available than in science, but it is not sure that this material has been conceived to enhance teachers' creative teaching and children's creative learning.

In science, it seems that biology is frequently proposed in class. As the teacher in FRA5 who

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has snails in her classroom, or the teacher who grow wheat and avocados in FRA1.

4.2.5.3 Opportunities and challenges for creative learning and teaching

It constitutes a big challenge to propose to teachers, especially in preschool, material which can help them to practice creative approaches in science and in mathematics. Nevertheless, it seems to constitute an important aspect.

In FRA5 (FRA5Joelle_Pre_Sch_FiedNotes_Video_Montessori'sDrawers), the teacher has tested an adaptation of the Montessori's drawers use after children's siesta. Her experience lets us think that it constitutes a great opportunity for children to realized different activities in autonomy at a period of the day where children are coming back progressively into collective time. This dispositive constitutes a great idea to foster science and mathematics in preschool (if the drawers are linked to those topics).

4.2.6 Grouping: *With whom are children learning?*

The focus of these factors is on whether children are learning individually, in small groups, or whole-class, and whether and how are they allocated to age or ability groups for learning.

- Multi-grade teaching
- ability grouping
- small group settings
- number of children in class

Most of the time, in preschool, teaching and learning appear during workshop where there are 5 or 6 children (FRA1, FRA3, FRA5, and FRA6). In traditional primary school, teachings occur during collective times where there are 25 to 30 children (FRA4). In Montessori's primary school, teachings occur during individual work or in small group (3-4 children).

4.2.6.1 Differences between preschool and primary school

There is a clear gap between preschools' and primary schools' organization of the classroom.

In preschool, children do workshops by team of 5-6 children. This organization is facilitated by the presence of the teacher and the teaching assistant.

In primary school, the number of children in each class is bigger than in preschool. Moreover, there is only one adult who does it teaching for the entire group. So few time is dedicated to small group activities. Nevertheless, in FRA2 teachers have make the choice to group all the children from 6 to 12 years old in the same classroom, and to provide teaching to small groups of children. In FRA4, the teacher uses to use the reading corner as an area

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for children to work in little group.

4.2.6.2 Differences between science and mathematics

No differences depending on the domain.

4.2.6.3 Opportunities and challenges for creative learning and teaching

Multi-grade teaching can constitute here too a solution to help teachers to provide teaching to smaller groups. For example, the teacher in FRA1 works with half of the group each time.

The number of children may constitute the most important barrier to teach to small group. Teaching to and learning with 20 children is easier than with 30 children.

4.2.7 Location: *Where are children learning?*

The factors of this dimension can be seen as referring to the macro (i.e. education system), meso (i.e. the school) and micro (i.e. classroom) levels.

- Education system level, centralised/decentralized
- School level (e.g. state/public, private, fee paying/non-fee paying, size of school, urban/rural location, student intake)
- Classroom level (e.g. outdoors/indoors, formal/informal learning settings, small group settings)

All the observations have been done in public school in urban locations except for FRA2 which were a private school in rural area.

4.2.7.1 Differences between preschool and primary school

The classroom's organization is different in preschool compared to primary schools. In preschool the classroom is organized into corners which invite children to play. In primary school, the number of corner is reduced. Many reasons can explain the disappearance of the corners. The number of children is bigger in primary schools compared to their number in pre-school when, the size of the room seems to be constant. Nevertheless, it seems to be teacher choice to have or not specific corner in primary school. For example, Nani stresses that in her classroom there is still a ridding corner. Moreover, in this classroom they are spaces for plants, mathematics material and animals. FRA2 is constructed by corners (cf Map of Robert's classroom). Usually, in primary school, children have to work on the same activity. What is interesting is that in this primary school, the most obvious corners are linked to material used for mathematics or science.

4.2.7.2 Differences between science and mathematics

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Mathematics corners are less present in preschool compared to science corners. It can be supposed that mathematic cannot constitute in teacher's mind a free playing activity when experiences in science can be reproduce in the science corner; or science books can be read by young children.

4.2.7.3 Opportunities and challenges for creative learning and teaching

In preschool, the class organization is focus on small-group activities orientated toward different goals (autonomy, mathematics, art craft…).

Usually in primary school teaching are dedicated to the entire-group. Classroom from primary schools which keeps some 'corners' can be used for lecture but also for small-group activities (FRA4). Nevertheless, in France classroom size in primary school might constitute the bigger challenge to do it.

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5. Implications

5.1 Implications for teacher training

The main challenge for young teachers to do creative teaching is to feel comfortable with the curriculum expectations in order to become more flexible with children. So if teacher training can include this aspect it might help teachers to become creative earlier.

Teacher's representations of 'a good teacher' and 'a working class' might be also introduced in teacher training. Indeed, it can be supposed that creative classroom organization is not obvious.

Teacher capacity to lead children as a group toward free exploration, sharing discussion time, should be also introduced in teacher training. Indeed, classroom's organization and functioning constitute one of the key aspects to develop creative teaching and learning.

Obviously, to provide creative teaching in science and in mathematics to future teacher constitute basic but a key aspect if we expect them to propose some to children.

To provide some key resources for teachers to find ideas, materials, and supports to realize creative activities in sciences and in mathematics can also be a great improvement for teacher who are already in classes.

Interestingly, our observations don't let us think that there are 'one' or 'a few' creative attitudes to teach, learn and assess in science and mathematics but as many approach as teacher who are involved in this way to do teaching.

5.2 Implications for policy development

To express clearly that creativity constitutes a key aspect which has to be develop for and by each child through their daily learning, and through the teaching their received might be a first step.

To explain clearly that science is an important aspect of young children development in pre-school.

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