



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

**D4.3 Country Reports**

**Report 7 of 9:**

**Country Report on in-depth field work in  
Portugal**

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## 1. Aims of this Report

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

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 five cases (each case comprises one teacher and the children they work with), based in three sites of pre-primary and early primary education. Each case contains episodes, documenting examples of science and mathematics through the lens of creativity.

Finally, this report is one of the working documents that will provide input to the *Report on*



#### *D4.3: Country Report (7 of 9) on in-depth field work in Portugal*

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



## 2. Methodology

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

### 2.1 Research Questions

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

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

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

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

Sub-questions running across all research questions probe:

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

inquiry-based science education (IBSE); views of creativity in relation to perceived purpose.

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

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

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



Table 1: Dimensions, Sub Questions and Factors

	Dimensions	Sub questions	Factors important to nurturing creativity in science and mathematics in the early years	Coding
PEDAGOGICAL INTERVENTIONS	Learning Activities <i>Interaction</i>	How are children learning?	<p><i>Focus on cognitive dimension incl. nature of science</i></p> <ul style="list-style-type: none"> <li>• Questioning</li> <li>• Designing or planning investigations</li> <li>• Gathering evidence (observing)</li> <li>• Gathering evidence (using equipment)</li> <li>• Making connections</li> </ul> <p><i>Focus on social dimension;</i></p> <ul style="list-style-type: none"> <li>• Explaining evidence</li> <li>• Communicating explanations</li> </ul>	<ul style="list-style-type: none"> <li>• LA: Ques</li> <li>• LA: Plan</li> <li>• LA: Obs</li> <li>• LA: Equip</li> <li>• LA: Connect</li> </ul> <ul style="list-style-type: none"> <li>• LA: Expl</li> <li>• LA: Comm</li> </ul>
	Pedagogy <i>Interaction</i>	How is teacher facilitating learning?	<ul style="list-style-type: none"> <li>• role of play and exploration; <i>role of play valued</i></li> <li>• role of motivation and affect ; <i>Efforts made to enhance children’s attitudes in science and mathematics</i></li> <li>• role of dialogue and collaboration; <i>collab. between children valued</i></li> <li>• role of problem solving and agency ; <i>use of IBE/PBL, Children’s agency encouraged</i></li> <li>• fostering questioning and curiosity - <i>Children’s questions encouraged</i></li> <li>• <i>Diverse forms of expression valued</i></li> <li>• <i>fostering reflection and reasoning; children’s metacognition encouraged</i></li> <li>• <i>teacher scaffolding, involvement, Sensitivity to when to guide/stand back</i></li> </ul>	<ul style="list-style-type: none"> <li>• P: Play</li> <li>• P:Affect</li> </ul> <ul style="list-style-type: none"> <li>• P:Collab</li> </ul> <ul style="list-style-type: none"> <li>• P:Agency</li> <li>• P:Ques</li> </ul> <ul style="list-style-type: none"> <li>• P: Express</li> <li>• P: R and R</li> </ul> <ul style="list-style-type: none"> <li>• P: Scaff</li> </ul>
	Assessment <i>Framing and Interaction</i>	How is teacher assessing how far children’s learning has progressed, and how does this information inform planning and develop practice?	<p><i>Assessment function/purpose</i></p> <ul style="list-style-type: none"> <li>• formative</li> <li>• summative</li> <li>• recipient of assessment results <b>NO CODE</b></li> </ul> <p><i>Assessment way/process</i></p> <ul style="list-style-type: none"> <li>• strategy</li> <li>• <i>forms of evidence ; excellent assessment of process +product, Diverse forms of assessment valued</i></li> <li>• <i>locus of assessment judgment – involvement of children in peer/self assessment</i></li> </ul>	<ul style="list-style-type: none"> <li>• A:Form.</li> <li>• A:Summ.</li> </ul> <ul style="list-style-type: none"> <li>• A:Strat.</li> <li>• A:Evid.</li> </ul> <ul style="list-style-type: none"> <li>• A:Peer/self</li> </ul>

Materials and Resources <i>Framing and Interaction</i>	With what are children learning?	<ul style="list-style-type: none"> <li>rich physical environment for exploration; Use of physical resources thoughtful; Valuing potential of physical materials; Environment fosters creativity in sci/ma</li> <li>sufficient space</li> <li>outdoor resources; recognition of out of school learning</li> <li>informal learning resources</li> <li>ICT and digital technologies; confident use of digital technology</li> <li>variety of resources</li> <li>sufficient human resources</li> <li>policy documents; NO reliance on commercial schemes</li> </ul>	<ul style="list-style-type: none"> <li>M:Explor.</li> <li>M: Cr</li> <li>M:Space</li> <li>M:Outd.</li> <li>M:Inf.</li> <li>M:ICT</li> <li>M:Variet.</li> <li>M:Human</li> <li>M: Pol.</li> </ul>
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	Dimensions	Sub questions	Factors important to nurturing creativity in science and mathematics in the early years	Coding
PEDAGOGICAL FRAMING	Aims and Objectives <i>Framing and Interaction</i>	Toward which goals are the children learning?	<ul style="list-style-type: none"> <li>knowledge/understanding of science content</li> <li>understanding about scientific inquiry</li> <li>science process skills; IBSE specifically planned</li> <li>capabilities to carry out scientific inquiry or problem-based activities; use of IBSE/PBL</li> <li>social factors of science learning; collaboration between children valued</li> <li>ffective factors of science learning;efforts to enhance children's attitudes in science and maths</li> <li>creative dispositions; creativity specifically planned</li> </ul>	<ul style="list-style-type: none"> <li>AO: Kn.Sc</li> <li>AO: Und. SI</li> <li>AO: Sc Proc Skills</li> <li>AO: IBSE/PBL</li> <li>AO: Social</li> <li>AO: Affect</li> <li>AO: Creative</li> </ul>
	Location <i>Framing and Interaction</i>	Where are they learning?	<ul style="list-style-type: none"> <li>outdoors/indoors Recognition of out of school learning</li> <li>formal/informal learning settings/</li> <li>small group settings</li> </ul>	<ul style="list-style-type: none"> <li>L. Out/ Indoors.</li> <li>L.Formal/ Informal</li> <li>L.grp</li> </ul>
	Grouping <i>Framing and Interaction</i>	With whom are they learning?	<ul style="list-style-type: none"> <li>multigrade teaching</li> <li>ability grouping</li> <li>small group settings</li> <li>number of children in class</li> </ul>	<ul style="list-style-type: none"> <li>G:MG</li> <li>G:Abil.</li> <li>G:SmallG</li> <li>G:No.</li> </ul>

## 2.2 Research Instruments

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

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

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

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

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

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

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

## 2.3 Data Collection

### 2.3.1 Sampling principles

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

The sample of cases was thus deemed to be a purposive one, involving a range of contexts,

learning opportunities and teacher populations and age ranges of children. Moreover, the following selection criteria were identified to be used as part of the selection of each national sample (see D4.1, p28):

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

### **2.3.2 Ethical issues**

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

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

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

## 2.4 Data Analysis

### 2.4.1 Process

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

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

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

### 2.4.2 Final sample

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

Fieldwork Sites		1	2	3	4	5
General Selection Criteria		Isabel	Carol	Florence	Olivia	Megan
Phase	Preschool	X	X		X	
	School			X		X
Governance	Non-fee paying					
	Fee paying		X	X	X	X
Age(s) of children	3					
	4					
	5	X	X		X	
	6					
	7					X
	8			X		
Mixed age groups						
Special school						
High Diversity	SEN					

	Non-native speakers					
	Socio-economic disadvantage					
Location	Urban		X	X	X	X
	Suburban	X				
	Rural					

This study included three sites, one public school (preschool – PT1) and two private, one Catholic, preschool (PT2, PT4) and school, (PT3,PT5) which resulted in five cases (3 preschool and two primary school). The sites are located mainly in urban location, and only one of them is suburban (PT1).

In this project 105 students were observed, in total of five teacher’s and three teacher assistants (which have no active role in student learning, only support teacher, in part time).

### 2.4.3 Limitations

The three sites are located geographically in the same district in the north west of Portugal within a radius of 20km, which may not allow the generalisation and a more comprehensive characterization of the country in the overall.

This project requires an involvement and more availability of schools and teachers. Despite the fantastic collaboration obtained, the curriculum of the courses is much extended and do not allow much time for such activities to be implement. The main limitations encountered relate to the fears and lack of habit to accept intervention of this nature. As well the deadlines of the project for this part of the work being too tight, adding to the Easter school vacation, raised problems with the observations needed.

### 3. Case Studies

#### 3.1 Case 1 – “Isabel”

##### 3.1.1 Context

Where?	Country	Portugal			
	Setting name	PT1			
	Location within setting	Pre-school			
Who? (children)	Year group/age of children	5 years old			
	Number of children in class	19			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher and 1 collaborator			
	Case teacher role	Co-ordinator			
When?		1	2	3	4
	Dates of visits	11/1/13	31/1/13	06/2/13	06/3/13
	Times of visits	14:30-15:30	14:00-15:00	14:30-16:00	14:30-16:00

##### a) School

The school 1, located in the suburbs of Braga town is focused in pre-school teaching, children with age between six months and six years old. Children come from different socio-cultural families. It has good conditions, with outdoor space where the children can play. The building is built from scratch for this purpose with architecture design. Has a good physical structure, with large windows and good surroundings.

It has two rooms for educational activities, each with their toilets and clothing. It also has a multipurpose room for leisure time activities of children and family support, a dining room and a toilet for adults.

Outer space is composed of a playground with play equipment, a lawned garden with trees and a covered space.

The normal working period is from Monday to Friday from 8am to 7pm, including extension.

##### b) Teacher

The teacher has many years of experience and she is very enthusiastic with her work. She is always receptive to new experiences and activities. She thinks that mathematics and science learning is very important in these early years. They have the mathematic day every Thursday. She also thinks that creativity plays a fundamental role at this stage but she admits it is easier

to forest creativity in science than in maths.

### c) Classroom

The group has six children of three years old and nine children of five years old. The teacher says it is difficult to plan activities for these two groups of different ages. We witnessed this difficulty on the proposed activities.

The classroom is divided in different areas, each one identified with a subject (expressions, construction (Lego), little house, relaxing activities). See (PT1Isabel\_PreSch\_map.docx).

The daily routine starts at 9.30am with the large group activities until 10.30am when they have the playing time. At 11.15am, they have the small group activities until 12.00am. They start again at 2.30pm when they work in the areas. In the end, they have a review time. At 3.30pm, they have the story time.

In the large group activities of the teacher initiative involves the whole group of children. The educator plans the activity, and this must be contextualized with the work done throughout the day.

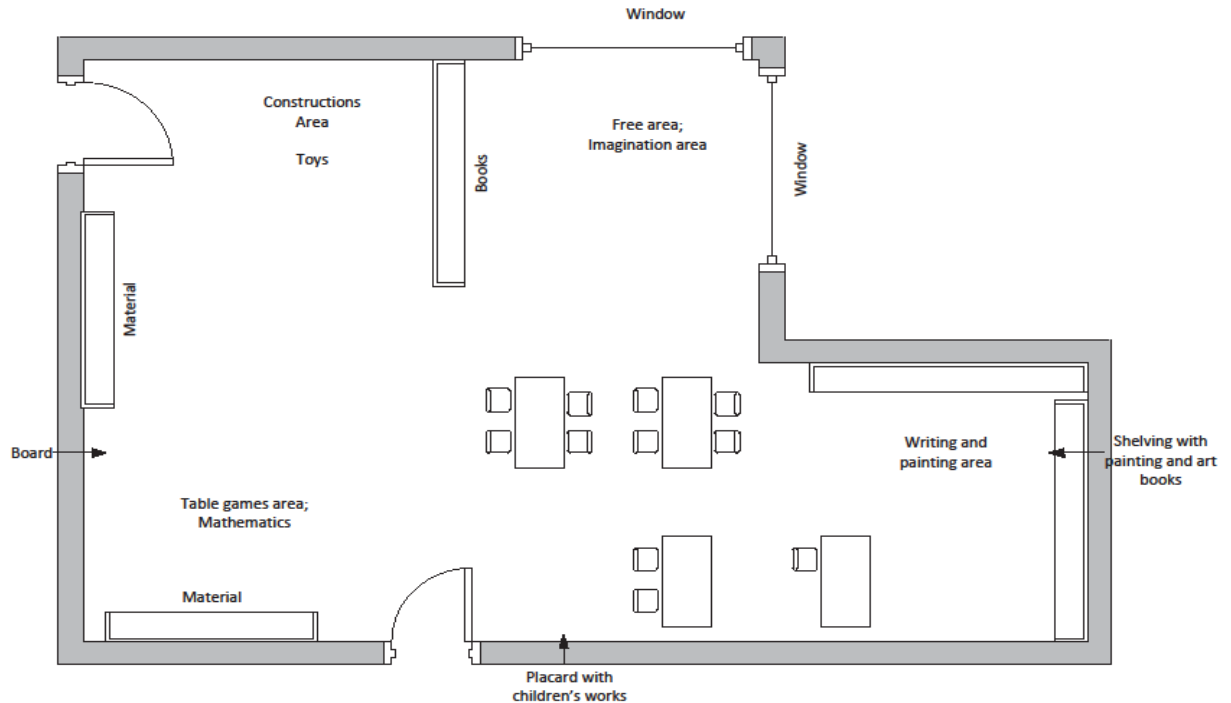
In the small group activities, the teacher introduces structured activities to promote key experiences -encouraging the child to extend its field of activities, presenting new options and new materials. Children learn through activities they undertake and the conclusions that draw from their own experiences.

When they work in the areas, the child performs work following his plan and may change area at its discretion. The child, however, should gradually get used to stay in an area long enough to carry out his plan of work to be increasingly complex. It is up to the educator encourage the child to progress in this direction.

At review time children remember what they did during the day, which gives them a deeper awareness of their actions and ideas while sharing and learning from the experiences of other children.

The classroom space and organization:





### 3.1.2 Episodes

#### a) Zoo game

The activity consisted on a game about a trip to the zoo. There is a zoo drawn on the floor with 9 houses. There are connections between some of the houses.



Fig.3.1.1.1 - Zoo map

Children are arranged in pairs. One member of each pair will play directly on the zoo on the floor. The other member will draw the zoo path of his pair in the worksheet.

The teacher explained the rules to the children. The game started with two pairs of children. The game started with the children in four predetermined houses.



**Fig.3.1.1.2** - The game starts.

After, the teacher indicates the number of moves that the child should do (they only can move to certain houses). After those movements, some of the houses are destroyed and the children who are in these houses must leave the game - those who did not follow the rules correctly.

The child must understand the rules, she has to make choices before the various possibilities it has. The other element of the pair has to follow the route of his colleague and has to be able to describe it on the worksheet.

It is noted that the day before, the children had gone to visit a zoo.

The teacher intervened with many questions to verify that the children followed the game and were aware of its rules and possibilities.

The fact that they play in pairs with a child playing on the zoo and another in the worksheet, allowed seeing if there were differences in the spatial perception of location.

There wasn't great interaction between children but there was between the teacher and children through questions about the progress of the game.

In this session, we do not know how the presence of two strangers changed the usual behaviour of the actors. Some of the children were quieter than usual, according to the teacher.

After a visit to the zoo, the children played a game that aimed to improve the spatial perception and oral expression. They used up informal means to do so and there was an effective action of the teacher to facilitate the understanding of children on the subject.



Fig.3.1.1.3 - Children with the worksheet.

### Mathematics activity

In this activity, the aim is to develop some important mathematic skills:

- understand the rules of the game and the given instructions;
- identify the several possible options and make choices;
- verbalize his actions;
- describe in the worksheet the colleague path;
- develop some spatial perception and representation.

The group of children who were watching the game were capable of describe the several paths and choices made by their colleagues.

In the episode, the moments when the objectives are achieved by the children are pointed out with bold characters.

### Creativity

In this activity, the children didn't have much freedom to explore, to do questions and make hypothesis. However, they could imagine what other possible paths they could have followed.

#### Example 1:

One girl "child C" was only watching the game, was rather attentive to what was happening. After teacher question: "Who has more possible paths to follow?", she answers immediately: "child E". There were three children on the game, she counted how many possibilities each colleague had and compared it. She was capable to identify the several options of each one. She has done this without any additional help or question from the teacher.

#### Example 2:

"Child D" was capable of representing mentally his path and without doing it on the floor, jumped directly to the right house. The teacher asked him what path did he follow and he

explained.

## b) Logic Blocks

This is a very classic mathematics activity with commercial material. In this activity we had the group of three years old and five years hold. The teacher started the activity with the three years old. She wanted that they learned to classify geometric forms. The other children were watching.

She used pieces of different types of geometric forms (triangles, squares, rectangles, circles), different colours (blue, yellow, red), and different sizes (big, medium, small).

A cardboard was distributed to each child. The teacher showed a representation of a geometric form (circles) and the children chose the pieces with that characteristic; after that, she asked for the squares; the rectangles and finally the triangles. After that, she asked to classify the red triangles, and so on. We saw children helping each other. Each child arranged his pieces in different ways.



Fig.3.1.2.1 - Three years old children with the circles.



Fig.3.1.2.2 - Each child arranged his pieces in different ways.

After this, they sat at the desk to draw pictures using geometric forms.

At the same time, the group of three years old worked in the pictures; the teacher started the activity with the five years old. The children were divided in groups of two and she asked to each one piece with different four types of characteristics. This was not an easy task to the children.



Fig.3.1.2.3 - The four types of characteristics.

After, she asked to make sets of geometric forms and then, asked to create prescribed subsets inside the previous sets. The teacher gave importance to used language, namely, sets, subsets, inclusion.



Fig. 3.1.2.4 - Creating subsets of pieces.

## Mathematics

The aim is to learn mathematics concepts from Set Theory: classification, inclusion, intersection. At the same time, they work with geometric forms.

## Creativity

In this activity, we think there was opportunity to creativity when the children of three years old could draw pictures with geometric forms.

### Example 1:

When the teacher asked pieces with four different types of characteristics, we saw children making mistakes and the teacher correcting those mistakes. There was one girl with the wrong piece and she was correcting her own choice (blue circle) by observing the teacher remarks to the others. When the teacher noted her piece, she had already the right one (yellow circle). She was capable of correcting her own choice with the other's mistakes.



Fig. 3.1.2.5 - The first girl's choice – the blue circle.



Fig. 3.1.2.6 - She makes a wrong correction and adds a yellow square.



Fig. 3.1.2.7- Finally, she replaces the blue circle by the yellow one.

Example 2:

The children of three years old created pictures using their imagination.



Fig. 3.1.2.8 - Creating pictures with geometric forms.



Fig. 3.1.2.9 - Creating pictures with geometric forms.

### c) Patterns

With 6 children of five years old, the teacher started the activity by initializing a pattern with the logic blocks and asks a child to continue. After, she asks another child to create a pattern. In the end, the children should represent through a picture the pattern they built or they could create another. We saw that children preferred create new patterns than represent the ones already made.

When asked what activity they preferred, the children said the one of the patterns because they could invent.

### Mathematics

Patterns and geometric forms involved. Children should identify geometric forms; identify patterns and create new ones.

### Creativity

The teacher foster creativity when ask children to create new patterns. She gave sufficient time and liberty to this activity.

### Example 1:

The patterns constructed by the children show creativity. A child was capable of constructing a new pattern with bottle caps.

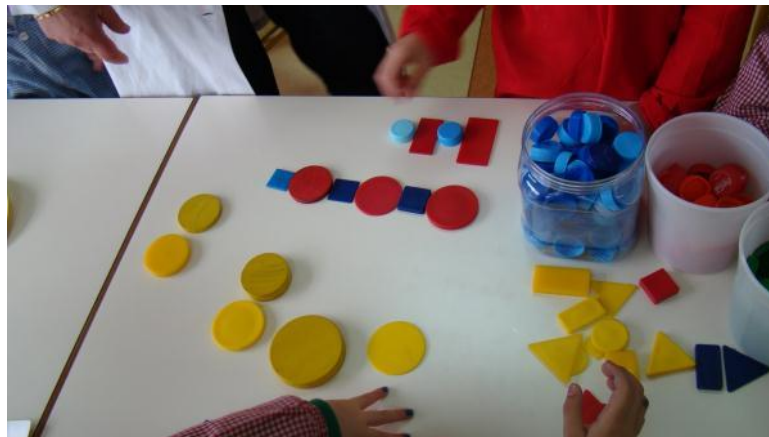


Fig. 3.1.3.1- The child starts a new pattern.



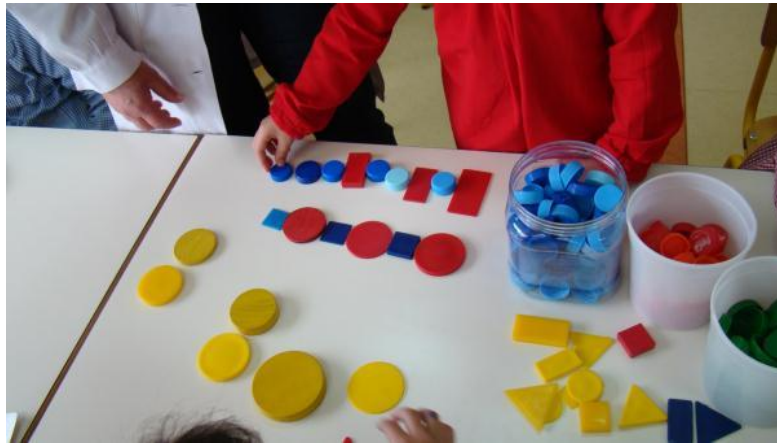


Fig. 3.1.3.2 - The new pattern.

Another child draws a pattern at various stages:

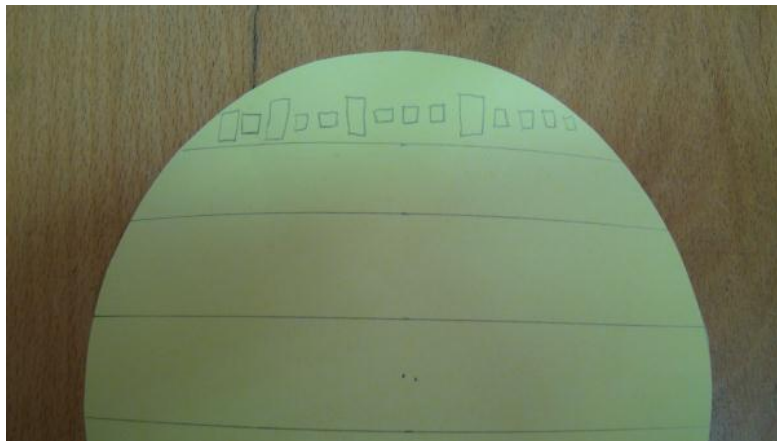


Fig. 3.1.3.3- first, she draws the geometric forms;

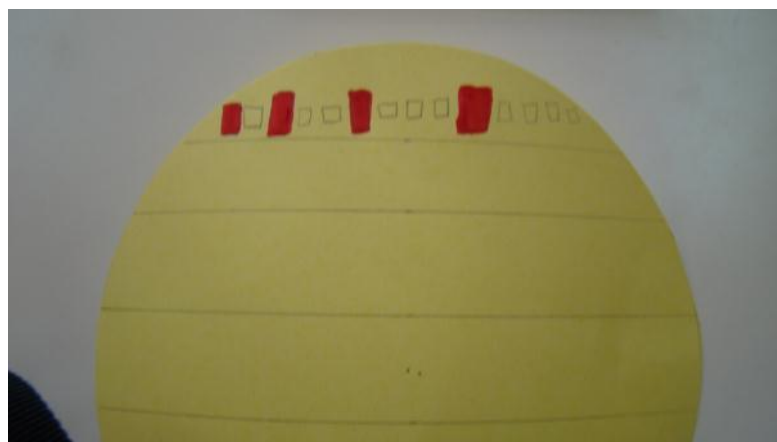


Fig. 3.1.3.4- then she paints one type of geometric forms



Fig. 3.1.3.5- and finally she paints the other geometric form.

### 3.1.3 Summary and conclusions

#### **RQ2: Probing practice**

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

In this case, the teacher gives opportunity to enjoy diverse educational experiences.

The activities are focused on children's interests and organized so as to respect the achievement of each one. Every child has the possibility of free activities with which she affectively engages. Oral and plastic self-expression is stimulated in a climate where the teacher encourages dialogue, questions that stimulate thinking. The teacher provides opportunities for children to create imagine and express freely their thoughts and emotions. The teacher is always present and very much involved in the child work, encouraging and scaffolding.

#### ***What role if any does creativity play in these?***

In these activities, after exploring the concepts, the teacher gives opportunity to the child self-expression. We see it explicitly in the Patterns activity or when the 3 years old children are invited to draw pictures with geometric forms.

#### **RQ3: Probing practice**

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

This teacher is aware of the importance of creativity in the activities she creates. As said before, she has more facility on encouraging creativity in science activities rather than mathematics activities.

## 3.2 Case 2 – “Carol”

### 3.2.1 Context

Where?	Country	Portugal			
	Setting name	PT2			
	Location within setting	Pre-school			
Who? (children)	Year group/age of children	5 years old			
	Number of children in class	24			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher and 1 collaborator			
	Case teacher role	Co-ordinator			
When?		1	2	3	4
	Dates of visits	08/1/13	14/2/13	21/2/13	11/3/13
	Times of visits	10:00-11:00	2:30-3:30	10:00-11:00	10:00-11:00

#### a) School

This is a private school located in the suburbs of Braga town. It has nursery, pre-school, primary school, 2nd, 3rd level of basic education and secondary school for children between three to 18 years old.

The normal working period is from Monday to Friday from 7.30am to 8pm, including extension.

The class time is 9am to 4.30pm; from 5pm to 8pm is the extension time for nursery, pre-school and primary children.

They have extracurricular activities and Summer Camp. The students have to use a uniform.

The school calendar is officially defined by the central and national Ministry of Education.

The school is very well equipped. It has laboratories for the practice of experimental disciplines and it is equipped with audio visual technology.

The school has a small outdoor space. However it has large corridors and indoor spaces.

Children came mostly from middle class families.

#### b) Teacher

The teacher is a young teacher and has a good background on sciences. She is very active and

concerned with teaching /learning strategies. She believes the teaching/learning process must be based on constructivism and the learning activities must be child-centered.

For instance, the idea of the project theme for this school year – The Solar System – came up in a conversation with the children.

The activities are planned after questions and group conversations with the children. Example: One child told she asked her mother: “Where does the sun rise?” Her mother answered: “The sun rises in the east.” This motivated the following teacher question: “What is east?” and there was a discussion about west and east and they made drawings representing his ideas about the theme.

The teacher makes questions to begin the exploitation of a theme where the children show and represent their ideas about it. Afterwards, on Thursdays, they have a session with a science teacher in a different classroom who explains the right theory about the theme.

### **c) Classroom**

This class consists of 24 children with five years old. The students are from the city of Braga and surrounding area. 15 of these children have extracurricular activities as piano, ballet and sports. Only two pairs of parents don't have at least a first level academic degree.

There is a consistent daily routine that allows different types of interaction and promotes safety, self-control, initiative, self-esteem and autonomy. There is time for small group activities and large group activities.

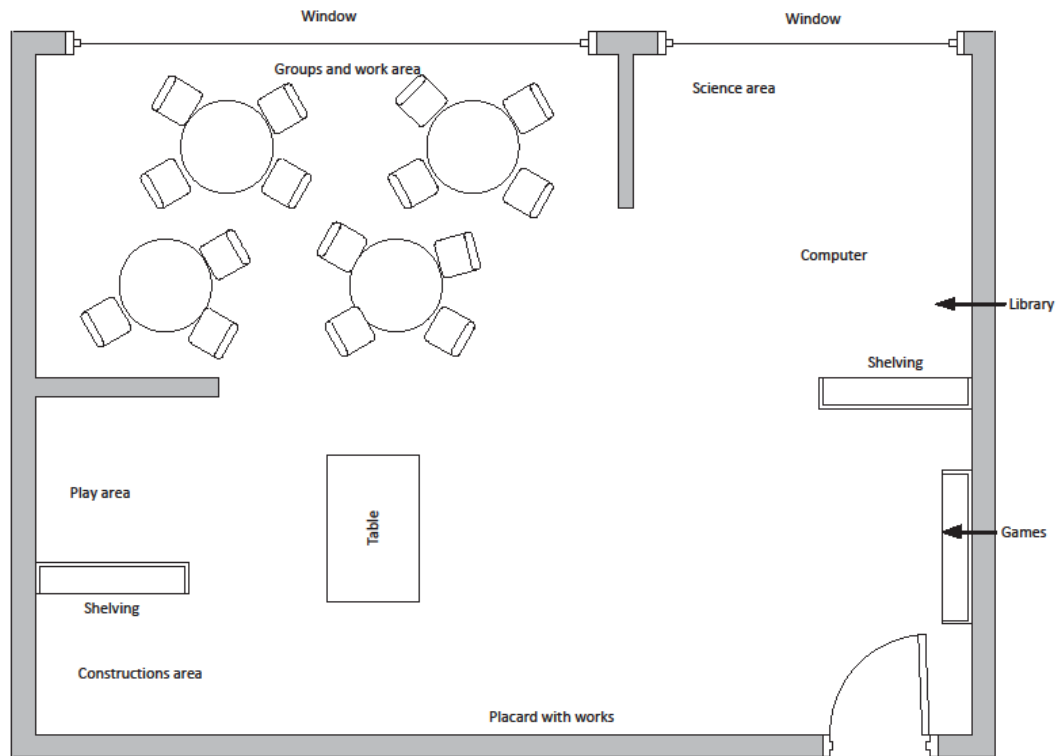
In the large group activities, all children participate actively, initiate ideas, give suggestions, find solutions, live shared experiences, build a sense of community and are encouraged to participate in group problem solving experiencing together.

In small group activities, learning experiences are initiated by the adult and based on the interests and developmental levels of children. These explore, play with the materials and talk about what they are doing. Solve problems, contact with materials and experiences that hardly would experience and interact regularly with peers. In this time of activity, the educator observes the interactions and makes records.

In the morning, they have small group activities; between lunch and afternoon snack, large group activities and after snack, different activities during the week, Lecture time, English, Physical Education, Music and Science.

The classroom is divided in different areas, each one identified with a subject (plastic expression, library, construction (Lego), table games, and little house).

The classroom space and organization:



### 3.2.2 Episodes

After some sessions talking about the Solar System, the teacher prepared an activity where the children may compare the Sun and Earth sizes as well as the distance between them.

If the Sun is represented by a ball what would be the Earth size? And what is the distance between them?

First, in their classroom, they had a conversation with questions and hypotheses about the Sun size, the Earth size and the distance between them. Through a dialog between the teacher and the children, they gathered many facts about the Sun and its importance for life.

Using a ball and a little piece of plasticine, they compared the proportion between the Sun size and the Earth size.



**Fig.3.2.1** - The ball and the little piece of plasticine.



**Fig. 3.2.2** - Measuring the ball with their hands.



**Fig. 3.2.3**- They used a piece of paper to measure the ball diameter

Using one hundred colored pieces of paper, they went to the school corridor and represent the distance between the Sun and Earth, because they have known that this distance is one

hundred times the Sun diameter.



Fig. 3.2.4- In the corridor.



Fig. 3.2.5- The earth is not visible from the Sun.

### Science and Mathematics activity

We have seen an activity where they **apply their knowledge** about the Sun and the Earth.

The teacher talked about the **notions of distance and proportion** between the objects. She used **several ways to represent** the ball diameter. She gave opportunity to the children to make several questions and explore hypotheses about it. They were very much involved in the activity and interested about the theme. They compared the size of the Sun and the Earth using proportions and also compared the distance between them using the size of the Sun.

### Creativity

The activity created by the teacher was creative: they have discussed the distance from the Sun and Earth and compared sizes; the teacher used a ball and a little piece of plasticine to compare the Sun and Earth. This sparked the group curiosity and the children had the opportunity and time to make many hypotheses and questions. Afterwards, they have made

an experience, where they could witness the proportion between the Earth size, Sun size and the distance between them.

In the end, they noticed that they couldn't see the Earth from the Sun. The distance between them was too big and the size of the Earth was too small. They have interpreted the evidence that they couldn't see the Earth from Sun. In the end, they had a good idea of the proportion of size and distance.

After some days, when talking with the group about the activity, they explained very well what they have learned and made in that activity.

#### Example 1:

When they were at the classroom, they had time and opportunity to make many questions and hypotheses about the Sun, Earth and people size. For example, they asked "If this was a person (pointing to a piece of plasticine), what would be the Sun size?", "If the Sun was this room size, what would be the Earth size?" The teacher gave them enough time to explore this.

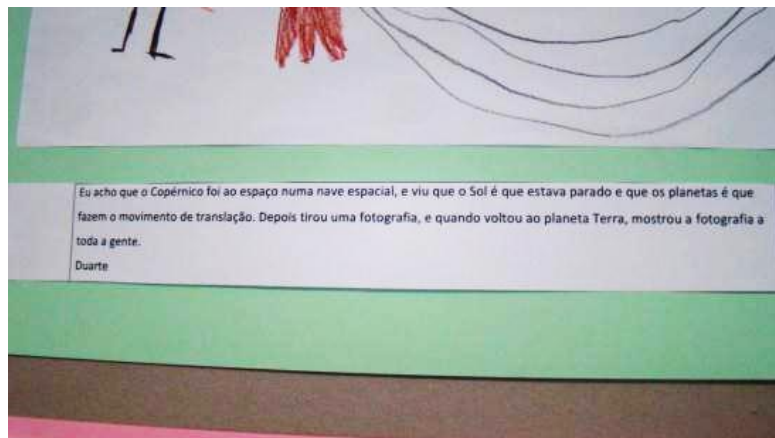
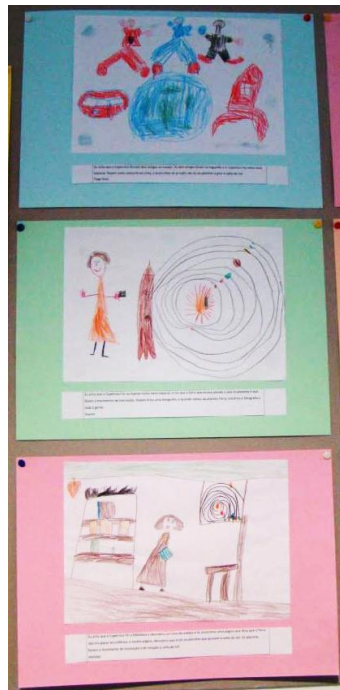
#### Example 2:

In the end of putting pieces of colored paper between the ball and the piece of plasticine, they evidence that "We can't see the piece of plasticine from the ball".

### **3.2.3 Summary and Conclusions**

I have seen an activity where the children could foster their curiosity about scientific facts, where they question and they put hypotheses. In the end, they interpret the evidence. They do scientific thinking. This activity is one of many where the children explore scientific facts about the Solar System. They represent their ideas in various ways: dialogs in group, they draw pictures where they may use their imagination; their curiosity is stimulated, they bring books about the theme, they talk with their parents and make them questions about it. I have seen drawings where they answer to the question: "How Copernicus finds out that that is the Earth that moves around the Sun?" We have many interesting hypotheses: "He went on a rocket and he saw the Earth moving", "He searched in the web", "He searched in his books in his big library",... (See photos).





**Fig. 3.2.6-** Examples of works about Copernicus – “Copernicus went in a space shuttle and saw the Sun wasn’t moving and the planets were moving. He took a picture and showed it to everyone.”

**RQ2: Probing practice**

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

In this school, they give a particular importance to the science education in the early years. As said before, they have a class with a science teacher every week where they discuss the subjects. In this case, they have explored a theme emerged in a group conversation, between the teacher and the children. The subjects are explored in many ways: with oral questions, drawings, experiences (they have made an outside door experience to see the change of

shadows throughout the day), activities like the one I witnessed. After a week of exploring a subject, they have the explanation with the science teacher.

**What role if any does creativity play in these?**

In these activities, the children have time and opportunity to make questions and put hypotheses, to make predictions and the teacher gives importance to the communication of the children thoughts and believes. These children are used to start a conversation about a subject even if they are not questioned about.

**RQ3: Probing practice**

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

This teacher is aware of the importance of creativity in the activities she creates. As said before, she believes that the child must build, with the teacher’s help, his knowledge. And this demands time, work and dedication.

These children are very motivated and interested in science facts. They go home and make questions to his parents; they look in the web and in books.

### 3.3 Case 3 – “Florence”

#### 3.3.1 Context

Where?	Country	Portugal			
	Setting name	PT3			
	Location within setting	Primary School			
Who? (children)	Year group/age of children	3rd. grade; 8 years old			
	Number of children in class	27			
Who? (adults)	Number of adults	1			
	Role of adults	1 teacher			
	Case teacher role	Co-ordinator			
When?		1	2	3	4
	Dates of visits	29/01/2013	15/02/2013	21/02/2013	04/03/2013
	Times of visits	15:00-17:00	14:00-17:00	16:00-17:00	16:00-17:00

**a) School/setting**

The CT (pseudonym), situated in a very large city in Portugal, located northeast in a town

which play an important role at the development of the Portuguese territory, focused in teaching the preschool, primary school, the 2nd and 3rd level of primary and basic education, aged between three to fifteen year old in a total of 600 students.

It attracts families with Socio-economic advantage. There is a strong active parental involvement.

The CT is an educational Catholic institution integrated covering four levels of education:

- Preschool - five / six classes;
- Primary school (1st level of basic school) - eight classes;
- 2nd level basic school - four classes;
- 3rd level basic school - six classes.

The normal working period is from Monday to Friday from 8am till 7.30pm, including extension. It also offers students a time specific prayer/reflection of 15 minutes before start classes.

The time of each level of education is the segment as shown:

- Preschool: 09 am -12pm | 14 pm -16.30 pm;
- Primary school: 08.45 am -12.10 pm | 14 pm -16.30 pm /17: 15 pm;
- 2nd and 3rd level: 08.45 am -16.30 pm (except the 9th grade, one day a week, 08:45am -17:15 pm).

The school calendar is officially defined in each school year, the Ministry of Education.

The CT offers outdoor spaces for recreation and sports, wooded areas and garden. It has several spaces to service curricular activities and non-curricular:

All rooms are equipped with materials specific to the functioning of the various classes and activity. Laboratories for the practice of experimental disciplines, the computer room, with updated equipment and internet connection in network and wireless access in classrooms.

Regarding audiovisual, the College is equipped with televisions, videos, slide projectors, overhead projectors, multimedia projectors, DVD and CD players and laptop computers.

#### **b) Teacher (using the interview)**

The teacher for the episodes detailed below was Florence (pseudonym). Florence holds a graduation in early years education in a Public Higher Education Institution. The Ministry of education recognizes the degree to apply for a teaching position in early years education. She has worked for over twenty seven years and as such has known many of the children of the CT and their parents since the children were infants. This has meant that she has built strong relationships with the families and the children. She draws on this deep and extensive knowledge of the children, along with her day-to-day observations, to inform her everyday

practice.

Teacher during the interview showed a lot of enthusiasm related to her profession. Reported usual recourse to a wide variety of materials, innovating daily and using various sources, reiterated that the planning is done weekly at this school. The planning of these classes always takes account of the interaction between all disciplines (mathematics, science and Portuguese language). Reported that, the basis of her work with students, of these ages, is guided by the closeness and affection, honesty and dialogue with students. Regarding creativity, believes that this is part of her job, looking for activities and challenges that encourage students. Further considers that encourage activity in science and maths is a way to stimulate students' interest and enthusiasm students to these disciplines.

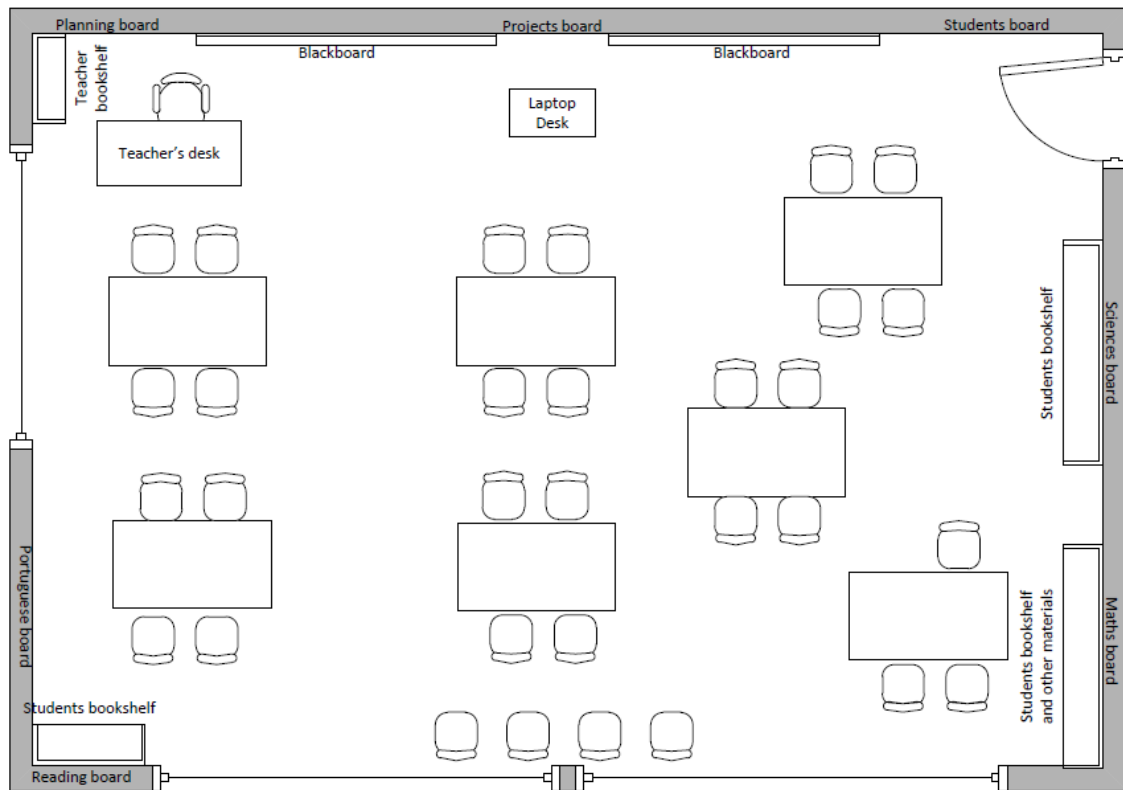
As teacher referred in the interview: *“I base myself on the very close relationship and affection with students, I think it is very important because we can have very good students but if not we give motivating and rewarding work eventually lose motivation and end up disrupting the work of others. Seeking motivated, diversify the issue of closeness and affection, also try to have a relationship of transparency and honesty, let students talk a lot and reflect on the challenges and problems and what I meant is that the conclusion reached allows us to learn something for the real life. The mathematical challenges teach us to be patient, to reflect, to not give up, help concentration, and seeking to do this in any of the areas, almost like a moral lesson that take into your life, because I think fundamentally, not only the intellect, but also the formation of affects and values. Because the society we're in is also a bit complicated and if we think only in intelligence and not think about the heart, we stay poor, I try to take the class to a develop of complete human being, as a whole.”*

### **c) Classroom (age children)**

The class has twenty seven students (seventeen boys and ten girls), with average age of 8 years old. Students are mainly from the city of Braga, except one student that is from Brazil.

There are no students with learning disabilities, and the class is very heterogeneous in terms of school results/grades.

The classroom space and organization:



### 3.3.2 Episodes

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

#### a) Wolf, sheep and cabbage

The aim of the problem is to move the wolf, sheep and cabbage to the opposite shore of the river. It gets more difficult though because when the man is not around the wolf will eat the sheep, the sheep will also do the same when alone with the cabbage.

#### Science/Mathematics

Students must have knowledge of food chain. They have to know Maths contents, as combinatorial –have to make combinations (groups) between the objects (animals) involved, regarding food chain relationships; and problem solving – analysing possibilities and predict if there is more than one solution.

There were a number of different areas of learning that the students were developing during the lesson – both scientific and non-scientific, like: develop read and interpret the problem; identify the rules and constraints; predict /anticipate results based on constraints; consider each part by itself (wolf, sheep, kale) and relate it with the other; using the process of trial and error; discover the possibilities and impossibilities; share and justify inferences; interact within

the group and between groups.

### **Creativity**

Mathematical creativity, as defined in the conceptual framework, is present in the resolution of the problem/approaches by the students, and evident in expressions like: “The sheep has to go first because the wolf doesn’t eat the cabbage.”, showing how the children generate alternative ideas and strategies as an individual or community; in the exchanges below we also see how the children reason critically between these ideas and strategies.

*Child R: “if we took the sheep first, then the cabbage, then the sheep will eat the cabbage”*

*Child R: “so we have to let the sheep and bring the cabbage back”*

*Child R: “if we took the cabbage in first place, the wolf will eat the sheep”*

Students were exploring and discussing the several hypotheses to solve the problem situation, and the relations between the actions they could take and the implications.

*Child G: “First we take the sheep across, then we go back and get the cabbage, then we take the sheep back and take the wolf across, then we take the sheep across.”*

The child leads to the solving of the problem, and made his explanation with the paper (boat, wolf, sheep, cabbage).

*Child LA: “With this activity we learned that to solve a problem we have to make relationship between what we are “analysing”.*

The whole class reach the conclusion and solve the problem presented in the beginning, and they verify it in the computer simulation. Based on this, we may consider that, students develop science skills like, predicting, observing, analysing and describing, alongside the scientific or mathematical creativity of generating alternative ideas and strategies and reasoning critically between them.

Suggesting a potential way to extend the activity or to provide a solution to the problem/question also shows everyday creativity, also defined in the Conceptual Framework for CLS, in other words engaging in purposive activity generating original and valuable outcomes.

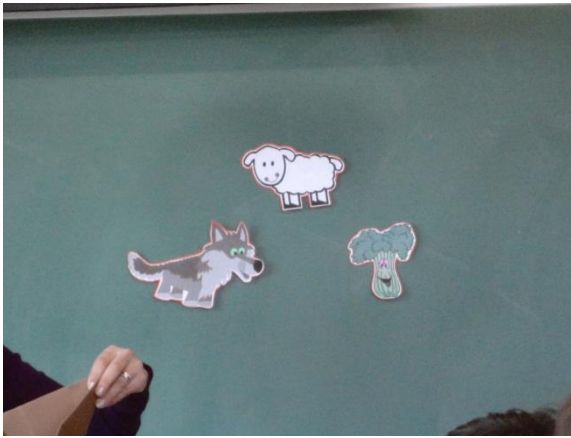


Fig.3.3.1.1- Teacher presenting activity and support materials.



Fig.3.3.1.2 – Teacher questioning children.



Fig.3.3.1.3 - Children collaborative nature.

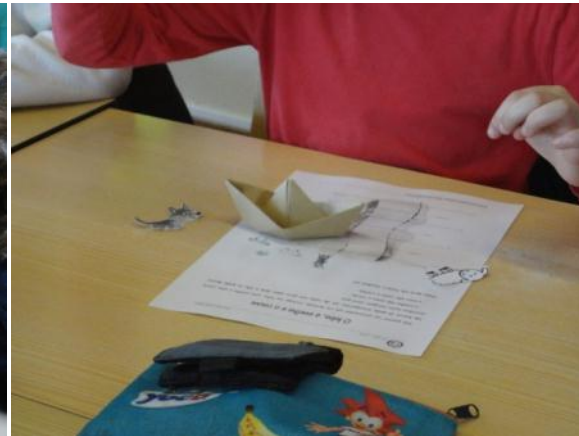


Fig.3.3.1.4 - Children testing.



Fig.3.3.1.5- Children verifying, using computer.

## b) Buttons episode

The aim of the problem is to transform the pattern of a triangle formed by buttons in pattern

of a hexagon, just moving two of the buttons of the initial pattern. Apply mathematics in practical situations including translation of objects and (plan) geometry – recognizing geometric forms (triangle and hexagon). Problem solving – analysing possibilities and predict if there is more than one solution.

**Mathematics**

Mainly maths sciences were present. Students have to know geometric plan forms like triangle and hexagon.

There were a number of different areas of learning that the students were aiming to foster during the lesson – both scientific and non-scientific, like: develop read and interpret the problem; identify the rules and constraints; predict /anticipate results based on constraints; using the process of trial and error; discover the possibilities and impossibilities; share and justify inferences; interact within the group and between groups.

**Creativity**

One of the students suggest a different approach to the problem which consists in moving all the buttons to similar positions, between the two pictures, and in doing so she realizes that only two buttons don't have a correspondence in the hexagon figure, so she figures out that she will have to move those two buttons. Although the student hasn't solved the problem following the rules, her approach also shows some creativity, because she used imagination and innovative thinking. We see her doing what the activity is set up to do in terms of fostering the mathematical and scientific creativity discussed in the conceptual framework as “generate alternative ideas and strategies as an individual or community and reason critically between these”. This example seems to be an example of a child generating everyday creativity through an enquiry meaningful to herself and generating original valuable outcomes which reflects the everyday creativity definition in the conceptual framework i.e. “purposive imaginative activity generating outcomes that are original and valuable in relation to the learner”.



**Fig.3.3.2.1-** Sequence of the child steps to solve the problem with an alternative approach.



**Fig.3.3.2.2-** Sequence of the child steps to solve the problem with an alternative approach.





**Fig.3.3.2.3-** Sequence of the child steps to solve the problem with an alternative approach.



**Fig.3.3.2.4-** Sequence of the child steps to solve the problem with an alternative approach.



**Fig.3.3.2.5-** Conclusion of the two buttons that have to be moved.



**Fig.3.3.2.6-** Conclusion of the two buttons that have to be moved.



**Fig.3.3.2.7-** Child solved the problem.

### c) Marbles episode

The aim of the problem is to solve one worksheet focused on maths, reasoning. Consists in apply mathematics in practical situations, or problems. Students should use problem solving – analyzing possibilities and predict if there are more than one solution.

#### Mathematics

This worksheet was focused in concrete problems that were proposed for the students to solve. Mainly the contents in it focused arithmetic progressions, combinatory, set maths questions, and problem solving.

There were a number of different areas of learning that the students were developing during the lesson – both scientific and non-scientific, like: develop read and interpret the problem; identify the rules and constraints; predict /anticipate results based on constraints; discover the possibilities and impossibilities; share and justify inferences; interact within the group and between groups.

#### Creativity

This activity that appears to be a more routine exercise of maths skills of the students seemed to be one of the best examples of creativity during problem solving. During the activity it was registered a diversity of approaches to the problem, as shown by the worksheets collected from the students.

All the students suggest their way of presenting the solution to the problem/question, interestingly some students use a formal analytical approach, using “successions”, and others use schematic approach, mainly, using (colored) draws, showing multiple problem solving skills.

Using different methods all children reach the correct answer, despite the different approaches. This is a good example of mathematic and scientific creativity, i.e. “generate alternative ideas and strategies as an individual or community and reason critically between these”.

The “correct answer” needed to be reached however children found their own ways to it. To this extent the process of reasoning can be considered to reflect the general definition of creativity i.e. “purposive imaginative activity generating outcomes that are original and valuable in relation to the learner”

#### Example 1

*Child R: “I’m going to make some drawings... with the marbles on.”*

*Child A: “I’m trying that way too.”*

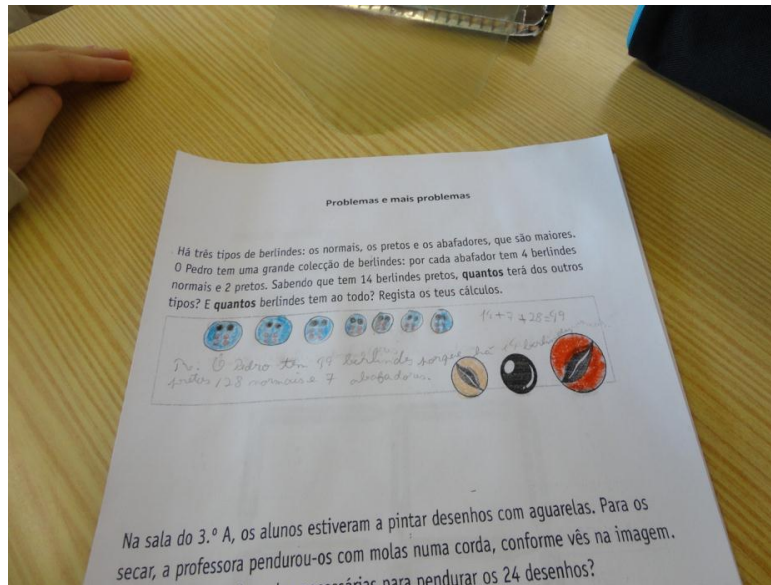


Fig.3.3.3.1 - Schematic approach, mainly, using (colored) draws

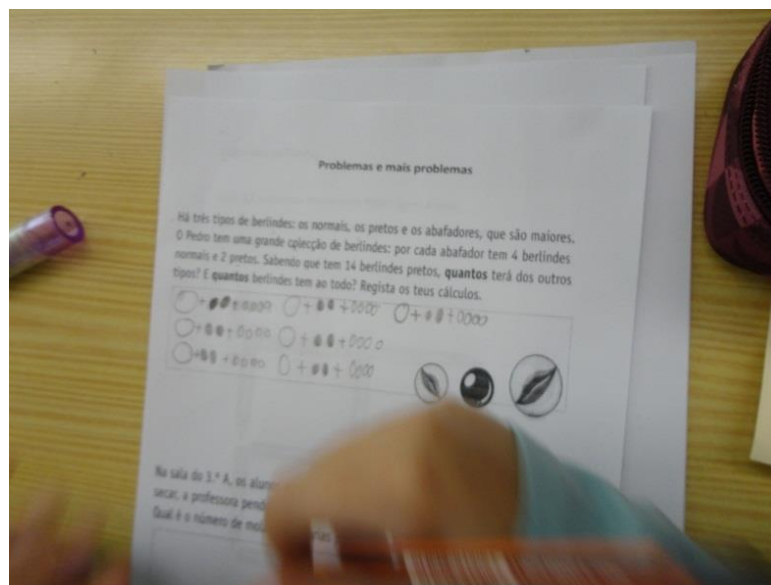


Fig.3.3.3.2 - Schematic approach, mainly, using draws

Example 2

Child M: "I make some proportions, regarding all the marbles involved in the situation, like this: 1 marble damper, 2 black marble, 4 white marble, so next, 2 marble damper, 4 black marble, 8 white marble, and so on until we reach 7 marble dumpers. Then we count all the marbles we need."

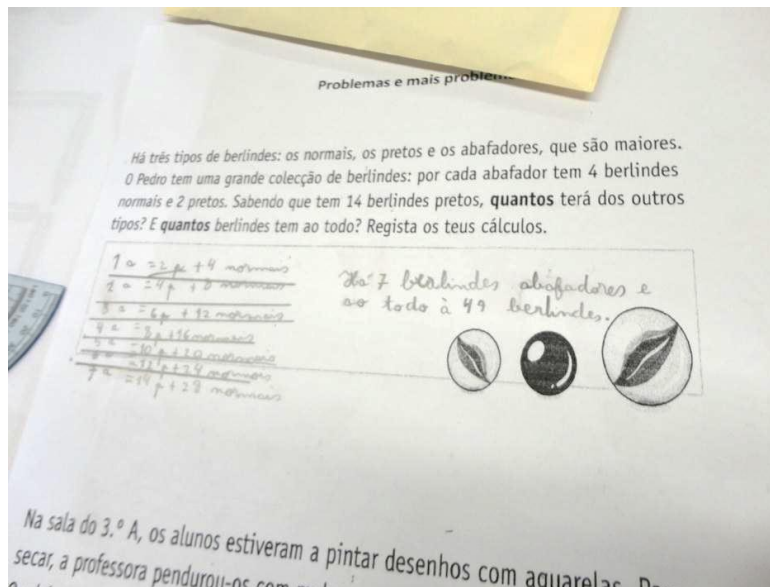


Fig.3.3.3.3 - Formal analytical approach, using “successions”,

Example 3

Child P: “The first marble damper has 4 white marbles and 2 black marbles, the second marble damper has 4 white marbles and two black marbles,... the seventh marble damper has 4 white marbles and 2 black marbles. If we count all of it, there are 49 total.”

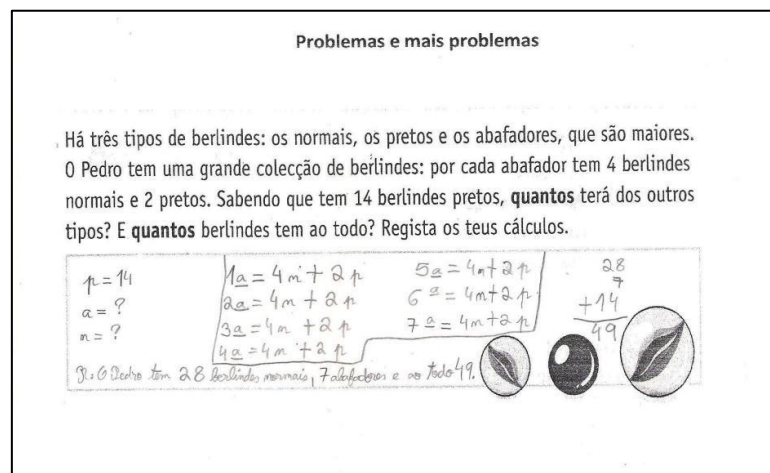


Fig.3.3.3.4 - Formal analytical approach, using “successions”,

There were many different approaches among the students, from schematic resolutions to analytical resolutions, that shows different approaches to the same problem, and creative dispositions such as problem solving skills, reasoning skills and connections making.

### 3.3.3 Summary and conclusions

#### RQ2: Probing practice

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

The teacher initiated activities promoting the interest and curiosity of students, presenting problematic situations and discussing with students initially.

During the activity the teacher was always careful to guide students in their learning and guiding them to a way forward, not invalidating the trials and errors of students in order to solve the problem. The teacher has many years of experience that means she is very sensitive as to when to guide. She fosters reflection and reasoning, encouraging students.

#### ***What role if any does creativity play in these?***

These three episodes showed creativity is through the encouragement of problem-solving and children's agency. As Florence referred in the interview: "creativity is important, because how more creative students are, more motivated they feel, because she considers the fact that they can discover multiple paths to get to the result, gives them a great joy and takes them to get excited fostering the interest in these disciplines (maths and sciences)". Teacher finds this relation between mathematics and science very important, very tight, never forgetting that our native language is the Portuguese which is also very important.

#### RQ3: Probing practice

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

Teacher prepares her activity depending on students' interests, not forgetting the national curriculum and student achievement, looking to find activities that promote students' interest in mathematics and science and creativity.

Teaching approaches appear to provide children with a "starting point" from which they can ask questions, experiment, observe phenomenon and so on, mainly teacher provides guidance so the students can achieve the purpose of the activities proposed and building their network of knowledge. As noted teacher has the ability to foster creativity.

#### ***How do teachers perceive their role in doing so?***

Teacher perceives activities as led by children's interests, and activities develop according to events as they arise in the classroom;

Development of scientific language and scientific method;

Reinforcing/revisiting concepts in a number of different ways (starting classes with math's questions, etc);

There was noticeable emphasis on scientific facts;

### 3.4 Case 4 – “Olivia”

#### 3.4.1 Context

Where?	Country	Portugal			
	Setting name	PT4			
	Location within setting	Pre-school			
Who? (children)	Year group/age of children	5 years old			
	Number of children in class	22			
Who? (adults)	Number of adults	2			
	Role of adults	1 teacher (T) + 1 teacher assistant (TA)			
	Case teacher role	Co-ordinator			
When?		1	2	3	4
	Dates of visits	29/01/2013	21/02/2013	04/03/2013	08/04/2013
	Times of visits	15:00-17:00	14:00-16:00	14:00-16:00	16:30-17:00

#### a) School/setting

The CT (pseudonym), located northeast of town, focused in teaching the preschool, primary school, the 2nd and 3rd level of primary and basic education, age between three to fifteen year old in a total of 600 students.

The CT is an educational Catholic institution integrated covering four levels of education:

- Preschool - five / six classes;
- Primary school (1st level of basic school) - eight classes;
- 2nd level basic school - four classes;
- 3rd level basic school - six classes.

The normal working period is from Monday to Friday from 8am till 7.30pm, including extension. It also offers students a time specific prayer/reflection of 15 minutes before start classes.

The time of each level of education is the segment as shown:

- Preschool: 09 am -12pm | 14 pm -16.30 pm;
- Primary school: 08.45 am -12.10 pm | 14 pm -16.30 pm /17: 15 pm;
- 2nd and 3rd level: 08.45 am -16.30 pm (except the 9th grade, one day a week, 08:45am -17:15 pm).

The school calendar is officially defined in each school year, the Ministry of Education.

The CT offers outdoor spaces for recreation and sports, wooded areas and garden. It has several spaces to service curricular activities and non-curricular:

All rooms are equipped with materials specific to the functioning of the various classes and activity. Laboratories for the practice of experimental disciplines, the computer room, with updated equipment and internet connection in network and wireless access in classrooms.

Regarding audiovisual, the College is equipped with televisions, videos, slide projectors, overhead projectors, multimedia projectors, DVD and CD players and laptop computers.

#### **b) Teacher (using the interview)**

The teacher for the episodes detailed below was Olivia (pseudonym). Olivia holds a graduation in early years education in a Public Higher Education Institution. The Ministry of Education recognizes the degree to apply for a teaching position in pre-school education.

Olivia thinks that children were learning in large groups, and suggestions were always given by them, there wasn't the possibility of working in smaller groups, but, ensuring that, all gave time to everyone, everyone respected the time to talk to, each and every one had the opportunity to experience all the pendulums built (according to the variations and all objects used) so she thinks that there was a social dimension, social interaction and collaboration among children, more than if they were not learning in the field of citizenship and respect for each of them permission to express themselves in due time. In this case Olivia thinks that was somehow learning of a few simple physics concepts. Regarding the planning of lessons that is usually done weekly, however this activity was something special because she starts from something that was not planned, left a wire and just try to see what we could achieve with this activity. She had some support materials if they were needed, but initially all started with the plastic bottles that child brought and the wire. From this we took ways to find out what could be done and so this class could not be planned.

When Olivia was asked about how she were facilitating learning she considers that: *" Here what seems important, above all, it was hear children, their opinion, their issues, their proposals, and work from their proposals, so they were proposing and we were walking. I found myself on top of a chair to hang a wire in the arc of a bathroom, which really was not supposed, nor could imagine that to happen, but this was an exceptional situation that the students suggested, students who were understand what they should do and it came to me. This can encourage and motivate me and then immediately realize the motivation of these children, because when we make experiments with significant interest and in order to be meaningful to the children, they are necessarily motivated and their imagination and creativity, the imagination, certain a first way and then flowing creativity and creative thinking of children is something that we must respect, much more than the teacher "standard". These are ideas that advocate for a long time that I have written, but the teacher really "standard" let me*

*many questions on what is the future citizens who want to develop and what is the mind that we want to expand. So children in this age group is where we have more possibilities to invest in creative thinking, freedom and liberation of ideas, in appreciation of ideas, in appreciation of their concepts, without shame, without fear and show the children what they think and say has some workability, or some degree of workability. Not "this makes no sense, silent, not now, this is not no way", these things should not be said to children. The adult, one day eventually comes, and remember that it was hopeless, he should be silent, he always said the greatest nonsense and we have no right to do this in small children. We have to respect the creative thinking, the options and the views of children and have the courage to go after them, which the teacher gives a lot more work."*

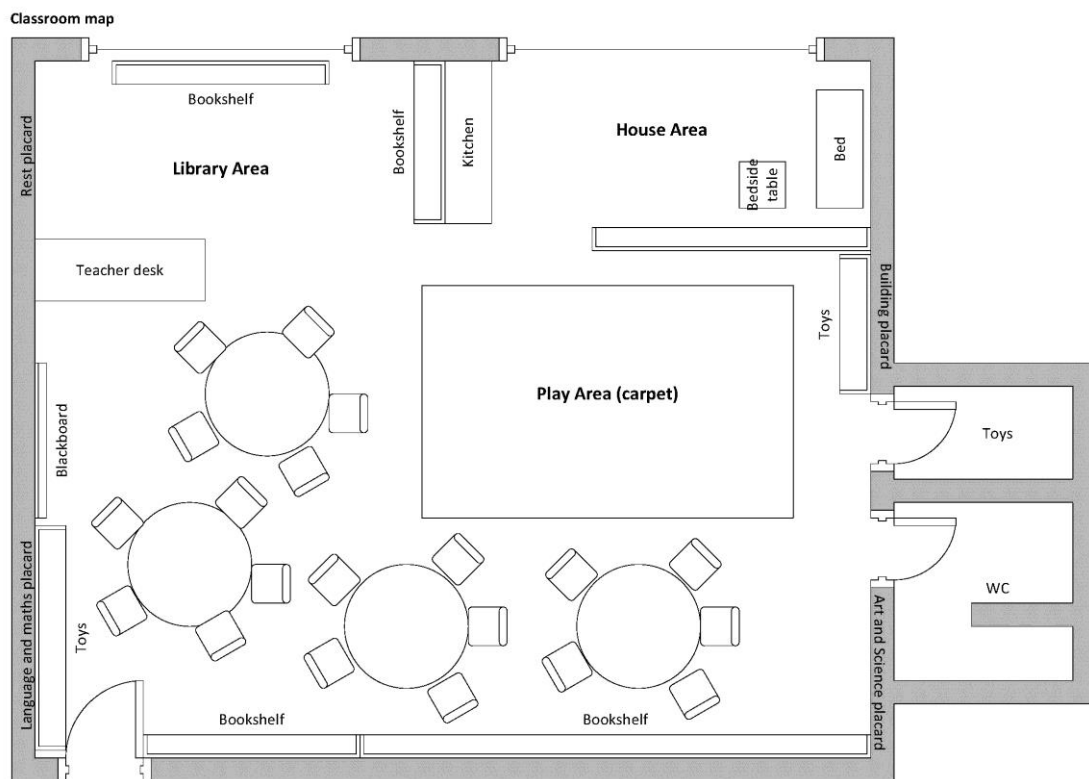
When Olivia was asked about if there was anything else she would like to tell about science, mathematics and / or creativity in the early years, she says: *"I learned to discover that this potential is in students and not the teachers, but I'm twenty years in this institution and had the idea, wrong idea, that the teacher who is the holder of knowledge and that is really all he knows. We do not always know everything and often students give us good suggestions that we do not want to take. Proposals by students lead us out of our comfort zone and go further, but this is because we listen to creativity, spontaneous message, the discerning eye, we (teachers) do not have, our look is formatted. So I learned to respect the opinion of my students and realize that there is a lot of potential and it's them who have to do the story, making the way and if they do this construction, great, that was supposed as a teacher. Every time I'm more convinced that the student are the centre of our attention, is that the student is there for it, if we want students lead us to question, and even ourselves in the way we work, so I am at this stage of discovery and pure passion what is the potential that each student has, and that we (teachers) have just as experienced, open paths that is our obligation."*

### **c) Classroom (age children)**

The class has twenty two students (ten boys and twelve girls), with average age of 5 years old. There are no students with learning disabilities.

The classroom space and organization:





### 3.4.1 Episodes

The aim of the activity is to build a pendulum (swing game) and study the factors that affect its motion (movement). Children practice and develop the skills of systematic observation, questioning, planning and recording to obtain evidence, also, plan and execute an experiment whereby one variable is altered in order to obtain a certain result. Children work in a large group.

During the activity were identified three episodes, which are presented next.

#### a) Swing game - Rope

Teacher started the discussion questioning and dialoguing with the students about the length of the rope and its effects in the pendulum motion, *“Which rope should we use? A long one or a short one?”*; *“If you want to make a swing (game), then you need a good swing. What is a good swing?”*.

Olivia decided to perform an activity related to the pendulum and its movement. Regarding aspects of the lesson that involved creativity she believes that from the moment she started the activity with only one wire, all had the same size, and began to predict that it was possible to have multiple movements and they have concluded that the movement could be tilting to one side and the other, with a rhythm and they also came to the conclusion that we could hang something at one end of the wire, that look like clock room of the home of the

grandparents. And from there, students began the discovery of the simple pendulum, even built a possibility with a wire and espresso capsule, and themselves gave the suggestion to see where we could see the pendulum movement. The first attempt was not successful because it was against the wall and therefore was contact between the pendulum and the wall, the desired effect wasn't obtained, students suggested to use the arch of the door and from there they were able to realize exactly what was in their heads and what they wanted.

### Science

At the beginning of the activity students weren't full aware that the foothold of the rope will affect its motion. They start the activity with exploring the rope of the swing. After this short exploration phase, children are confronted with specific scientific problems concerning the swing game:

For example: *"If you want to make a swing game, then you need a good swing. What is a good swing? And what can be the rules for the game? How can you make such a game of your own?"*

While the children are building, they are engaged in an inquiry activity. They want to build a swing which meets the expectations of the game they have in mind. *"Which swing goes the longest time best back and forward? Which materials are the best to attach on the rope? What are the best objects for the swing to hit?"*

The importance of this activity is the inquiry that is done before the making of the swing game. In order to integrate the results of the inquiry into the game, children need to have the chance to do the research themselves. Children practice and develop the skills of systematic observation, questioning, planning and recording to obtain evidence, plan and execute an experiment whereby one variable is altered in order to obtain a certain result (*Does the support of the swing has an effect upon the swing time?*). Children discover some principles of swings by executing experiments with the swing game.

### Creativity

Creativity is present in the resolution of the problem/approaches by the students because they are able to choose the context of their swing game, so they therefore make their own connections with experience, and registered in expressions like: *"My grandmother pendulum clock as a swing like the one we are looking for."*, that shows science process skills such as observing and describing the surrounding world. When child was asked *"How can we build a swing like your grandmother has?"* it promptly answers: *"Attach the swing to the wall, hanging something in the end of the rope."* by this, child show signs of imagination and problem solving skills. So by making it possible for the children to contextualize the enquiry in meaningful experience of their own, the children engaged in both kinds of creativity outlined in the CLS Conceptual Framework. They engaged in 'everyday creativity' i.e. purposive imaginative activity generating outcomes that are original and valuable in relation to the learner. They also

engaged in the kind of creativity found in science and mathematics, also outlined in the Conceptual Framework, i.e. “generate alternative ideas and strategies as an individual or community, and reason critically between these”.

Suggesting a potential way to extend the activity or to provide a solution to the problem/question also shows creativity, students were able to build the proposed swing, and fix it to the wall. When trying to make the swing swings they observe that *“This isn’t a swing! It hits the wall and doesn’t swing.”*. Many child try to make it swing, unsuccessfully... so they reach a conclusion *“The swing can’t be fixed in the wall, because it’s impossible to make it swing, hanged in there.”* This part of the activity shows that students were able to questioning, gathering evidence, interpreting evidence and communicating findings. And we see the process of scientific creativity at work as the children reason critically between their strategies, as follows.



**Fig.3.4.1.1** – Student hanging the swing in the door opening.



**Fig.3.4.1.2** – Student experiments the swing movement in the door opening.

After the first trial of building a swing, Child R suggested *“Maybe we can fix it to the top of the door opening.”* and Child S observed and predict that *“We need to use a longer rope, because we don’t reach the top of the door opening.”*.

Child show science process skills, when said that *“we need to use a long rope, an open space (like the door opening) so the pendulum doesn’t hit anything while moving.”* and also, social factors of science learning, such as: collaborative and communal engagement and communication and creative disposition as sense of initiative.



Fig.3.4.1.3 - Student hanging the swing in the door opening, second try.



Fig.3.4.1.4 – Teacher questioning and fostering reasoning of the students.

#### b) Swing game - Swing

In this episode was supposed that students discover some principles of swings by executing experiments with the swing game by practice, and develop the skills of systematic observation, questioning, planning and recording to obtain evidence.

#### Science

The teacher guides this process, *“How can the pendulum tumble down these three plastic bottles?”* forming hypotheses, and gives no feedback on the content of the concept of the swing. She only scaffolds the children to express their findings to each other and to find some challenges children can investigate. Children plan and execute an experiment whereby one variable is altered in order to obtain a certain result, *“Why are you pulling the bottles closer?”*; *“What happen if the bottles are away?”*; *“What happen if the rope is small?”*.

Many children try to explain their ideas and put them in practice (helped by the teacher), mainly trial and error experiments to tumble the bottles: Child R, build one pendulum with the plastic bag holding the oranges fastened to the rope, Child J, builds an aluminium foiled heart-shape. Child R to Child J: *“Your heart shape is too light to hit the bottles”*.

Children have to find a way to solve these research questions by using the materials including the universal holder, started using weights and other objects to support laterally with some care and checking out what we could do to bring down the objects. From now on they are engaged into real inquiry to solve the questions. Child M: *“We have to use a long rope, and we have to put the bottles closer, so that we can drop them of more easily.”*

#### Creativity

Students realize that if they attach the pendulum to the tripod, it moves more freely and as more pendulum like movement.

The children build the swing. All elements come now together: the swing, the weight, the bottles, the place of the bottles. The children are working on the swing and are guided by the different teacher questions.

So before the game can be played, the children have to think about some options on how they will have to build the swing. They also need to take into account the different playing rules that were put forward earlier, *child G: "We have to bring the bottles closer to the pendulum."*, *child R: "We have to pull the pendulum more backwards."*

While students are busy, the teacher can observe and engage the children into inquiry (designing and running experiments and observations). Children plan and conduct investigations in order to collect data. In this way we again see them engaging in scientific creativity as defined in the CLS Conceptual Framework, in other words, reasoning critically between alternative ideas and strategies that they have generated.



**Fig.3.4.2.1** - Children plan and conduct investigations in order to collect data.



**Fig.3.4.2.2** - Children plan and conduct investigations in order to collect data.



**Fig.3.4.2.3** - Children plan and conduct investigations in order to collect data.



**Fig.3.4.2.4** - Children plan and conduct investigations in order to collect data.



Fig.3.4.2.5 – Final swing. (Sequence)



Fig.3.4.2.6 - Final Swing. (Sequence)



Fig.3.4.2.7 - Final Swing. (Sequence)

### c) Swing game – Full Bottles

The situation that gave this episode was proposed by teacher, at the end of the activity in order to challenge students and to realize if students understand the contents involved in all the activity. The main purpose of the activity was consolidating knowledge *“If one or two bottles are full of water how can you tumble them?”*.

#### Science

This situation was proposed for evaluation (evaluating evidence), so children can demonstrate understanding of concepts and/or ability to use inquiry skills. They used data collected/observed in the previous activities, to construct knowledge and generate evidence.

*Child M pulls the rope further backwards, adding to the bag containing two oranges, the tangerine, and still, only one bottle (of two) tumbled.*

*Child S: “The tangerine has fewer weight, we have to add to the bag something more “heavy”. We should use a wood block.”*

[Child S testing their hypothesis...]

Child S was succeeded, the bag with two oranges, the tangerine and wood block, was able to tumble the two full of water bottles.

### Creativity

Again this episode reveals children engaging in critical reasoning between their own alternative ideas (scientific creativity) but we see how this also involves everyday creativity, in other words imaginative, purposeful activity, interpreting evidence, communicating findings, generating valuable and original outcomes in relation to the learner. During the episode we see the emergence of creative dispositions, such as, imagination and connection making, for example, Child M “If we use a machine washer, all the bottles will also tumble.” Connection making is also observed in Child J “If we use more object inside the bag, heavy objects, easier it is to tumble the bottles.”



Fig.3.4.3.1 – Many children trying to tumble two, full of water, bottles.



Fig.3.4.3.2 - Many children trying to tumble two, full of water, bottles.



Fig.3.4.3.3 - Many children trying to tumble two, full of water, bottles.



Fig.3.4.3.4 - Many children trying to tumble two, full of water, bottles.



**Fig.3.4.3.5** - Many children trying to tumble two, full of water, bottles. Adding an extra orange.



**Fig.3.4.3.6** - Child trying to tumble two, full of water, bottles. Adding an extra orange and a block of wood.



**Fig.3.4.3.7** - Child experiment the swing with an extra orange and a block of wood.



**Fig.3.4.3.8** - Child swing tumbles the full bottles.



### 3.4.3 Summary and conclusions

#### RQ2: Probing practice

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

The teacher initiated activities promoting the interest and curiosity of students, presenting problematic situations and discussing with students initially.

During the activity the teacher was always careful to guide students in their learning and guiding them to a way forward, not invalidating the trials and errors of students in order to solve the problem. Teacher as many years of experience, that makes her lot sensible to when to guide, she fosters reflection and reasoning, encouraging students.

These children were learning in large groups, and suggestions were always given by them, there wasn't the possibility of working in smaller groups, ensuring that all gave time to everyone, everyone respected the time to talk to, each and every one had the opportunity to experience all the pendulums built (according to the variations and all objects used) so there was a social dimension, social interaction and collaboration among children, more than if they were not learning in the field of citizenship and respect for each of them permission to express themselves in due time.

##### ***What role if any does creativity play in these?***

These three episodes showed creativity is through the encouragement of problem-solving and children's agency. As Olivia referred in the interview, what seems important, above all, is to hear children, their opinion, their issues, their proposals, and work from their proposals, so they were proposing and we were walking.

Teacher values creative dispositions such as, sense of initiative, motivation, imagination, and curiosity, affective and social factors of science learning.

Olivia feels encouraged and motivated when realize the motivation of those children, because when they are making experiments with significant interest, meaningful to the children, they are necessarily motivated and their imagination and creativity, the imagination firstly and then following creativity and creative thinking of children is something that she respects.

#### RQ3: Probing practice

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

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

**How do teachers perceive their role in doing so?**

Teacher perceives activities as led by children’s interests, and activities develop according to events as they arise in the classroom. Olivia and her Teaching Assistant facilitate learning and development through:

- Planning activities that stimulate interest and curiosity in the children.
- Providing support and scaffolding learning where appropriate and standing back and allowing the children space to make their own learning decisions and solve problems in their own way
- Allowing the children to make decisions about the focus of their inquiry, even if that takes them away from the planned learning objectives
- Making connections between scientific concepts and phenomena, but not introducing scientific concepts artificially. Children are exploring their world and the teacher introduces new ideas or encourages further exploration as appropriate.
- Reinforcing scientific concepts and vocabulary and thus supporting the development of the learning objectives.

**3.5 Case 5 – “Megan”**

**3.5.1 Context**

Where?	Country	Portugal			
	Setting name	PT5			
	Location within setting	Primary School			
Who? (children)	Year group/age of children	2rd. grade; 7 years old			
	Number of children in class	23			
Who? (adults)	Number of adults	1			
	Role of adults	1 teacher			
	Case teacher role	Co-ordinator			
When?		1	2	3	4
	Dates of visits	29/01/2013	15/02/2013	08/04/2013	09/04/2013
	Times of visits	15:00-17:00	14:00-17:00	16:00-17:00	16:00-17:00

**a) School/setting**

The CT (pseudonym), situated in a very large city in Portugal, located northeast in a town

which play an important role at the development of the Portuguese territory, focused in teaching the preschool, primary school, the 2nd and 3rd level of primary and basic education, aged between three to fifteen year old in a total of 600 students.

It attracts families with Socio-economic advantage. There is a strong active parental involvement.

The CT is an educational Catholic institution integrated covering four levels of education:

- Preschool - five / six classes;
- Primary school (1st level of basic school) - eight classes;
- 2nd level basic school - four classes;
- 3rd level basic school - six classes.

The normal working period is from Monday to Friday from 8am till 7.30pm, including extension. It also offers students a time specific prayer/reflection of 15 minutes before start classes.

The time of each level of education is the segment as shown:

- Preschool: 09 am -12pm | 14 pm -16.30 pm;
- Primary school: 08.45 am -12.10 pm | 14 pm -16.30 pm /17: 15 pm;
- 2nd and 3rd level: 08.45 am -16.30 pm (except the 9th grade, one day a week, 08:45am -17:15 pm).

The school calendar is officially defined in each school year, the Ministry of Education.

The CT offers outdoor spaces for recreation and sports, wooded areas and garden. It has several spaces to service curricular activities and non-curricular:

All rooms are equipped with materials specific to the functioning of the various classes and activity. Laboratories for the practice of experimental disciplines, the computer room, with updated equipment and internet connection in network and wireless access in classrooms.

Regarding audiovisual, the College is equipped with televisions, videos, slide projectors, overhead projectors, multimedia projectors, DVD and CD players and laptop computers.

#### **b) Teacher (using the interview)**

The practitioner for the episodes detailed below was Megan (pseudonym). Megan holds a master degree in early years education in a Public Higher Education Institution. The Ministry of Education recognizes the degree to apply for a teaching position in primary school education. She has two years experience.

Reported usual recourse to a wide variety of materials, innovating daily and using various sources, reiterated that the planning is done weekly at this school. The planning of these

classes always takes account of the interaction between all disciplines (mathematics, science and Portuguese language). Regarding creativity, believes that this is part of her job, looking for activities and challenges that encourage students. Further considers that encourage activity in science and maths is a way to stimulate students' interest and enthusiasm students to these disciplines.

As teacher referred in the interview: "I think creativity existed because the students had to "guess", or predict what will happen when certain used objects, for example, when students thought that particular object has static electricity and then went to check their predictions and concluded that, and so learned thereafter. There are students who need help from their colleague's need to be stimulated, but most are very intuitive, and have some prior knowledge, have ideas of what will happen and then make a comparison with what they observe. Even during the rest of the classes, I confess, that not so often as I liked, we performed experiments where other activities always begin with discussion and subsequent prediction and experimentation. As I mentioned, the class is working on organized groups from the first year, particularly since November 2011, and I feel very comfortable with this type of teaching methodology. At first some of the students were very individualistic, very focused on themselves, and they were afraid to show their knowledge to colleagues (sometimes they commit error's too), but this year is different, they try to help each other when they feel difficulties and thus "pulling for each other" and even the more timid who do not have as much at ease as they know each other, take the initiative to collaborate and help each other."

Megan facilitates learning basically through the students' own curiosity. As they were acquiring knowledge other questions posed and the students ended up complement each other. The fact that they are in a group, which facilitates such an activity, is increased by the fact that they are used to working in groups and overall, the group likes to work in groups and share knowledge among them. Megan appreciates different forms of expression and fosters discussion among students.

When teacher was asked if there was anything else she would like to tell about science, mathematics and / or creativity in the early years, she referred:

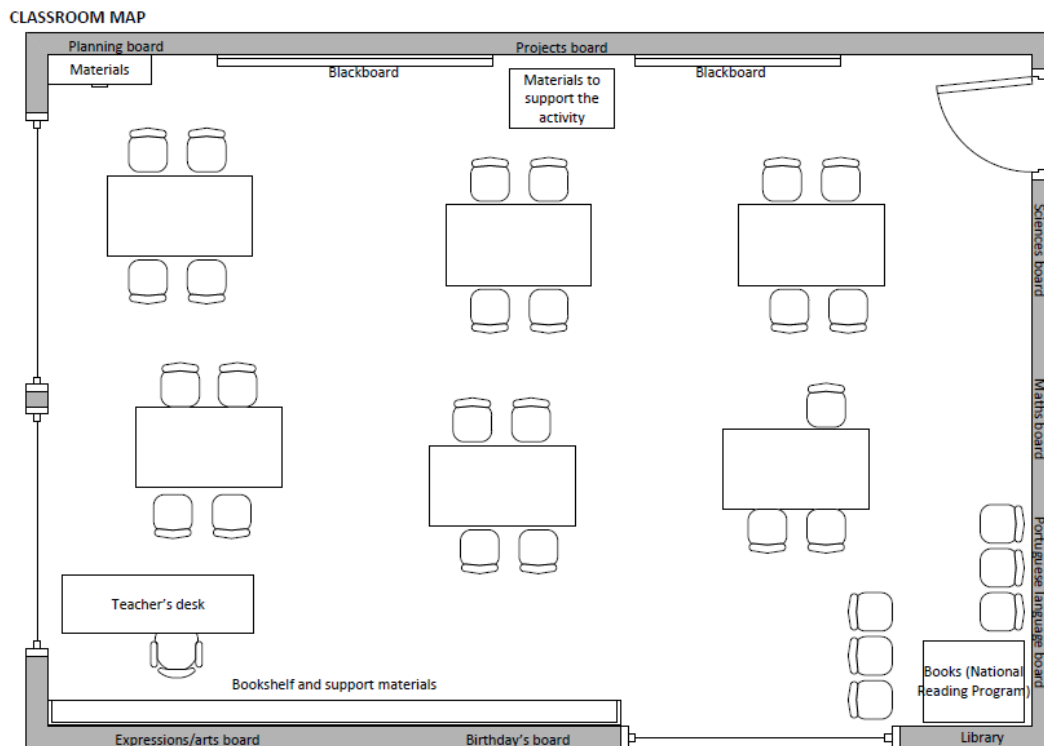
"I confess that since I had my training, even in college, in my degree in elementary education, we focus not so much in science, when I say focus, I mean doing things not just theory, and even in other areas we are not prepared to be teachers, for example, special educational needs were concentrated at the end of the course, when you consider that should have been addressed before, during graduation. I think it should have more math and science component along the course. Throughout the first year in this class, performed science activities all Fridays, this year I confess that I have not done as often as desired. I wish I knew more about science to also convey more to my students."

**c) Classroom (age children)**

The class has twenty three students (then boys and thirteen girls), with average age of 7 years old. Students are mainly from the city of Braga.

There are no students with learning disabilities, and the class is very heterogeneous in terms of school results.

The classroom space and organization:



**3.5.2 Episodes**

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

The main target of their further inquiry is aimed at investigation of how the static electricity can be created and how it is possible to measure “amount” of static electricity created different ways and using different materials.

The objective of these episodes is to mention and recognize that objects are made of different materials and the materials differ in surface, shape, color, size, etc.; to develop science process skills, mainly observation and categorization skills in simple inquiry activities; to develop ability to construct simple, but objective conclusion to realized inquiry activity; to develop ability to observe objective way – by simple measurement; to develop preconceptions about static

electricity

Materials: balloon, comb; confetti ; aluminium foil; plastic bag; book; paper; towel; sweater; wooden board; metal spoon; ball of wool; metal lid; plastic spoon; pencil; plastic bottle, ruler, rubber, balloon, comb.

#### a) Static electricity

This first episode is mainly focus on teacher scaffolding, involvement, during the discussion of the main themes of the activities that the class will develop.

#### Science

Main science aspects are focused in the scientific contents that are going to be part of this activity. Obviously teacher is very concerned about this aspect; many questions were made by the students, and teacher as the ability to guide the class through the discussion of the “static electricity” concept. Many students have already knowledge about the theme, others haven’t so.

#### Creativity

In this learning activity creativity was present when teacher encourages children to make connections between previous ideas and cross curriculum concepts and ideas.

In particular one students that we might consider that he recognizes one situation from out of the school learning, referring to the slide park: *“The slide park sometimes gives shock in our hands.”* Where he experienced: *“After we slide the park very often, particularly in the summer, it gives us a shock.”*

Many children, after the comment of their colleague achieve the conclusion: *“That’s why we caught shocks, we rub the slide and then it is electrically charged and gives us shocks.”*



Fig.3.5.1.1- Teacher questioning children.



Fig.3.5.1.2 – Teacher presenting activity and support materials.



Fig.3.5.1.3- Teacher questioning children.

Fig.3.5.1.4- Teacher questioning children.



Fig.3.5.1.5- Teacher fostering reasoning for children.

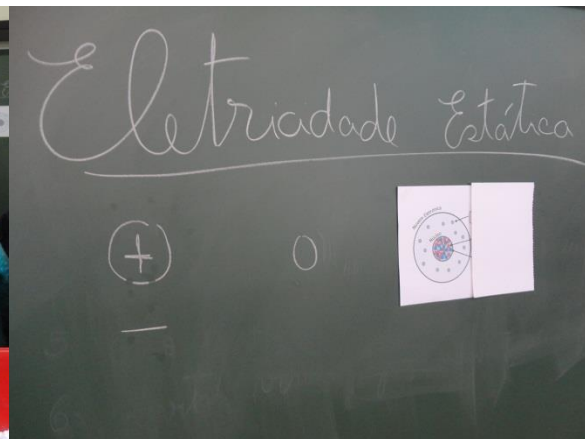


Fig.3.5.1.6 – Teacher presenting activity and illustrating scientific content.

**b) Static electricity experiments (predicting and verifying four objects day-to-day chosen by students)**

The teacher promotes the pupils to think like an inquiring person which is looking for an answer to the identified question (what kind of objects can cause rising up static electricity, in what kind of cases we can experience effect of static electricity). The teacher gives the pupils worksheets and explains that at first we need to set predictions based on our previous experience and knowledge. She asks the pupils to draw a symbol ✓ or ✗ into the first column beside specific picture representing an object considering what they think about behaviour of the object when it will be rubbed against hair (making prediction). In a case they predict that rubbing the hair by the object will cause attracting hair against the object, they draw symbol ✓, otherwise they are asked to draw ✗. The teacher directs pupils' attention to discussion about predictions. After finishing the expression of prediction, she asks the pupils to verify the prediction and mark the results similar way into the second column of the table.

Further the teacher offered the pupils material for verification of their predictions. She

explained that it is important to rub all the inquired materials against the hair the same way to get the comparable results.

### Science

The teacher shows the pupils precise combing of hair while the hair attracts the comb. The teacher demonstrates what she speaks about and allows the pupils to try it offering the combs. Further the teacher invites the pupils to investigate the observed phenomena, to get more information about this anomalous situation: *“You should write up your predicting before starting the experiments, then the groups make the experiments and observe. In the end you should compare your predicting’s with the observations, and make some conclusions.”* After the demonstration the teacher motivates the pupils to find out what kind of materials can cause the observed phenomena - *What kind of objects can cause attracting hair against it after rubbing it against the hair?* Children observations like: *“My bottle doesn’t acquire static electricity.”; “My pen doesn’t get electrised.”* The descriptive research problem has been set. Further the pupils work in groups of 4 members on their predictions and verifications *“You have to rub it for longer time... otherwise it won’t be electrised.”*

### Creativity

Creativity, as defined in the conceptual framework, is present in the resolution of the problem/approaches by the students, and registered in expressions like: *“I cannot explain to you why, but I know that the cloths have bristles, and that will, somehow, have something related with the electrisation process.”; “Why can’t we electrise one object in our hand? Why we have to use a cloth?”; “I will experiment my wool sweater that has a lot of bristles.”*, once it generates alternative ideas and strategies as an individual or community and reason critically between these.



**Fig.3.5.2.1-** Predicting and verifying day-to-day objects.



**Fig.3.5.2.2-** Predicting and verifying day-to-day objects.





**Fig.3.5.2.3-** Predicting and verifying day-to-day objects.



**Fig.3.5.2.4-** Predicting and verifying day-to-day objects.



**Fig.3.5.2.5-** Predicting and verifying day-to-day objects.



**Fig.3.5.2.6-** Predicting and verifying day-to-day objects.



**Fig.3.5.2.7-** Predicting and verifying day-to-day objects.



**Fig.3.5.2.8-** Predicting and verifying day-to-day objects.

### c) Static electricity measuring “power of attracting”

After the verification and making conclusions, pupils continue in their inquiry process by finding out, which of the investigated objects attracts hair (or other tiny objects like confetti and Styrofoam) the most. It means that pupils are directed to realise, that some of the objects attracted hair better and some of them not so well. Further the teacher directs the pupils to find a way how it would be possible to measure the “power of attracting”.

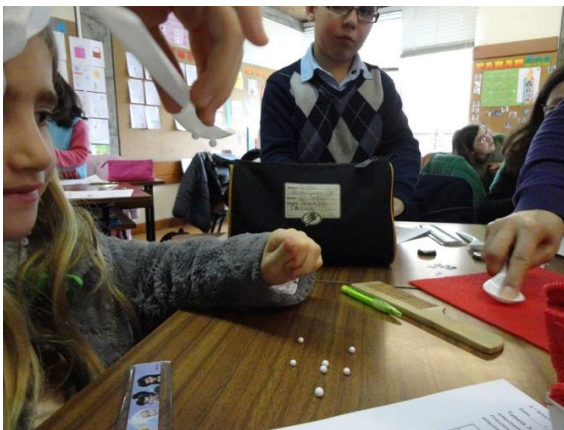
Pupils should rub a carpet with an object illustrated in the table and put it near to small pieces of paper (confetti or Styrofoam). They have to colour as many squares in the table as many pieces of paper the rubbed object attached.

#### Science

At the end of the activity the teacher tries to come back to the initial situation and the identified research problems. Pupils are asked to create a conclusion about their inquiry. They need to express their finding in a proper way. It means they need to say what was the research question about (finding out what kind of materials can cause static electricity and how it is possible to measure strength of the attraction the static electricity causes); how they have been finding the answer (the procedure they have designed and used) and what the findings looks like (the results contains answer to research questions). The pupils’ attention should be aimed at results written in the particular tasks – drawing of evidence based conclusions.

#### Creativity

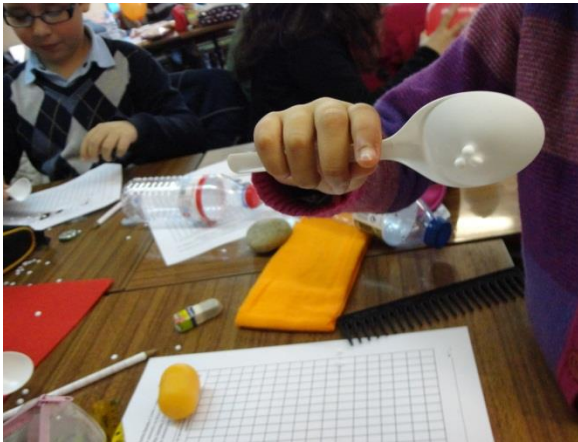
This activity was supposed to measure the “power of attracting” between the object and the tiny objects like confetti and/or Styrofoam and they have to colour as many squares in the table as many pieces of paper the rubbed object attached. At the middle of the activity one student suggests that she could use the electrised balloon in the hair of a colleague, “*Let me try the balloon in your hair.*” so she can measure the “power of attracting”. This example suggests creativity, so the student has proposed an alternative method to measure the “power of attracting”.



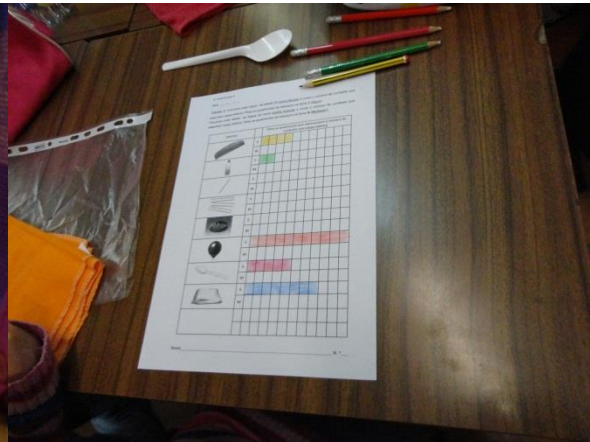
**Fig.3.5.3.1-** Students measuring “power of attracting”.



**Fig.3.5.3.2-** Students measuring “power of attracting”.



**Fig.3.5.3.3** - Students measuring “power of attracting”.



**Fig.3.5.3.4**- Worksheet with colour as many squares in the table as many pieces of paper the rubbed object attached.



**Fig.3.5.3.5** - Students measuring “power of attracting”.



**Fig.3.5.3.6**- Students measuring “power of attracting”.



**Fig.3.5.3.7**- Alternative method to measure the “power of attracting”.



**Fig.3.5.3.8**- Alternative method to measure the “power of attracting”.

### 3.5.3 Summary and conclusions

#### **RQ2: Probing practice**

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

The teacher initiated activities promoting the interest and curiosity of students, presenting problematic situations and discussing with students initially.

During the activity the teacher was always careful to guide students in their learning and guiding them to a way forward, not invalidating the trials and errors of students in order to solve the problem. Teacher is sensible to when to guide, she fosters reflection and reasoning, encouraging students.

#### ***What role if any does creativity play in these?***

These three episodes showed creativity is through the encouragement of problem-solving and children's agency. As Megan referred in the interview, creativity is important, because how more creative students are, more motivated they feel, because she considers the fact that they can discover multiple paths to get to the result, gives them a great joy and takes them to get excited fostering the interest in these disciplines (maths and sciences). Teacher finds this relation between mathematics and science very important.

#### **RQ3: Probing practice**

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

Teacher prepares her activity depending on students' interests, not forgetting the national curriculum and student achievement, looking to find activities that promote students interest in mathematics and science and creativity.

Teaching approaches appear to provide children with a 'starting point' from which they can ask questions, experiment, observe phenomenon and so on. As noted teacher has the ability to foster creativity.

#### ***How do teachers perceive their role in doing so?***

Teacher perceives activities as led by children's interests, and activities develop according to events as they arise in the classroom;

Development of scientific language and scientific method;

Reinforcing/revisiting concepts in a number of different ways (starting classes with maths questions, etc);

There was noticeable emphasis on scientific facts;

The access that the children had in each of the tasks to either following their own interests or extending the activities was a key feature of the creative pedagogy used at CT.

## 4. Discussion of findings

### 4.1 Enabling Factors or Barriers at Contextual Level

We consider Florence as an exemplary case. Regarding teacher, to emphasize the demonstrated experience in the classroom, the will of learning on its own initiative, fostering the emotional closeness with students, honesty and dialogue. To emphasize the fact that the teacher worry about preparing additional material for more advanced students they don't demotivate. In the proposed activities is very present concern with interdisciplinary. During the visits the key barriers identified relate effectively with the need to comply with the national curriculum and national exam test of mathematics and Portuguese that happens next year, therefore there is the teacher intended to prepare students for this disciplines that are subjected to national exam.

With regard to class, comes from higher social classes, students are interested and motivated enough and they have a lot of family back and accompanying. Regarding the work of the classroom, not being unique group work, the ability to work in groups is developed by students; they emphasize the collaborative nature, and mutual aid. Verifies the existence of a group leader, responsible for group dynamics, division of tasks and roles to be played by each one is properly assimilated and negotiated. As the main barrier or enabling factor depending on the viewpoint, it is heterogeneity in terms of results.

The visited institution is part of a deeply Catholic region, and there are other private teaching institutions that are also Catholic. The guiding principles of the institution that defines itself as Catholic and rigorous in terms of attitudes and values principles, is primarily focused on the development of the human person. Effectively these principles appear in the classes observed, and are an integral part of the institution and a constant concern of the teachers.

The main barrier identified at the institution relates to the pressure of the families in order to achieve good academic results.

Also the Carol case is an exemplar one. A young teacher with a good background in sciences. She is very active and concerned with teaching/learning strategies. She believes the teaching/learning process must be based on constructivism and the learning activities are essentially child-centered. In this school, they give importance to the learning of Sciences: they have one hour per week with a Science teacher to discuss a theme previously explored during the week.

The students are mostly from middle class families. The observed group is very interested and participative.

Also in this private school, the teachers are concerned with parental pressure about academic results and what their children learn in school. But the teachers have total support of the

pedagogical direction to explore new experiences and strategies.

#### 4.1.1 Differences between preschool and primary school

In preschool, teachers have more freedom to work with diverse topics and interesting students, depending on their interests. There are many subjects in primary education, because the curriculum is very wide-ranging, and teacher doesn't have the need to comply it. Moreover, it is necessary to prepare students for the final exams at the end of primary education. Teachers in pre-school education are therefore always more open to new experiences and new approaches to exploit with their students.

In pre-school, in the cases we observed, many themes and issues emerge in dialogue with students about their day-to-day or interests. A daily routine always includes a time where large groups are held group chat with the teacher about what will be explored. However, children also have a daily time previously and individually define what will make a space theme of their choice within the room. This link gives more opportunities for creativity and exploration of subjects.

#### 4.1.2 Differences between science and mathematics

Greater emphasis on math for results at the national level, and mathematical challenges help students to achieve patience, to reflect, to not give up, helps concentration, and any other areas do this often, almost like a moral lesson that take into your life, so there are no relevant differences observed between science and mathematics.

Children at this age level they realize the reality as a whole globalized. For this reason, the Estudo do Meio (Physical and Social Environment) is presented as an area for which competing concepts and methods from various scientific disciplines such as: history, geography, natural sciences, Ethnography, among others, contributing to progressive understanding of the interrelationships between Nature and Society.

It is increasingly given greater importance to the teaching of Science and Mathematics, wants to prevent future bad results and bad dispositions for those disciplines, what happens too often in the development of mental abilities.

In different cases, the pre-school, we saw that a specific time is dedicated to the treatment of Mathematics and Science. In school, the time devoted to science is guided by a science teacher (PT2Carol).

#### 4.1.3 Opportunities and challenges for creative learning and teaching

The availability and acceptance for our visits indicate a predisposition to welcome posture to creative projects. There was good receptivity of CLS Project at the schools involved.

The personal motivation of the teachers, accompanying the motivation factor of the institution differentiates them in the market in which they compete.

As challenge we identify the interconnection between the national curriculum and the goals that the institution intends.

The theme of creativity is a "relatively recent trend" and very often teachers do not have the necessary tools and training to foster creativity.

When we want to awaken creativity and increase it, the time available for exploration of a theme has to be higher, as liberty in its orientation. This requires more and better preparation by teachers because they have to be prepared for questions and comments from students and guide them to know the intended goals without defraud their expectations.

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

### 4.2.1 Aims and Objectives

#### 4.2.1.1 Differences between preschool and primary school

There are no differences in terms of scientific knowledge between preschool and primary school. In preschool was registered also creativity and was noticed that en primary school is more focused on social learning.

Primary school classes appear to be more teacher-led and may provide fewer opportunities to develop creativity.

#### 4.2.1.2 Differences between science and mathematics

In Science prevails scientific knowledge and mathematics knowledge and creativity.

In Portugal, there is a move away from problem-based inquiry in both mathematics and science and within both preschool and primary school, although the case studies illustrate the way cross-curricular, child-initiated play and exploration are encouraged in preschool practice (PT4 Olivia).

Creativity wasn't registered in science, perhaps needing to comply with a protocol guide activity, "recipe type", where there wasn't any opportunity for students to deviate and register some creativity. The creativity recorded in mathematics is located in preschool.

The aims for preschool and primary school are very similar but there is greater emphasis in primary schools on communicating reasoning and reflecting on the inquiry process and less emphasis on collaboration and communication (see case studies).

#### 4.2.1.3 Opportunities and challenges for creative learning and teaching

In the current Science Portuguese National Curriculum, from 2004, there are any connections to creativity. Despite the curriculum does not appeal to the creativity, the teachers are aware of its importance. Teacher interviews emphasized the importance of creativity in aims and

learning objectives and these were evident in planning.

There is no explicit reference in the curriculum guidelines for environmental studies, given more emphasis to knowledge. However the Law of the Portuguese educational system can read that principles are: "Education promotes the development of democratic and pluralistic spirit, respectful of others and their ideas, open to dialogue and free exchange of views, forming citizens capable to judge critically and creative social environment in which they are involved and to engage in a progressive transformation."

At preschool level should be a priority "Developing the capabilities of expression and communication of the child, as well as creative imagination, and encourage recreational activity".

In pre-school, the treatment area World Knowledge is not intended to promote encyclopedic knowledge, but provide relevant learning meaningful for children who may not necessarily be related to immediate experience. Even if the child doesn't dominate entirely the contents, introduction to different scientific domains creates an awareness that awakens the curiosity and desire to learn. What seems essential in this field, whatever the issues addressed and their development, are the aspects that relate to the processes of learning: the ability to observe, the desire to experience the wondering, the critical attitude.

The objectives of basic education: "Ensure a general instruction for all Portuguese that guarantees the discovery and development of their interests and skills, reasoning ability, memory and critical thinking, creativity, aesthetic sensibility and moral sense, promoting the realization individual in harmony with the values of social solidarity;

In some observed episodes creativity was more evident than others through emphasis on motivation and encouragement of problem-solving and children's agency that result in solutions to problems and expressed scientific ideas that are unexpected and show creativity. Other evidence, such as teacher interviews, as well as observations of practice, indicate creativity through interaction that encourages children to make connections between prior and new conceptual understandings in science, develop new reasoning and creating ideas and artefacts.

## 4.2.2 Learning Activities

### 4.2.2.1 Differences between preschool and primary school

Majority for observation, establishing connections and designing or planning investigations in preschool. In primary school predominates establishing connections and explaining and communicating evidence.

Teacher initiated activities in both the preschool and school observations tended to include questioning that made connections between previous learning and current concepts, thus



explaining evidence and communicating explanations.

In primary school observations the learning activities were usually highly structured, with a whole class introduction, which emphasised and reinforced connections and questioned the children's understandings, although teachers very often left insufficient time between questions and expected answers.

A whole class plenary, during which the teacher again questioned the children and reinforced connections between the learning objectives and the small group activities. In some observations, children were encouraged to explain findings during this plenary.

In the preschool observations, there was more emphasis on child-initiated activities that encouraged children to plan the next step of their play and exploration, although this was more evident in preschool settings.

#### *4.2.2.2 Differences between science and mathematics*

In science there is an almost uniform distribution among all of the parameters, while in mathematics stands watching and making connections.

#### *4.2.2.3 Opportunities and challenges for creative learning and teaching*

There has been little impact on the questioning by students in mathematics and science, which mean that there aren't significant differences between the school and preschool, except in the case PT2Carol.

Encourage children to ask questions, to explain and communicate the evidences found, stimulate the social dimension of learning through communication. The type of activity may be more open, always keeping in mind the willingness of the teacher to facilitate the expression of curiosity and doubt thus fostering students creativity.

The teacher interviews indicate many opportunities, outside of the observations, for creativity. In these learning activities creativity was seen through learning activities that encourage the children to make connections between previous ideas and activities, question assumptions and cross-curricular concepts and ideas.

### **4.2.3 Pedagogy**

#### *4.2.3.1 Differences between preschool and primary school*

In preschool we highlight the role of play, collaboration and expression, while in primary school, there is the teacher's role in agency student learning. Regarding teacher scaffolding and questioning, it encourages student's questions, that are equally relevant in preschool and school.

The role of play and child-initiated exploration was more evident in preschool than primary school observations. There was also some evidence that preschool teachers are more likely to stand back and allow children to follow their own avenues for inquiry based on their curiosity



and to value diverse forms of expression.

In preschool play and learning are often synonymous and children do not distinguish between the two and this approach to play and exploration capitalizes on children's interests and encourages allows problem solving and agency.

In primary school episodes, children are motivated by being encouraged to express their ideas, negotiate boundaries and engage in free play and expression (see PT3 Florence case study).

#### *4.2.3.2 Differences between science and mathematics*

There is a strong component of collaboration and scaffolding of the teacher in the discipline of mathematics, on the other hand, in sciences is registered equivalent effect on the various parameters.

In one observed primary school mathematics episode (see PT3 case study) motivation took the form of competition, which motivated children to achieve in mathematics.

#### *4.2.3.3 Opportunities and challenges for creative learning and teaching*

The emphasis, in the observed activities, of the teaching of mathematics and science shows that there is purpose in valuing attitudes and increase motivation for these areas. It is imperative to foster and develop the students thinking and reasoning. This may involve the teacher in standing back and allowing free exploration, or by teacher questioning that allows and values free expression of ideas

### **4.2.4 Assessment**

#### *4.2.4.1 Differences between preschool and primary school*

In the episodes observed, assessment tended to be formative, there are no relevant differences between mathematics and the sciences.

#### *4.2.4.2 Differences between science and mathematics*

In the episodes observed, assessment tended to be formative, there are no relevant differences between mathematics and the sciences.

#### *4.2.4.3 Opportunities and challenges for creative learning and teaching*

Creativity in assessment is evident in the schools that use a variety of evidence and peer/ self-assessment. There is some evidence that in some schools the absence of national tests in science has resulted in a greater focus on maths.

Summative assessment is more evident in Mathematics. The summative assessment results from the National testing in Portuguese primary schools. In the discipline Estudo do Meio (environmental sciences - including science) there is no national exam. This has led to science having a lower status than when the national curriculum was introduced in 2004, and from 2013 even more, due to the requirement of the national examination in Mathematics and



Portuguese Language.

#### 4.2.5 Materials and Resources

##### 4.2.5.1 Differences between preschool and primary school

In pre-school shows the presence of more human resources (teacher and teacher assistant) and rely heavily on non-commercial materials. In school there is considerable variety of materials and articles (as seen in the diversity of materials employed in each case reported). ICT resources were used more in primary school (PT3 Florence case study). In Portuguese policy documents ICT is mentioned.

##### 4.2.5.2 Differences between science and mathematics

Mathematical activities are more likely to occur indoors and do not use the opportunities, mainly uses human resources. Most science resources were everyday objects or materials. It can also increase the relevance of science to everyday life.

##### 4.2.5.3 Opportunities and challenges for creative learning and teaching

It would be nice if Portuguese schools had a physical environment richer for exploration and use of physical resources that foster thinking, especially where children can explore the use of resources in creative and imaginative ways. Further teacher training is fundamental and this is stressed by the teachers themselves.

#### 4.2.6 Grouping

##### 4.2.6.1 Differences between preschool and primary school

There was a difference between preschool and primary school groupings. Preschool activities were more likely to large group (Olivia case study). Primary school activities tended to be whole class for the introduction and plenary and small group activities in between.

##### 4.2.6.2 Differences between science and mathematics

In the observed episodes there were few differences between science and mathematics groupings with more predispositions for group work in mathematics.

##### 4.2.6.3 Opportunities and challenges for creative learning and teaching

According to the latest publications of the organization of the school year the minimum number of students per class is 24 and the maximum 28 in the first cycle, in this sense, it becomes very difficult for a single teacher to organize the class into groups and give them the support and monitoring required for fostering creativity in students.

More than an environment rich in materials and suitable space, the number of students per class seems to be the major constrain for the teacher.



#### 4.2.7 Location

##### 4.2.7.1 Differences between preschool and primary school

Except for the case PT2Carol all occurred within the classroom in a context of informal learning. Teachers feel freer and ease at preschool. Time and syllabus constrains have a significant influence at primary school even in early ages.

##### 4.2.7.2 Differences between science and mathematics

No major differences were found (it should be noticed that the maths oriented activities where less the science oriented ones)

##### 4.2.7.3 Opportunities and challenges for creative learning and teaching

The high number of students per classroom and the lack of support staff prevent informal activities outside of the classroom environment. Again the length of the curriculum and the existence of national examinations, even at these early ages, limits the development activities such as the one CLS proposes.

Further it should be highlighted the fact that, in case the activity occurs outside of school space, entails legal permissions parents / guardians making it even more difficult to perform than the activities outside the classroom, but within school space.

## 5. Implications

### 5.1 Implications for teacher training

Upon our observations and the case studies presented in this report, we would like to address some key points that may summarize our findings and shed some light on teacher training issues, based on a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis.

#### STRENGTHS

- We have found teachers who were highly motivated to participate in this research by providing us the observation of teaching moments without any prior input from us.
- They did not fear to be under observation.
- They dare to face new challenges outside their comfort zone.
- The children were easily engaged in the activities, encouraged to share their thoughts and suggestions, showing confidence, creativity and participated with enthusiasm, feeling at home. This denotes a good relationship between teacher and students, which is fundamental for these actions to have success.

#### WEAKNESSES

- The sample reported in this document is not representative, neither it should be, of the average of our country. The cases were chosen after our previous knowledge that they would be interested in cooperating with this research.
- Generally speaking during their graduation the training in sciences and mathematics is weak and superficial.
- The teachers feel the need to have training in sciences and mathematics in the framework of their mandatory **continuous professional**, and yet the offering of those kind of trainings is scarce.
- There is a lack of interaction among teachers to share expertise and to make some reflection on their practices.

#### OPPORTUNITIES

- The results presented show that teachers and children are easily engaged in sciences and mathematics activities beyond the curriculum, giving them the chance to discover new subjects of interest and through which imagination and creativity are put to work.
- This research endeavored the cases under study the opportunity to get away from their usual territories with pleasant results.
- There is an urgent need to create and to offer training workshops for the early years of education, not only for updating scientific knowledge, but also for different and effective

teaching techniques and strategies.

- In one of our cases, it can be seen that starting with a simple string it is possible to draw an extraordinary session of science learning with imagination and creativity of the children guiding the process. It is not a matter of money, but will and creativity of both teachers and institutions.

#### THREATS

- The political, economic and social context of Portugal is a major constraint for the implementation and development of new ways to promote science and mathematics in early years of school.
- The teachers are under an extreme stress and menace, as their binding to the educational system was drastically weakened, which compromises their best wishes to participate in improving the system.
- Increasing academic qualifications is no more rewarding for teachers: they may spend a lot of money and time to make a masters or a PhD, but in the end they are not promoted and their improved knowledge and skills are not an asset to the system, so they feel.
- The fear to interact, to share knowledge and skills, to assess and to be assessed by peers is not a habit in the Portuguese culture.

## 5.2 Implications for policy development

### Early teacher training

The teacher training during their graduation should include more and deeper learning in sciences and mathematics. From the data collected earlier and from our observations, the teachers recognise their poor proficiency in these matters and are willing to access opportunities to improve their scientific knowledge and related didactical and pedagogical skills.

### Continuous teacher training

The educational Portuguese policy for teacher continuous professional development (CPD) should be reinforced in the areas of science and mathematics in early years of education, which lack diversity and extensive territorial range. Namely, at pre-school level, the opportunities for this kind of CPD is scarce and in many regions is absent.

### Valuing CPD and academic degrees

In the Portuguese educational system, CPD is mandatory. However, it is possible a teacher to complete a full teaching career without making any CPD in sciences and mathematics. Therefore, it would be very much welcome the obligation for every teacher to make a CPD in these areas from time to time.

Additionally, in recent years the Portuguese government has not been valuing the masters



and PhD degrees teachers have achieved, discouraging the whole class to pursue

Indeed, not long ago, a teacher with a bachelor degree would progress a few years in his career after a masters or a PhD. Nowadays, any academic degree acquired by a working teacher is irrelevant for any promotion.

### **Time, space and reflexion in school curricula**

Science and mathematics teaching would benefit from having explicitly their own space in curriculum and time in teaching activities. At present time, these subjects are included in a wider area which comprises other subjects (e.g. History), making them a minor contributor for children, in preschool and primary school.

In our observations it was clear that children are easily engaged and show high levels of motivation for science and mathematics activities, are creative, make connections and are inquisitive: they are eager to discover new things every day.

### **Training trainers**

For early years of education there is an evident need to create opportunities to train teachers in sciences and mathematics. That means there should be training courses for trainers too. The majority of teacher trainers (other teachers and professors from universities) are tailored to address to 2th, 3th cycle and secondary teachers. The specific targets of pre-school and primary school teachers need different and specific training.

This training should provide a framework for developing teaching activities and skills taking into account the younger ages of the students, their level and rate of emotional development, fostering creativity and strengthening the consistency of logical and scientific thinking.