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# Creativity in Early Science Education. A Case Study

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**Abstract.** *The importance of creativity in education is recognized and is mentioned in Portuguese educational policy documents.*
*The need and importance of science education to foster students' creativity was the main driving point of this study.*
*This qualitative study aims to reveal the potential for creativity and the role of Inquiry Based Science Education in preschool and early primary education.*
*The fieldwork was documented by the use of sequential digital images capturing detailed interactions; field notes supplemented by audio recording later transcribed; and an overall timeline.*
*This communication presents a set of data analysis in relation to one case -application of one hands-on IBSE activity in one classroom. The case study herein reported contains different episodes, documenting examples of mathematics learning through the lens of creativity.*

**Keywords.** Creativity, IBSE, primary school, science teaching.

## 1. Introduction

In a world lead by technological innovations, creativity is a critical component; human skills and people's powers of creativity and imagination are key resources in a knowledge driven economy [1].

Creativity is not restricted to special people or to particular arts based activities, nor is it undisciplined play, it is however, particularly difficult to define. It has been defined as "*a state of mind in which all our intelligences are working together*"…involving *"seeing, thinking and innovating"* [2].

And isn't science all about reasoning? Yes and no, because proving something requires logic, but first of all someone has to have an idea.

In the context of the classroom, developing opportunities for children to *"possibility think"* their way forwards is consequently critical. This will involve engaging the class in an issue or subject and helping them ask questions, take risks, be imaginative and playfully explore options as well as innovate [3].

*"Creative teaching is a collaborative enterprise which capitalises on the unexpected and variously involves engagement, reflection and transformation, patterned at such a rate as to invite and encourage a questioning stance and motivate self-directed learning. Creative learning involves asking questions, exploring options and generating and appraising ideas"* [4].

This investigation was carried out in the context of a master thesis about creativity in the teaching/learning of sciences, from preschool to primary school, and we present the outcomes from a specific case among all the case studies. The case study reported contains three narrative episodes, documenting examples of mathematics through the lens of creativity.

A narrative episode in this case was defined as a written narrative account that describes an event or series of connected events but which forms a coherent story by itself. In this

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study, the episodes will illustrate creativity in science and/or mathematics in the early years. These were drawn from selected observations and supported by information gathered through several types of data.
The findings of this qualitative study aim to reveal the potential for creativity and the role of inquiry in the classroom realities of primary science and mathematics education. Seeking to find children creativity in maths at this level, a primary school class was challenged to solve three tasks.

## 2. Instruments and methodology

### 2.1. Instruments

From a wider range of instruments used to record and to analyse the data collected, in this case we report only on the field notes [5], photographs [6] and the interviews made both to the teacher [7] and to some of the children [8] in the end of the lesson observed.

### 2.2. Methodology

The objective of the observation during this activity is to illustrate at least three episodes of children creativity [9].
The notes taken include a timeline along which the observer records the development of the activity: the teacher's actions and speech, the children's interventions and comments, the actions taken and the events happened.
The latter processing of these field notes from different observers, together with the pictures taken, enables to better identify and to characterize the quested creativity episodes.
The interviews include the observation by the teacher and the children of a sequence of pictures relative to one or more moments identified as having creativity.

## 3. Characterization of the class

**Figure 1. Classroom map**

The school, placed in Braga, in northern Portugal, is a private education educational catholic institution covering four levels of education: preschool, primary school, 2nd and 3rd level of basic education; the students in a total of 600, are aged between three to fifteen years old. The class in this case has twenty seven students (seventeen boys and ten girls), with average age of 8 years old.
The classroom is wide with perfectly identified functional areas capable with suitable materials (Fig.1).

## 4. Narrative episodes

### 4.1. Wolf, sheep and cabbage

The aim of the problem was to move the wolf, sheep and cabbage to the opposite

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shore of the river. It got more difficult though because when the man was not around the wolf would eat the sheep, the sheep would also do the same when alone with the cabbage. This involves the use of knowledge of food chains to solve the problem – analysing possibilities and predicting if there is more than one solution.

The teacher introduced the well-known problem 'Wolf, Sheep and Cabbage' on the blackboard, and explained the rules of the game to the children. The children had to carry the wolf, sheep and cabbage on a boat from one side of the river to the other, one by one. The conditions were that 1) if the wolf is left alone with the sheep, it will eat the sheep; 2) if the sheep is left alone with the cabbage, it will eat the cabbage; and 3) the wolf will not eat the sheep and the sheep will not eat the cabbage if the farmer, who is sitting in the boat, is right nearby to side of the river that they are on.

Using the paper cut-out models of the wolf, sheep and cabbage that the children had made and painted previously, and an origami boat that they created at the start of the game, they were encouraged to work in groups to solve the problem.

Throughout the activity, the children collaborated with their peers to think of different possibilities; to try out the different potential solutions; and to give reasons why certain ideas would not work.

The whole class reached conclusions and solved the problem presented in the beginning, and had the opportunity to verify their solutions against the online version of the game, which is available freely on several websites. The uses of ICT allowed the children to experience and represent the same problem in different ways.

## Opportunities for creativity

The context of the game provoked children's imagination and the informal and fun nature of the task motivated the children to become engaged in the problem. Working in groups encouraged children to articulate their ideas and reasoning. Children collaborated in sharing and discussing different ways to solve the problem.

Children's problem solving skills were fostered as they suggested and modelled different potential solutions and gave reasons why certain ideas work or would not work. Children used and developed science skills such as predicting, observing, analysing and describing, demonstrating scientific or mathematical creativity in generating alternative ideas and strategies and reasoning critically between them. They also had to make connections between the combinatorial / mathematical aspect of the task and their knowledge of food chains.

## Illustrative extracts from data

**Figure 2. An example of children collaborating and giving reasons**

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**Figure 3. Examples of children explaining why certain ideas would work and would not work**

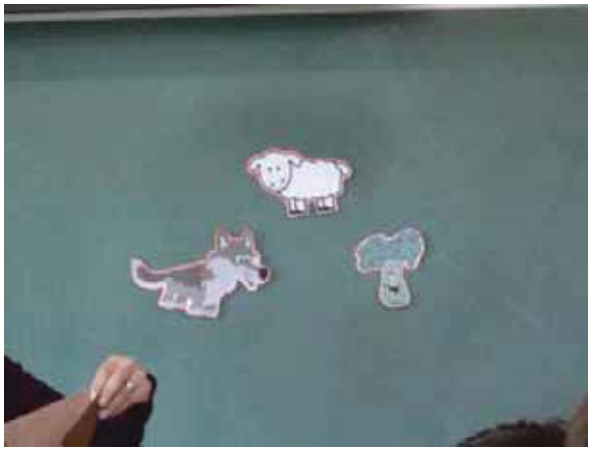

**Figure 4. The informal and fun nature of the task helped in engaging children**

**Child L:** *The sheep eats the cabbage.*
**Child R:** *The sheep has to go first because the wolf doesn't eat the cabbage.*
**Child R:** *If we took the sheep first, then the cabbage, then the sheep will eat the cabbage.*
**Child R:** *So we have to leave the sheep and bring the cabbage back.*
**Child R**: *If we took the cabbage in first place, the wolf will eat the sheep.* (…)
**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*

## Reflecting on learning

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

**Figure 5. The integration of ICT for children to verify their solution**

## 4.2. Buttons episode

The aim of the problem was to transform a triangle formed by buttons in a hexagon, just moving two of the buttons of the initial form. Mainly maths sciences were present. Students have to: know geometric plan forms like triangle and hexagon; apply mathematics in practical situations including translation of objects and (plan) geometry – recognizing geometric forms (triangle and

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hexagon); problem solving – analysing possibilities and predict if there was more than one solution.

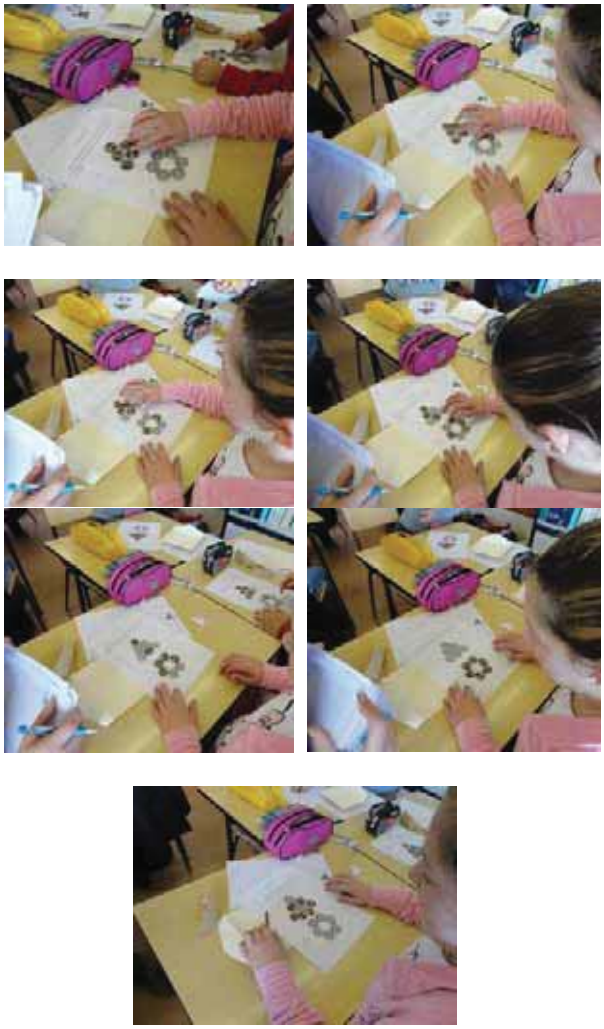

**Figure 6. Sequence of the child steps to solve the problem with an alternative approach**

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.

## Opportunities for Creativity

One of the students suggested 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 realized that only two buttons didn't have a correspondence in the hexagon figure, so she figured out that she would 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. This example seems to be a case of a child generating everyday creativity through an inquiry meaningful to herself and generating original valuable outcomes.

## Illustrative extracts from data

### 4.3. Marbles episode

The aim of the problem was to solve one worksheet focused on maths, reasoning. 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

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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.
The teacher introduced the problem: "*There are three types of marbles: normal, black and dampers, which are larger. Peter has a large collection of marbles: each damper has four normal and two black marbles. Knowing he has 14 black marbles, how many will be the others? And how many marbles has in total?"*

## Opportunities for 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 (Fig. 7, Fig. 8, Fig. 9 and Fig. 10).
All the students suggested their way of presenting the solution to the problem/question. Interestingly, some students used a formal analytical approach, and others use schematic approach, mainly, using (coloured) draws, showing multiple problem solving skills.
Using different methods all children reached the correct answer, despite the different approaches. This is a good example of mathematic and scientific creativity. The "correct answer" needed to be reached however children found their own ways to it.

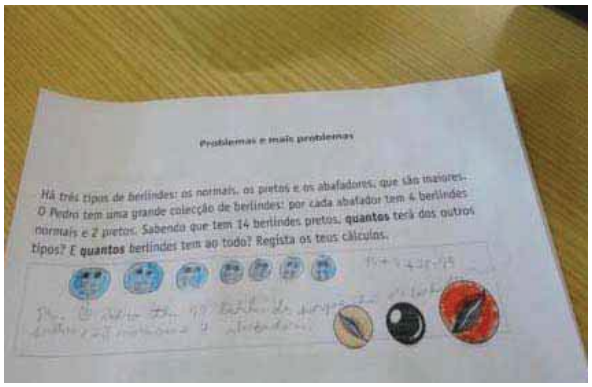


**Figure 7. Schematic approach, mainly, using (coloured) draws**

## Illustrative extracts from data

### Example 1

**Child R:** *I´m going to make some drawings… with the marbles on.*
**Child A:** *I´m trying that way too.*

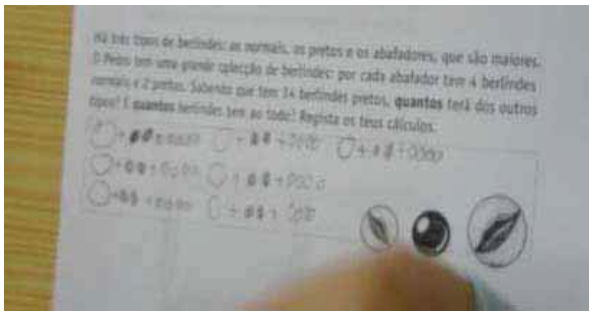

**Figure 8. Schematic approach, mainly, using draws**

### 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*

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*damper, 4 black marble, 8 white marble, and so on until we reach 7 marble dumpers. Then we count all the marbles we need.*

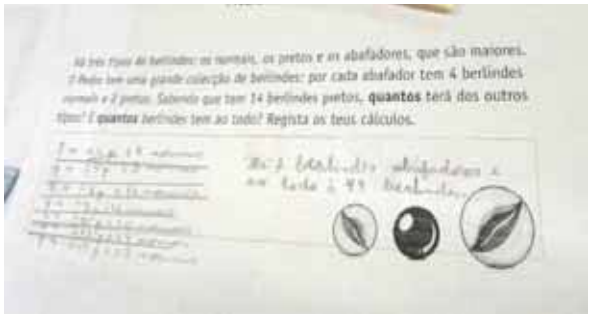

**Figure 9. Formal analytical approach**

## 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.*

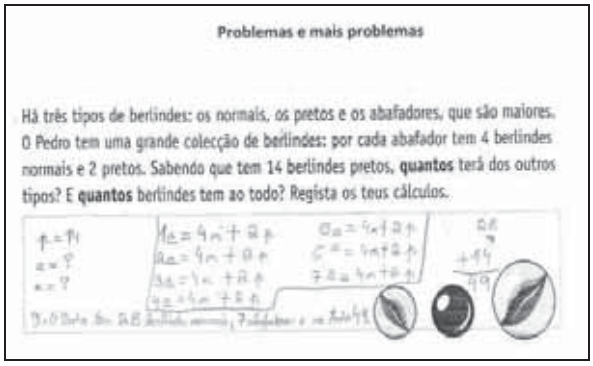


**Figure 10. Formal analytical approach**

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

## 5. Summary and conclusions

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

During the activities, 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, which means she is very sensitive as to when to guide. She fosters reflection and reasoning, encouraging students.

These three episodes showed creativity through the encouragement of problem-solving and children's agency.

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.

Opportunities for the generation of ideas, for example, were fostered by rich motivating contexts for play and exploration.

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Dialogue and collaboration, fostered by use of group work and teacher questioning, played important roles in encouraging the processes of reflection and explanation. The potential of sensitive teacher scaffolding to extend inquiry was emphasized, particularly in relation to when to mediate and when to stand back in order to listen to and build upon children's creative engagement and the development of their ideas and questions. Across the episodes there were many examples of children observing and making connections. The teacher made reference to the importance of encouraging and supporting children's engagement in early years science and mathematics as an important starting point for learning. Also emphasised the need to foster motivation and collaboration and provide a rich environment with space and time for exploration and problem-based learning, underlining key role for teacher in encouraging reflection and making connections to promote children's conceptual understanding and the application of ideas.

As the teacher 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 creativity, mathematics and science very important.

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