The Role of Creativity in the Teaching and Learning of Science and Mathematics

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Abstract. The purpose of this paper is to identify and characterize what creativity is evidenced in early science and mathematics. As a consequence, this qualitative study sought to produce a description and map of lived experience in a primary school classroom, explores how creativity can enhance learning and examines some relationships and synergies between science and mathematics education and creativity. In this paper we discuss the concept of creativity in the context of science and mathematics education. Then we recommend an activity and strategies that encourage creativity, and more specifically imaginative/creative thinking. The episode herein reported was drawn from selected observations and supported by information gathered through several types of data and offers many examples of children’s dynamism and rising abilities to collaborate in deciding what to do in carrying out investigations.

Keywords. Creativity, primary school, science education, mathematics.

1. Introduction

There is a rising recognition that scientific literacy plays a progressively important role not just for individuals but also for 21st century society as a whole [1]. Developing scientific and mathematical literacy in individuals then becomes an important part of the development of the child and the citizen. Looking at the world from a scientific perspective enriches the understanding and interaction with phenomena in nature and technology, enables students (and consequently future adults) to take part in social discussions and decision-making processes, and gives them an additional element from which to form interests and attitudes [2]. High quality scientific thinking [3] is one of the key goals in contemporary schooling, especially when facing vast quantity of information and in using new technologies.

As the need for more innovative thinkers increases, so the need to improve attitudes, and the importance of scientific reasoning skills arguably become more important. Indeed, in order to compete globally as future scientists, it is further important that individuals develop the skills and confidence to apply their knowledge in innovative ways. In Europe then, scientific literacy is viewed as a dimension of “democratic citizenship”, as an informed citizen can better contribute to the decisions of the community to which he/she belongs [4].

It is important to develop socially aware and responsible citizens. Education must therefore strive to achieve this aim in the development of the child. In order to avoid a simplistic view of science and mathematics as the acquisition of factual information and conventional explanations of natural phenomena and to move understanding towards a view of science and mathematics as a range of widely applicable skills and competencies, researchers have argued a primary objective of science and mathematics education should be to increase motivation and foster positive attitudes [5]. Young people’s attitudes towards science and their motivation are increasingly recognised as crucial.

Science, mathematics and creativity are all altered by rapid advances in digital technologies which are shaping new literacies. Digital technologies enable children’s creativity, in connecting with others and, in particular content generation in [6]. Creativity needs to be encouraged in primary school classes. Creativity involves more than making something new or creating something, and can be applied to sciences [7]. It also involves thinking and problem solving [8, 9], as well as discovery [10] and innovation.

Creative science teaching and learning is active and child-centred, involving problem solving and exploration [11]. Allowing children to solve problems for themselves is also a creative way to achieve learning goals. These can range from simple challenges, whilst children are playing or exploring, to more refined problem-solving activities.

The challenge for teachers is to achieve equilibrium between structure and freedom in early years educational settings, adopting a more dialogical pedagogical model in which the teacher coordinates standing back with
collaborative intervention in science and mathematics classroom.

The episode herein reported illustrates an example of creativity in mathematics in the early years. It was drawn from selected observations and supported by information gathered through several types of data.

The notes taken included a timeline along which we recorded 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, enabled to better identify and to characterize the episode.

The findings of this episode aim to reveal the potential for creativity and the role of inquiry in the classroom reality of primary science and mathematics education. Seeking to find children creativity in maths at this level, a primary school class was challenged to solve a task.

2. Instruments and methodology

The fieldwork involved the use of sequential digital images capturing detailed interactions, with field notes supplemented by audio recording later transcribed and an overall timeline. The fieldwork instruments were: observation with field notes and a timeline [12], sequential digital images taken during the observations [13], audio recordings (with relevant sections transcribed), a map of the space, individual interviews with the teacher [14] and a group interviews with children [15].

The objective of the observation during this activity was to illustrate an episode of children creativity [16]. The notes taken included a timeline along which the observer recorded 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, enabled to better identify and to characterize the creativity episode. The interviews included 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

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.

4. The wolf, sheep and cabbage problem

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

4.1. 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.

4.2. Illustrative extracts from data

Child 1: “The sheep eats the cabbage.”
Child 2: “The sheep has to go first because the wolf doesn’t eat the cabbage.”
Child 2: “If we took the sheep first, then the cabbage, then the sheep will eat the cabbage.”
Child 2: “So we have to leave the sheep and bring the cabbage back.”
Child 2: “If we took the cabbage in first place, the wolf will eat the sheep. (…)”

Figure 2. An example of children collaborating and giving reasons

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

Figure 4. The integration of ICT for children to verify their solution

Child 3: “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."

4.3. Reflecting on learning

Child 4: "With this activity we learned that to solve a problem we have to make relationship between what we are 'analysing'."  

5. Conclusions

Creativity is an attribute that we can all develop. Creativity in early science involves children in solving problems. We need to support children in being creative in science and for this to happen we need creative teachers, who think flexibly and provide motivating experiences for the children.

The episode showed creativity through the encouragement of problem-solving and children’s agency.

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. She fosters reflection and reasoning, encouraging students.

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 proposed activities 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.

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 episode there were many examples of children observing and making connections.

In the interview 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 emphasized 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.

Dialogue and collaboration, promoted by widespread use of group work and teacher questioning, played important roles in encouraging the processes of reflection and explanation related with the evaluation of ideas and strategies.

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7. References


