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Early mathematical experiences: the importance of curricular integration

Ana Barbosa and Isabel Vale, *Polytechnic Institute of Viana do Castelo*

School of Education, Viana do Castelo, Portugal

Abstract

In this paper we explore the implications of some tasks that promote integrated activities in a preschool context. In early years education, children should have meaningful experiences, involving discovery, experimenting and solving challenging problems, based on their interests. All of this should be regarded in an articulated way, intertwining contents, knowledge and processes from different areas. Our main goal is to explore the potential of this approach from were mathematics stands, perceiving the kind of mathematics pre-schoolers should learn, operationalizing it through different types of connections.

Key words: Pre-school; Mathematics; Learning; Integration

Introduction

Much of our world can be better understood through a mathematical lens, and preschool is a good time for children to open their horizons and become interested in exploring phenomena that leads them to mathematical concepts like counting, sorting, measuring, building and describing shapes, finding patterns, estimating, among other experiences (Clements, 2001). Mathematics is an everyday activity for young children, emerging naturally from day to day problems, and teachers just have to make the most of them, building on children's spontaneous discoveries and on their prior knowledge to deepen the understanding of mathematical concepts.

Working in teacher training, especially pre-service teacher training, related to the teaching of Mathematics in the early years, there are some questions that normally arise, either from students that attend these courses, but sometimes also from in-service teachers in preschool contexts, like:

(1) What kind of mathematics is to be expected in preschool?
(2) How and when should mathematics be explored in this educational context?
(3) What is the impact of curricular integration in the learning of mathematics at this level? And how can it be operationalized?

Taking these perspectives into account, this study will address the previous questions, with the purpose of exploring preschool children's mathematical knowledge, through tasks that emerge from daily experiences and problematic situations, considering possible connections between mathematics and other curricular areas.

Curricular guidelines for preschool education

In order to contextualize the work developed in preschool education in Portugal, it's pertinent to start by highlighting the main curricular guidelines. The Portuguese preschool curriculum (DEB, 1997) is organized in three content areas. They contemplate different kinds of learning experiences and goals. The *Personal & Social Education* area has to do with the way the child relates with her self, with the others and with the world, and implies the development of attitudes and values, focusing the importance of social interactions. The *Expression and Communication* area covers psychomotor and symbolic development, determining comprehension and progressive grasp of several forms of language. This particular area is differentiated in several domains: language, mathematics and expressions (motor, drama, arts, music). Finally, the area of *Knowlege of the World* relates to the natural curiosity of children and their need for knowledge, making sense of the world around them, triggering the beginning of learning in natural and human sciences. In spite of having these distinct content areas to approach, the teacher must articulate and contextualize them in a specific educational environment. This contributes to the achievement of a flexible process of learning, following the educational goals determined, hence making sense for each child (DEB, 1997).

These aspects take into consideration how children learn. For instance, they have a fundamental role in the construction of their own knowledge. Children are continually acting on and organizing experiences mentally, either of social or physical nature. Knowledge emerges through repeated experiences involving interaction with people and objects (Piaget, 1952), as a result of dynamic interactions between the child and the physical and social environments. As said, social interaction is necessary for intellectual development, but it also has impact in developing social competence and self-esteem. Another important feature that teachers in preschool have to consider is that children learn by doing, by experimenting, by choosing and discussing (Jones, 1989). The relations they discover through these processes and their thinking about the consequences of their actions, enlarge their knowledge and refines their reasoning. The day-to-day play also provides opportunities for children to practice naturally, in a variety of situations, the newly acquired skills or knowledge. In these contexts they are spontaneously motivated in participating, questioning, being active, which will deepen their understanding of concepts.

One of the most fundamental demands for preschool teachers is the need to identify contents and themes that intrigue children and stimulate their curiosity to figure something out (DeVries & Kohlberg, 1990). Activities that are based on children's interests provide intrinsic motivation for learning. Curricular guidelines that are based on children's interests and internal motivation to understand a given phenomenon or situation foster desirable attitudes, such as initiative, curiosity and attention.

Mathematics in preschool: general ideas

Initiating mathematics instruction as early as possible may be particularly beneficial. The foundation for children's mathematical development is established in the earliest years and many mathematics concepts start to develop before formal teaching. Young children possess powerful beginnings of mathematical ideas, using them to make sense

of their everyday activities. So, it must be stated that, mathematical thinking starts long before entering school, through the interaction with the environment and through everyday experiences (e.g. DEB, 1997; NCTM, 2000). Young children tend to develop an *everyday mathematics* that can be surprisingly broad, complex and even sophisticated (Baroody, Lai & Mix, 2006; Clements & Sarama, 2009). In this sense, traditional teaching approaches don't tend to promote an adequate construction of mathematical knowledge (Baroody, 2000). Teachers have to consider what children already know, be alert and open to their interests, create an environment that promotes self confidence to share ideas and foster children's natural curiosity. These aspects should not be neglected in favour of a traditional approach (Clements, 2001). The most powerful mathematics for a pre-schooler is usually not acquired while sitting down in a group lesson but brought forward by the teacher from the child's own self-directed, intrinsically motivated activity (e.g. Clements & Sarama, 2009; DEB, 1997; NCTM, 2000). These perspectives suggest that pre-schoolers can and should engage in an effective mathematical thinking.

The Portuguese curricular guidelines for preschool mathematics (DEB, 1997) suggest that children gradually construct mathematical ideas through daily experiences, being up to the teacher to use quotidian situations as a starting point. The teacher must also take into account what children already know, what may be called informal knowledge, to diversify experiences and support children's reflections, in order to develop mathematical thinking, contemplating moments of consolidation and systematization of mathematical concepts. The privileged methodology in this educational level should be based on problem solving. Preschool teachers must promote problem solving and allow children to find their own solutions and discuss them, enhancing communication, reasoning and the development of critical sense. More recently the learning goals for Preschool Mathematics were organized into 3 main themes: Numbers and Operations; Geometry and Measurement; Organization of Data and Data Treatment (ME-DGIDC, 2010). This document lists a set of goals, related to the mentioned mathematical themes, that children are expected to achieve at the end of preschool education, however it also considers abilities like problem solving, reasoning and communication as being transversal to all of them.

Appropriate mathematical experiences should challenge young children to explore ideas related to patterns, shapes, numbers, measurement and space, with increasing sophistication and in a meaningful way (DEB, 1997; NCTM, 2000). But, as important as mathematical contents are, equally fundamental are general mathematical processes like problem solving, reasoning, communication, connections, and representation, as well as specific mathematical processes such as organizing information, patterning, and habits of mind, like curiosity, imagination, inventiveness, persistence, willingness to experiment (Clements & Sarama, 2009). In general, teachers should focus on meaningful mathematical tasks, developing rich environments, creating opportunities for children to collaborate and encouraging them to talk and write about the mathematics learned (Van de Walle, 2004), having an active role in the learning process.

The importance of establishing connections

The different curricular areas, stated for preschool education, should not be perceived separately. One of the main reasons is because young children do not conceive the world as if it were divided into separate cubbyholes. Knowledge should be constructed through the articulation of the different curricular areas, interpreting them in a globalizing and integrated way, and promoting proper and meaningful connections (DEB, 1997).

Considering the particular case of Mathematics, in the first years, this domain comes alive for children through tasks that reflect significant contexts and the integration of contents (Schwartz, 1995). In this paper we consider significant contexts to be the ones that are meaningful and defying for children. An effective teaching practice should not limit mathematics to a specific period of the day, rather it should be explored throughout the day and across the curriculum, according to the opportunities that arise. This approach should involve tasks that implicate previous experiences of children, their interests or daily problematic situations, thus stating the importance of mathematics and the way it is linked to quotidian. It's also important to consider the possible connections between mathematics and other curricular areas, perceiving knowledge as a whole, connecting concepts and events (Boavida, Cebola, Paiva, Pimentel & Vale, 2008). The opportunity for students to experience mathematics in a context is important, once they may apply and deepen contents and processes, through an interplay where mathematics illuminates a situation and the situation illuminates mathematics (NCTM, 2000).

Children's everyday activities and routines in preschool contexts can be used to introduce and develop important mathematical ideas. Also fundamental is weaving mathematics into children's experiences with other areas, like literature, language, science, social studies, art, movement, music, and all parts of the classroom environment (e.g. DEB, 1997; NCTM, 2000). In this sense, it's relevant to consider that helping children connect mathematics to other subjects, develops knowledge of both subjects, as well as knowledge of the wide applicability of mathematics (NAEYC, 2002). This approach facilitates the comprehension of the usefulness of mathematics and contributes to a positive attitude towards this content area.

Methodology

Given the nature of this study, we adopted a qualitative approach (Erickson, 1986) to address the questions stated initially. The study implicated 22 preschool children (5-6 years old) and was developed within the context of pre-service teacher training. Throughout 4 months, pre-service preschool teachers, from the course of Preschool Education, were supervised while working with their class. For this study we chose the context attributed to one of the pairs of preschool teachers we accompanied in the area of Mathematics. To understand the potential of curricular integration in early mathematical experiences, the participants explored several tasks, in whole or small groups, emerging from children's interests or intentionally proposed to highlight

connections between mathematics and other areas, although is these cases the tasks were intertwined with the Class Curricular Project.

The data collected was essentially descriptive in nature, resulting from three fundamental sources: observation, audio/video recordings and document analysis. All the sessions corresponding to the implementation of each task were observed and videotaped, for later viewing and analysis. The document analysis was based on all the registers produced by the children involved, on biographical records related to the educational background, and field notes written by the researcher throughout the study.

The data analysis process followed the model proposed by Miles and Huberman (1994). Data resulting from observing each session, from the audio and video recordings, as well as the registers produced by the students, were reduced in order to identify regularities for further interpretation.

Results from some of the tasks

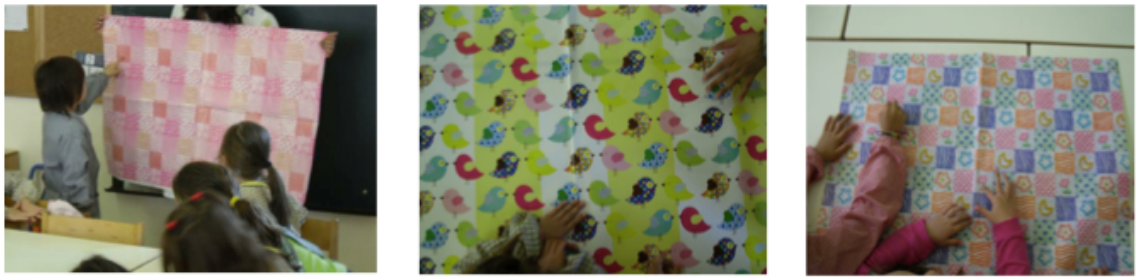
During the semester, corresponding to the pre-service teaching experience, several tasks of different nature were implemented. In this paper, we chose to present four of those tasks, highlighting curricular integration and, naturally, the links to mathematics. In each case we aim to describe when and how the situation was proposed and the mathematical concepts mobilized to solve it, focusing also on the connections between mathematics and other areas of knowledge.

Wrapping paper for Mother's day

With Mother's day approaching, the group decided to build their own wrapping paper, to wrap the gift each child would give to their mother, gift also made by them. This task promoted clear connections between Plastic Expression (Arts) and Mathematics, since they used different techniques of artistic expression (e.g. recycled paper, stamping, painting), working with diverse materials that lead to the exploration, search and creation of patterns.

Children where divided in small groups to analyse and discuss properties of wrapping paper, so they had enough information to build their own later. One of the most common conclusions was "all the wrapping papers have patterns". Since the papers analysed were different (Figure 1), a whole group discussion was promoted in order to share some of the findings. Children described several repetition patterns (e.g. orange dots, pink dots, pink square, orange dots, pink dots, pink square; white column, green column, white column, green column; bird to the right, bird to the left, bird to the right, bird to the left) and perceived the idea of cyclical repetition of the unit, saying things like "and then we repeat it" or "the other line has a flower, pink square, another flower, dots, and then the same".

Figure 1: Wrapping papers analysed by children



After the initial exploration, children created a project of what their wrapping paper would look like. For this work, they used sponge stamps with different shapes, brushes and watercolours. As we can see in figure 2, mainly, children created AB and ABC patterns. Some of the patterns formulated reflected the use of different elements throughout the lines, maintaining the structure, like they had observed in some of the wrapping papers. In particular cases, the need to shift to another line provoked a conflict in their reasoning, leading them to break the sequence and reinitiating it.

Figure 2: Projects of the wrapping papers

After concluding and presenting their projects, explaining the content, children copied the structure created to the recycled paper the group had made along the week, presenting no type of difficulties in this activity. Looking back, this was a meaningful task for this group of children, emerging from a necessity of their educational context, leading them to the learning of a diversity of concepts in a natural, not imposed, way.

The recipe

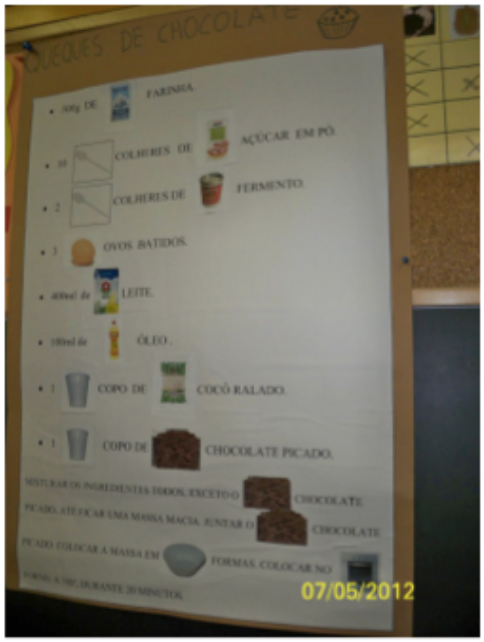
Children manifested interest in making chocolate cupcakes after reading a story that mentioned it. So, it was considered as an opportunity for a problematic situation where they would have to deduce all the process of making the cupcakes, analysing and deciding all the necessary phases. This task promoted connections between everyday knowledge, related to children's day-to-day experiences, and Mathematics. They needed to decide all the ingredients, materials and procedures they would have to use to do the cupcakes, evidencing number and measurement skills.

The group started by discussing and deducing what they would need to make the chocolate cupcakes. They remembered some ingredients (e.g. eggs, flour, sugar), some utensils (e.g. bowl, oven), and also identified the need to follow a recipe, claiming they had "to use the right amount". This lead to the presentation of a pictogram (Figure 3) that represented the recipe.

Teacher: So, what do we need to make the cupcakes?

A.R.: Eggs, flour, sugar, …
M.V.: Chocolate!
J.P.: A bowl.
I.C.: An oven.
Teacher: And considering those ingredients, do we put them all in a bowl?
S.T.: No! We have to use the right amount.
Teacher: How do we know that?
A.R.: You have to read it. In a recipe.

Figure 3: Recipe for the cupcakes



Following the initial discussion, the focus was on exploring and interpreting the content of the pictogram. Along the group discussion, children revealed and applied knowledge related to their daily experiences, identifying the ingredients, the materials and the measures. Even some of the conventional measures were recognized, like 500g of flour, saying that it was half a package because they saw their mother do it.

Teacher: What is the first ingredient?
Group: Flour.
Teacher: The recipe mentions 500g of flour. What does this mean?
M.V.: Half a package.
Teacher: How do you know that?
M.V.: Because it's half flour.
Teacher: How much does a package have?
I.C.: 1 kg
Teacher: And how do you know that?
I.C.: My mother told me!

This example states the importance of informal knowledge and its consideration in school activities. After interpreting the pictogram, children went on to the procedures. They had a measuring box in the classroom containing a diversity of materials, like common use objects (e.g. ping pong balls, pens, clips, squared cards, cubes) and measuring instruments (e.g. scale, measuring cup, ruler, measuring tape). They knew that in measuring situations the box was a possible resource they had at their disposal. They were able to make adequate choices and measurements according to the

magnitudes involved. Despite having some difficulties with the magnitude of some numbers, like 500g or 400ml, they were able to make generalizations from the numbers they already knew, like 5 or 4 looking for them on the scale. They also used non-standardized units, as the recipe suggested (e.g. spoons), applying counting skills.

T.F.: Lets use the cup.
Teacher: But here says milliliters.
A.R.: We can use the scale. But it has many numbers.
J.P.: It starts in zero. The pointer has to stop at 5.
Teacher: Why?
J.P.: Because the recipe has a five for the flower. (it said 500g of flower)

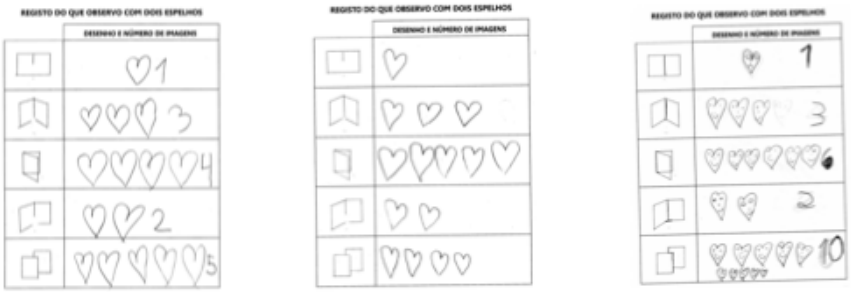
This task was non intentional, in the sense that it was not initially predicted by the teacher but rather proposed by the children. They were extremely motivated, revealing and applying knowledge, not only linked to mathematics, but also to their social environment and day-to-day experiences.

Reflection

While freely exploring the playing areas of the classroom, some children made pertinent assumptions and questions about their reflection on a mirror. Thus the reason of proposing this task: *What can we see in a mirror? Lets experiment and see what happens*. Considering the way it was implemented, it promoted connections between children's literature, Sciences and obviously Mathematics, highlighting the concept of symmetry of reflection.

The teacher started by reading a story that focused the idea of reflection, *The reflection of Lola in the mirror* (AdosAguas, 2009). Lola was a cow that had never seen her reflection and as she was confronted with a mirror, she discovered what happened as she made several movements and expressions. Children had the opportunity to do the same as the character in the story. Individually, they experimented different actions in front of the mirror in the classroom, making predictions and discussing what they saw: raising a hand, walking towards the mirror or stepping back, making funny faces. After the group discussion, children individually explored a mirror applying it to some images (e.g. half a heart, half a pizza, boy smiling, sad boy), verbalizing their findings in each step. It was considered pertinent, as the group was so interested in experimenting, to explore what would happen when they used two mirrors in different positions, making the respective registers. In figure 4 it's possible to observe the productions of three children. They were asked to register what they say when the positioned the two mirrors: side by side; like a book (making a 90º angle, an acute angle and an obtuse angle); in a parallel position.

Figure 4: Registers of the reflection task



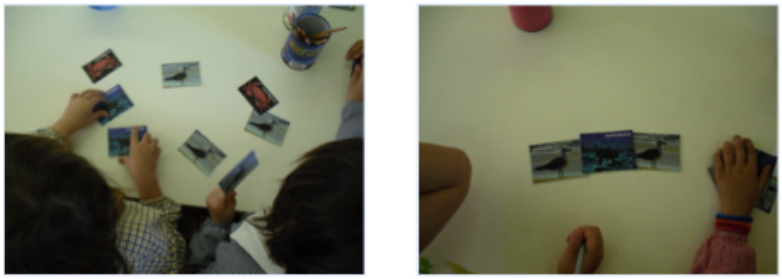
Children concluded that the position of the mirrors would influence the reflection, hence what they observed, and that, as they reduced the angle between the mirrors positioned like a book, the number of images increased. The most complex situation emerged when the mirrors were on a parallel position, however they had the notion that there were "to many".

The number of paws

One of the parallel projects developed by the teacher with this group of children was *The animals*. To obtain and confirm information about different types of animals, children consulted books, searched the internet, questioned family members and went on field study visits. At certain point the discussion focused on the animals found on the sea or near the sea (e.g. types, number of paws, covering, feeding). In this context, it seemed logic to develop children's mathematical reasoning proposing the following problem: *Simon went to the beach and saw 2 types of animals: seagulls and turtles. He spotted 8 paws. Which animals could they be?* This task hence promoted connections between the area of Knowledge of the World, in the Science domain, and Mathematics. Considering the knowledge of children about animals and its features, connections were established to mathematics through problem solving and number concepts.

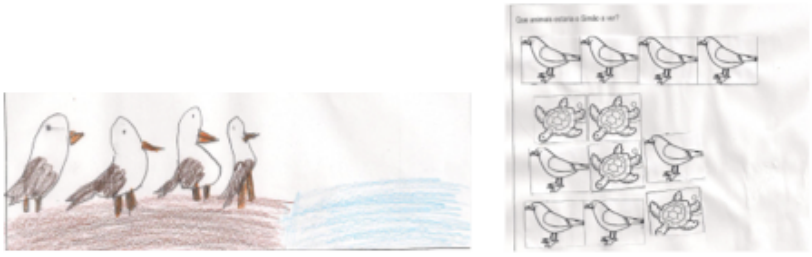
After the presentation of the problem, children had access to cards with the animals, to facilitate reasoning about the conditions proposed. They manipulated the cards freely, discussing about the content, the animals and their features (Figure 5). Then they tried to find solutions using the cards as resource to facilitate trial and error.

Figure 5: Manipulation of the cards to solve the problem



After manipulating the cards and finding different solutions, children made the respective representations by drawing them. Those who had difficulties with drawing used images of the animals and pasted them in the register sheet (Figure 6).

Figure 6: Register of the solutions



Children were able to find different solutions to this problem, presenting them. Not all of them could find all the possible solutions and some of them repeated the same case, changing the order of the animals. In spite of this, the whole group discussion aloud children to overcome these aspects. This task contributed to the refinement and development of problem solving strategies and to put to practice the knowledge children had about the animals involved.

Discussion

It's evident that tasks contemplating curricular integration constitute more effective and natural learning experiences, especially in these educational levels. Knowledge is perceived as a whole and concepts of specific areas are intertwined in order to produce a sequence of common benchmarks, and this happened throughout the tasks proposed along the study.

Focusing on the examples presented in this paper, we can highlight rich opportunities of curricular integration, allowing us to state that: (a) Many natural connections arise between art (plastic expression) and mathematics, mainly because there is a visual component that facilitates the exploration of geometric shapes, patterns, colours, geometric transformations; (b) Daily activities (e.g. cooking/recipes, snack time, daily routine) constitute privileged contexts to develop measurement skills, like learning about standard and non standard units, and also aspects of number sense; (c) Science and nature turn the focus to the environment and to the comprehension of phenomena, which leads to predicting, observing, comparing, measuring, classifying, looking for patterns (including symmetry of reflection); (d) Reading books can also enhance mathematical experiences, since many of the children's literature have good story elements that focus on subject areas, such as mathematics.

The approach intended and proposed, in this case focusing on mathematics, tends to encourage children's curiosity, leading them to make connections, and to build their confidence. These connections help them make sense of the world, understanding facts, events and concepts in a more meaningful way fostering even more their curiosity.

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Correspondence:

Ana Barbosa (anabarbosa@ese.ipvc.pt) and Isabel Vale (Isabel.vale@ese.ipvc.pt)