Connecting mathematics and sciences through children's literature. An experience with Pre-service Preschool Educators

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Abstract. Having in consideration that science and mathematics can be articulated through children's literature, this study, focused on future preschool educators, aims describe how future preschool educators' use children's literature to create mathematical and science tasks and to analyze how future educators mobilize pedagogical content knowledge to build those learning tasks. Future educators, divided into groups, were asked to select a book from a list provided to them and to designed science and mathematics task. Results suggest that they had difficulties in designing the tasks and that many of them were closed-ended and based on behaviorist theories of education. However, there were some exceptions.

Résumé : En tenant compte du fait que les sciences et les mathématiques peuvent être articulées par le biais de la littérature pour enfants, cette étude, dirigée vers les futurs éducateurs préscolaires, vise à décrire comment ces derniers utilisent la littérature pour enfants pour créer des tâches mathématiques et scientifiques et à analyser comment les futurs éducateurs mobilisent les connaissances en matière de contenu pédagogique pour construire ces tâches. Les futurs éducateurs, divisés en groupes, ont été invités à choisir un livre dans une liste qui leur avait été fournie et à concevoir des tâches en sciences et en mathématiques. Les résultats suggèrent qu'ils ont eu des difficultés à concevoir les tâches et que beaucoup d'entre elles restaient sur des théories behavioristes de l'éducation. Cependant, il y a eu quelques exceptions !

1. Introduction

Since an early age, children often employ mathematics and science in their everyday life (e.g. to appreciate the main geometric forms in nature and their advantages for animals or to build a paper kite). Current theoretical perspectives on teaching and learning, namely constructivism, suggest that learning is more effective when children's personal life experiences, interests and knowledge are taken in consideration. These perspectives are reflected in the Portuguese curriculum for preschool education (Ministério da Educação, 2016), which highlights the importance of designing learning tasks that connect different areas of knowledge, e.g. mathematics and science. Rather than approaching them in isolation, as knowledge in "drawers". These orientations pose pressure on preschool educators' training because educators often draw on their own early learning experiences (often based on traditional perspectives) to engage children with mathematics and science (Brand & Wilkins, 2007; Zacharos et al., 2007). Furthermore, these educators often do not have a strong subject content knowledge in science and mathematics: many of them perceive mathematics as arithmetic operations and shapes (Copley, 2004), and science as collection of facts, models, principles to be known by heart (Van Driel et al., 2001). Conversely to mathematics and science, preservice preschool educators often feel confident to develop children's questioning, creativity, communication skills through language-oriented activities, namely reading (Copley, 2004).
One way forward in encouraging mathematics and science connections is to take advantage of pre-

service preschool educators' self-confidence in language-oriented activities, for example, through children's literature books. From a very early age, and even before being at the kindergarten, children contact with children's literature. This is because it is essential not only to learn new vocabulary but also to have access to different perspectives about the world. Furthermore, research has shown that children's literature can contribute to develop mathematical and science thinking, and to break the logic of compartmentalized knowledge (Flevares & Schiff, 2014). Supporting pre-service preschool educators' integration of mathematics and science through children's literatures requires developing their ability to select, to deconstruct and to reconstruct the literary text. Indeed, mathematics and/or science are sometimes implicit in children's literature books, the language used is not the specific language of mathematics and science, and their aim is not to educate children's in mathematics and science. Hence, because they are not teaching resources, the mathematical and scientific ideas may be presented without taking in consideration the necessary prerequisites to understand them. For example, the authors may state that in space all the distances are huge without a scale of comparison.

Given the potentiality children's literature has to connect mathematics and science, and the preschool educators' positive attitudes towards reading tasks, it seems important to offer future preschool teachers the opportunity to design learning science and mathematics tasks based on these books, and to reflect on their potentialities and limitations.

2. Aims

Having in consideration that mathematics and science education can be integrated through literature, this study aims to:

- describe how future preschool educators' use children's literature to create mathematical and science tasks.
- Analyze how future educators mobilize pedagogical content knowledge to build those learning tasks.

3. Methodology

The sample is composed by 19 future preschool educators, enrolled in the first year of a master degree on preschool educators, in Portugal. They all hold a bachelor in basic education, in which they were exposed to a broad approach to several sciences and mathematics, alongside other subjects (such as history or pedagogy of childhood) and an initiation to the professional practice. Only after completing the master course in pre-school education do these future preschool educators become professionalized. Hence, their experiences as preschool educators are low.

The study was developed in "Didactics of Mathematics and Science" course, which is a compulsory curricular unit within the master degree in pre-school education. In the second week of the course, future preschool educators were divided in five groups and were asked to select a children's book from a list provided to them. Once the book was selected (Table 1) they were invited to create a science and mathematics tasks based on it. In this assignment, future educators were required to mobilize accepted pedagogical content knowledge to develop the tasks. They were asked to deliver the assignment two weeks after the end of the curricular unit, which was 15 weeks long. The corpus of analysis is composed by the tasks designed by the groups for the selected book. To each selected book a code was attributed which is a letter from A to F. Only in the book "the giant turnip", mathematical ideas (i.e. counting) are explicitly provided. Data was content analyzed by creating *a posteriori* categories (Bardin, 2014).

Table 1. Synopsis of the selected books

Book	Synopsis of
A – A story of fingers, by L. Ducla Soares	The popular names of fingers are provided and their names reinforced by using amusing sentences about them.
B - The giant turnip, by N. Sharkey	A turnip grows so large that only one person cannot pull it up. Several animals are successively recruited to pull the turnip up collaboratively. However, it is only when a mouse joins the group that the turnip is pulled up.
C – Box, by M. Flyte	Four children find some toys in cardboard boxes, they play with them for a while. But, the children then turned their attention to the boxes themselves. They decided to use their creativity to build, e.g. castles, dinosaurs, or space ships.
D - What is there?, by I. Martins & M. Matoso	The book uncovers what is inside several everyday objects, namely fridge, the mothers' purse, and so on.
E - I'll love you forever, by O. Hart	Polar Bear and Cub explore the Arctic habitat, as the seasons change. The characteristics of each season are then explored. Polar Bear reassures Cub that no matter changes in nature the loving bond between them will never be broken.

4. Results

An analysis of the designed tasks shows that the most of the science tasks are, to some extent, related to the theme of the book (Table 2) However, they are rarely used to deconstruct the story covered in them. Indeed, the science tasks are often designed to extend the story. For example, in book E ("I'll love you forever"), the designed tasks either make use of the illustrations to develop a parallel narrative (e.g. that answer the question "why do bears do not get cold?") or extend the book story (e.g. the book finishes with the mother bear telling the cub that: "you can have your own adventure". A task is designed to project a boat that can take the cub to a trip). Concerning the mathematics tasks, they are also, in majority, related to the theme of the book but they are never used to deconstruct the story. Some tasks are constructed to extend the story. For example, in book E, following the construction of a boat (science task), a task is proposed to decorate the boat using patterns. Another example is the creation of an itinerary (inspired in the bear's journey) where concepts related with spacial orientation are developed.

Table 2. The relation between the designed tasks in mathematics and science and the books' stories

	A	B	C	D	E
Tasks	(n=6)	(n=5)	(n=4)	(n=4)	(n=7)

in	NR	R	NR	R	NR	R	NR	R	NR	R
Mathematics	2	1	2	-		3	2		-	4
Science	2	1	-	3	-	1	_	2	-	3

L – Related; NR – not related

Furthermore, the designed tasks in mathematics and science and often not related. In the majority of the proposals, future educators designed science tasks, followed by mathematics tasks. There are, however, some few exceptions. That is the case of the tasks designed for the book D (Box). The tasks designed extend the story by asking children: "which purpose would you give to the boxes". Supposing that children would say a castle, the future teachers would then encourage children to explore the unit "forces and levers" to design and to build a gate, catapult, mechanism to pull water from a well etc. Once the "castle" is built, children are asked to" choose a view and draw it". Then they will change their drawings and guess the colleagues view. This task will explore the "spatial location" and help children develop the "language of space".

Accepted pedagogical content knowledge is not always employed to design the science tasks (Table 3). They are often close ended, without children's participation in the design of the task. For example, in the book D "What is there?", there is an image of the content of a fridge. The science's tasks involve: 1) asking children to infer whether or not certain food is in their fridge, 2) discussing healthy food, and 3) analyzing to what extent the food in their fridge is healthy. Some science tasks for other books (e.g. book E) have in consideration the children's misconceptions and are designed to support children explore them (e.g. which material could be used by the cub to build a boat?). Rarely are tasks based on a project based approach. Only the science tasks for the book "castle" encourage children to think about which artefacts they would like to include in their castle and to build them. As far as mathematics is concerned the majority of the tasks proposed are routine, closed tasks, not challenging. For example, in book B, children are asked to select and order, by size, some turnips. One can find some relatively open but easy tasks (exploration tasks, Ponte, 2005) for book E. In fact, children are asked to decorate a boat using patterns or to measure the mother bear and her cub, using the cover image. None of the tasks involves Problem solving.

Table 3. The nature of the relevant tasks

	Nature	A	B	C	D	E
Mathematics	Exercise	√	√	√	√	
	Problem solving					
	Exploration tasks			√		√

Science	Close-ended	√	√		√	√
	Exploring misconceptions					√
	Project-based learning			√		

5. Discussion

The results suggest that articulating science and mathematics through literature is a difficult task for future educators. One of the difficulties may result from the fact that the selected books do not often approach mathematics and science explicitly. Hence, it seems important in future pedagogical methods course to discuss the potentialities of literature books to articulate science and mathematics. One way forward might be to explore literature books (e.g. biographies of scientists and mathematicians) in which mathematics and science are explicitly included as part of the message.

The designed tasks, overall, also show that the future educators do not articulate science and mathematics tasks, which suggests that they perceive science areas as compartmentalized knowledge (Flevares & Schiff, 2014). In spite of being introduced to accepted educational theories, namely constructivism, future educators seem to have behaviorist models deeply rooted. Indeed, most of the science tasks are close-ended. This fact is not a surprise as it is well known that future educators tend to educate as they were taught.

6. Final considerations

Future educators need to become aware and value the potential connections between literature, mathematics and science, instead of considering them as unrelated areas of knowledge. Because educators tend to educate as they were taught, it seems important to increase the articulation between mathematics and science within the didactics methods course. For future research work, it seems also important to evaluate the scientific accuracy of the designed tasks in mathematics and in science.

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