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In-service teachers' design, teaching and reflection on probability tasks

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The development of students' stochastic literacy has become an overarching goal of statistics education internationally. In particular, teachers design lessons with engaging contexts, focus on conceptual understanding (Watson, 2001) and pose critical questions. The present research focuses on the development of early childhood teachers' thinking on designing and teaching probability tasks. Five early childhood in-service teachers participated in this research, which was organized around three stages of teaching: lesson design, classroom implementation and reflection. The study provides some useful insights into the varying levels of attention that teachers paid during their teaching and into the different types of instructional material they used.

Keywords: Statistics education, teacher education, early childhood, tasks, randomness.

Background of the study

Statistics education research suggests that enhancing teachers' subject matter knowledge about uncertainty and statistical inference must be given high priority. Building teachers' knowledge of pedagogical structures and tools by itself is not sufficient. Deep understanding of probability is also needed for identifying student errors and implementing effective teaching practices (e.g., Paparistodemou, Potari, & Pitta, 2006).

Consequently, statistics education researchers have, in recent years, engaged in professional development efforts aimed at facilitating the development of both subject matter knowledge and pedagogical content knowledge of teachers (e.g., Groth, Kent, & Hitch, 2015; Leavy, 2010; Serradó, Meletiou-Mavrotheris, & Paparistodemou, 2014). The importance of introducing probability tasks in the early mathematics classroom is related to the idea of constructing stochastic knowledge based on children's intuitions. Currently, probability and statistics have an important role to play in everyone's daily life, and particularly in children's lives where most of the games they engage with include the idea of chance. Research on learning stochastics (Paparistodemou & Noss, 2004) has shown that young children use spatial representations for expressing stochastic ideas. Research (Paparistodemou & Noss, 2004; Pratt, 2000) also shows that the design of activities targeting children aged 4-8, is critical for them to be able to express their probabilistic ideas. For analysing the complexity of teaching mathematics, Potari and Jaworski (2002) used the teaching triad (management of learning, mathematical challenge and sensitivity to students) as an analytical device and as a reflective agent for teaching development by teachers. Management of learning describes the teacher's role in the constitution of the classroom-learning environment by the teachers and students, for example planning of tasks and activity. Mathematical challenge describes the challenges offered to students to engender mathematical thinking and activity and sensitivity to students describes the teacher's knowledge of students and attention to their needs. The present research focuses on teachers' planning, teaching and reflection on young children's (4 to 6 years-old) stochastic activities. The work is part of a previous work

(Paparistodemou & Meletiou, 2018) and it concentrates on teachers' attention on the activity in terms of the mathematical challenge it offers and the development of children's stochastic ideas.

Methodology

Participants and context

Five early childhood teachers (all females) participated in this research, which was organized in three stages: Stage 1 – Lesson Planning, Stage 2 – Lesson Implementation, and Stage 3 – Reflection. In Stage 1, the teachers were engaged in lesson planning. They selected a topic from the national mathematics curriculum on probability and statistics and developed a lesson plan and accompanying teaching material aligned with the learning objectives specified in the curriculum. The lesson plans were shared with the researchers for comments and suggestions, and were revised based upon received feedback. In Stage 2, the teachers implemented the lesson plans in their classroom, with the support of the researchers. Once the classroom implementation was completed, in Stage 3, teachers were interviewed and prepared and submitted a reflection paper, in which they shared their observations on students' reactions during the lesson, noting what went well and what difficulties they faced and making suggestions for improvement.

Data collection

Multiple forms of data were collected: (1) Observations and artifacts collected during Stage 1: Early childhood teachers' submitted work (students' entry slips-student's responses on pre-knowledge tasks, lesson plans, etc.), researchers' observations and field notes; (2) Observations and artifacts collected during Stage 2: Each early childhood teacher intervention that took place lasted for 80 minutes (two teaching periods). Researchers were present, observing closely and videotaping the lesson, keeping field notes, and collecting samples of student work; (3) Individual interviews and reflection reports during Stage 3: Upon completion of Stage 2, the researchers conducted semi-structured interviews with each of the teachers. Qualitative data were also obtained from the reflection papers prepared by the teachers.

For the purpose of analysis, we did not use an analytical framework with predetermined categories to assess how teachers' perceptions evolved. Our coding was open and we tried to recognize mathematical challenges (Potari & Jaworsky, 2002). We identified, through careful reviewing of the transcripts, reports, and other data collected during the study, recurring themes or patterns in the data. To increase the reliability of the findings, the activities were analyzed and categorized by the researchers. Inter-rater discrepancies were resolved through discussion.

Designing, teaching and reflecting on probability tasks

Findings, concerning the study research question on what early childhood teachers attend to when designing, implementing and reflecting on probability tasks, will be discussed with regards to one of the three elements of the teaching triad (Potari & Jaworski, 2002): mathematical challenge, which we call here "stochastical challenge". The learning objectives included in all lesson plans refer to stochastical challenges like the probabilistic concepts of certain, impossible and probable events. Moreover, the lesson plans included activities that involved children in authentic statistical inquiry. The activities included in their lesson plans indicated that they tended not to recognize the concept of randomness, as it appeared difficult for them to see the stochastical idea underlying tasks

(the context). In presenting the main insights from our study, we focus to the *existence of randomness*.

The stochastic challenge of making predictions

In Alice's case, the aim of the lesson plan she designed was for "children to make predictions based on impossible, possible and certain events". She decided to use the context of children making hats for a party:

Alice: You know, children need an everyday scenario... I decided to ask them to make hats with dots. The dots will be blue and/or red... they [the children] will select a spinner, make a prediction as to whether it would be possible for the hat to have blue dots or not, mark it on their board and then make their hat...

Researcher: So, will they use their spinners?

Alice: If they like to...yes. I know that some students will know beforehand...

The other activities included in Alice's lesson plan also indicated lack of attention to the concept of randomness. Alice was focusing only on children making decisions on what might have happened and what not. We had a discussion with Alice to find out why she did not 'allow' children to spin the spinners. She referred to management issues, but after we pointed out the importance of children experiencing randomness, decided for children to spin their spinners. Figure 1 shows how Alice organized her classroom based on the above task.



Figure 1: Material used in Alice's task

The stochastic challenge of controlling the uncontrolled

In Sally's case we recognized an awareness of the concept of randomness. Sally was very specific in her two aims for the lesson, which were the following: "Children should be in a position to select the appropriate sample spaces for certain, impossible and fair events", and "Children should experience the concept of randomness". At the beginning of Sally's lesson, children selected their favorite flavor of ice cream. They had this selection stacked on their chair and were given a "fair" spinner with three flavors. They worked in pairs, with one child spinning the spinner and the other one comparing the flavor that had come up in the spinner with his/her favorite flavor (see Figure 2).



Figure 2: Children playing with spinner in Sally's task

It was good to see Sally letting the children experience randomness. Another activity she planned and implemented was to show children different spinners, which had different sample spaces (for example, whole brown (as a chocolate flavor), whole red (as a strawberry flavor), whole white (vanilla flavor), $\frac{1}{4}$ brown- $\frac{3}{8}$ red- $\frac{3}{8}$ white etc.). Children were asked questions such as: "Which spinner should you use in order to get your favorite flavor? Why? If I spin this spinner will I get strawberry? Why or why not?"

Sally's case is interesting from the point of view that although we recognised from her lesson plan a stochastic challenge awareness, we can see from her teaching that she put a lot of effort in understanding the probability concept and the presence of randomness in her activities. On this point, in her interview she stated:

Researcher: What did you want children to learn?

Sally: Certain, Possible, Different sample spaces...Well, the activity went well. It was not difficult for them... and I think children built a good understanding of the idea of randomness [...] you know, I spent a lot of time to design the lesson...finding the scenario, making the materials...but the "key" was for me to understand...you know...to feel confident that I know...this subject [probability] seems easy but it is not so easy to teach... you need to know.

Researcher: What was it that you needed to know?

Sally: There were many times that in order to continue teaching I had to grasp from their predictions, continue with having the experience and then find a way lets say...giving them [to the children] a chance to "control" this "uncontrolled idea" [randomness]... For example, Dani was sure that he would get brown in a fair spinner...that was not the case...At that point I had to be able to give him an experience of randomness and also help him build his new prediction...

Sally seemed able to recognize some critical incidents in her lessons and to reflect on them. She paid particular attention to the provision of opportunities for children to experience randomness, something that was critical in building on children's intuitions.

Similarly, Alice reflected on her lesson: "I spent hours trying to find the scenario, making the materials and I felt that everything was ready...In this lesson that was not the case... I had also to be able during my teaching to find ways to help children adjust their predictions, making questions and giving the right spinner..."

In the above paragraphs we present two cases of the five we observed, as these can be also an example of the other two that are missing. Among the five cases of teachers in our study, there was one teacher who did not recognize at all the importance of randomness in her probabilistic activities. Katie expressed her thoughts as follows: “You know, I feel that the lesson did not go so well mainly because I posed too many closed questions and I didn’t feel confident when I got the ‘wrong’ answer... I didn’t realize the need for children to experience randomness until we talked...”. Katie was aware that a deeper understanding of this important probability concept would have helped her to improve her lesson planning and implementation. Besides that, she also reflected on how she should have given the opportunity for children to experience randomness.

Discussion and conclusions

Teachers in our study recognized that they needed to know not only what randomness is and how to deal with this concept, but also how to make it visible in their lesson. They pointed out that successful introduction of the idea of randomness in the early mathematics classroom requires knowledge of how to build upon children’s prior intuitions regarding random phenomena, as well as how to react during the lesson to students’ predictions regarding stochastic events and to the actual outcomes of such events. Teachers discussed on critical incidents they observed (Goodwell, 2006; Hanuscin, 2013). Critical incidents were crucial for jointing reflection between teachers and researchers on concrete classroom situations (Scherer & Steinbring, 2006).

Most of the teachers’ attention during the planning stages was focused on including knowledge of educational goals, where specific concepts appear. This is what Ball and Bass (2000) spoke about what curriculum knowledge is. This type of knowledge may help teachers appropriately sequence the introduction of statistical ideas in a curriculum (Godino, Ortiz, Roa, & Wilhelmi, 2011). The findings show that it was through actually teaching the lesson and after reflection that the knowledge components/challenges became more evident for these early stage teachers. Similar findings were obtained in a previous study conducted by Paparistodemou et al. (2006), which had investigated prospective teachers’ awareness of young children’s stochastic activities. The fact that similar tendencies were observed in both pre-service and in-service teachers might lead us to conclude that awareness is not only a matter of teaching experience, but also of the extent to which teachers engage with the process of noticing and understanding their teaching. In the case of Sally and Alice, we saw some degree of awareness of important concepts like randomness. At some instances, these two teachers indicated some understanding of randomness and of how it relates to other probabilistic concepts, but this was not always the case. We could say that their awareness remains at the level of action (mathematical) and it does not indicate a greater degree of awareness that of the awareness in discipline (Mason, 1998).

Summing up, this study adds the term of “stochastic challenge” in Potari’s and Jaworski’s (2002) teaching triad and in addition to previous work of Paparistodemou and Meletiou (2018). Furthermore, it shows the kind of experiences that a small group of early childhood teachers’ incorporated into the design, implementation and evaluation of teaching related to stochastics (for more details see also Paparistodemou & Meletiou, 2018). It can be argued that these teachers did build some relations between theory and teaching practice, but that their transition and reflection to more specific stochastic and pedagogical issues appeared to be a difficult endeavor. This calls

upon special attention and reflection on behalf of mathematics teacher educators to tackle this problem.

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