An exploration of how mathematics teacher educators invite pre-service teachers to participate in lessons about the teaching of number concepts and operations in early years

Justina Longwe-Mandala[1] and Janne Fauskanger[2]

[1]University of Malawi, Faculty of Education, Malawi; jlongwe@cc.ac.mw

[2]University of Stavanger, Faculty of Arts and Education, Department of Education and Sports Science, Stavanger, Norway; janne.fauskanger@uis.no

This study explores the nature of pre-service teachers' participation in their lessons on how to teach number concepts and operations to learners in early years of primary school. The paper is part of a qualitative case study aimed at exploring how pre-service teacher education prepares pre-service teachers to teach number concepts and operations in early years (Grades 1-4) in Malawi. This paper reports on findings from two mathematics teacher educators. The lessons were analyzed using the Mathematics Discourse in Instruction framework. The analysis involved segmenting the lessons into episodes, each of which was recognized by change in content focus. Findings indicate that the pre-service teachers were mostly invited to participate through answering yes/no questions or supplying one-word responses to the teacher educators' unfinished sentences. Implications of these findings are discussed.

Keywords: Pre-service teacher education, early years mathematics, learner participation, malawi.

Introduction

In any mathematics lesson, meaningful learner participation is fundamental for understanding the mathematics made available for learners to learn (Carpenter et al., 2003; Trocki et al., 2014). Mathematical understanding develops best when learners participate actively and are encouraged to discuss mathematical concepts and to generate and argue mathematical solutions with one another (Carpenter et al., 2003). However, Trocki et al. (2014) argue that it is usually challenging for teachers to facilitate such type of discourse in their mathematics lessons. This suggests that teachers need to be supported to learn the practice of inviting learners to active participation. Inviting learners to participate in the lessons is one of the practices that teachers perform regularly in their work of teaching. As such, teachers need to learn how to do it (Adler & Pournara, 2019). This learning needs to begin from pre-service teacher education because pre-service teacher education is expected to expose pre-service teachers (PSTs) to learning environments that help them to experience active and meaningful learning, while at the same time helping them to learn to create the same learning opportunities for their learners (Taylan, 2017).

In Malawi, little is known about how teacher educators (TEs) invite PSTs to participate in their mathematics lessons and how these PSTs are enculturated into the practice of inviting learners to participate actively in the lessons about number concepts and operations. Number concepts and operations is the predominant focus of early years mathematics in Malawi; it also takes a big part of mathematics teacher education content (Ministry of Education Science and Technology [MoEST], 2017). Mastery of number concepts and operations plays an important role in the development of

learners' future mathematical abilities. Yet, studies continue to show that early years learners in Malawi perform below the expected achievement level in mathematics, including in the core-element of number concepts and operations (Brombacher, 2011, 2019). A study by Saka (2019) indicated some challenges in the way teachers teach number concepts and operations in early years. Saka argued that the way teaching is done in early years does not fully support the development of number concepts and operations for learners. This finding may indicate some gaps in the way PSTs are helped to learn to teach number concepts and operations. Research indicates that what teachers learn during their pre-service training greatly influences how they teach (Ball & Forzani, 2009). Thus, if PSTs are engaged in active and meaningful participation during their teacher education, they are likely to engage their learners in active and meaningful participation during their work of teaching. This makes it necessary to explore how the teaching practice of inviting PSTs to participate in the lesson is enacted in pre-service teacher education. The main argument being put forward here is that teachers' ability to encourage meaningful participation among learners does not come naturally; it is a function of how they were enculturated into the practice during their pre-service teacher education. Thus, this study focused on answering the question 'How do mathematics TEs invite PSTs to participate in the lessons about how to teach number concepts and operations in early years?' In this paper, 'teacher educator' refers to the one teaching pre-service teachers how to teach, 'pre-service teacher' is the one learning the work of teaching, while 'learner' is the one whom the PSTs are expected to teach at the end of their pre-service teacher education.

Theoretical Framework

This study was guided by the Mathematics Discourse in Instruction (MDI) framework, developed by Adler and Ronda (2015). This framework was chosen for use in this study because it helps in describing the mathematics that is made available during teaching (Adler & Alshwaikh, 2019), and it specifically targets mathematics teaching practices that teachers meet regularly in their teaching. The framework considers four key elements to the teaching of mathematics: object of learning, exemplification, explanatory talk and learner participation as shown in Figure 1.

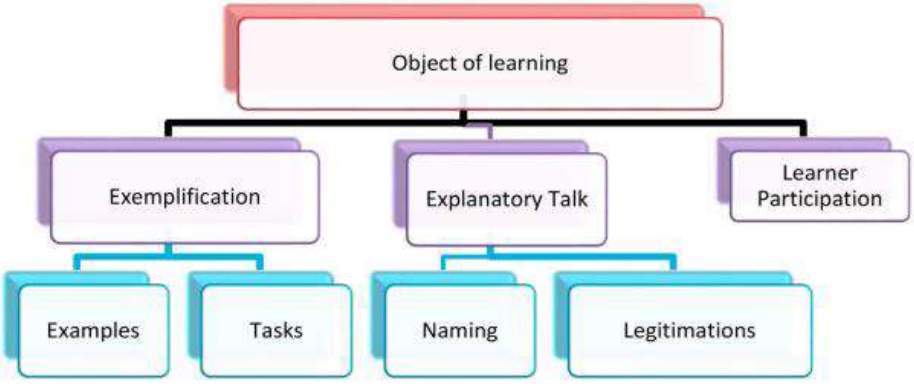

Figure 1: Constitutive elements of the MDI framework (Adler & Ronda, 2015, p. 239)

The object of learning is what learners are expected to know and be able to do. In a mathematics lesson, the object of learning is brought into focus through three mediational means: exemplification, explanatory talk and learner participation. Exemplification is concerned with examples and tasks used in the lesson, and how these provide opportunities for learners to learn mathematics. Explanatory talk

is talk which names and legitimates important aspects of the object of learning, while learner participation is about how learners are invited to participate in the lesson (Adler & Ronda, 2015).

In the larger study, which explored how pre-service teacher education prepares PSTs to teach number concepts and operations in early years (Longwe, 2021), all these elements of the MDI framework were used to analyze how the TEs enacted the teaching practices of exemplification, explanation and PST participation in helping PSTs to learn how to teach number concepts and operations. However, the focus in this paper is on the element of learner participation, which is concerned with interactions that happen in a mathematics lesson. With this element, attention is focused on how learners are invited to talk mathematically and verbally show their mathematical reasoning (Adler & Ronda, 2015). Adler and Ronda (2015) characterize learner participation in three categories depending on the level of participation and opportunities they provide for learners to learn mathematics. Level one is where learners are invited to either answer yes/no or supply words to teachers' unfinished sentences. Level two is where learners are invited to answer what or how questions in phrases or sentences, while level three is where learners are invited to answer why questions, present ideas in discussion and the teacher re-voices, confirms or asks questions (Adler & Ronda, 2015). This framework was used in the present study to analyze how mathematics TEs invited PSTs to participate in their lessons about the teaching of number concepts and operations.

Methodology

This was a qualitative case study (Creswell, 2014). Four mathematics TEs were purposively selected for participation in the larger study where all the lessons were conducted through face-to-face mode of learning. Data being reported here is from two TEs. These were selected for this paper because data from one of the two TEs showed some differences in the way PSTs were invited to participate while the other one was selected as a representative of the three TEs who presented some similarities in the way they invited PSTs to participate. Data were collected through lesson observations. From the first TE (TE1), six lessons were observed. Two lessons focused on the teaching of place value of whole numbers and four lessons focused on the teaching of addition. This class had a total of 37 PSTs. From the second TE (TE2) four lessons on addition of whole numbers were observed. In TE2's class, there were 39 PSTs. It is important to note that the core-element of number concepts and operations is a wide area which encompasses many topics, and the topics of place value and addition of whole numbers also fall under this core-element (MoEST, 2017). Each of the lessons was videotaped and subsequently transcribed.

Data analysis was done by dividing the transcribed data into episodes. Coding for PST participation was done by indicating beside the utterances whether the PSTs participated by answering yes/no; answering what/how questions; or answering why questions, involved in discussions, or asking questions. At the end of each episode, a descriptive summary of all forms of participation was provided. The summary also included the number of occurrences of each form of participation. This quantification guided the analysis in determining the extent to which each form of participation was enacted and later make claims of how PSTs were invited to participate based on how each form of participation was enacted.

Findings

As stated earlier, this study explored how mathematics TEs invited PSTs to participate in the lessons on number concepts and operations. Following the MDI framework, analysis focused on whether PSTs were invited to either answer yes/no questions or one-word responses; answer what/how questions; answer why questions, present ideas in discussion, or ask questions (Adler & Ronda, 2015). Attention was also paid to how these forms of participation provided opportunities for PSTs to further their knowledge of number concepts and operations and learn how to teach these concepts to their learners. The findings are presented by first providing a summary of instances of how PSTs were invited to participate in all the lessons as shown in Figure 2. In presenting the findings in Figure 2, the forms of participation are presented as 'Y/N' where PSTs were invited to participate through answering yes/no or provide one-word responses, 'what/how' where they were invited to answer what or how questions, 'discussion' where they were invited to present ideas in discussion, 'why questions' where they were invited to answer why questions, and 'ask questions' where they were invited to ask questions. As explained in the methodology section, six lessons were observed in TE1's class (presented as L1-L6 in the graph) and four lessons were observed in TE2's class (L1-L4).

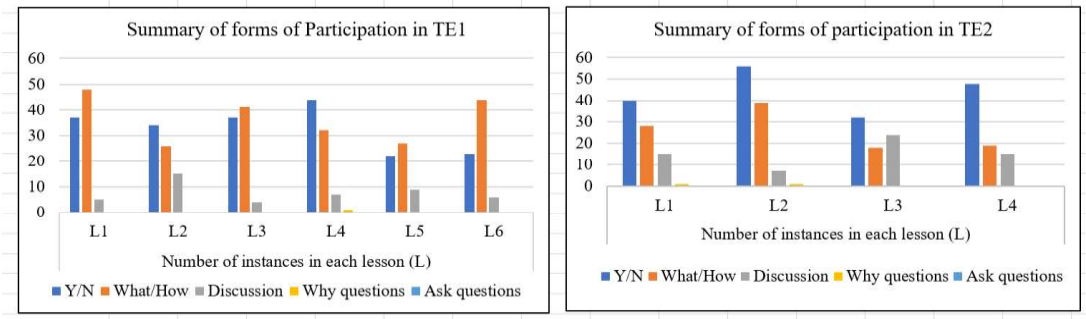

Figure 2: Summary of forms of PSTs participation in TE1 and TE2 lessons

As Figure 2 shows, TEs invited PSTs to participate through different forms of participation, as categorized in the MDI framework. PSTs were invited to participate through answering yes/no or one-word response, answering what/how questions, presenting ideas in discussion and answering why questions. However, these forms of participation were enacted to varying degrees.

Participation through answering yes/no or supplying one-word responses

While all forms of participation were observed in the lessons, findings indicate that TE2 mostly invited PST to participate through answering yes/no or supplying one-word responses. In all the 4 lessons the most common form of participation was where he invited PSTs to participate through this form of participation. For TE1, however, findings indicate that it was in 2 out of 6 lessons (L2 and L4), where he mostly invited PSTs to participate through answering yes/no or supplying one-word responses (see Figure 2). The following excerpt offers a representative example of how TEs invited PSTs' to participate through answering yes/no or supplying one-word responses (TE2, lesson 2 episode 1.2).

35 TE:	Yes. If I say ten plus nine, will this be a basic addition fact?
36 PSTs:	No
37 TE:	Why say no?
38 PST:	Because there's two-digit number

39 TE: Because we have used two-digit number, are we together?
40 PSTs: Yes
41 TE: Otherwise, we would like to concentrate on one-digit number added to one-digit number…In addition, what are addends? When you put two addends together, you get a sum, so what are addends. Yes!
42 PST: Are numbers which can be added
43 TE: The numbers that can be added. Are we together? So, in this case, if ten is added to nine, therefore, ten is a what?
44 PSTs: Addend
45 TE: Nine is a what?
46 PSTs: Addend
47 TE: And nineteen is what?
48 PSTs: Sum
49 TE: The sum, the result, are we together?
50 PSTs: Yes

In this dialogue, the TE focused on the basic facts of addition and how to come up with addition sentences from the basic facts of addition table. Throughout this dialogue, PSTs participated by answering yes/no or supplying one-word responses, except in utterances 38 and 42 where they went beyond giving yes/no or supplying one-word responses. This implies that most of the mathematical talk was being done by the TE while the PSTs were only supplying one-word responses.

Participation through answering what/how questions in phrases or sentences

Findings from data analysis indicate that PSTs were also invited to participate through answering what/how questions in phrases or sentences. For TE1, findings indicate that this was the most prevailing form of participation through which he invited PSTs to participate (see Figure 2). For TE2, findings have indicated that the most common form of participation was through answering yes/no or one-word responses, as indicated in the section above, but participation through answering what/how questions was also present as shown in Figure 2. Instances where TEs asked PSTs to answer what/how questions, such as to define concepts about number concepts and operations were observed. Below is an example of how PSTs were invited to participate through answering what/how questions.

TE: Our today's lesson is about place value, (writes place value on the board). Have you ever heard of that word, place value? Or what comes into your mind when you hear about these two words, place value? (TE1, lesson 1, episode 1.1)

In this excerpt, the TE invited the PSTs to explain what the concept 'place value' means. This form of participation invited PSTs to go beyond supplying single words to TE's questions, to reasoning about the concept of place value.

Participation through presenting ideas in discussion, answering why questions, and asking questions

In all the lessons, findings indicate some instances where PSTs were invited to participate through presenting their ideas in discussion. Some of the activities in which PSTs were invited to participate through discussion include discussing how to model addition of whole numbers using different resources such as place value box, spike abacus, and on a number line. Findings also show few instances where PSTs participated through answering why questions—one instance for TE1 and two instances for TE2 (see Figure 2). In these forms of participation, PSTs were seen to be exposed to

more open discussions where they shared their mathematical thinking. Below is a representative example of instances where PSTs were invited to participate by answering why questions.

TE: Now, can you explain why addends in the basic addition facts do not go beyond nine? (TE1, lesson 3, episode 2.1)

This question provided opportunities for PSTs to go beyond just giving a definition, to applying their mathematical thinking considering the properties of basic facts of addition. Findings also indicate that participation through asking questions was not observed in any of the lessons (see Figure 2), implying that the PSTs were not exposed to the practice of getting to ask questions from their TEs.

Discussion and conclusion

In this study, an exploration of how TEs invited PSTs to participate in their lessons about how to teach number concepts and operations in early years, the observed TEs invited PSTs to participate through all the three forms of participation as characterized by the MDI framework, namely, participation through answering yes/no or supplying one-word responses, participation through answering what/how questions in phrases and sentences, and participation through discussions and answering why questions (Adler & Ronda, 2015). However, it was revealed that PSTs were mostly invited to participate through answering yes/no or supplying one-word responses and through answering what/how questions. In few instances, they were invited to participate through discussion and answering why questions. Also, findings have revealed that in these observed forms of participation, there were some variation in the way the two TEs enacted them. It was observed that TE1 mostly invited PSTs to participate through answering what/how questions, while TE2 mostly invited PSTs to participate through answering yes/no or supplying one-word responses. Although there were such differences, both forms of participation—participation through answering yes/no and participation through answering what/how questions—as enacted by the TEs, did not appear to provide enough opportunities for PSTs to engage in more active and meaningful participation. This finding appears to be in contrast with what Taylan (2017) argues about engaging PSTs in meaningful participation. Taylan (2017) contends that PSTs are expected to create active and meaningful learning situations for their learners. But for these PSTs to be able to do this with their learners, there is need for them to encounter similar learning opportunities during their pre-service teacher education. This implies that if PSTs are given opportunities to participate meaningfully in their mathematics lessons, they are likely to provide the same learning opportunities to their learners during their work of teaching. Thus, this finding from the current study suggests that the PSTs had limited opportunities to learn to do this to their learners.

During mathematics teaching, What learners are invited to say determines their opportunities to talk mathematically and demonstrate their mathematical reasoning (Adler & Ronda, 2015). The same can be said about PSTs, implying that exposing PSTs more to participations that required them to answer yes/no or one-word responses limited their opportunities to talk mathematically, develop and demonstrate knowledge about number concepts and operations. Also, when PSTs are only invited to supply one-word responses, it is difficult for TEs to spot misconceptions that PSTs might have about the mathematics they are learning (Taylan, 2017).

On the other hand, inviting PSTs to participate through answering what/how questions in phrases or sentences appeared to create opportunities for them to show what they know and also opportunities to learn about number concepts and operations, but it may not have provided enough opportunities for them to argue mathematically and expose their mathematical thinking. The few instances where PSTs were invited to participate through discussions and making presentations appeared to have provided opportunities for them to engage in greater and more meaningful participation where they shared their ideas and were able to make mathematical arguments. The MDI framework advocates inviting students to participations where they present their ideas in discussion, answer why questions and also ask questions (Adler & Pournara, 2019). However, the finding that the practice of inviting PSTs to answer why questions was rare and that there was no instance where they asked questions may indicate that the PSTs had limited opportunities to demonstrate their mathematical reasoning and to learn to provide such kind of participation to their learners. It might also indicate that the practice of facilitating meaningful mathematical discussions is challenging for TEs. Encouraging PSTs to ask questions is an important practice for teachers to learn to do as it promotes active learning and also helps to unveil misconceptions that PSTs might have (Taylan, 2017).

The findings of this study suggest that PSTs were mostly exposed to participations that provided limited opportunities for them to talk mathematically and verbally show their mathematical reasoning. The challenges in the way teachers teach number concepts and operations, and the resultant poor learner performance (Brombacher, 2019; Saka, 2019), as indicated in the introduction section, might be related to the way these teachers were prepared to teach during their pre-service teacher education— how they were invited to participate in their mathematics lessons as PSTs, as visualized in this study. In order for early years learners in Malawi to improve from performing under the expected achievement level in the core-element of number concepts and operations (Brombacher, 2011, 2019), an implication from this study might be to extend the ways PSTs are invited to participate in Malawi pre-service teacher education. Learners learn more from their mathematics lessons when they are given the opportunity to discuss mathematical concepts and argue mathematical solutions with others (Carpenter et al., 2003; Taylan, 2017). Therefore, exposing PSTs to such a learning environment would be useful in helping them understand primary school mathematics better, and at the same time help them to develop knowledge of how to facilitate such type of participations with their learners.

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