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Student teachers' reflections on the pedagogy of play as a modelling approach in mathematics: Opportunities and challenges

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Abstract

The purpose of this article is to explore student teachers' reflections on the pedagogy of play (PoP) as a modeling approach in mathematics. PoP has generally been perceived as a model characterized by a playful classroom environment where learners take risks, make mistakes, and explore new ideas. When student teachers are equipped with PoP knowledge, they can create effective learning environments in mathematics classrooms based on learners' everyday contexts. This aligns with modern educational trends that advocate for integrating the arts into science, technology, engineering, and mathematics education. The phenomenological research design was employed to describe, understand, interpret, and explain student teachers' reflections. The participants were 10 mathematics education student teachers who participated in post-intervention focus group interviews, which were used as the main data collection instrument. The findings revealed that PoP can bring a new innovative perspective into the teaching and learning of fractions. It was also revealed that music and boomwhackers may create disruptions in the learning of mathematics.

Keywords: boomwhackers, common fractions, contextualization, mathematics knowledge for teaching, music, pedagogy of play, pre-service mathematics teacher education, pedagogical content knowledge

INTRODUCTION

The importance of pedagogy of play (PoP) in the teaching and learning of mathematics has been widely documented (Potgieter, 2020; Potgieter & Van der Walt, 2021; Reikerås, 2020; Van der Walt et al., 2019; Vogt et al., 2018). Fleer and Veresov (2018) define PoP as a pedagogical model that supports the development of play from learners' perspectives. PoP as a pedagogical tool is often characterized by a playful classroom environment where learners take risks, make mistakes, and explore new ideas (Mardell et al., 2016). PoP consists of games, puppetry, and music. In this article, the focus is on the latter. Music, which is an integral part of human social activity (Potgieter, 2020; Van der Walt et al., 2019), can address multiple intelligences (Gardner, 2008). One of the ways to incorporate music is by "allowing learners to write rap songs about the mathematics content, or to perform a dance to illustrate certain principles, which accounts for a lot of creativity and fun in the mathematics classroom" (Potgieter, 2020, p. 34). Furthermore, musical intelligence has a positive impact on the enhancement of learners' ability to establish mathematical connections (Booth & O'Brien, 2008; Kusuma & Dwipriyoko, 2021; Lovemore et al., 2021; Rifqi et al., 2021). The contention is that music and mathematics share a meaningful connection that can bring out effective mathematics teaching and learning, where learners are stimulated and motivated to learn. Different types of music and musical instruments exist. This aligns with modern educational trends that advocate for integrating arts into science, technology, engineering, and mathematics education (Başaran & Erol, 2023; Mafokwane, 2023). As such, this article focuses on boomwhackers, which Van der Walt et al. (2019) define as colored plastic tubes accurately cut into specific lengths to produce different tones when hit against a surface (table, hand, or floor) and work like xylophones. They offer opportunities for contextualizing

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Contribution to the literature

- This article contributes to the literature by exploring the PoP as an innovative modeling approach in mathematics education, highlighting its potential to enhance learning by connecting mathematical concepts to learners' everyday contexts.
- It provides empirical evidence through student teachers' reflections, revealing the effective integration of music and playful activities, such as boomwhackers, in mathematics instruction.
- Furthermore, the study underscores the necessity of developing pedagogical content knowledge (PCK) among pre-service teachers to create meaningful learning experiences that resonate with learners' sociocultural backgrounds.

some of the mathematics topics (Speight-Vaughn & De Beer, 2020; Van der Walt et al., 2019).

Previous research conducted by Mabotja (2023), Moloi (2014, 2015), and Van der Walt et al. (2019) asserted that mathematics is often not contextualized in learners' sociocultural or everyday contexts. The contention is that teachers seem to use pedagogies that do not provide opportunities for integrating learners' social or everyday contexts in the classrooms. As a result, learners find it difficult to understand and learn mathematics concepts meaningfully (Van der Walt et al., 2019). Empirically, Potgieter and Van der Walt (2021) argue that many mathematics teachers lack awareness of the integration of PoP based on learners' everyday contexts. Along the same vein, Spangenberg (2020) contended that many student teachers in South Africa find it challenging to relate mathematics to sociocultural practices. As a result, Van der Walt et al. (2019) underscored the necessity "for research invested in mathematics [student] teachers' PCK in their own local … contexts, and their readiness to contextualize and mathematise it" (p. 220). The challenges, as evidenced in the literature, suggest the need to develop student teachers' PCK to use learners' contexts. By so doing, they will be well-positioned to design instructional approaches that value and appreciate learners' everyday contexts. Hence, in this article, student teachers were exposed to a one-day contextualized intervention that focused on music and boomwhackers as sociocultural contexts to contextualize the concept of fractions. The intervention aimed to equip student teachers with ways they can integrate learners' sociocultural contexts in mathematics classrooms.

Teaching and Learning of Fractions

Previous studies on the teaching and learning of fractions have been carried out by Kurniawan et al. (2018), Lovemore et al. (2021), and Naidoo and Hajaree (2021). Although the concept of fractions serves as a prerequisite for understanding other topics in mathematics (Fennell & Karp, 2017; Japar et al., 2022), it is often considered difficult for learners to learn and understand (Japar et al., 2022; Kurniawan et al., 2018; Naidoo & Hajaree, 2021). For example, learners often interpret numerators and denominators as separate components of whole numbers instead of perceiving a fraction as one number (Fitri & Prahmana, 2019; Namkung & Fuchs, 2019). Such misconceptions result in erroneous calculations when performing basic operations in learning fractions. In such instances, learners can erroneously compute $\frac{2}{5}+\frac{3}{7}$ to be equal to $\frac{5}{12}$, which suggests confusion between fractions and whole numbers.

Research (Makhubele, 2021; Wiest & Amankonah, 2019) pointed out that learners focus on the memorization of procedures instead of understanding the logic in fractional operations. This was evident in instances where "learners will get the common denominator and also change the corresponding numerators and multiply the find the product of the numerators and product of denominators" (Makhubele, 2021, p. 11). The difficulties in learning the concept of fractions suggest a possible need for innovative teaching and learning strategies that assist learners in developing a nuanced understanding of fractions. In this regard, Moyo and Machaba (2021) consider the use of physical manipulatives as an essential way of developing learners' understanding of fractions before they can be inductively guided to construct and perform abstract algorithms. Hence, in this article, the focus is on equipping student teachers with pedagogical knowledge on how to integrate physical manipulatives, such as boomwhackers, to contextualize the teaching and learning of fractions.

Lovemore et al. (2021) argue that music plays an essential role through which an integrated teaching approach could be employed to create potentially richer fraction-learning opportunities. Hence, Lovemore et al. (2021) found the integration of music and mathematics to be effective in the teaching and learning of the concept of fractions. What can be understood from Lovemore et al.'s (2021) finding is that student teachers should be trained to contextualize mathematics during pre-service mathematics teacher education training or in-service professional development workshops. Along the same vein, Van der Walt et al. (2019) recommended that "[student] teachers should be introduced to mathematics topics or themes contextualized in … learners' everyday lives" (p. 185). Consequently, the current study focused on equipping student teachers with pedagogical

knowledge and skills for contextualizing fractions through music and boomwhackers.

By training student teachers on the PoP, their mathematics knowledge for teaching (MKT) may be developed. Ball et al. (2008) describe MKT as 'the mathematical knowledge needed to carry out the work of teaching mathematics' (p.395). They describe subject matter knowledge and PCK as two fundamental domains of MKT. Although these two domains can be differentiated, they are interconnected. For this article, the emphasis was on the PCK domain. This domain, according to Ball et al. (2008), consists of three key elements: knowledge of content and students (KCS), knowledge of content and teaching (KCT), and knowledge of content and curriculum (KCC). Firstly, KCS refers to knowledge that combines knowing about how students learn and about mathematics (Nolan et al., 2015; Petro & Goulding, 2011; Wilkie, 2016). This element seems to suggest that student teachers should be equipped with KCS to teach mathematics effectively in their prospective classrooms. Secondly, KCT combines knowledge about appropriate teaching strategies that may enhance student learning and alleviate their misconceptions in mathematics (Petro & Goulding, 2011; Wilkie, 2016). To develop student teachers' KCT, they were exposed to PoP as an overarching modelling approach that can be used to enhance student understanding of the concept of fractions.

Lastly, KCC focuses on the knowledge of the content requirements of the (mathematics) curriculum and teaching-learning resources that are used to teach certain topics within the allocated time (Kılıç, 2011; Van der Walt et al., 2019). The CAPS mathematics curriculum requires teachers to contextualize mathematics topics in learners' everyday contexts as outlined in specific aims (SADBE, 2011). Although the CAPS do not provide guidelines on how such contextualization can be realized in mathematics classrooms, the responsibility is for mathematics teachers to use teaching strategies that promote contextualization. There is a concern that teachers lack the pedagogical knowledge to use contextualization approaches such as POP (Mabotja, 2023; Potgieter, 2020). Consequently, to develop student teachers' KCC, they were exposed to boomwhackers (musical instruments) and how they can use them to contextualize CAPS mathematics topics such as the concept of fractions. The central argument of this article is that a focus on student teachers may provide them with pedagogical knowledge on how they can use learners' everyday contexts, such as music, to teach the concept of fractions in their prospective classrooms.

THEORETICAL FRAMEWORK

In this article, Warford's (2011) zone of proximal teacher development (ZPTD), which is based on Vygotsky's notion of zone of proximal development, was adopted to scaffold student teachers' professional development towards contextualizing fractions through music and boomwhackers. ZPTD consists of four key stages: self-assistance, expert other assistance, internalization, and recursion. However, this article focuses on expert-other assistance and the internalization stage. Firstly, expert-other assistance is characterized by knowledgeable individuals who play an essential role in scaffolding (student) teachers' professional development in contextualizing teaching-learning environments (De Beer, 2017; Mabotja, 2023; Potgieter, 2020; Van der Walt et al., 2019; Warford, 2011). Lastly, internalization focused on critical reflections (De Beer, 2017; Potgieter, 2020; Van der Walt et al., 2019) on music and boomwhackers as sociocultural or everyday contexts to contextualize the concept of fractions. De Beer (2017) considers critical reflections as an integral aspect of professional development, as they provide (student) teachers with opportunities to develop a more nuanced teaching philosophy of using learners' everyday contexts. Student teachers engaged in critical reflection by participating in focus group interview discussions. During the discussions, student teachers reflected on both the possibilities and challenges regarding the use of music and boomwhackers as pedagogical tools to teach the concept of fractions.

METHODOLOGY

The phenomenological research design was employed to describe, understand, interpret, and explain student teachers' reflections on the PoP as a modeling approach in mathematics (Cohen et al., 2018). The study involved a purposive sample of 10 mathematics education student teachers who had undergone training in PoP at a public university in Northern Cape Province. Focus group interviews, which promote interactions among the participants and the researcher, were used as the data collection method. Although the participants were sampled at a group level, they were encouraged to share their authentic meanings and interpretations, ensuring multiple perspectives (Marshall & Rossman, 2016).

Data analysis in this study involved a systematic approach to examining and interpreting the qualitative data collected from post-intervention focus group interviews with student teachers. The transcripts were carefully reviewed to identify recurring themes and patterns related to their reflections on the PoP as a modeling approach in mathematics education. Thematic analysis was employed to examine the qualitative data gathered from participants, focusing on their experiences with integrating play and music, such as boomwhackers, into mathematical instruction. Key themes emerged that highlighted both the opportunities and challenges of the PoP as a modeling approach in mathematics. This process involved an in-depth exploration of how participants framed their

experiences, allowing for a nuanced understanding of the innovative aspects of this pedagogical approach.

Trustworthiness in this article is premised upon confirmability, credibility, transferability, and dependability. Firstly, the analysis and interpretation of the student reflections were based on their direct quotations to ensure confirmability (Forero et al., 2018). Secondly, credibility was achieved through member checking by requesting student teachers to verify the accuracy of their responses (Merriam & Tisdell, 2016). Thirdly, the description of participants' responses and the context of the study in terms of describing the contextualized intervention played an essential role in ensuring transferability. Lastly, dependability was achieved through methodological documentation of how and why the student teachers were sampled in the study (Ahmed, 2024).

To ensure ethical considerations, permission was obtained from the research site and the student teachers involved in the study. For confidentiality, pseudonyms were used to protect the identity of the research site and participants (Cohen et al., 2018).

RESULTS AND DISCUSSION

To reiterate, this article sought to describe student teachers' reflections on the PoP as a modeling approach in mathematics. The student teachers' reflections are presented according to three main themes that emerged from the focus group discussions.

Student Teachers Perceive Music and Boomwhackers as Pedagogical Tools to Promote Learners' Interest and Participation in Learning Fractions

The results of the study revealed that student teachers' positive experiences of music and boomwhackers as pedagogical tools may promote learners' interest in learning fractions. As the extracts show, these reasons range from the perception that integration of music builds on what learners know, the love of music, creating fun-based learning environments, and active participation.

> The advantage of [music and boomwhackers] is that we are using learners' interest to build upon what they know because now we all like music … and now you are using it in your class (student teacher 1).

> [We] use music to make learning easier for learners because most of the time, learners take more time listening to music, and wanting to know every word of it and what it means. So, when you teach them through music, the learners will be very interested to learn [fraction] concepts (student teacher 2).

These quotations illustrate student teachers' perceptions that music is part of learners' everyday lives, as they often spend time listening to and singing various songs. Learners might be keen to learn the concept of fractions using music and boomwhackers. The perceptions provide evidence that the teaching of the concept of fractions should be based on learners' everyday contexts to develop their understanding.

The results further revealed that the integration of music and boomwhackers will promote learners' active participation in the classroom. In this regard, student teacher C8 expressed that learners

> have this perception maths [is] a tough subject or a difficult subject. When you use things like boomwhackers, it gives learners an opportunity to be involved in the lesson.

Along the same line, student teacher 6 stressed that

> it's a wonderful way to bring learners more into … the lesson by making it more fun …

Among the plausible explanations for these results is that when learners become active in the learning process, their difficulties concerning the concept of fractions may be alleviated. In addition, the results provide evidence that music and boomwhackers as pedagogical resources can create exciting learning environments for learners. Learners are likely to enjoy learning fractions when they are taught using boomwhackers. Potgieter (2020) asserted that providing learners with opportunities to "… write rap songs about the mathematics content; or to perform a dance to illustrate certain principles accounts for a lot of creativity and fun in the mathematics classroom" (p. 34), which is in good agreement with the results of the present study.

Another student teacher reflected on the integration of music and boomwhackers as follows:

> It took me back to primary [school] because, like her, we used to do music. So, it took me back to that and the whole clapping, it's a half [clap], it's a quarter [clap] … it was just fun creating the music (student teacher 4).

This is further elaborated by student teacher 7 who pointed out that

> the inclusion of music in learning is very interesting … introducing them to fractions using boomwhackers will help learners to become more strategic … the moment you make that beat, in a learners' mind fraction will come up.

Along the same vein, another student teacher agreed that

> learners can relate music symbols with fractions especially when clapping with boomwhackers (student teacher 8).

These reflections reveal student teachers' perceptions that learners are likely to discover the connection between music and fractions. Among the possible explanations for these results is that contextualizing the concept of fractions through learners' sociocultural contexts, such as music, may provide learners with opportunities to identify and examine mathematics concepts embedded in such contexts. The result is consistent with the findings of past studies by Booth and O'Brien (2008), Kusuma and Dwipriyoko (2021), Lovemore et al. (2021), and Rifqi et al. (2021), which agree that music has a positive effect on learners' ability to develop mathematical connections.

Contextualized Intervention Based on Music and Boomwhackers Provides Student Teachers With a New Pedagogical Perspective on the Teaching and Learning of Fractions

The results of the study revealed that contextualized intervention provides student teachers with a new perspective on the teaching and learning of the concept of fractions. The student teachers generally agreed that fractions are often considered difficult, possibly due to various forms or representations used to teach learners. Reflecting on their experiences regarding fractions, one student teacher elaborated,

> Like learners, when I think of fractions, I also become frustrated because for so many years, if you want to teach fractions, let's go with the blocks, charts, fruits … boomwhackers bring a different perspective that we can teach learners about the fractions (student teacher 4).

Student teacher 6 added that

> [boomwhackers] … is bringing a new way of teaching fractions, I think we have exhausted the whole pies, blocks.

Along the same vein, student teacher 3 expressed,

> It was interesting to see how you use them [boomwhackers] for fractions, because fractions are the most difficult concepts to teach. It was interesting to see fractions without them being depicted as […] a cake, or muffins […] Now we know, fractions are not just blocks, they can also be music.

Moreover, another student teacher expressed that

> what I have learned from boomwhackers is that […] it taught us different ways of teaching (student teacher 7).

These results illustrate student teachers' perception that music and boomwhackers can serve as alternative and innovative teaching and learning resources for the concept of fractions. The present finding also supports Lovemore et al.'s (2021) study, which argued that music plays a valuable role in promoting possibly richer fraction-learning opportunities.

Furthermore, the results provide evidence that the contextualized intervention developed student teachers' pedagogical content and skills on how they can use music and boomwhackers to contextualize fractions. Expressions such as *"now we know"* (student teacher 3), *"I have learned … it taught us"* (student teacher 7), and *"it's a new experience and it's something we are not used to"* (student teacher 1), provide evidence on student teachers' growth of knowledge in contextualizing fractions through music and boomwhackers. In this regard, student teacher 4 *also* pointed out prior to the intervention,

> I hadn't seen how the music we learned back in the day could be translated into fractions … that had never occurred to me.

These results further suggest that student teachers appreciate the role of contextualized intervention in scaffolding their professional development in contextualizing the concept of fractions. The student teachers express positive responses to the opportunities for improving their own PCK in contextualizing mathematics through learners' everyday contexts such as music. The results are consistent with the results of Van der Walt et al. (2019), who found that teachers' PCK improved because of contextualized intervention.

To take the analysis further, the student teachers revealed that music and boomwhackers provide opportunities to simplify the concept of a fraction such that it becomes accessible to the learners. In this regard, student teacher 9 elaborated that

> the advantage of [boomwhackers] is the issue of simplicity [to] broke down the whole concept of fraction … so simple in a way that we understood it better.

Along the same vein, another student teacher reflected that

> when you mention fractions to learners, they get so confused, they get so uneasy because it's a complex concept for them but then … from this [music and boomwhackers] exercise is that even most of the complex concepts can be simplified (student teacher 1).

Among the plausible elucidations for these results is that learners may understand fractions when they use music and boomwhackers. The results further provide evidence that music and boomwhackers can help

teachers present, demonstrate, and explain fractions easily to their learners. Hence, Lovemore et al. (2021) found the integration of music and mathematics to be effective in teaching and learning the concept of fractions.

Student Teachers Have the Perception That Music and Boomwhackers May Create Disruptions in Learning Mathematics

Student teachers believe that while music and boomwhackers play a significant role in helping students understand fractions, they also worry that these tools might disrupt the learning process. As the perceptions below show, these reasons ranged from noise, loss of concentration, and being carried away while playing.

> Disadvantage will be that the noise and distractions, like learners may focus on boomwhackers and end up losing concentration (student teacher 7).

> Disadvantages for the boomwhackers is noise (student teacher 3).

> Learners in the classroom may become too playful, like they will want to continue (student teacher 2).

The quotations illustrate student teachers' perceptions that learners may concentrate on music and boomwhackers rather than the mathematics concepts embedded in such contexts. The results provide evidence that the excitement linked to boomwhackers may result in learners playing rather than learning. A similar concern was noted by Metz (2013), who mentioned that learners may concentrate on everyday contexts rather than mathematical concepts. Subsequently, one student teacher also stressed the possibilities of being

> … carried away during the lesson if I were to use music in my classroom. So, I think I would not use but I think for other people, it is a good way to teach fractions (student teacher 6).

The results further provide evidence that teachers' reluctance to use music and boomwhackers does not necessarily imply that it should not be used in the teaching and learning of fractions. This highlights that "*the advantage* [of using music and boomwhackers] *outweighs the disadvantage*" (student teacher 4).

CONCLUSION

The purpose of this article was to explore mathematics student teachers' reflections about the PoP (music and boomwhackers) in the teaching and learning of fractions. The results provide evidence that the student teachers are of the view that the use of music and boomwhackers can stimulate learners' interest in learning fractions. Among the plausible explanations for these results is that learners will be actively involved in a lesson based on their everyday contexts. Furthermore, student teachers are of the view that PoP (music and boomwhackers) can serve as a new pedagogical perspective to teach fractions. It also seems to be the case that the contextualized intervention was found to be effective in scaffolding student teachers' pedagogical knowledge and skills to infuse music and boomwhackers in the teaching of fractions. The findings further indicated that music and boomwhackers may lead to distractions in learning, suggesting that learners may become noisy and concentrate on the boomwhackers instead of learning mathematics concepts. Herein, the suggestion is that while the use of music and boomwhackers may offer valuable teaching and learning benefits, learners must be monitored to guard against learning distractions.

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AI statement: The author stated that ChatGPT was solely used for paraphrasing and improving the clarity of the text. All ideas, analyses, and conclusions belong to the author.

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