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A Survey of Mathematics Pre-Service Teachers' End-of-Teaching Practice Reflections of Educational Contexts

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Abstract. Pre-service teachers need to identify their understanding and beliefs about mathematics learning and teaching against the backdrop of the environment where, they teach during teaching practice. Pre-service teachers will one day be responsible for full-time teaching and their current reflections of educational contexts' knowledge serve as a point of reference to their acquisition of teacher knowledge. Of the four knowledge bases for teaching, namely, pedagogy, pedagogical content knowledge, subject matter and educational contexts, the focus in this study was on the last. This study purposed to promote and describe mathematics pre-service teachers' reflections of educational contexts at the end of a six-month teaching practice session. The 2022 cohort of 140 Bachelor of Education mathematics students participated in the study. The judgmental sampling technique was used to select 40 reflection reports. Moreover, four students were selected for interviews purposively based on their earlier reflections in the reports. The reflective reports and the interview transcriptions were analysed thematically through the lens of the Van Manen framework. The findings revealed that most of the pre-service teachers operated at the practical reflection level and very few attained the critical reflection stage. Student teachers took class preparation seriously, but they were disadvantaged by lack of teaching resources. They engaged themselves in many school duties, but this was only helpful if they were guided by experienced teachers. In response to some school management shortcomings, pre-service teachers projected wishes that could improve their teaching practices.

Keywords: educational contexts; pre-service teachers; self-reflections; teacher knowledge; teaching practice

1. Introduction

To try to stem the tide of incessant poor performance in mathematics in South Africa, the training of new secondary mathematics teachers comes to the fore. Good grounding of teacher knowledge in pre-service teachers (PSTs) is fundamental for the future of the teaching profession so much that Shulman's (1986) seminal work on teacher knowledge was centred on initial teacher

education. In fact, "researchers have honed Shulman's ideas to the extent that his construct now forms the basis for both understanding how teachers work and how they are educated to become teachers" (Fraser, 2016, p. 142). According to Shulman, the skills and knowledge that teachers possess contribute immensely to effective learning and teaching. He identified the following seven types of knowledge: knowledge of learners; knowledge of educational contexts; pedagogical knowledge; knowledge of educational ends, values and purposes; pedagogical content knowledge (PCK); content knowledge and curriculum knowledge. Shulman later discarded the first four because these were not subject-matter specific, leading to a model with pedagogical content, content and curriculum knowledge types. However, the effect of this model was studying individual teacher's knowledge in the absence of educational contexts and culture (Ellis, 2007). In addition, learners' temperaments in the learning process and other educational contexts were not adequately explored by Shulman. If school and learner contextual factors are not addressed, the resultant teacher knowledge becomes surreal.

In the subsequent derivatives to Shulman's models of teacher knowledge, educational contexts' knowledge was considered as a third type of teacher knowledge after content and pedagogy (Gess-Newsome, 1999; Grossman, 1990). The intersection of the three, gives rise to PCK, which is the penultimate. Gess-Newsome (1999) regarded this model of PCK as transformative, as he believes that PCK is "new knowledge arising from the act of transforming subject matter, pedagogical and contextual knowledge for the purposes of instructing students" (Kind, 2009, p. 180). Grossman (1990) also argues that teachers must possess all PCK, pedagogy, subject matter and educational contexts. Furthermore, a teacher needs to know the subject-matter, the instructional strategies and student knowledge in order to teach effectively. Borich (1995) considers teaching as being problematic since schools are bedevilled by curriculum, resource, discipline, family and parental problems. Basically, good teachers must be able to adjust their teaching according to prevailing contextual factors which ensures their learners are at ease to learn.

The educational contexts' knowledge has remarkable influences on teachers' instructional practices through their experiences in learners' thinking processes and school setting. Unlike content knowledge, which is taught in teacher education at campuses, PSTs accumulate school-contexts' knowledge in the teaching field. Thus, teaching practice is a necessary component of the initial teacher education which is used intentionally to link theory and practice (Department of Education, 2011a). Teaching practice is an opportunity for PSTs to experience teaching in the actual environment (Nkhata et al., 2016). To bring about the necessary links between practice and theory, teacher education uses its component of school-based teaching practice. According to Leijen, et al., (2014), teacher reflection is an overarching activity meant to develop PSTs' practical knowledge and connecting it with educational theories in teacher education programmes. Furthermore, reflection is a critical skill and characteristic of an effective teacher in a teacher education programme.

Teachers assert that learning from teaching experience is better than learning from course work, leading to the age-old saying that "experience is the best teacher" (Schmidt, 2010, p.3). Some researchers have highlighted the concern that coursework on its own does not adequately prepare future teachers to link education theories to the practical situations found in the classroom (Allas et al., 2016; Altan & Sağlamel, 2015). Knowledge of educational contexts is basically situated in the intricacies of everyday classroom life, for example, knowledge of school settings and learners in a particular school. Consequently, PSTs and beginner-teachers often experience difficulties when dealing with certain situations encountered in everyday teaching practice and feel inadequately prepared to deal with the challenges of their profession (Grossman et al., 2009; Meijer, 2010).

The journey of becoming an expert mathematics teacher is career-long. This journey involves doing conscious reflections on one's experiences and making deliberate attempts to improve on them. Assisting PSTs to develop reflective practices is one of the goals of teacher preparation programmes (Moore-Russo & Wilsey, 2014). Reflection can be in-practice (occurs during instruction and is often spontaneous), on-practice (occurs after instruction and often careful and deliberate) and for-practice (looking forward to future actions based on current instruction). This study focused on reflections on-action and for-action, which necessitated use of end-of-semester reflections and how the reflections create future-oriented insights (Buchbinder et al., 2021). The purpose of this study was to instil reflection skills in mathematics PSTs and characterise their reflections on educational context knowledge at the end of a semester-long teaching practice. The goal was to explore how PSTs interpret and manipulate the environment within which they taught secondary school mathematics. The research question was, "What is PSTs' understanding of reflection on educational contexts and how does it manifest in practice according to their reflections?" Encouraging PSTs to reflect on their teaching in a real classroom context provides PSTs with much needed pedagogical repertoires which have the potential to provide an understanding of their teaching practices through a commitment for professional and/or personal growth (Nyaumwe & Mtetwa, 2011).

2. Literature and theoretical framework

The mathematics knowledge for teaching can be summed up as the ability to know what to teach and how to teach it in each educational context. This is what Shulman (1986) described as PCK. Shulman (1986, p. 9) in his seminal work on PCK posits that "there are no single most powerful forms of representation ..." but teachers should have multiple ways to present given subject matter and make it meaningful to their learners in diverse educational contexts (Umugiraneza et al., 2017). The content, pedagogical content and general pedagogy types of knowledge are taught in teacher education in content, methodology and theory of education courses respectively, but the actualisation thereof is accomplished during school teaching practices. Teaching practice is incomplete without PSTs reflecting on their practice. Reflection acts as evaluation on what worked and did not work, as well as making decisions for future instructional practices based on outcomes of the evaluation. To that effect, a study by Almusharraf (2020) examined the effect of using e-portfolios during teaching practice in developing

PSTs' reflections in an English language course. After considering eight Saudi PSTs, the findings revealed that while they struggled developing appropriate teaching philosophies, their levels of reflection improved throughout the eleven-week period. In another study, Nyaumwe and Mtetwa (2011) sought to give insight to the on-going debate on ways to improve PST instructional practice through reflection. By applying the cognitive theory of collaborative reflection to paired end-of-teaching practice reflection by mathematics PSTs, Nyaumwe and Mtetwa discovered that reflective dialogues were effective as a means of providing PSTs with multiple perspectives on implementing and interpreting teaching strategies in mathematics.

To investigate the assertion that a teacher learns better from teaching experiences rather than from teacher education, Schmidt (2010) investigated how six pre-service teachers valued teaching experiences whilst they were enrolled in a music teacher education programme. Data for that study was collected using PSTs' self- and instructor assessments over a period of two years. Making use of Dewey's (1933) theory of experience framework, findings revealed that participants were active in their teaching experiences, they each created continuity and derived their own meanings from them. A balance between action and reflection produced meaningful learning from all types of teaching experiences, both as individuals and/or within a community of educators.

The PSTs' reflections on educational contexts during teaching practice were viewed and analysed through the lens of Van Manen's (1977) theoretical framework. Van Manen developed a three-level hierarchical structure to understand the development of reflectivity, which consists of technical, practical and critical. The lowest category is technical reflection which focusses on the teacher, what happens in the classroom and the post-lesson reflections of events that occurred during the lesson. For example, technical focusses on whether learners have done what the teacher asked them to do. At practical reflection level, PSTs reflect on clarifying assumptions and predispositions while assessing the educational consequences to which teaching actions lead. In accordance with Van Manen (1977), the practical reflection facilitates "an interpretative understanding both of the nature and quality of the educational experience, and of making practical choices" (p. 226). PSTs are concerned with the learners' learning experiences as well as the underlying and predispositions of classroom practice (Wong et al., 2016). Critical reflection, the highest level, involves deep-thinking and self-assessment to which a PST conceives broad understanding of the ethics and morals of an instructional environment. At this level, a PST possesses interpretive skills of learning outcomes in response to teachers' actions during instruction. Critical reflection focusses on the context and the value of knowledge. Hence, the PSTs' end-of-teaching reflections fell into the practical and critical categories.

3. Methodology

This study used a case study design, which is an in-depth empirical inquiry of an existing phenomenon in its natural settings (Yin, 2014). The author wanted to determine the mathematics PSTs' reflections of the educational learning environment at the end of the school-based teaching practice period. The

participants were a cohort of the 2022 final-year Bachelor of Education degree students majoring in mathematics and a science subject, both at the senior secondary level. Students in the faculty of education at the university where this study took place started with school observation in the first and second years of their study. In the third and fourth years, they spent five weeks and six months respectively in schools where they practiced teaching under the guidance of a qualified teacher. Nyaumwe (2001) identified four models of teaching practice, which are apprenticeship, reflective-practice, practical theorising and theory into practice. This university adopted the mentorship model of teaching practice, where a PST is paired with a host teacher at the school. Thus, each PSTs had two mentors, one for the mathematics class and the other for the science class to which they were allocated.

The 2022 cohort of 140 Bachelor of Education mathematics students took part in the study. A judgmental sampling technique was used to select 40 reflection reports. As a qualitative study, data saturation was arrived at 40. According to Creswell and Creswell (2018, p. 262), "one stops collecting data when the categories (or themes) are saturated: when gathering fresh data no longer sparks new insights or reveals new properties." In addition, four students were selected for interviews purposively based on their earlier reflections in the reports. Data was in the form of end-of-teaching reflections written by all students. Guided reflection was adopted in this study to elicit certain kind of responses in the reflection. The main guiding precepts centred on the PSTs' strengths, weaknesses and the ways they could do teaching practice differently if given another chance. Follow-up semi-structured interviews were conducted with individual PSTs to get a deeper understanding of their reflections. The interviews were recorded and transcribed by the author. For clarity of data presentation, participants were labelled P1, P2 and so on. Thematic data analysis was employed where the author read and re-read all the written reflections and transcriptions to identify patterns and similarities emerging from the data. The author used the Van Manen levels to determine the categories of the different levels of PSTS' reflections in the data. However, the technical level was not applicable in this study as it focusses on immediate post-lesson reflections, and it circumvents the contexts of the society and/or the school (Ballard, 2006). The use of a case study design leads to the following limitations: the non-generalisability of results from one case study to another and the possibility of researcher bias, emanating from personal preferences and opinions. Moreover, the limitation of this study was that it was conducted with one cohort of PSTs from one teacher education programme.

4. Findings

As mentioned earlier, PSTs were given guidance on what to reflect but in their responses, some aspects of educational contexts emerged as contributing factors to the PSTs' training towards becoming mathematics teachers. The results revealed some insights into PSTs' appreciation of educational context knowledge in their quest of becoming effective mathematics teachers. The narrative analysis of PSTs' reflections revealed some broad categories of PSTs' perceptions of educational contexts as they pertain to teaching mathematics. Studies by Bada & Jita (2023) and by Boateng and Tatira (2023) also identified broad themes

emerging from data as part of data analysis. The categories are stated below, and evidence is provided under each category.

4.1. Preparing for the class

The participants knew that being PSTs, lesson planning was expected of them. Moreover, some participants also had further preparations to do, P6 used a preparation book which contained more information on the problems and their solutions that were to be used to support learning of a mathematics concept. P9 called it the planning book but it served the same purpose as the preparation book. P2, admitted he "*could not take part in after-school activities due to lesson preparation*". Some like P30 said they never went to class unprepared, which was supported by P1 who said, "*I do prepare well my lesson because without preparation, no meaning teaching will be taken place*". Preparation for teaching also meant getting the learning and teaching support materials (LTSM) ready for instruction. But using electronic resources meant making necessary preparation. P2 posited one needs to put LTSMs in place beforehand since digital resources can easily malfunction – "*technology easily fail*". P2 used a laptop and projector in his classes.

4.2. Availability of resources

In the wake of digital technologies, most PSTs attempted to incorporate them in their lessons. It was smooth sailing for P1 who said, "*Use of resources such as ICT were making things easier for me because I was able to show them the things I was presenting through video clips by using projectors and laptops*". However, it was not easy for most PSTs to use digital resources due to their non-existence in rural schools chosen by many to do their teaching practices. P5 said that his school was unprepared for e-learning. Not only was his school and others short of electronic resources for learners-use, internet, printing and copying facilities were non-existent, according to P5. For P10, his school had "*no textbooks so learners had to depend on what I say*". P4 lamented about the limited resources at his host school. P6 and P9 encountered a sad reality whereby learners had no scientific calculators due to poor economic backgrounds. P6 further said that learners could not use the calculators as a result of the economic backgrounds. As a matter of fact, learners use calculators "to perform standard numerical computations" (DBE, 2011b, p. 54), and starting in Grade 11, usage of calculators is mandatory, specifically in Statistics. The Curriculum and Assessment Policy Statement states that "variance and standard deviation may be calculated using calculators." (DBE, 2011b, p. 15). The cumbersome computations of regression analysis and coefficient of correlation in Grade 12 are entirely calculated using a calculator.

4.3. Extra school duties

Being in the teaching field, PSTs found themselves responsible for extra duties in addition to instruction of the two major subjects. P3, was "*overloaded with full teacher duties and other non-majored subjects.*" The concern by P3 is the overloading of duties to someone who is still under training. Other duties are normal as they induct PST into the profession, for example, conducting assembly (mentioned by P40), setting examination papers, marking the examinations, recording marks and invigilation. In the interview, P40 posited that "*teaching is more than standing in front of learners*". P30 and P22 "*also did administration work and invigilation over and above teaching duties.*" Moreover, any other duties may be done by PSTs as and

when necessary, but they should not shoulder the burden alone. For instance, P27 "*played multiple roles of counsellor, parent, social worker, psycho-teacher alone since these teenagers spent more time at school than at home*". It was going to be a noble experience for P27 had he carried out those duties under the guidance of an experienced teacher. Nevertheless, sometimes PSTs are given duties beyond the expected simply because the school or the mentor does not fully know their roles in coaching PSTs. This happens when universities that have teacher education programmes do not conduct training or awareness to schools on the expectations of the roles of schools, mentors and PSTs (Nyaumwe & Mtetwa, 2011). At the same time some schools were hard hit by teacher shortages in mathematics and sciences so much that they intentionally recruit PSTs to fill that gap. P28 posited that he "*taught 6 classes including grade 12 with no mentors because of serious teacher shortage.*" In South Africa, Grade 12 is the final grade where learners write the national examinations in preparation for university. Hence, we have the situation where PSTs perform all duties of a teacher without guidance.

4.4. Job preparation

The goal of some PSTs to do the final-year second semester teaching practice was to fulfill the degree programme requirements and qualify to be mathematics teachers. Many PSTs concurred that this final six-month teaching period was sufficient to see them as qualified teachers (P6, P7, P38 and P32). In a way, they regarded this experience as a means to qualify and get a job. "*School-based experiences were enough preparation for next year*", said P6. On the other hand, some PSTs valued the life-long skills they gained through this exercise (P11, P29, P39 and P33). For example, P11 said that the "*experience prepared me for teaching field*", which was supported by P29 who said, "*I will take everything my mentor taught me throughout my teaching career.*" The follow-up interview with P11 revealed that teaching practice marks the end of the degree programme and he can confidently walk into any mathematics classroom and deliver.

4.5. Extra classes and envisioned practice

PSTs obviously could not rectify the problems they encountered in schools, for example, the issue of limited resources. PSTs acknowledged that indeed it was the responsibility of the school management to do that, but they still voiced their envisioned practices in their reflections. To increase contact time with their classes, P26, P9, P11, P25, P5 and P14 wished to conduct extra weekend/afternoon classes. "*I conduct Saturday classes to increase mathematics fluency and familiarity with calculator usage*" cited P26. The desire to have more contact time with classes was shared by many PSTs. To P10, the desire was rooted in the fact that he was allocated a weak class so that the extra time is to be used to uplift the condition of the class-understanding of mathematics. In P15's case, her learners actually "*asked for extra classes being eager to learn*". Some PSTs admitted they improved their respective pass rates in the six-month period but they felt they could have done better had they taught for longer period. P17 explained: "*I could have improved or produced a high passing rate on my class if I found them beginning of the year. Yes, I improved the results a little bit but I could have done it better than this given enough time.*" Nonetheless, P8 and P18 saw positive results after they successfully participated in extra lessons. They reported, "*my passes rose from 30% to 54% due to extra lessons*" and "*improve mathematics results from 55% in term 2 to 87% in term*

3 – extra lessons played a key role" respectively. In response to some under-privileged school environments they encountered, P3, P20 and P21 proposed to build more classrooms, buy own printer and make textbooks available respectively. Asked how they would do it if school authorities could not provide such, P3 suggested that it was his desire to work with donors for financing his projects.

4.6. School management and administration

The realisation of the PSTs' envisioned practices rested in a good supportive environment created by the school management team. The school management was very supportive of P23 who was coached how to handle learner-discipline and other aspects of the teaching profession whilst P24 was given strict dos and don'ts on the very first day. P34 was also given rules but they were suppressive as he was "*always reminded that you are a preservice teacher and not allowed to be free thinkers*". That left P34 no room for initiative in pursuing his aspirations of becoming a mathematics teacher of his choosing. Two PSTs (P19 and P35) indicated that they had no choice but to stick to the supplied annual teaching plans which dictate what was to be taught for that particular period of the year. P19 said she was "*stuck to the annual teaching plan with no flexibility even when faced with mixed-performing learners.*" Furthermore, P16 faced difficult situations as a result of the school management's laxity in some instances. She said that "*absenteeism was a challenge: you teach half a class today and another half tomorrow and the management did not do anything about it*." On the other hand, P6, P12, P13, P37, P32 and P36 were affectionately treated as professional teachers by the school management and other teachers, so that they were given absolute control of their classes. Regrettably, P31 was not only regarded as a colleague by the teachers, but learners treated her as a peer by virtue of her age. Hence, PSTs still looked up to the school management team for school-wide contextual factors in order to maximise their teaching endeavours.

5. Discussion

An important characteristic of effective teaching is knowing what needs to be done and when to do it. This has pushed to the fore the preparation of reflective teachers, which has become a central theme in teacher education (Kaasila & Lauriala, 2010). A teacher should be able to think deeply about the educational consequences of a teaching action and conceive broad understanding of an instructional environment. Reflection is a process of self-inquiry and learning through introspection in order to realise possible visions of practice (Johns, 2010). This was intended to realise a collaboration of researchers, school mentors and the PSTs in order to understand the contextual nature of desirable practices and the possible factors that limit attaining these practices. This coincides with the practical and critical levels of Van Manen's (1977) model of PSTs reflection and fits well with the knowledge of educational contexts (Gess-Newsome, 1999).

Most of the PSTs' reflections fell in the category of practical reflections, whereby they narrated the description and interpretation of the school environments they encountered. This was the case for the categories of lesson preparation, shortage of teaching resources, extra non-teaching duties, job-training and activities of the school management teams. For example, P34 and P19 narrated about rigid

teaching environments whereby they were always told what to do and instructed to follow annual teaching plans in curriculum delivery respectively. PSTs' endeavours to think critically and act on those thoughts were thwarted. However, the goal of every teacher-education programme is to inculcate critical reflections by creating opportunities for deep thinking. A few students alluded to the critical reflection stage when they attempted to give an envisioned practice to the challenges they identified in the course of instruction in their respective school environments. These PSTs sought to manipulate the teaching environment to suit their espoused visions of practice. Reflection involves looking backward and forward realising "new understandings, greater insights and/or greater responsibility for future actions" (Anderson, 2019, p. 2). The new insights came because of some teaching challenges shortage of resources and poor infrastructure which acted as a hindrance (John, 2019; Bada & Jita, 2023).

Reflection on broader educational contexts remains one of the ways to help PSTs to better understand what they claim to know and do as they develop their knowledge of teaching through engaging educational theories, they learn in teacher education (Loughran, 2002; Leijen et al., 2014). PSTs can perform complementary duties to instruction but need to be assisted by a qualified teacher according to the mentor model. However, without any form of training or induction on mentoring PSTs, some mentors may not know how to offer proper guidance to PSTs. Reflection of the six-month teaching practice experience builds confidence in becoming a mathematics teacher as well as raising awareness of career opportunities that lie ahead. The reflections for the final-year teaching practice places PSTs at the threshold of mathematics teaching whereby they would be required to navigate a myriad of educational contextual factors which both militate and support mathematics instruction. Already, there are concerns that the initial teacher education programmes do not adequately prepare PSTs to link theories of learning to the practical classroom and school situations (Allas et al., 2016). Consequently, beginner-teachers grapple with everyday teaching practice situations (Meijer, 2010) and feel unprepared to deal with some inherent challenges of the teaching profession. Even though teacher knowledge is unconscious and tacit, it is vital to commit PSTs to conscious reflection, which in turn can be shared and used as a reference point for action (Buchbinder et al., 2021). The goal for teacher education is to motivate PSTs to take ownership of their career development and build confidence to make decisions and risks in an ever-changing education landscape. PSTs' experiences in the school setting emphasise self-reflection to be useful in making them good teachers (Boateng & Tatira, 2023).

The PSTs' practical reflections of educational contexts were detailed and encompassing, which covered both on-action and for-action. However, they were presented at pre-critical levels which depicts lack of interpretive skills of educational consequences where teaching action culminates (Nyaumwe & Mtetwa, 2011). A PST conceives a broad understanding of an instructional environment through deep-thinking and self-assessment. Teacher educators should inculcate critical reflection skills in the methodology courses to make it easier for PSTs to enact them during teaching practice. A shift away from the currently used mentor model of teaching practice also facilitates PSTs to reflect objectively. Currently, PSTs tend to model their mentors by observing, imitating,

getting advice on how to teach and overcome other educational issues (Samuel, 2010), instead of becoming themselves. Sometimes mentors dictate what they deem to be good teaching practices and PSTs are bound to listen. Hence, the critical reflection aspect is conspicuous as the PSTs fail to construct and understand their own teaching identities.

6. Conclusion

Conscious reflection of context knowledge may improve secondary school mathematics attainment through the development of teachers' PCK. This occurs when PSTs narrate and critically reflect their experiences in educational contexts knowledge. Reflection is central to teaching and PSTs' reflections on educational contexts contribute to the development of their PCK. PSTs demonstrated the ability to give practical reflections on the processes of teaching and learning, how to work in diverse school climates and simultaneously make visionary judgments leading to modifications of their practices to match the needs of learners. Although the findings of this study may not apply in all settings, it is important for teacher educators to recognise the roles played by Van Manen's levels of reflections of technical, practical and critical in order to help PSTs balance their in-depth self-assessment of educational contexts as they consummate teacher education.

The study has implications for education faculties to assist PSTs develop balanced critical reflections in teacher education which they would use to navigate the diversity of educational contexts during teaching practice and beyond. The PSTs are still expected to be critical even in the South African education system which unilaterally provides annual teaching plans for all subjects in the curriculum, which in a way constrains teacher initiatives regarding topic and duration of teaching units. In addition, the study recommends the national Department of Education partners with teacher education to conscientise school-based mentors on the revolving expectations PSTs undergoing teaching practices using the mentor model. (Boateng & Tatira, 2023). This is critical because all teaching practices in the South African teacher education system are- based on the apprentice model. Future research can explore the types of practical and critical reflections PSTs communicate in content and methodology types of teacher knowledge in different social and cultural contexts.

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