Using video-based mathematics lesson analysis to develop pre-service teachers' reflective practice

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Our qualitative case study explored the nature of pre-service teacher (PST) reflections when analysing video-based lessons aimed at developing their reflective practice. 14 PSTs participated in the study. Data were collected through lesson observation and individual PSTs' written reflections. The initial data show that PSTs find lesson reflection challenging. Many PSTs' initial reflections were below technical description, the first level provided in Muir and Beswick's (2007) reflection framework. A few reflections revealed some aspects of technical description; however, no PST's reflection went beyond Level 1. In this paper we share how we adapted their framework to accommodate PSTs' initial reflections.

The complexity of the work of teaching requires teachers to be in the habit of critically reflecting on their practice to improve both professional growth and instruction, which in turn influences learner performance (Shandomo, 2010). Dewey (1933) alleged "it is impossible to become, and continue to be, an effective teacher without a personal commitment to reflective practice" (p. 9). However, because reflective practice (RP) is not an inherent skill, it can be argued that initial teacher education (ITE) should incorporate firmly grounding PSTs in RP as part of teacher preparation. Researchers associate several benefits with developing RP during ITE. According to Griffin (2010), learning to reflect during training affords PSTs feedback from their educators that may help them develop a decision-making schema. Griffin further argues "if beginning teachers are not firmly and confidently grounded in pedagogy and curriculum with an effective decision-making schema based on reflective and critical thinking, the knowledge and skills gained in their training program may be quickly and easily obliterated" (p. 208). In agreement, Williams (2014) states that for reflection to become established, it is important that teacher educators help new teachers develop "a frame of mind that promotes self-reflection through an attitude of open-mindedness, responsibility, and wholeheartedness, and who reacts and can interpret the decisions that are made about a situation or a problem" (p. 18).

This research is part of a larger study that seeks to explore the role of video-based lesson analysis in developing PSTs' RP. This paper reports on the initial data collected to answer the question: What is the nature of the reflective practices pre-service teachers engage in and develop when involved in video-based reflections? The research is conducted with a group of South African third-year Foundation Phase (Grades R, 1, 2 and 3) PSTs. While the research is conducted in the South African ITE context, its findings are applicable to international engagement on mathematics teacher education and the role of reflection within this.

Contextual Background

Both international and national assessments have established that South African learners perform poorly in mathematics (Graven, 2013). The South and East African Consortium for Monitoring Educational Quality (SACMEQ) and the Trends in International Mathematics and Science Studies (TIMMS) have consistently reflected weaknesses of our mathematics students as they tend to be placed at the bottom of the lists of the participating countries. Research alleges that the majority of South African mathematics teachers lack adequate knowledge and skills to effectively teach mathematics even when they hold appropriate

teaching qualifications (Venkat & Spaull, 2015). This suggests weakness in teacher preparation for the complex work of teaching mathematics. The South African department of education (DBE) has noted concern for the quality of ITE and urges improvement (DBE, 2009). There is growing research and development of policies that seek to strengthen initial teacher education (ITE) in South Africa in an effort to improve mathematics teaching and learning. Our qualitative case study is part of research that seeks to contribute to this work through focusing on ITE. Developing teachers' RP is one reform effort that has gained widespread international popularity (including in South Africa) as a significant means of developing mathematics teachers' professional knowledge (Geiger, Muir & Lamb, 2015; Rowland et al., 2014).

Reflective Practice and its Importance for Mathematics Teaching?

RP has gained popularity in teacher education because of growing research that points to its usefulness in learning to teach. RP as a theoretical concept for learning is traced back to Dewey's (1910) seminal work on 'How We Think'. Dewey (1933) conceptualised reflection as a process of thinking about action. He defined it as an "active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends, constitutes reflective thought" (p. 6). Schön's (1983) seminal work, 'The reflective practitioner: How professionals think in action' brought attention to the importance of reflection in the teaching profession. Since Dewey and Schön, many definitions have emerged in the context of teacher education. While Ward and McCotter (2004) asserted that RP engages teachers in a purposeful and systematic inquiry into their practice, Sherin and van Es (2009) claimed that the ability to do so is often predictive of how well one will be able to teach. Shandomo (2010) explained that RP "leads educators to act deliberately and intentionally rather than randomly and reactively" (p. 103). Brookfield (2017) similarly saw RP as a tool that helps teachers make wise decisions and good judgements. He argued that without reflection, teachers run the risk of making poor decisions and bad judgments. Thus, RP on teaching offers teachers the opportunity to understand the complexities of teaching and to develop knowledge that influences the decisions they make.

Although the word 'reflect' translates to mean 'looking back' (Postholm, 2008), Sellars (2017) warned that reflection is not just looking back on past actions and events, but "is taking a conscious look at emotions, experiences, actions, and responses, and using that information to add to … existing knowledge base and reach a higher level of understanding" (p. 127). Similarly, Bolton (2010) claimed reflection involves paying critical attention to the practical values and theories which inform everyday actions, by examining practice reflectively and reflexively leading to teachers' professional development. Bolton argued the key rationale for RP is that it leads to understanding, learning, and professional growth that cannot be achieved through experience alone. He claimed deliberate reflection on experience is essential to facilitate learning from that experience. Postholm (2008) further argued, "With reflections, traditions are made available for change. Teachers need to have the ability and strength to reflect on their teaching because mechanical teaching will be suppressing" (p. 1720). Rowland et al. (2014) in their book that focuses on ways of building up knowledge about mathematics and mathematics teaching, emphasised reflection on classroom situations as one of the means to develop mathematics knowledge needed for teaching. Karsenty, Arcavi and Nurick (2015) conducted the VIDEO-LM project in Israel where in-service high school mathematics teachers were supported to reflect on video-based mathematics lessons with an aim to develop their knowledge needed for teaching mathematics effectively. Karsenty et al. (2015) reported an improvement in the teachers' effectiveness in mathematics teaching and professional knowledge. Our study has similarities to Karsenty et al.'s (2015)

VIDEO-LM project. However our study is focused on PSTs. More research has been conducted on in-service teachers' RP with very little on PSTs (Sellars, 2017; Shandomo, 2010). This research therefore seeks to contribute to this less researched area of the use of video-based lessons for the development of RP in ITE programmes for strengthening mathematics teaching.

Developing Pre-service Teachers' Reflective Practice

Jay and Johnson (2002) advocated developing PSTs' reflective practise should become an integral part of ITE. Lee (2007) reasoned "through reflection, pre-service teachers become more aware of themselves as would-be teachers and of the pedagogical context that impinges directly on teaching and learning … reflection is a skill that has to be fostered from the beginning of the learning-to-teach process" (p. 321). Journal writing has been advocated and used as instruments to develop RP in ITE because "they allow teacher learners a space to reflect. They provide a venue for teacher learners to establish connections between content and practical experience…and engage in active learning, linking prior knowledge with new understandings" (Lee 2007, p. 321). Journals are reflections on teaching and learning that PSTs are often assigned to do on a regular basis. Ward and McCotter (2004) however are concerned that teacher educators often ask PSTs to reflect on teaching practice experiences or write a reflective journal with very disappointing results because they often assume PSTs know how to reflect. They claimed:

> Students do not automatically know what we mean by reflection; often they assume reflection is an introspective after-the-fact description of teaching. Reflection, meant to make teaching and learning understandable and open, has itself been an invisible process to many of our pre-service teachers (Ward & McCotter, 2004, p. 255).

Ward and McCotter (2004) therefore suggested that journal writing is not an adequate means to develop RP in PSTs and propose ITE should find better strategies to develop RP. Lee (2007) argued, "It is important that teacher educators help student teachers develop reflective thinking as soon as the teacher learning process starts, so that they can experience success in the classroom when they practise teaching in the classroom both as teacher learners and later as practitioners" (p. 321).

There is concern however that there is more rhetoric about the importance of RP than "there is detail about how professional educators can help beginning professionals develop the skills of reflective practice and acquire initial experiences" (Russel, 2005, p. 199). Furthermore, Giaimo-Ballard and Hyatt (2012) observed that very little direction is given to ITE regarding approaches and processes of developing RP and it is also unclear how the PST educators apply the process of reflection. Video-based lesson analysis has been observed to be a useful tool for professional development (van Es & Sherin, 2002). Coffey (2014) stated video "provides a means by which a teaching episode can be captured more permanently to be used as a point of reference for reflection" (p. 86). Several mathematics education research teams (e.g. Geiger et al., 2015; Karsenty et al., 2015; Rowland et al., 2014) have used video-based lesson analysis to develop mathematics teachers' RP and knowledge for teaching with positive reports. Hence our research explores the role of video-based mathematics lesson analysis in developing RP among South African PSTs.

However, developing RP is not easy, particularly with PSTs. Lee (2007) attested to this stating it "is a difficult process, since it requires critical thought, self-direction, and problem solving coupled with personal knowledge and self-awareness" (p. 321) which the majority of PSTs do not possess (Schäfer & Seidel, 2015; Ward & McCotter, 2004). Jay and Johnson (2000) mentioned that the elusive boundaries of RP make it difficult to define and teach,

while Schäfer and Seidel (2015) noted difficulties related to PSTs' lack of adequate professional knowledge and skills, particularly the skill of noticing. Sherin, Jacobs and Philipp (2011) defined noticing as the process of identifying and attending to important and noteworthy classroom events that influence teaching and learning and claim it is an essential component of teaching expertise in mathematics. Schäfer and Seidel (2015) positioned the ability to notice as a prerequisite to reflective practice. They claim RP "involves the process of making sense of what has been noticed by linking observed situations to knowledge about teaching and learning" (p. 38).

Karsenty et al. (2015) in their VIDEO-LM project developed and employed the Six Lens Framework (SLF) to guide the teachers' focus to mathematical aspects as they analyse the video-based mathematics lessons. The SLF directed teachers attention to: (1) *mathematical and meta-mathematical ideas* which relates to the mathematical concepts and ideas developed in the lesson being analysed; (2) *explicit and implicit goals,* that is, the goals the teacher is working to achieve through the lesson; (3) *tasks and activities* refer to the work the teacher gives learners to help achieve the lesson goals; (4) *interactions* with students is how the teacher interacts with students in the lesson to facilitate learning of concepts; (5) *dilemmas and decision*-making are the challenges with regard to mathematics and its teaching and the decisions the teacher makes while teaching; and (6) *beliefs* relate to the teacher's orientation with regard to mathematics and the teaching of mathematics.

The ITE course that forms the empirical field for our research employed Karsenty et al.'s (2015) Six Lens Framework (SLF) to support PSTs in their third year of study to develop RP. In our study, the SLF provided the lecturer and PSTs with tools for focusing their reflections on mathematics lessons they watched of local and international mathematics teaching videos.

Theoretical Perspective and Analytic Frame

Our study is theoretically framed by Muir and Beswick's (2007) levels of reflection framework. We used this framework to inform the data analysis discussed in the next section. Muir and Beswick (2007), working in the field of mathematics education, propose that professional learning practices such as RP are effective in promoting mathematical reform. They claim engaging teachers in analysing video-based lessons and classroom stories support their professional learning which progresses through three hierarchical levels: Level 1 - technical description involves teacher descriptions of the classroom experiences focusing mainly on the technical aspects of teaching without considering the importance of those experiences. Level 2 - deliberate reflection involves teacher identifications of critical classroom events and provision of explanations for them; Level 3 - critical reflection involves teacher reflections that go beyond identifying and explaining critical events to suggesting alternative actions. We considered these levels useful for analying PSTs' RP while observing video-based lessons.

Research Context and Methodology

The larger study employed a qualitative case study with fourteen third-year FP Bachelor of Education PSTs at a conveniently selected university in one of the poorer and more rural provinces of South Africa. Data were collected through lecture observations; PSTs written individual reflections; verbal group and class reflections; assignments and interviews. The RP development course was introduced and conducted with the whole third year 2018 FP Bachelor of Education cohort. Fourteen PSTs in the cohort consented to participate in the study. The SLF was used by the lecturer as a tool to guide the PSTs on what to notice and reflect on as they analysed selected video-based lessons. In the first session the PSTs were

put in groups and all six lenses were assigned to different groups with each group focusing on only two of the six lenses. For this paper we focus on the individual written reflections of the PSTs on the video of a mathematics lesson shown to them in their first session where RP and the SLF were introduced to them. The reflections thus capture PSTs written RP at the start of their introduction to RP on mathematics lesson videos. Furthermore, as space is limited, we focus only on PSTs' reflection using one lens, namely the 'tasks and activities' lens. This lens had received the most attention by the lecturer in the introduction of the lenses. Nine of the fourteen participating PSTs in this study were allocated this lens. The other five PSTs were allocated different lenses.

A content analysis was done on the written reflections and then considered against the indicators of the three levels of reflection as suggested by Muir and Beswick (2007). Our analysis instrument was double coded to ensure its trustworthiness. We colour coded the statements that fell within each category of reflection. The categories of reflection were adapted to suit the focal lens of 'tasks and activities' as shown in Table 1.

Table 1
Levels of Reflections on Tasks and Activities

| SLF Lens | Levels of reflection (Muir & Beswick, 2007) | | |
	Technical description	Deliberate reflection	Critical reflection
Tasks and activities	PSTs describe technically the key tasks and activities assigned to learners without explaining their importance	PSTs identify and describe the key tasks and activities and give explanations for them	PSTs go beyond description and explanation to suggest alternative tasks and activities

Data Presentation and Analysis

The reflections used in this paper are based on a video-based lesson of a Grade R teacher teaching the bonds of five through a dramatised story of five children moving one by one from one small umbrella to a big umbrella. The lesson begins with the teacher asking learners to count in ones from one to five, and then back again. Learners then dramatise the story while the teacher reads the story. At the teacher's instruction children start moving one at a time to the bigger umbrella (pausing each time to note how many children are under each umbrella: 5-0; 4-1; 3-2; 2-3; 1-4; 0-5). The teacher had in place flash cards with number names, number symbols, and comparison words (more, less) on them. These the learners placed at the umbrellas to describe each paused situation. For example, at the 1-4 stage of the enactment, learners placed the word 'less' and the numeral 1 with the word 'one' at the small umbrella and the word 'more' with the word 'four' with numeral 4 at the big umbrella. Learners thus identified the number of children, then identified the corresponding number symbol, number word and compared the size of each group of children using comparative language (the words more and less). Evolving patterns of the decreasing and increasing numbers under each umbrella (i.e. 5, 4, 3, 2, 1, 0 and correspondingly 0, 1, 2, 3, 4, 5) were also noted.

Analysis of the nine PSTs who reflected using the 'tasks and activities' lens revealed sometimes an absence of noting the key tasks and activities and relatively superficial attention to the tasks and activities when they were noted. Such difficulties are acknowledged in the general literature as noted above. However, of interest here is that the nature of student reflections seemed to start below Muir and Beswick's (2007) technical description level. Of the nine PSTs, six did not describe the tasks and activities despite the explicit focus in the SLF 'tasks and activities' lens they were using. Instead they discussed

more general classroom occurrences that did not particularly relate to the tasks or activities in the lesson. For example, Mandy's full written reflection stated:

> The teacher made her lesson very active. While the learners were very actively involved in lesson in order for teacher to put her point across in the lesson. The idea to make the lesson more active is a life like representation to allow learners to grasp the aim of the lesson.

These six PSTs reflections thus did not provide indicators for identification at the technical description level - we therefore ascribed a pre-technical description level to accommodate the nature of their responses. According to Knox (1999), technical description describes an object or process in terms of its function. Technical descriptions focus on structures and characteristics of objects or processes. Knox (1999) distinguished technical description from summaries. While technical descriptions focus on structures and characteristics (of tasks and activities in this example), summaries inform what transpired. Mandy's reflection above however does not describe the tasks and activities assigned to learners in the lesson, and while she comments on the nature of the lesson (i.e. the teacher made the lesson active and that learners were actively involved), she also does not summarise what transpired in the lesson. This concurs with Schäfer and Seidel (2015) who noted PSTs find it difficult to notice "aspects of events that require deeper understanding of teaching and learning processes… pre-service teachers often focus on other, more superficial aspects of classroom teaching and learning (e.g., interior design, teacher speech habits/clothing)" (p. 40).

Two PSTs' reflections were identified as a mixture of comments on broader classroom occurrences with some description of tasks and activities. Here, one or two activities were identified explicitly. For example, Lutho stated:

> She started by asking the learners what they see. From then she involved language incorporated in math. She asked the children to count up to 5. Then she elaborated on number 5. Firstly by using concrete apparatus which were the 5 children and then asking the learners on the mat questions so that they may be involved in the lesson.

Lutho did not mention the key tasks and activities the teacher assigned to her class. Lutho's reflection was thus considered relatively weak in terms of technical description. Dee on the other hand provided the following reflection:

> The first task that was given to the learners is going under the umbrella, so the children together can present number 5. The second one is when the child counted all the children under the umbrella. The third one is when the children are asked to bring number 5 and 0 and picking out the word that has many etc.

Dee's reflection described a wider range of key activities (with greater specificity) in the lesson and was thus considered a stronger technical description. Of interest, no written reflection of the nine PSTs could be described as being at Muir and Beswick's (2007) Level 2 (deliberate reflection) or Level 3 (critical reflection). In the broader study, sub-levels of technical description are introduced in order to capture the difference between stronger and weaker reflections within each level. This also enables us to examine the way in which PSTs strengthened their reflections over the course of the year. These initial data on PSTs' reflections concur with the discussion earlier that reflection on teaching, if it is to inform and strengthen practice, must be explicitly developed and one should not assume that without careful exposure to what powerful RP might look like that PSTs will develop these skills.

Discussion and Findings

This study found that the majority of PSTs find it difficult to reflect even at the most basic technical description level. The PSTs' reflections were categorised as somewhere between pre-technical description to technical description indicating the challenge PSTs have with this important professional skill. This suggests the need for pre-service teacher educators (PTEs) to acknowledge that PSTs' reflection is a skill to be developed and is not innate. RP that develops knowledge for mathematics teaching is a particular practice that likely needs modelling for PSTs. Darling-Hammond (2006) noted that PTEs often have limited control of the practical knowledge PSTs learn in classrooms during teaching practice. They critiqued that such practical professional skills as learning to reflect on practice are often left to the mercy of mentor teachers. Using video-based lessons for developing RP may enable PSTs to have a more powerful learning experience during teaching practice. While the broader study found that Muir and Beswick's (2007) model of levels of reflection are useful for analysing PSTs' RP, adaptations were needed for our context. In particular, to enable classification of 'beginner' reflections we added a pre-technical level of description. The implications of this for our teacher education context is to not take for granted that PSTs will be able to provide technical descriptions of lessons even when the explicit focus is on 'tasks and activities' as provided in the SLF. Thus we suggest, while the SLF is likely useful to assist PSTs in paying attention to and noticing the tasks and activities in lessons, examples of strong RP will need to be modelled for PSTs in each of the lenses if we want them to progress to levels of deliberate and critical reflection.

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