Chapter 5

Conclusions and implications

5.1 Introduction

In Chapter 4 the results of the data analysis of this research study were discussed. In this chapter I provide the conclusions and implications of the study. After summarising the chapters the research questions are verified, followed by a discussion of my own reflections on the procedure I followed to conduct the study as revealed in my researcher diary. I also make provision in this chapter for the fact that I may have been wrong in my interpretation of the participants' reflective practice. This is followed by conclusions, recommendations and final reflections on the research study.

5.2 Chapter summary

In Chapter 1 I introduced and contextualised the research study. This study aimed to explore mathematics teachers' reflections before, during and after teaching a lesson. I situated my investigation in the context of lesson study, mainly because I believed that teachers would reveal their reflections more openly in a setting where they jointly discuss their teaching experiences. In this chapter I also formulated three research questions to guide the inquiry. I briefly discussed methodological considerations, as well as possible contributions and limitations of the study.

In Chapter 2 I reviewed the theoretical underpinnings of teacher reflection and reflective practice as found in the literature. Research studies dealing with the reflective practice of pre-service and practising teachers were investigated. I focused on teacher reflection in general and mathematics teachers' reflective practice in particular. The content and depth of teacher reflection are measured at different levels and in this chapter I discussed various categories of reflection as depicted by different researchers and theorists. I also explored the different meanings of reflection found in the literature and developed a tentative definition of reflection and conceptual framework for this study, based on this review and exploration.

Chapter 3 described the research design that guided this case study. An in-depth exploration of five mathematics teachers' reflection before, during and after teaching a lesson was qualitatively conducted through interviews, classroom observations and lesson study group reflections on the lesson observed. The teachers' lesson plans and reflective writings were

also analysed. The strategies for data analysis were discussed, and measures of quality assurance were provided. Ethical considerations were presented and the possible limitations of the study were indicated.

In Chapter 4 I discussed the results of the analysis of this research study. The data were analysed qualitatively using the computer programme Atlas.ti 6. The interview transcripts were coded and six themes, related to the conceptual framework of the study and the research questions that guided the study, were created. The voices of the five mathematics teachers were heard, explaining their understanding of reflection, their reflection-for-action, reflection-in-action and reflection-on-action, as well as the contextual factors perceived to influence their reflections. Each teacher's level of reflection was established by using Lee's (2005) and Jay and Johnson's (2002) levels of reflection.

5.3 Verification of research questions

In this section I discuss the interpretations of the participants' reflective practice as they relate to the research questions.

The research questions that guided the study were the following:

Question 1: What is the nature of mathematics teachers' reflective practice?

To address this main question, the following subquestions guided the enquiry:

a) How do mathematics teachers understand the concept of reflection?
b) How do mathematics teachers reflect before, during and after teaching?
c) What is the possible relationship between mathematics teachers' reflection and their classroom practice?

Question 2: How do contextual factors influence mathematics teachers' reflective practice?

Question 3: What is the potential significance of mathematics teachers' reflective practice for the science and art of mathematics teaching?

5.3.1 Research question 1

To understand the nature of mathematics teachers' reflective practice the study attempted to answer three subquestions. The first subquestion deals with mathematics teachers' **understanding of reflection**.

The findings of the study indicate that only two of the five mathematics teachers understood the concept of reflection, as measured by the working definition of reflection defined in Chapter 2.7. Morgan stated that he *looked back on his actions* to think about what he could have done differently to help the learners gain a better understanding of the concepts he taught. Vicky said that because of her reflection on her learners' circumstances she was able to change her way of teaching. For her reflection meant *looking forward to transform her actions.* This finding is very much in line with findings in the literature that suggest that there is no single definition of reflective practice (Osterman & Kottkamp, 1993; Sparks-Langer, 1992; Zeichner & Liston, 1987).

The second subquestion asked **how mathematics teachers reflect before, during and after teaching a lesson**. This subquestion relates to teachers' reflection-for-action, reflection-on-action and reflection-in-action. The findings of the study indicate that none of the teachers involved in the study completed the sections in the lesson plan that relate to reflection on their expectations of their learners. They did not tailor their planning with the idiosyncratic needs of their learners. According to Butke (2003) a teacher's lesson plan formulates the concrete, tangible product of **reflection-for-action**. In this research study the planning, teaching and reflection on the lesson observed formed a cycle in which the reflection-for-action dimension was an extension of the reflection-on-action where certain understandings had been reached concerning the previous teaching episode, and how the next teaching episode would be affected. However, the five teachers' lesson plans did show an improvement from the original lesson plans presented at the initial interview to the final lesson plans submitted for the observation lesson.

The five teachers all reflected on their actions during the initial interviews and the post-observation interviews (**reflection-on-action**). They reflected on various aspects of their teaching, their time management, their classroom arrangement, their learners' lack of understanding of basic concepts and understanding of mathematics amongst other things. One teacher, Mary, reflected on the curriculum that does not allow question papers to be set in such a way that most of the learners will pass the papers. She also reflected on the learners' use of calculators and obsession with cell phones and blamed these for the learners' lack of interest in mathematics. Only one teacher, Sipho, reflected on his learners' thinking while they were busy doing mathematics. The five teachers' reflection-on-action are in line with the understandings of Dewey (1933) and Schön (1983, 1987) who focused on reflection as a method of thinking about experience that leads to inquiry and problem solving[13]. The finding also confirms Hatton and Smith's (2006) argument that as

[13] Discussed in Chapter 2, Sections 2.2.1 and 2.2.2

professionals, teachers should frame and reframe complex and ambiguous problems that they face, test out various interpretations and modify their actions as a result.

Three teachers displayed moments of **reflection-in-action** while teaching their observation lessons. All three explained the deviations from their lesson plans in terms of reflection while teaching the lesson. By reflection-in-action they solved problems that had emerged from their planning. Morgan realised while teaching that he should expose his learners to a more difficult example, Sipho said he realised that he should have revised the distributive property in more detail and Vicky wanted to prepare her class for more challenging binomial products because they were to write a general Grade 9 exam. By reflection-in-action they found a way to re-appreciate a problematic situation. Schön (1987) described reflection-in-action as that moment when a teacher becomes surprised, interprets something in the teaching-learning situation as a problem and invents procedures to solve the problem.

To answer the third subquestion (**What is the possible relationship between mathematics teachers' reflection and their classroom practice?**) the study considered each participant's reflection in relation to his/her observation lesson. Mary, who reflected mostly on Level R1 (recall) (Lee, 2005) did not involve her learners actively in her lesson. My impression was that she did not understand her learners' thinking and did not encourage the learners to clearly explain and justify their reasoning. She also frequently interfered with her learners' thinking. According to Warfield, Wood and Lehman (2003) such teachers base instructional decisions on the expectations of external voices rather than on their learners' thinking. They do not reflect deeply about either their learners' mathematics or about their own teaching (Warfield, Wood & Lehman, 2003).

Morgan however, reflected critically (Level R3) (Lee, 2005) on his learners' understanding of mathematics concepts and how to possibly transform his own practice to improve their understanding. In his observation lesson he allowed learners to solve problems in their own ways and expected them to both explain and justify their reasoning and to listen to and question the reasoning of other learners, actively involving all learners in class.

To sum up, the first question deals with the nature of mathematics teachers' reflective practice. From my investigation I found that only two of the five mathematics teachers understood the concept of reflection (based on the working definition of reflection for this research study) before the onset of the research. Although the lesson plan template made provision for reflection-for-action (with space provided for writing about expectations of how the content will be received by the learners), none of the teachers completed these sections. Three teachers reflected in-action while they were teaching and changed their lesson plans

to adapt to unexpected happenings in the classroom; and all five teachers reflected on-action during the interviews and in their lesson study group discussions. They reflected on pedagogical matters (classroom management, time management, teaching style, learners' understanding of mathematics), personal issues (language, shortcomings as a teacher), external factors (curriculum, interferences while teaching, class size), and critical issues (learners' needs, learners' thinking). Their reflections were rated on Lee's (2005) levels of reflection and ranged from R1 (recall level of reflection which is descriptive in nature), R2 (rationalisation level of reflection) and R3 (reflective level, thinking critically about their own teaching and the impact of their actions on their learners' understanding of mathematics). Furthermore, by relating each teacher's level of reflective thinking to his/her observation lesson, it seems that a possible relationship might exist between a teacher's reflection and his/her instructional decisions. Teachers who were reflecting on a critical level of reflection seemed to pay more attention to their learners' thinking about mathematics and how their own instruction of mathematics might influence their learners' understanding of mathematics.

5.3.2 Research question 2

To answer the second research question (**How do contextual factors influence mathematics teachers' reflective practice?**), the participants' reflections during the interviews as well as during the lesson study group reflections were analysed. Contextual factors that emerged through these reflections were 1) the opportunity created for reflection by the lesson study group experience and 2) language. Support for the first contextual factor, the lesson study group experience is provided by Coe, Carl and Frick (2010), who mention that 1) lesson study can act as an agent of change in a culture of isolation; 2) participants become comfortable with having colleagues observe them teach; 3) an increase in content knowledge is realised by participating members; and 4) lesson study provides an approach that is continuously effective in meeting the needs of learners. Language as a possible contextual factor is confirmed by Reed, Davis and Nyabanyaba's (2003) who suggest that teachers may need to be apprenticed into reflective discourses, whether in their main language or an additional one.

To sum up, the second question deals with how contextual factors influence mathematics teachers' reflective practice and from my investigation I found that teachers reflect on their practice when granted the opportunity to do so (through interviews and within the context of lesson study). In addition language seemed to influence the teachers' ability to reflect on their practice.

5.3.3 Research question 3

The third research question, **What is the potential significance of mathematics teachers' reflective practice for the science and art of mathematics teaching?** encapsulates the other two main questions. The results of this study indicate that not all teachers are reflective practitioners, but by creating an opportunity for reflection, through lesson study, the participants of this study did reflect-on and in-action. Their individual reflections were descriptive, rationalising their actions and not directed to transformation of their classroom practice. However, in the lesson study group reflections the individual participants achieved a critical reflective level, and this finding can be utilised to bring teachers out of isolation by way of meaningful collaboration. The findings highlight that a lesson study model has potential for effective continuous professional teacher development (CPTD) within the South African context (Coe, Carl & Frick, 2010).

To sum up, the third question deals with the significance of mathematics teachers' reflective practice and I found that through the lesson study experience the teachers in my study were able to reflect on their classroom practice, reporting that they had gained a lot from observing themselves and their colleagues' teaching.

5.3.4 Summary of verification of research questions

In Table 5.1 a summary of the findings of this research study to verify the research questions of the study is provided.

Table 5.1 Summary of verification of research questions

Research questions	Verification
What is the nature of mathematics teachers' reflective practice?	Mathematics teachers reflect in-action and on-action, but not for-action. The content of their reflections indicate that they reflect mainly on pedagogical matters, personal issues, external factors and critical matters. The level (depth) of their reflections range from Level 1 (recall/descriptive), Level 2 (rationalisation/comparative) to Level 3 (reflective level/critical reflection). They reflect whenever they are given the opportunity to do so (during interviews and in the context of the lesson study group). Furthermore, a number of contextual factors influence their reflective practice. In the current study, the lesson study experience seemed to have a positive influence on their reflective practice. In addition, inadequate language and verbalisation skills seemed to hamper reflective abilities.
How do mathematics teachers understand the concept of reflection?	Whereas one teacher understood the concept of reflection as *looking back on action*, another teacher understood the concept of reflection as *looking forward to guide action.* The other three teachers were unable to explain their understanding of the concept of reflection.
How do mathematics teachers reflect before, during and after teaching?	No evidence was found in this study that mathematics teachers reflect **before** their teaching of a lesson, even though the lesson plan template made provision for such reflection. Three teachers reflected **during** their teaching by deviating from their written lesson plans and adapting their examples and classroom arrangements to cater for unexpected events or responses from learners. All five teachers reflected **after** their teaching by recalling or describing certain incidents (R1 level of reflection). Moreover, all teachers increasingly rationalised or generalised their experiences as the research study progressed (R2 level of reflection). However, only two of the teachers were able to eventually reflect critically on their action (R3 reflective level) during the lesson study group reflections (Lee, 2005). Individually, teachers reflected verbally on their actions during the interviews and cooperative participation during the lesson study group reflections. Their post-observation written reflections on their actions in class were at a recall level only (describing what had happened in class).
What is the possible relationship between mathematics teachers'	Evidence was found that a relationship between the teachers' reflection and their classroom practice exist. Teachers who reflected on a lower level (R1 level of reflection) neglected to allow learners to solve problems using their own methods and communicate their findings to their fellow learners in contrast with

reflection and their classroom practice?	teachers who reflected on a more critical level (R3 level of reflection) about their learners' understanding of concepts and their own classroom practice.
How do contextual factors influence mathematics teachers' reflective practice?	The lesson study context experience proved to be a positive influence on all the teachers' reflective practice. All teachers reported positively on the cooperative planning of a lesson, revealing that they learned much from the experience of planning with the goal to improve learners' understanding of concepts. Additionally, they reported that they were teaching with more confidence as a result of watching themselves as teachers and learning from watching their colleagues. They also reported a sense of increased and deeper awareness of their learners' needs and the importance of involving learners in their lessons. Lastly, two of the teachers regarded the lesson study experience as self-research that enabled them to compare themselves with their colleagues and observe their own actions critically while watching the post-observation videos. Teachers' inadequate linguistic skills and inability to verbalise basic mathematical concepts properly seemed to influence mathematics teachers' reflective practice negatively. One teacher constantly reflected on her poor command of English and the fact that she code-switched to Sesotho to explain content to her learners. As the research project progressed, the teachers increasingly talked more openly and freely during the group reflections in English, in contrast to their first planning session when they all wanted to talk in Sesotho. A plausible explanation for this phenomenon seems to be that teachers' lack of experience ion teaching Mathematics in English impacted their self-confidence negatively.
What is the potential significance of mathematics teachers' reflective practice for the science and art of mathematics teaching?	The results of this study show that when mathematics teachers' are made aware of their reflections on their practice in a context of working cooperatively, they are encouraged to reflect at a more critical level. This finding has some potential value for planning professional learning programmes, where teachers can be encouraged to talk about their classroom experiences, share their joys and challenges with each other and strive to build a community of reflective practitioners to enhance their learners' understanding of mathematics.

5.4 What would I have done differently?

As a novice researcher I learned a lot during the course of this research study. My own reflective capabilities grew and I am now more able to reflect on my own role as researcher and teacher educator. I also learned more about the reality of teaching in a rural school using a language of instruction that is not your home language, teaching mathematics without resources, and trying to deal with the pressure from the school management and district office to increase the pass rate of the learners. This caused me to expand my thinking about the development of mathematics teachers. I now realise that effective professional learning programmes need to establish supportive and interactive communities that use reflection as a means for growth.

What would I have done differently? I would have liked to extend the opportunities for participant reflection, but due to time constraints this was not possible since I could only meet the participants once a week on a Thursday afternoon.

In addition, I initially wanted the participants to complete a daily reflective diary, so that I could follow their teaching lives during the week, but they were reluctant to submit their diaries as arranged. Lee (2005) argues that it is important to create various opportunities and climates where reflective thinking about their practice can flourish rather than to limit teachers to a particular approach. With this view in mind, I then asked the participants in my study to write a one-page reflection on the observation lesson, so that I had at least some form of reflective writing from each participant. I agree with Russell (1993) who suggests that some teachers need support in learning how to reflect. If I were to repeat this study, I would provide for reflection on critical incidents and ask the teachers to write reflectively about these incidents on a weekly basis.

When I originally planned this research study, I proposed to invite teachers teaching the same grade (e.g. Grade 10) from neighbouring schools to become participants to this study. However, the district official suggested that I use only one school, with the result that the participants of my study were teaching mathematics to learners ranging from Grade 8 – 11. This turned out to be a beneficial arrangement as I realised that the teachers learned more about learners' understanding and misunderstanding of concepts by observing each other's video-recorded lessons, than they would have if the group had remained homogenous as originally planned.

Finally, when I coded the data I realised that language emerged as a possible contextual factor that influences teachers' reflection. There is a possibility that the participants in my study might have reflected more openly and freely in their own language if an interpreter was available from the start of the research project.

5.5 Providing for errors in my conclusions

I engaged with five mathematics teachers who opened their classrooms to me and revealed themselves as teachers and human beings in the context of my study. I have made some decisions on their reflective capabilities as teachers, and I have to provide for the fact that I may have been wrong in my conclusions. I have tried to ensure that the results of this study are trustworthy. I have used interviews, video recordings of lessons, reflective writings and group reflections to gather data. I have also asked two experienced colleagues to verify my coding of the data and the families I created from the coding of the data, in order to enhance the trustworthiness of the data analysis process. The emerging reality I described in my results chapter (Chapter 4) was a crystallised reality obtained from different perspectives that *all reflected the unique reality and identity of the participants of this research study* (Nieuwenhuis, p. 81, 2010).

However, I often struggled to make sense of the abundance of data, frequently consulting with my supervisor and co-supervisor to share my feelings of disequilibrium. Although I sometimes became confused, I persevered and with time succeeded to piece together a picture of each participant's reflective journey. I have learned that teachers, once they are aware of their reflective capabilities, realise the value that reflection can add to their classroom practice. I am convinced that reflection created opportunities for the participants in my study to grow as teachers, as professionals and personally.

5.6 Conclusions

This research study focused on mathematics teachers' understanding of reflection, the content and level of their reflections before, during and after teaching a lesson, and the contextual factors that influenced their reflections. The findings indicate that the participants of this study experienced growth in their reflective practice as the research study progressed. Although their lesson planning improved, they still neglected to reflect on their expectations of learners in their planning and their final reflective writings were on a descriptive/recall level (Level 1) only. All the participants reflected on their actions in class during the interviews and lesson study group reflection sessions. The content of their

reflections differed, ranging from pedagogical issues, curricular matters, personal issues and critical issues. The level of their reflection-on-action (Jay & Johnson, 2002; Lee, 2005) during the interviews ranged from Level 1 (descriptive/recall) to Level 2 (comparative/rationalisation), but during the lesson study group reflections they reflected on Level 3 (critical/reflective) on each other's lessons as well as on their own teaching. Three of the participants reflected in-action, as indicated by their deviations of their lesson plans. The contextual factors that seemed to influence the participants' reflections are the opportunity the lesson study group provided for collaborative reflection and language. The participants reflected positively on the lesson study experience, and mentioned the following benefits: 1) They felt that they improved their lesson planning; 2) They gained confidence as mathematics teachers; 3) They reported a deeper awareness of learners' needs; 4) They learned from colleagues, watching each others' video recordings and discussing their own and each others' lessons after observation of the video; and 5) They felt that the lesson study experience helped them to research themselves as teachers, seeing themselves in their classrooms, becoming aware of not only their mistakes, but also the positive aspects of their teaching.

5.7 Recommendations

Additional questions have been generated by this research study. For example, it would be worthwhile to undertake a follow-up study with the participants of this study to understand the long-term effects of reflective process.

Furthermore, I believe that there might be other contextual factors that influence mathematics teachers' reflective practice that need to be researched further, for example gender, personality characteristics and culture. The reason why I consider gender to possibly influence the reflective process is because the male participants in my study were very reluctant to write about their reflections in a reflective diary. Personality characteristics might play a role in a teachers' reflective practice and I base this belief on Dewey's (1933) three attitudes that he considered to be integral to reflection: openmindedness, responsibility and wholeheartedness. Reflection might also be culturally bound, for example Lee and Tan (2004) investigated student teachers' reflective practice in Malaysia and found that their private reflections were on a deeper level than their public reflections. An intercultural study, for example comparing South African mathematics teachers' reflective practice to that of a different culture will provide for a more comprehensive body of knowledge on reflective practice.

Lastly, the results of this study can be used in the planning of future CPTD programmes. The positive feedback of the participants on the lesson study process suggests that lesson study should be initiated in other settings. Further research should explore lesson study as a model in South Africa for successful CPTD programmes.

5.8 Limitations of the study

As already stated in Chapter 3 Section 3.9, the small number of participants (five) makes it impossible to generalise the data from this research study. However, within the qualitative paradigm I tried to study the reflective practice of these five participants from multiple perspectives, using various methodologies.

Another limitation of this research study pertains to the researcher's inability to speak the home language of the participants. Language emerged as a contextual factor that possibly influences the participants' of this study's reflective practice, although I allowed for an interpreter during the last group reflection. I evaluated the participants' verbal and written reflections as they struggled to express themselves in English, and I have to make provision for the fact that I may have misinterpreted their understanding of reflection.

5.9 Last reflections

As much as any qualitative study can draw any conclusions, this research study represented not only the professional and personal development of the five teachers who were so willing and eager to share their stories with me, but also the personal and professional culmination of three years of hard work. During this time I gained new insight into mathematics teachers' classroom practice, as well as the realities which these teachers have to deal with every day. The lesson study context of my research offered an effective strategy to bring teachers out of isolation, allowing them to experience meaningful collaboration with their fellow teachers, observing and criticising their own and each other's lessons and planning lessons together. All five of these teachers proved to be reflective practitioners to a greater or lesser degree. However, these teachers need ongoing support if they are going to continue to develop as reflective practitioners and they need professional learning opportunities to help them to develop their reflective capabilities.

In Chapter 1 I mentioned that the importance of this research study rests on its unique connection of reflective practice with mathematics teaching. I am convinced that through engaging in the lesson study experience the five participants of this study improved their

reflective practice, reporting an increase in self-knowledge and finding new ways of teaching mathematics to learners. As for myself, my own reflective journey and involvement with mathematics teachers' professional learning will continue. In the words of Carl Friedrich Gauss (cited in Fleming & Varberg, 1992)

> *Does the pursuit of truth give you as much pleasure as before? Surely it is not the knowing but the learning, not the possessing but the acquiring, not the being-there but the getting-there, that afford the greatest satisfaction. If I have clarified and exhausted something, I leave it in order to go again into the dark. Thus is that insatiable man so strange: when he has completed a structure it is not in order to dwell in it comfortably, but to start another.*