

Developing a cognitive theory from student teachers' post-lesson reflective dialogues on secondary school mathematics

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This article describes phases of post-lesson reflective dialogues that were enacted by secondary school mathematics student teachers with their peers. Five pairs of student teachers on 12 weeks of teaching practice provided data through lesson assessments, post-lesson reflective dialogues, and end-of-teaching-practice reflective interviews. A cognitive theory of collaborative reflection with a peer that encapsulates phase characteristics of a post-lesson reflective dialogue is proposed. Dialogue at each of the phases of the theory may not easily change student teachers' conceptions of teaching, but could provide a platform and structure for reviewing, modifying, or even maintaining teaching cognitions. While the older and more familiar 'apprenticeship' models are based on an expert teacher coaching a novice student teacher instructional skills, this fresh 'social' model is based on novice student teachers and their peers coaching each other teaching skills. An important implication of this observation is that current discourse on strategies for improving the quality of student teaching may move towards a consideration for a fresh school attachment model.

Keywords: cognitive theory of teaching; collaborative teaching; post-lesson reflective dialogue; reflection; reflective practice; student teacher pair; teaching practice

Background of the study

Current mathematics educational research is dominated by studies that seek to improve student teacher integration of theoretical and practical knowledge for teaching. For instance, Ball, Thames & Phelps (2008) observed that, two decades after Shulman (1987) noted that pedagogical content knowledge can bridge the theory and practice gap, the process is still underdeveloped and inadequately understood. Research is needed to report the "new progress on the nature of content knowledge for teaching" (Ball, Thames & Phelps, 2008:389). Such content knowledge for teaching can influence pedagogical changes in student teachers from teaching mathematics as transmission of rules and formulae through drill and practice to teaching the subject as active engagement of learners in sense-making activities that can lead to the construction of viable mathematical knowledge. Sense-making in mathematics lessons entails engaging learners in problem-solving activities and meaningful tasks. That in turn may encourage deeper thinking that is shared in class discussions and individual written work (Clarke, Thomas & Vidakovic, 2009; Peressini, Borko, Romagnano, Knuth & Willis, 2004). When successfully enacted in mathematics lessons, problem-solving strategies may facilitate effective teaching. Effective teaching entails presentation of concepts using multiple forms that can integrate demonstrations and explanations with pictorial representations in order to make mathematical concepts familiar to the learners' contexts. Student teacher knowledge of appropriate facts, algorithms, and procedures is sometimes not sufficient for effective teaching (Clarke *et al.*, 2009). They (student teachers) can marry theory with practice in order to enact

effective teaching through trial and error with the help of cooperating teachers and peers. As noted by Tabachnick and Zeichner (1984) student teachers have the flexibility to amend their teaching practices in negotiated and interactive processes that enable them to review their attitudes, conceptions, and beliefs on teaching and learning mathematics. Teacher educators have a responsibility to utilize student teachers' flexibility to learn how to teach effectively through encouraging a "culture of thinking and rethinking, constructing and reconstructing the processes and ways of thinking during the preparation" (Clarke *et al.*, 2009:25).

Such a culture of thinking about teaching involves student teachers making judgements and decisions that can necessitate thoughtful deliberations on purposeful actions in order to improve learner understanding. Reflection is often recognised as important in enabling student teachers to make effective decisions that can improve their teaching. Reflection can provide a context for student teachers to use their decision-making skills to analyse the learning environment, assess learner knowledge gaps and how to reduce them, improve questioning techniques, and evaluate the pace of a lesson and suitability of activities to enhance learner understanding. Effective decision-making during teaching enables student teachers to question the relevance of the content the learners are learning, level of challenge, and decisions on other viable alternative ways of presenting the same content so that all the different ability levels of learners in a class can be challenged to think deeply. Schon (1987) argues for teacher reflection because pedagogical theories alone are not sufficient to guide student teachers' decision-making processes for coping with the complexities and uncertainties of teaching mathematics. Two types of reflections, namely, reflection-in-action and reflection-on-action, are usually used to monitor the effectiveness of student teachers' instructional decisions. Reflection-in-action refers to the process of interpreting, analyzing and providing alternative solutions to teaching problems at the time they are happening (Schon, 1987). It involves looking at a teaching episode as it unfolds, assessing the level to which it is effective in terms of learner understanding, and attending to theories-in-use. A theory-in-use is the theory that is implicit in what student teachers do during instruction, that is, the knowledge-in-use or mental maps that guide their decisions and actions during teaching (Smith, 2001).

Reflection-on-action or post-lesson reflection involves thinking in retrospect on what a student teacher has done during an instructional episode to assess how knowing-in-action produced intended or unintended learner outcomes. Post-lesson reflections take place when a student teacher has left an instructional arena and mentally reconstructs it in order to analyze decisions, actions, and outcomes of a lesson. During post-lesson reflections student teachers spend some time exploring the rationales for their actions and learner responses to them through making careful analyses of what happened, why it happened, and what they could do differently to improve their teaching performance and learner understanding (Galvez-Martin, 2003). The insight derived from post-lesson reflections makes it possible to evaluate the effectiveness or ineffectiveness of implementation strategies of instructional theories, decisions taken, or activities organised for a lesson. Such insight sometimes provides student teachers with pedagogical choices in ways that can provide an understanding of their teaching practice through a commitment to personal and professional growth. The commitment is expressed through an ongoing examination of their judgments, pedagogical knowledge, beliefs, and sensitivity to interweave theory with practice. That is how one becomes a reflective practitioner.

Many student teachers on teaching practice in Zimbabwe have been observed to write post-lesson reflective texts that typically belong to technical reflection level category (Nyaumwe, 2005). Their post-lesson reflective texts show a "tendency to allege that their

teaching was successful, without indicators to support those conclusions” (Nyaumwe, 2005: 632). Technical reflection reveals a student teacher’s concerns on classroom management and pedagogical strategies in order to achieve basic predetermined learning outcomes (Hatton & Smith, 2006; Van Manen, 1977). An example of such self-written technical level reflective text is shown below:

The lesson was successful. Almost all the learning outcomes on finding the solutions of simultaneous linear equations were achieved. Time management was good since all work planned was covered. Classroom management was also good because learners did not make noise during the lesson (Zimbabwean student teacher’s post-lesson reflective text: February, 2006).

From the above post-lesson reflective text, one can notice that the claims made by the student teacher were not supported by evidence drawn from the lesson taught. Van Manen (1977) describes student teachers who write such technical level post-lesson reflective texts as being preoccupied with teaching techniques in ways that overshadow their criteria for effectiveness. Pre-occupation with instructional success during post-lesson reflection is a common phenomenon to student teachers world-wide. For instance, Hoffinan-Kipp, Artiles and Lopez-Torres (2003) noted that student teachers’ reflections on technical competencies that focused on conformity of teaching practice with learner achievement of predetermined outcomes is common in the US. In Australia, Frid, Redden and Reading (1998) concluded that some student teachers in Australia wrote technical level post-lesson reflective texts that were seldom critical of their teaching.

Few studies have investigated whether student teachers show evidence of critical reflection during talk about their teaching with expert teachers (Williams & Watson, 2004). A study by Rhodes, Phillips, Tomlinson and Reems (2006) recommended research on how student teachers can conduct reflective dialogues on an equal basis as colleagues with their cooperating teachers. In line with that, the present study is an attempt to contribute to debates on student teacher development of instructional skills with their peers on an equal basis. The study analyses the phases of secondary school mathematics student teachers’ post-lesson reflective dialogues with their peers. Student teachers and their peers share similar commitment to engage in reflection, decision-making, and suggestions to improve their teaching during post-lesson reflective dialogues on equal bases. Listening to peers’ interpretation of instructional actions and decisions can facilitate student teachers’ sense-making about each other’s teaching.

Studies that analyse post-lesson reflective dialogues of student teachers and their peers are long overdue. In particular mathematics teachers and educators may be interested in answers to the research question such as: What are the phases of secondary school mathematics student teachers’ post-lesson reflective dialogues with their peers? Such a study may provide them with insights on how reflective student teachers can marry pedagogical theories and practice in efforts to improve their practicum teaching in order to align it with curriculum demands, learner needs, interest and capabilities.

Conceptual framework

Three levels of reflection, namely, technical, practical, and critical are often used to monitor student teacher reflection sophistication (Hatton & Smith, 2006; Hall, 1997). In the lowest category of technical reflection, student teachers present their post-lesson reflective texts through narration of events that occurred during teaching. The reflections prematurely point

out successes of a lesson without providing evidence from a teaching episode. A student teacher's technical reflection level can sometimes be associated with some genuine causes such as: refraining from exposing teaching challenges, believing that admitting them may attract low assessment grades from tutors (Hatton & Smith, 2006), the model of teaching practice used, expert teachers' dominance in post-lesson reflections (Williams & Watson, 2004), and student teachers' lack of experience to focus post-lesson reflections on relevant aspects of teaching (Power, Clarke & Hine, 2002). In the second category of practical reflection, student teachers reflect on the strengths and weaknesses of teaching episodes and present them at uncritical levels. The reflections show lack of interpretative skills of learner behaviour or outcomes in response to student teachers' actions during teaching. The highest level that can possibly be attained is critical reflection. At critical reflection level a student teacher gets involved in deep thinking, self assessment, and self directed learning that can emerge from a broad understanding of an instructional environment.

The model of teaching practice in use can also influence a student teacher's post-lesson reflection level. A model in which cooperating teachers supervise student teachers sometimes has an inherent weakness of not helping some student teachers to achieve high reflection levels. This is possible because the model suggests that by observing, imitating the craft knowledge and getting advice on how to teach, student teachers can automatically model their instructional practices on those of their cooperating teachers (Samuel, 2010). Loughran (2001) questions whether the model of cooperating teacher telling of good teaching practices while the student teacher listens and imitates exemplary teaching practices may be effective to enable student teachers to reflect on their teaching. Instead, student teachers' listening to cooperating teachers' suggestions of good teaching may make them miss the opportunity to reflect, construct, and understand their own teaching identities.

In cases where student teachers receive useful teaching support from cooperating teachers, their post-lesson reflective dialogues is sometimes dominated by the latter's talk (Williams & Watson, 2004). Cooperating teachers can capitalize on student teacher instructional inexperience and dominate post-lesson reflective dialogues. The dominance is influenced by cooperating teachers' tried and tested instructional knowledge which is not held by student teachers. Cooperating teachers can use their teaching experience to pose and defend their opinions (Chen, 1993). Their dominance sometimes renders a post-lesson reflective dialogue ineffective to challenge a student teacher's deeply held perspectives on teaching because development of reflective skills cannot be achieved by coercion through cooperative teacher coaching, but can be developed socially through interactions with peers (Bryan, Abel & Anderson, 1996). Isaac's (1999) model of building dialogue capacity of listening, respecting, suspending and voicing is the conceptual framework that guided this study in organising post-lesson reflective dialogues.

Student teachers involved in post-lesson reflective dialogues were attentive listeners for meaning, feelings, intonations and patterns of reflective arguments using the context of instructional milieu. They had respect and honoured boundaries of a speaker's legitimacy to express personal understanding of the professional suggestions made to such an extent that they gave each other turns to express their points of views without interruptions. In this way the student teachers were open to sharing their points of view, receive suggestions and more importantly they were willing to learn from each other. Because sharing was at the centre of post-lesson reflective dialogues suspension of personal assumptions enabled participants to neither suppress their thinking nor advocate it through coercion. In this way they voiced their

understanding of pedagogical theories and instructional conceptions using the local context of the school in ways that revealed what was true to them regardless of the influence that could be brought to the fore.

To facilitate student teachers to listen, respect, suspend and voice their sentiments during post-lesson reflective dialogues a collaborative reflection with a peer (CRP) framework was used (Nyaumwe, 2005). The cyclic CRP framework consisting of four phases of conception, learning context, evaluation, and development, can slow down student teacher natural inclination to prematurely jump to conclusions about classroom events without providing evidence. For this study, it was used to facilitate student teachers' collection of evidence from learning episodes for analysing the effects of their teaching, and then using that analysis to review and improve their subsequent teaching. Seeking evidence to support claims made during post-lesson reflective dialogues can enable student teachers to reflect deeply on their teaching and interpret their pedagogical actions in the light of learner outcomes. After peer-student teacher collaborative post-lesson reflections, the student teacher whose lesson was the focus of reflection would write the post-lesson reflective text. This text was then attached to the lesson plan used during teaching and filed in the teaching practice portfolio. The CRP framework was introduced to student teachers during their methods courses at the university. The students also practised on the CRP applications during micro-teaching sessions before they went out on teaching practice.

Context of the study

In Zimbabwe several challenges are encountered when trying to pair a student teacher with a cooperating teacher at a secondary school. Some of the challenges emanate from attachment schools not clearly understanding the concept of mentoring, some cooperating teachers not being aware of their roles, and lack of coherence between attachment schools and the university (Nyaumwe, 2001). These factors influence some cooperating teachers' ineffectiveness in developing professional skills such as reflection on student teachers' teaching because, generally, they (cooperating teachers) are not trained or supplied with a blue print on how to conduct their professional duties (Mavhunga, 2004). Most cooperating teachers are merely experienced classroom teachers without the capacity for training other teachers. Some cooperating teachers' mentoring weaknesses, coupled with shortages of mathematics teachers in some attachment schools, make some school authorities let student teachers learn about teaching while teaching by "leaving them alone to swim or sink" (Nyaumwe, 2001:243).

This study was conducted with student teachers enrolled on a four-year Bachelor of Science Education Honours degree programme during the first semester of their final year. The programme simultaneously integrates content and professional courses. This integration necessitates student teachers to go for four weeks of school attachment periods during the vacations between the first and second semesters in their first to three academic years. In the final year the student teachers go for full-time teaching practice during the whole first semester. In efforts to develop reflective practice of the student teachers, the university where the students were enrolled initially used an eclectic mentoring model of teaching practice where a student teacher was attached to a cooperating teacher. The use of the eclectic model sought to nurture open-ended inquiry that can make student teachers reflect on their teaching with their cooperating teachers in ways that can make learning to teach a life long process that forms an integral part of the student teachers' continual professional development (Hayward, 1997). The model also permitted student teachers to reflect on their instructional decisions and actions with their peers and other teachers in a school. This way the student teachers could interrogate

some of the conceptions they could be holding on mathematics teaching and learning based on experiences during their teaching.

Owing to the mentoring challenges alluded to earlier, reflective teaching remains a tacit skill that is usually difficult for some cooperating teachers to perform alone with student teachers attached to them. The difficulty arises from the fact that reflective teaching involves a critical evaluation of the implementation and applicability of pedagogical strategies that student teachers were encouraged to use, rationales for decisions made, as well as actions taken during instruction. On taking cooperating teachers' challenges into account, a collegial mentoring model was adopted. A collegial mentoring model encourages peers to augment cooperating teachers' assistance to student teachers during planning, implement pedagogical strategies theorized during university professional courses, and collaboratively reflect on teaching in order to get insight that is rooted in theory and practice (Nyaumwe, Mtetwa & Brown, 2005). Collegial mentoring encourages student teachers to "experience the Plan-Teach-Debrief sequence" that enables them to observe how peers "think about and teach from a reform perspective" (Clarke, Thomas & Vidakovic, 2009:27). To promote the implementation of the collegial mentoring model, the student teachers were encouraged to go for teaching practice in pairs, though some school needs at times could not permit deployment of the pairs to the same school.

Method

A case study approach was used for this investigation. Studies on professional development of student teachers are usually conducted in case study designs that involve small sample sizes (Crawford, 1998; Ensor, 2000). A small sample size of student teachers in a case study design permits collection of a large corpus of data that not only allows for methodological soundness, but also facilitates generalizations that could lead to emergence of an explanatory theory (Perressini *et al.*, 2005). This study was interpretive in nature because meanings and phases through which student teachers' collaborative post-lesson reflective dialogues went through were examined and inferred from narratives (Strauss & Corbin, 1990). The narratives used were grounded in the student teachers' experiences, thus facilitating the researchers' understanding of the collaborative post-lesson reflections from student teachers' contexts and perspectives (Tetley, Grant & Davies, 2009).

The study required mathematics student teacher participants who were willing to be posted to the same school with a peer for their regular teaching practicum. From a cohort of 39 student teachers, a total of 10 forming five pairs met the sampling criteria. The researchers explained to the student teachers that the demands and expectations of the study were that (a) participation was voluntary, (b) researcher visits were not intended for awarding assessment grades, and (c) the student teachers were free to withdraw their participation at any time that they felt. All the five pairs volunteered to participate in the study on the expectation that participation may increase their readiness for and grades in regular faculty assessments on their practicum performance. The student teachers were randomly assigned grade levels for teaching by principals at the attachment schools that were located in rural and urban settings.

The instruments and data gathering procedures designed were based on the CRP framework explained earlier in the conceptual framework section. Lesson observations, post-lesson reflective dialogues, and end-of-teaching-practice reflective interviews were used. Post-lesson reflective dialogues of the researcher, peer, and student teacher who taught a lesson were conducted three times at the beginning, middle, and towards the end of the teaching practice period in order to monitor how student teachers were conducting them. During a researcher's

visits to an attachment school, the researcher and a peer sat in the lesson taught by a student teacher and made independent notes on how the teaching was conducted. They used their respective field notes to make claims about teaching actions that provided background to the post-lesson reflective dialogues. In the absence of a researcher, student teachers and their peers were encouraged to sit in each other's mathematics classes, should the lessons be conducted when either of them was free. In the case where a student teacher and a peer taught mathematics lessons to their different classes at the same time, they conducted post-lesson reflective dialogues together when they were both free. The post-lesson reflective dialogues provided formative assessments that were used to interpret a student teacher's competencies to teach, how pedagogical strategies were implemented, and their responsiveness to learners' needs.

The post-lesson reflective dialogues that were conducted in the presence of a researcher were audio taped and transcribed as soon as the researcher returned to his base. The transcriptions were used during the end-of-teaching-practice interviews. These interviews were separately conducted with student teachers and their peers based at the same attachment school. In the interviews student teacher peers could identify and justify some collaborative reflection dialogues that characterized the phases they went through. The nature of reflective arguments distilled from any of these three instruments facilitated inferences of the phases of post-lesson reflective dialogues that the student teachers and their peers were capable of effecting.

Content analysis involving analytic induction was used to interpret excerpts of the student teachers' narratives of the post-lesson reflective dialogues that they conducted (Bogdan & Biklen, 1998). Content analysis suited analysis and interpretation of qualitative data from the lesson observations, post-lesson reflective dialogues, and end-of-teaching-practice reflective interviews because it allowed sorting and making sense of the data by observing patterns on perspectives and putting them into themes. Excerpts from audios of post-lesson reflective dialogues were revisited during the end-of-teaching-practice reflective interviews in order to create a name label for a theme of each phase. When a student teacher said something that seemed insightful s/he was stopped and asked to repeat that point in order to capture the words spoken verbatim. These processes facilitated identification of the phases inferred from the collaborative teams after modifications of some words that were used by some student teacher pairs to describe a post-lesson reflective dialogue phase. Pairs used different words such as clarification, claim, or statement to describe the starting point of a post-lesson reflective dialogue. A single word that represented these words was discussed and agreed upon with the goal of most accurately describing beginning of reflective interviews (Ratcliff, 2000). In this case one word that was agreed upon as synonymous and overarching to these three words is assertion. Words in different phases that were deduced from a post-lesson reflective dialogue were similarly derived. At the end of the reflective interviews the words that were written down describing different phases of reflective dialogues deduced by a pair were summarised in order to reach consensus on their place in the post-lesson reflective dialogue phases. This process ensured the reliability and consistency of the words that were used to describe a phase that the student teacher pairs identified in their post-lesson reflective dialogues.

Results

Vignettes are used with the explicit intention to present how the post-lesson reflective dialogue phases emerged from the end-of-teaching-practice interviews with student teacher pairs. The resulting theory deduced from the vignettes is an explanation of the phases and linear sequence that could characterize post-lesson reflective dialogues enacted by the participant pairs. To acknowledge the student teachers' privacy and to treat their responses with the sensitivity and

their right to confidentiality the student teacher pairs are labelled 1 to 5 in order to adhere to the research protocol agreed upon.

The first end-of-teaching-practice interview used the context of the post-lesson reflective dialogue on equivalent fractions taught to a Form 1 (Grade 8) class. The post-lesson reflective dialogue started with seeking an explanation of why a student teacher accepted a learner's

solution presented as $\frac{450}{900} \div \frac{450}{450} = \frac{1}{2}$.

Our reflective dialogues went through several stages that may be difficult to identify step-by-step. Um ... using a lesson on equivalent fractions ... we can summarize the stages as going through explanation ... statement of an instructional decision, ... support for the explanation/statement given. At times the explanations were accepted, challenged or ... opposed. Later, some evidences were sought from a lesson taught to clarify the explanation given. The evidence was discussed using the context of effective teaching as this was the intention of the reflective dialogues [Pair 1].

The end-of-school attachment interview with the second pair used the context of a post-lesson reflective dialogue of an 'A' Level lesson on calculating the mean and variance of given data.

We can use the CRP framework to identify the phases that our reflective dialogues went through. At the beginning of a post-lesson reflective dialogue a peer made a claim on the inappropriateness of a teaching decision. A teaching decision of using numbers 2, 4, 5, 6, 8 for calculating the mean and variance by learners with calculators was ... considered inappropriate. The claim was usually based on one's conception of the nature of content at hand ... and how one believed learners could best understand it. Ah ah ah the beliefs were sometimes elusive that they sparked heated debates before a claim is accepted or disagreed with to refute the claim. In the case of having ... disagreed we sought evidence from a lesson taught to clarify the differing views. The discussions that sometimes emerged when we failed to agree on a statement or ... a claim usually provoked analyses of different perspectives on interpreting teaching and learning actions. The different perspectives used to interpret some instructional actions led to suggestions of ways of making improvements on the teaching enacted [Pair 2].

The third end-of-school attachment interview used an example from the post-lesson reflective dialogue on conditional probability. The reflective dialogue reflected on a student teacher who wrote on the board the question "A and B are exhaustive events. The probability of A given

B is $\frac{1}{4}$ and the probability of B = $\frac{2}{3}$. Find the probability of A".

Our post-lesson reflective dialogues followed linear stages. Ah ... ah they started with a statement describing or even ... interpreting a teaching action. For instance, a reflective dialogue on conditional probability started with seeking explanation on why a student teacher wrote a question on the board and solved it. The defence given by the student teacher was that she was demonstrating how to express English words into mathematical symbols and demonstrate to learners how to solve problems on conditional probability. In order to understand the statement posed one of us usually requested evidence to support or elaborate it ... When the evidence was not strong we sometimes looked for alternative explanations to refute the interpretation or elaboration. Like ... the evidence of teacher demonstration instead of learner engagement was not convincing. The argument that sometimes emerged from reflective dialogues of this nature ... sometimes ... resulted in the negotiations of the instructional conceptions held by a student teacher

during teaching and that held by a peer holding opposing views. The negotiations were very fruitful because they engaged us into critical reflections that sometimes led to useful suggestions on how our teaching can be improved [Pair 3].

The fourth end-of-school attachment interview used the post-lesson reflective dialogue in which Student Teacher 4 demonstrated the multiplication and division rules of exponents in a Form 1 (Grade 8) class. In the post-lesson reflective dialogue there were contesting views on how the lesson could be improved, for example, by deriving the rules from known exponents in order for learners to generalize the rules on their own.

We can deduce the phases through which our post-lesson reflective dialogues went through. The starting points varied ... for instance, one post-lesson reflective dialogue started with a statement describing how teaching and learning took place during an identified episode. At times the reflection started with an elaboration of the insight drawn from an instructional action or clarification of an instructional decision. For instance, one reflective dialogue started with a clarification or elaboration of why the multiplication and division rules of exponents were demonstrated by a student teacher instead of letting learners to establish them. Ahhhh ... sometimes the statement ... elaboration that opened the reflective dialogue was accepted after more evidence was provided to support it. In other cases the opening statement was rejected on the basis of ... flimsy evidence. In the event of rejection of an explanation we sometimes engaged in negotiations of our instructional conceptions or our different interpretations of the evidence. The negotiations were based on pedagogical theories that we held and we sometimes came up with strategies of how an instructional action or future teaching can be improved in general. In cases where we disagreed, we would usually be engaged in evaluations of the effectiveness of the theories that we covered at campus in our contexts. Such discussions gave us understanding and developmental insight on how the theories can be adapted to our school contexts. Such understanding did not mean agreement on an instructional perspective but strengthening our different perspectives [Pair 4].

The fifth reflective interview drew the phases of post-lesson reflective dialogues from a Form 2 (Grade 9) lesson on Highest Common Factor. A student teacher had faced some instructional challenges on enabling learners to figure out the mathematical requirements of the problem solving task that reads: "Find the greatest mass that can be taken an exact number of times from 360 g, 504 g and 672 g."

We can use a lesson that I recently conducted on the Highest Common Factor (HCF) and Lowest Common Multiple (LCM) as an example showing the stages that our post-lesson reflective dialogues went through. Our post-lesson reflective dialogues started with a statement describing the actions of learners during a lesson. In this lesson learners had linguistic problems to model problem-solving tasks. The evidence of this claim was given on a problem requiring learners to calculate the "greatest mass that can be taken an exact number of times" by three different weights as involving LCM. In this example learners' inability to realise that the problem involved LCM was agreed upon and supported as a linguistic problem. [Peer intervenes] It was not always the case that agreement and support were achieved so easily. At times there were challenges to the evidence given. The challenges led to the evaluation of the teaching strategies used. For instance, were learners provided with contexts in their environment involving where LCM is applied or did the student teacher use generalizations outside the mathematical world in which the concept is used? Such challenges enabled us to note that for effective learner understanding of our teaching of mathematical concepts, they should be generalized to

their applications in the learners' contexts. The insight that we developed from this post-lesson reflective dialogue enabled us to theorize strategies for improving future teaching of the lesson in order to minimise learners' linguistic challenges [Pair 5].

The student teacher pairs' post-lesson reflective interview transcripts were summarised in a linear dialogic model as discussed below.

Discussion

In order to analyse holistically the end-of-teaching-practice reflective interview data, transcripts were re-played and field notes re-read to determine the sequence of the phases emerging from the raw data (Ollerenshaw & Cresswell, 2002). This process facilitated derivation of themes that transformed the student teacher pairs' reflective dialogues from being mere descriptions and thematic indicators into distinct phases that captured their experiences during post-lesson reflective dialogues. Italics are used here to highlight words describing phases in the post-lesson reflective dialogues that the student teacher pairs experienced. The post-lesson reflective dialogues typically started with a *statement* or *claim* that was based on both practical and theoretical understanding of a student teacher pair's teaching. For instance, a peer made a claim on the "inappropriateness of a teaching decision of using numbers 2, 4, 5, 6, 8 to calculate the mean and variance by learners with calculators" (Pair 2). The *claim* was supported by *evidence* drawn from a lesson observed that "some of the learners computed the mean mentally." A student teacher who taught this lesson *challenged the evidence* arguing that his decision for using such numbers was based on some learners without calculators who were free to compute the mean and variance manually. *Additional evidence* was provided that some learners with calculators were observed to compute the mean manually showing that calculators were not useful for that exercise.

The student teacher who taught the lesson further argued that the focus of the lesson was on developing learner procedural competencies without regard to the computational tool used. This view prompted *theorization* of the effective use of calculators as catalysts for student learning. For instance, learners with calculators could engage in problem-solving or exploratory activities rather than use them in conservative, casual, instrumental, and uncritical ways in computations (Goos, Galbraith, Renshaw & Geiger, 2000). The *theorization* of this nature led to *understanding* the types of data and appropriate pedagogical strategies that were possible in a classroom where learners have calculators. The *theorization* on the type of mathematical tasks that can suit learners with calculators was capable of providing *understanding* that learners attending high school mathematics require problem-solving tasks in order to challenge their thinking capacities. In classrooms that encourage problem-solving tasks a division of labour ought to exist between learners and calculators. In such classrooms learners become more thoughtful in designing strategies for solving the tasks while relegating execution of tedious calculations to calculators (Groves & Dale, 2004). The *theorization* emphasised use of real-world tasks in order to enable learners to apply mathematical concepts to solve the ill defined problems they sometimes encounter in their environments.

The third post-lesson reflective dialogue started with a *statement* seeking clarification on why the student teacher teaching the lesson wrote a task on conditional probability on the blackboard and then proceeded to solve it. The student teacher who taught the lesson *explained* her teaching action. The explanation given did not convince the peer. The argument that emerged from the reflective dialogue on teacher demonstrations versus learner engagement resulted in the *theorization* of instructional conceptions held by the student teacher pair. When learners are allowed to experiment with their prior knowledge in groups, learning can become

a social activity that involves individual learners making sense of their experiences (Prescott & Cavanagh, 2008). The student teacher who taught the lesson *agreed* with the *theoretical* perspectives discussed on letting learners use their prior knowledge to solve new problems and providing the learners with opportunities to try out their intuitive thinking on solving new problems.

In one of their post-lesson reflective dialogues, Pair 4 started with *clarification* of why the multiplication and division rules of exponents were demonstrated by a student teacher instead of letting learners establish the rules on their own. The student teacher who taught the lesson *challenged* the view of learners deriving the exponent rules on their own arguing that learner derivation of the rules was time consuming. A peer *supported* the student teacher who taught the lesson, arguing that to derive the two rules from expanding the bases to a given power was tedious. The peer's argument was that learner derivations were still to be followed by drill and practice tasks to enable the learners gain procedural competence. The student teacher pairs

used *evidence* of learners' performance on simplifying $\frac{27 \times 3^8}{54 \times 3^5}$

to *support* the effectiveness of the drill and practice method used in the lesson.

The researcher *challenged* the effectiveness of the drill and practice methods. His argument was that mathematical rules should be actively created by learners individually or socially and not demonstrated to them. The researcher's argument for *challenging* the drill and practice method was based on prioritization of learner conceptual over procedural understanding. The *disagreement* on an appropriate way of teaching the exponent rules provoked a discussion on whether active engagement of learner construction or passive reception of the rules was effective for learners' understanding. The discussion was informed by the differences in conceptions on how learners can learn the exponent rules between the researcher, on one side, and the student teacher pair on the other. The *support* of the *statements* on active learner engagement provided *additional evidence* that the researcher used to *challenge* the 'absolutist' conception of teaching exponents by the student teacher pair (Rule & Lassila, 2003). On the other hand, the student teacher pair based their preference for passive learning of exponent multiplication and division rules on the observed mastery of learner procedural competencies that were gained through drill and practice in the lesson.

The dialogue based on different conceptions of how learners can learn mathematical concepts generated *additional evidence* that led to the *theorization* of the efficacy of learner active engagement versus passive recipient of mathematical knowledge. The *theorization* was based on intuitive reasoning and practical experiences premised in pedagogical paradigms, the nature of the content at hand, and the interest levels of the learners. Engagement in the *theorization* nurtured new *understanding* (agreement, disagreement, or agreeing to disagree) on the effectiveness of active and passive learning approaches, the nature of mathematical concepts, and when to use either strategy in a lesson. The *understanding* that emerged from this dialogue was assumed to be valuable for improving future teaching because student teachers and their peers at times were exposed to different perspectives of teaching that were derived from different instructional conceptions.

The end-of-teaching-practice interviews generally show that the starting point of a post-lesson reflective dialogue was a *statement/claim/clarification*. The term *statement* presupposes that a post-lesson reflective dialogue started with a fact that is taken as true rather than a tentative statement that was open to contesting views. *Assertion* was preferred to *statement/claim/clarification* for portraying a view that the opening of a post-lesson reflective dialogue

can be contested. During validation of an *assertion*, *evidence* was sought to *support/challenge* it. Occasionally available evidences would not be strong enough to make sense of the *assertions*; hence, *additional evidence* would be necessary. For instance, in the calculation of the mean (Pair 2) the *additional evidence* posed was that the data provided were not relevant to learners with calculators because some learners computed the mean manually.

Discussion (Pair 1, Pair 2) and *negotiation* (Pair 3, Pair 4) of *assertions* in phase 3 pre-supposed reaching agreement at some point. *Theorisation* was preferred to *negotiation/discussion* (Pair 2, Pair 3) for not believing that post-lesson reflective dialogues could necessarily end in agreement. *Theorisation* on ways for improving teaching could lead to postulations of competing views of ideal teaching practices based on practical and/or theoretical understandings of instructional strategies used in a lesson as the objects of reflection. Conclusions of post-lesson reflections were reached on the basis of individual *understanding* of instructional theories and learning environments that unfolded in a lesson reflected on. The phases of the post-lesson reflective dialogues that emerged from the end-of-teaching-practice interviews are shown in a schema for a cognitive theory of collaborative reflection with a peer shown in Figure 1.

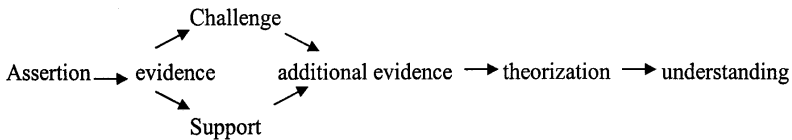


Figure 1 A cognitive theory of collaborative reflection summarizing the phases deduced from the secondary school mathematics student teachers' post-lesson reflective dialogues

This theory is an attempt to account for the phases of the post-lesson collaborative reflections with peers. The phases were in part deduced by the student teacher peer pairs themselves. The post-lesson reflective dialogues provided the student teachers with opportunities to analyse and understand classroom contexts in which they were immersed. Because the student teacher peer pairs were not preoccupied with judging or making instructional decisions to satisfy preconceived agendas (Isaacs, 1999), their critical reflections sometimes resulted in some unexpected outcomes that were born out of the realization that at times agreement could not be reached. But, as Isaacs (1999) warns, the quality of post-lesson reflective dialogues using a framework similar to this cognitive model depends on there being trust, openness to different pedagogical perspectives, good communication, no-one displaying or exercising undue power, and lack of distractions on the purpose of the reflective dialogues. When these attributes are attained genuine post-lesson reflective dialogues can enable student teachers to listen to their peers; learn about each other's experiences, insights, frustrations; and add new experiences to their instructional repertoire in ways that can enable them to constantly review their instructional conceptions (Abma & Broerse, 2010). The cognitive theory of collaborative reflection with a peer is based on theoretical and practical evidence drawn from teaching episodes focused on during post-lesson reflective dialogues. In using it one does not assume reaching consensus of good or bad teaching, but it facilitates student teachers and their peers to explore and understand teaching practice from a wide perspective that can enable them to

develop individual teaching identities. Understanding of pedagogical theories that can be used to improve teaching during post-lesson reflective dialogues was born out of agreement, disagreement, or agreement-to-disagree on an assertion, evidence, or theorization provided.

Conclusion

The cognitive theory of collaborative reflection with peers that was deduced from this study can be enhanced by student teacher pairs' possession of the skills of listening, respecting, suspending and voicing (Isaacs, 1999). The presence of a peer in a reflective dialogue provided a structure that helped a student teacher to review, modify, or maintain his/her teaching cognitions and conceptions. Consequently, post-lesson reflective dialogues were effective in providing student teachers with multiple perspectives on interpreting and implementing teaching strategies. The cognitive theory of collaborative reflection can provide teacher educators with insights into ongoing debates on how to improve student teacher instructional practice through reflection. The theory is by no means a comprehensive prescription for describing the character of ideal student teacher - peer post-lesson reflective dialogues across contexts. More investigations in different school contexts are necessary to augment the present study and, perhaps, apply the theory within a wider cross-section of Zimbabwean student teachers.

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