

Visions of Practice: Getting the Balance Right

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This investigation describes the beliefs and understandings that a beginning teacher developed as she engaged in two case investigations that were part of her undergraduate degree. The study also compared her perceptions about teaching mathematics at the end of her first term of teaching. Although the participant's identified beliefs and observed practices were consistent with constructivist principles, the case-study analysis indicated that contextual constraints influenced the way in which she was able to teach mathematics. It would appear that school-based structures and constraints need to be considered more at an undergraduate level, and concomitantly, teacher educators need to work to a greater extent in partnership with pre-service teachers to develop a range of strategies to address such constraints.

Over the past three decades, mathematics education reform has been a central focus for research on teaching and learning mathematics. In essence, the reform agenda reflects constructivist principles of learning that suggest students learn best when they participate in relevant, problematic activities that engage students in social interactions and require them to construct, or make meaning for themselves (Hiebert & Carpenter, 1992). Given the current emphasis on constructivist principles, many teachers seeking to address current reforms in teaching and learning mathematics have struggled with what constitutes an appropriate balance between explicit instruction and student-centred, inquiry-based learning (Noddings, 1990; Steen, 1999). Moreover, researchers who have followed novice teachers into their first year of teaching have reported an incongruity between pre-service teachers' university and student teaching experiences with classroom realities (Wideen, Mayer-Smith, & Moon, 1998).

It appears to be the case that tensions between ideal visions of teaching mathematics and the reality of practice need to be further explored at the pre-service level in order to address the issues in a supportive learning community prior to the commencement of full-time teaching (Mewborn, 1999). Such a process needs to acknowledge the contextual constraints that exist in real schools and how new orientations towards teaching may be challenged at a personal and school-based level (Wilcox, Lanier, Schram & Lappan, 1992). The present study seeks to establish whether the beliefs and understandings constructed and developed by pre-service teachers at university match the "realities" of classroom practice. Such comparisons cannot be made until pre-service teachers have established personal practical theories related to teaching and learning mathematics.

One approach for addressing this issue in teacher education is to provide opportunities for pre-service teachers to become action researchers during their school-based practical experiences (Gore & Zeichner, 1991). Research can be reported using written reflections in the form of case investigations (Kubler LaBoskey, 1992). Case investigations call for students to carry out a modified version of case-study research by identifying an educational concern or issue of interest, collecting relevant data, analysing the data and producing a case write-up.

Richert (1992) suggested that the writing-up process itself was a valuable reflective tool that empowered pre-service teachers to become creators and definers of their own learning. At the same time the writing process can be stimulating, intellectually challenging and rewarding in terms of personal learning and contributing to the learning of others. The purpose of engaging pre-service teachers in this type of inquiry is to assist them to think reflectively, share and learn from their experiences and develop a long-term inquiry orientation toward their teaching. Involving pre-service teachers in researching their own practice acknowledges that learning how to teach mathematics is a deeply personal activity that needs to accommodate students' prior beliefs in light of new personal discoveries (Bobis & Cusworth, 1995; Wideen, et al. 1998). It is important to ensure individuals' knowledge and beliefs about mathematics teaching and learning are scaffolded in ways that provide opportunities for interactions between theory and practice. In this way pre-service teachers are challenged to develop visions of practice using anticipatory reflection (Conway, 2001) in order to plan meaningful learning experiences. Frameworks for promoting understanding (eg., Smith, 2000) that have been developed in classroom contexts can provide informative guidelines for establishing links between theory and practice.

Theoretical Perspectives

Teaching for Understanding

The vision of practice that characterises learning as a generative and collaborative venture between teachers and students has been described as *teaching for understanding*. Teaching that has mathematical understanding as its major goal requires planned opportunities for reflection and communication of ideas and solutions (Carpenter & Lehrer, 1999; Hiebert, Carpenter, Fennema, Fuson, Wearne, Murray, Olivier, & Human, 1997).

In addition, Carpenter and Lehrer (1999) suggest that understanding is not an all-or-none phenomenon. Instead they characterise understanding in terms of five interrelated forms of mental activity: (1) Constructing relationships; (2) Extending and applying mathematical knowledge; (3) Reflecting about experiences; (4) Articulating what one knows; and (5) Making mathematical knowledge one's own. These authors suggest that the critical dimensions of classrooms that promote understanding require: engagement in tasks that foster understanding; the use of tools to represent mathematical ideas; and the establishment of classroom norms that foster problem solving and risk taking.

An empirically-based *Framework for Promoting Thinking and Understanding in Mathematics* (henceforth referred to as "the framework") has been developed by the first author (Smith, 2000) as a result of a collaborative action research study with seven classroom teachers over an eighteen-month period. The classroom teachers were seeking to incorporate the Working Mathematically Outcomes (Board of Studies NSW, 1998) into their teaching of mathematics. The framework provides a coherent vision of teaching mathematics for understanding and is supported by other research studies that seek to characterise teaching mathematics for understanding (Carpenter & Lehrer, 1999; Fraivillig, Murphy & Fuson, 1999; Hiebert, et al. 1997). Although each of these supporting research studies described core features of classrooms that promote mathematical thinking and

understanding, none of these studies have focused specifically on pre-service teachers' attempts to teach and assess mathematics for understanding.

Assessing for Understanding

In the present study, the framework was used to explicitly address the nexus between teaching, learning and assessment while working with pre-service teachers. Of particular interest was the use of such a framework to analyse a pre-service teacher's written reflections and interview transcript related to the "lived experiences" of trying to teach for understanding (van Manen, 1997). The framework includes actions for teachers as well as suggestions for the design of learner centred experiences and learner centred assessment, and constitutes *intentional interventions* that help provide new models of teaching consistent with constructivist perspectives (Simon, 1997). Conceptual frameworks for teaching may have short shelf lives and may need to be revised or replaced as data or new ideas emerge (Eisenhart, 1991). This study used the framework to analyse the lived experiences of one pre-service teacher to determine its suitability for framing teacher education programs that advocate current reforms in teaching mathematics. The framework begins with a description of the teacher's role as a guide for promoting thinking in a supportive classroom environment. In addition, it outlines learner centred experiences that lead to verbalising, clarifying and recording thinking, which provide opportunities for learner centred assessment (see Smith, 2000 for a more in-depth description of the framework).

A change in the way mathematics is presented to students requires concomitant changes in the way students' progress is assessed. Pre-service teachers who seek to make significant changes to their teaching of mathematics need support and guidelines to change their assessment practices. The current literature related to assessment in mathematics suggests that assessment should be:

- integral to, and naturally derived from good instructional practice (Clarke, 1997; MSEB, 1993);
- accessible, relevant and meaningful to all students so they can show what they know (Lajoie, 1995; MSEB, 1993);
- on-going and cyclic in nature (Bransford, Brown & Cocking, 1999; NSW Dept of Education, 1997); and
- an indicator of students' thinking processes as well as content knowledge (Bransford, et al. 1999; MSEB, 1993).

Clearly, constructivist principles of student centred learning and teaching of mathematics require authentic and consistent assessment strategies. In the present study, we examined the type of authentic strategies a pre-service teacher employed to assess children's mathematical understandings as she reflected upon her personal theories of practice. Furthermore, we investigated the level of transfer and relevance of the assessment strategies she used during the case investigations and compared these to the strategies employed during her first year of teaching.

The Study

Research Setting and Data Collection and Analysis

A case-study analysis (Yin, 1994) was conducted with a participant who engaged in two case investigations during a year-long subject (Assessment and Diagnosis in Mathematics) in her final year of an undergraduate education degree. Prior to that the participant had engaged in three mathematics methods subjects that emphasised and modelled constructivist principles of teaching, learning and assessing mathematics. In the initial data collection phase, two settings were used to represent the participant's lived experiences through the writing of case investigations. Both investigations focused on developing assessment strategies that were integral to mathematics instructional activities. The first case investigation was written as a result of a ten-week internship and the second case was written after a five-hour micro-teaching experience where pre-service teachers were required to assess a student's mathematical ability over two one-hour sessions, and then develop a teaching unit for three one-hour sessions.

An additional source of data was obtained through a follow-up, semi-structured interview towards the end of the first term of teaching. Prior to the interview, the case investigations were returned to the case study participant for reference and reflection. As a result, perceptions of practice were compared and analysed to provide an additional layer of reflection based on full-time practical experience in a classroom context.

Of particular interest were the participant's perceptions of changes to pedagogical practices since undergoing full-time employment; specific assessment strategies that were most beneficial in determining student progress; and the most difficult aspects of linking assessment with instruction. Therefore, data were collected over a two-year period with the case-study participant's "teaching role" moving from a pre-service teacher on her internship to a classroom teacher in her first year of employment. The data from the multiple sources were then compared and analysed using the framework to determine a) the extent to which the framework accommodated Shelley's lived experiences and b) aspects that would enhance the framework as a useful tool for pre-service teacher education.

Profile of Shelley

Shelley (a pseudonym used for this study) is a twenty-two year old female graduate of the Bachelor of Education (Primary) course from a rural university who is currently teaching a Year 4 class in a small rural school in NSW situated 35 kilometres north of the university setting. She considers herself to have been "just average" at school mathematics and her experiences learning mathematics at school were "textbook orientated" with very little focus on understanding. In contrast, Shelley's four years of learning mathematics content and pedagogy at University "made sense to me, I just seemed to pick it up quickly and I could see myself using those ideas in the classroom". Although her orientation towards teaching mathematics could be described as "teaching for understanding", there have been significant constraints she has had to accommodate within her current school context.

Results and Discussion

Developing a Mathematics Teaching Persona

During her course, Shelley's developing confidence and competence in teaching mathematics were evident in her insightful and reflective case investigations and the first author's observations during school-based experiences. In order to provide a framework for integrating assessment and instruction during her internship, Shelley used a fictional character scenario to provide opportunities for reflection and communication of mathematical thinking and conceptual understanding. The following transcript from Shelley's case investigation highlights the nexus between instruction and assessment in mathematics. Shelley wrote:

I chose a "please help Mr Maths because he has forgotten everything about maths" approach, which was well received by the students who remarked "oh why doesn't Mr Maths go back to school!" It was challenging for them, particularly the younger ones but I found that their writing was really consolidating their knowledge. I was able to discover exactly the processes each child relied on and was able to analyse student strengths and areas for improvement. This knowledge was particularly valuable when report writing! I discovered that if we had a discussion about the maths problem before the children even knew that Mr Maths was to appear, the children's writing was much more detailed and written with confidence. Some students still had difficulty getting the ideas to come out. These students were usually the ones who were not as confident in their writing ability, but because I knew they knew how to attack a problem, I transformed into Mr Maths and started to ask really silly questions about the problem. In this way I was able to help them begin. Once they started, they were usually able to complete it on their own...using drawings and writing about maths problems gave them the opportunity to work smarter at mathematics and thus their confidence grew. (Internship case investigation report, August 2000)

It was evident that she included aspects of the framework in her practice including: the creation of a supportive environment through teacher questioning (Mr Maths); encouraging children to verbalise their thinking (class discussions to establish a shared vocabulary); and providing opportunities for the children to clarify and ink their thinking (written explanations and drawings for Mr Maths). These techniques provided learning experiences that led to opportunities for assessment of thinking processes as well as content knowledge.

Shelley began to demonstrate an understanding of developing learning activities that were contextually based and closely linked to the student's interests. Moreover, the following excerpt illustrated Shelley's beliefs about the continuous nature of assessment and the importance of being flexible while teaching. Shelley commented that:

I also found that as I was developing the unit it was handy for me to make a written assessment of student learning straight after the lesson was taught. Recording student assessment straight away also helped me to plan for the next week. The more I reflected on my student's needs, the better I was able to cater for his learning...doing things that are unplanned really don't bother me too much because I am a big believer in living for that 'teachable moment'. I think if a teacher sees an opportunity for learning where a student is really switched on like Jared was when he wondered how many metres it was to the end of the hall, then they should drop their plans and go with the flow. (Micro-teaching case investigation, November 2000)

Clearly, Shelley's written case investigations represented a growing confidence and developing set of beliefs that reflect a reform-oriented approach to teaching and assessing mathematics for understanding.

A Mathematics Teaching Persona in Action: Getting the Balance Right

Several compelling issues emerged from the interview undertaken with Shelley towards the end of her first term of full-time teaching. Generally, most of the issues were associated with constraints placed on Shelley without her input, and were not negotiable. These external constraints included the compulsory use of mathematics workbooks and the formation of “ability maths groups.” Interestingly, her approach to overcoming these constraints was quite different from the type of teaching-learning situations she had developed in the action-research investigations in the previous year. This is understandable considering the fact that she was an inexperienced teacher.

Maths I am not happy with at the moment because I am using the Maths Plus book and it's expected that we use it and I don't like it because...I found that I am using the book from the first page and then the next page and it's jumping all over the place and I find the children don't have time to fully understand the concepts before we have to move on...Next term I decided I am going to stop doing that and I am going to group them into concepts so that we're going to find all the pages that develop a concept like Numeration 13 for example. I didn't like how I approached it this term, but that was just me being an inexperienced teacher with that resource and working my way through it and coming to the conclusion that there was a better way of using it. Parents pay for it and they expect you to use it, but I've also got other things going. (Interview transcript, March 2001)

Shelley went on to describe her attempts to compensate for the shortcomings of using a workbook and reinforced her commitment to student-centred learning when she stated:

That's why I want to change next term because it's (Maths Plus) not getting them ready for maths in real life, it's just in a book and you need to relate to what's 'out there'. You've got to understand the why behind doing it and that's why I'm going to change the Maths Plus approach. (Interview transcript, March 2001)

Shelley also elaborated on her continued use of journal writing where she focused on verbalising, clarifying and recording strategies for developing times table concepts to “help them remember” because that was an identified need. Next term she will introduce her Year 4 class to Mr Maths during their journal writing to develop the use of strategies to solve problems. This will occur “after they get used to thinking about strategies because they haven't had anything like this before”.

The second contextual constraint that emerged from the interview transcript was the use of ability groups for mathematics. Shelley indicated her frustrations at having to “do Count me in Too on Monday afternoons” for a number of reasons. In our interview, Shelley reflected that:

My biggest trouble in maths groups now is trying to get parents in to do Count me in Too and they are not confident with their own maths ability for Year 4 maths, it's just a fear and a stigma about their own abilities in maths...I have the “Facile group” on Monday afternoons, but the games that come in the “facile box” are too easy and the concepts we are working on don't link with our classroom maths...I get around this by giving them games that I have developed from the syllabus. (Interview transcript, March, 2001)

This case-study analysis draws attention to an additional dilemma facing beginning teachers seeking to teach mathematics in reform-oriented ways. The lived experiences of a confident and insightful pre-service teacher experiencing classroom teaching for the first time highlight the inconsistencies that can confront beginning teachers no matter how solid their beliefs may be. Despite the fact that Shelley graduated with a well-developed teaching persona that reflected constructivist principles, she was still faced with contextual

constraints that changed her approach to teaching mathematics. Although Shelley has indicated her intention to be proactive about changing her approach, the underlying question is how would less confident beginning teachers cope with such constraints?

Implications for Teacher Education

Some of the findings from this study highlight the dilemmas facing teacher educators and beginning teachers seeking to bridge the cultures of the school and the university. Clearly, there is an identified need for any framework that attempts to conceptualise teaching for understanding to be flexible enough so that the required use of resources such as workbooks can be incorporated. Concomitantly, pre-service teachers need to be prepared for such contextual constraints when they are placed on their internships or as beginning classroom teachers. A limitation of this study is the short amount of time that has transpired since Shelley began teaching. Although the data revealed some important messages for teacher educators and pre-service teachers, there is a need for longitudinal studies of beginning teachers and their attempts to teach mathematics for understanding.

Rather than focusing on the negative aspects of workbooks, the imperative action for teacher educators is to support the development of strategies such as those identified in the framework and explicitly deal with how they may be integrated to enhance the use of workbooks. Encouraging pre-service teachers to become critically reflective about the use of workbooks rather than ignoring their existence could provide them with the skills to address such a contextual constraint while still remaining true to the personal beliefs about teaching and learning that guide their classroom practices.

Strategies such as incorporating journal writing and encouraging class discussions that establish a shared vocabulary have been identified in this study as tools for enhancing understanding while still using mathematical workbooks. In essence, beginning teachers need to find a balance between meeting the requirements of school structures and expectations and maintaining a reform oriented, constructivist approach to the teaching of mathematics. Teacher educators can support such a balancing act by explicitly addressing the possible constraints that may face pre-service teachers.

One approach that has developed from this study is the use of written case investigations as a tool for developing pre-service teachers' skills in teaching and assessing mathematics for understanding. The case stories used in this study are situated in place, time and subject matter and reflect the uncertainties and unpredictability of becoming a teacher (Shulman, 1996). For teacher educators, the use of cases that have been crafted by pre-service teachers can provide an additional and authentic lens from which to view the processes of learning to teach and assess mathematics for understanding.

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