Supporting Reflection as Pre-Service Primary Teachers Develop a Mathematics Teaching Portfolio

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Fourth-year pre-service primary teachers (N=148) engaged in portfolio development during a semester of preparation for a final 10-week school internship. An interpretive research approach was used to analyse data from reflection sheets, classroom observations, lecturer teaching notes, and draft and final portfolio work samples. The findings indicated how the reflective process of portfolio development was supported by development of a mathematics teaching philosophy, submission of draft portfolio items, lecturer and peer mentoring, and formal assessment interviews with school principals and other educators.

A vehicle that has attracted recent attention in educational research on teacher development and change is that of professional portfolios. Various forms of a teacher professional portfolio have been promoted for supporting professional reflection and learning (Barton & Collins, 1993; Frid & Reid, 2002; Lyons, 1998; McLaughlin & Vogt, 1996). It is claimed that portfolios demonstrate 'professionalism' because the process of portfolio development necessitates articulation and development of knowledge, skills and values deemed essential for classroom teachers, along with capacities for and a commitment to lifelong learning, innovation and the ongoing improvement of education (Education Department of Western Australia, 2001). It was this potential to engender and support teacher development in a systematic, holistic way that prompted this study into the use of portfolios as a 'technology' to empower pre-service mathematics teachers to enact change and innovation in mathematics teaching and learning practices.

As a 'technology' – a mechanism for addressing a human problem or need – the use of a portfolio was adopted as a process for "applying knowledge, skills and resources … extending capabilities and realising opportunities" (Curriculum Council, 1998, p. 290). In this way the problem or challenge of supporting pre-service mathematics teachers to develop technical and professional competence would be addressed. The mathematics teaching capacities developed by the pre-service teachers through the portfolio process of this study have been reported elsewhere (Frid & Sparrow, 2003) and provided evidence of how the pre-service teachers developed substantially in their confidence as well as their capacities to clearly articulate and justify ideas for innovative mathematics teaching and learning practices. Another component of the study was the process of supporting the pre-service teachers in this development. Thus, this paper reports on the following component of the overall research study:

☐ What mechanisms and processes do lecturers and pre-service teachers find effective in supporting development of a mathematics teaching portfolio?

The significance of this study lies in its potential to inform mathematics educators of mechanisms and outcomes related to the development of pre-service teachers as mathematics teachers who have practical knowledge and skills along with more encompassing capacities for critical reflection, innovation and ongoing professional growth. More specifically, portfolio development requires both breadth (for demonstration of knowledge and skills) and depth (with regard to individuals' learning to think critically

and then justify and apply their ideas). Finally, at a more theoretical level, this research can offer insights into frameworks or models of teacher growth.

Theoretical Framework

Teacher Professional Development and Adult Learning Theory

Teacher professional development, as conceived of in this study, aligns with constructivist philosophy in that learning to teach is viewed as a process of personal growth that is influenced by beliefs, commitments, and ways of operating in and interpreting one's world (von Glasersfeld, 1995). Here, teacher professional development is viewed as a "process of growth in which a teacher gradually acquires confidence, gains new perspectives, increases knowledge, discovers new methods, and takes on new roles" (Jaworski, 1993, pp. 10-11). If one is to design appropriate support for teachers' professional development as mathematics educators, whether they are beginning or highly experienced teachers, then one needs to consider how adults learn. Adult learning theory – the science of andragogy – as proposed by Knowles (1980) emphasises that adults are self-directed learners whose need to learn arises from the challenges they encounter in their lives. Appropriate professional development for teachers must therefore include teachers' beliefs, values and teaching practices as key factors that impact upon personal and professional growth. It must also recognise that teachers need opportunity to engage in reflection and action that is self-directed and related to the challenges they encounter as teachers.

Thus, the notions of collaboration, self-direction, scaffolding, reflection and articulation that are highlighted by adult learning were used in this research to inform the design of the teaching unit within which the study was conducted. An outline of the key features of the related teaching and assessment activities for portfolio development is given in the upcoming Method section.

Reflection, Change, and Professional Empowerment

As indicated earlier, professional portfolios were chosen as a professional development tool in this study because of their capacity to foster reflection upon beliefs and practices while also fostering innovation and change (Frid & Reid, 2002; Loughran & Corrigan, 1998; Lyons, 1998). In the context of mathematics teaching this means any mechanism by which teachers are asked to act as their own change agents needs to gently challenge while providing a safe environment in which one can take mathematical, professional, emotional and intellectual risks (Robinson, 1989; Wilcox, Schram, Lappan & Lanier, 1991). In working with pre-service teachers, as in this study, an implication of these points is that learning activities need to create situations where teachers consider their beliefs and practices, particularly regarding what they value and do, why they do it, and how they do it:

> Only by confronting what you believe and reflecting on what you believe will you become a teacher who can match what you philosophically believe with what you practise in the classroom. Teachers who can do this appear to be the most empowered. (Harris, Turbill, Fitzsimmons & McKenzie, 2001, p. 1).

Further, this study adopted an empowerment perspective for teacher professional development, explicitly stressing that teachers should have ownership of their professional development so that 'coming to know' as a professional is based on their own reasoning

processes in relation to their daily classroom and school experiences, and so that their own ideas and voices are effectively integrated with those of others (Cooney, 1996). The teachers' ideas have likely come from several sources, but what is key is that the teachers themselves mediate the ideas, construct meanings from them, and act according to their own values and decisions (Richardson, 1994). This empowers them to act as their own change agents for immediate and long-term goals.

Method

Since its aim was to understand the nature of a professional development learning endeavour, this study was designed as a naturalistic, interpretive inquiry. Hence, qualitative methods, with their capacity to emphasise contexts, meanings and individuals' interpretations, were adopted. More specifically, the research involved four classes in 2002 (N=62) and four classes in 2003 (N=86) of 4th-year Bachelor of Education (BEd) pre-service primary teachers. The sample consisted of 2 males and 60 females in 2002 and 3 males and 85 females in 2003, which was typical of the enrolment patterns in the BEd program. The researchers, as the class lecturers, acted as participant-observers (Fraenkel & Wallen, 2003).

Research Context

The unit in which the students (the pre-service teachers) were enrolled, Mathematics Education II, is a compulsory unit for the first semester of the students' final year. Students had previously completed 1 other unit with a focus on mathematics education. The students had no prior experience with professional portfolios, and hence, the unit was designed to introduce and support portfolio development in ways that had proven successful in previous research by one of the researchers (Frid & Reid, 2002; Reid & Frid, 2000, 2001). However, since this previous work was not focused within the 'challenging' curriculum area of mathematics and was conducted as a longitudinal study with a small group of volunteers, it was essential that the research question focused on in this report – how to support professional reflection within portfolio development – be included as a main research focus.

As a first step in supporting portfolio development, and to fit within the adult learning theory theoretical framework of the research, it was decided to stipulate key components for the mathematics teaching portfolio while simultaneously allowing for individual choice. The unit outline therefore stipulated that a student's mathematics teaching portfolio must include the following: a personal philosophy of mathematics teaching, an item related to assessment in mathematics, an item related to the use of technology in mathematics teaching and learning, a 3-week mathematics program, and an item on a topic of one's choice. In 2003, an additional item, a report on a trial of a teaching idea contained in the portfolio, was also included to provide an opportunity to more fully connect theory and practice. Students were also required to include a table of contents, a cover letter, a reference/resource list, final self- and peer-assessments, and any additional items deemed to be essential to presenting oneself as a mathematics educator. With these final portfolio items in mind, and keeping within the mathematics learning area strands targeted for the unit, Chance & Data and Working Mathematically, teaching and learning activities for the semester were designed to support portfolio development through ongoing class time opportunities to: clarify the goals and nature of portfolios; examine possible presentation formats; share and discuss draft portfolio items; and, most importantly, negotiate and

develop assessment criteria that would reflect assessment of the students' achievement of the mathematics education learning outcomes for the unit.

Finally, as a mechanism to support portfolio development as an 'authentic' professional task reflective of the realities of a professional teacher, and hence to fit within adult learning theory, it was decided to include a public portfolio exhibition and interviews with school principals and other educators as formal components of assessment for the unit. Students therefore engaged in the formulation, planning, researching, implementing, and reporting on their personal learning agendas within the context of knowing they would need to present and discuss their mathematics education ideas with experienced educators.

Data Collection and Analysis

Data were collected from: classroom observations; draft and final portfolio work samples; written feedback provided to students on draft and final portfolio items; and formal reflection sheets completed by students at the beginning, middle and end of the semester. The multiple data sources served as a form of triangulation for the research.

Data analysis proceeded inductively through a grounded approach (Powney & Watts, 1987), with the initial emergence of key themes derived from classroom observations, student reflections, and written feedback sheets for draft portfolio items. The draft portfolio items and related written feedback were then considered further within examination of data from the final portfolios, and final student reflection sheets.

Findings

The development of a teaching portfolio is itself a reflective process, and a main reason portfolios have become vehicles for professional learning (Frid & Reid, 2002; Lyons, 1998). It therefore is not surprising that reflection emerged in this study as a fundamental process that supported students' portfolio development. Thus, 'reflection' is not reported here as a key finding, but rather, the aspects of the unit that emerged as integral to the effective engendering of reflection: (i) development of a mathematics teaching philosophy, (ii) submission of draft portfolio items, (iii) lecturer and peer mentoring, and (iv) formal assessment interviews. Each of these four themes is briefly described in the upcoming sections and explicated along with examples from the data.

Mathematics Teaching Philosophy

By requiring development in the first couple of weeks of the semester of a draft mathematics teaching philosophy it was intended that students begin to think about their previous learning in their BEd program, with a focus on what they personally "truly believed" from their university studies and school experiences about mathematics teaching and learning. As indicated in earlier discussions, feedback to students throughout the semester stressed that they needed to justify the key ideas of their philosophies and provide evidence in their portfolios of how they would put these ideas into practice. What the lecturers did not anticipate was the degree to which many of the students engaged deeply in development of their philosophies through an ongoing, regular revision process that sometimes led to a total re-write of ideas. The degree to which students came to recognise the difficulty and subsequent value of constructing a philosophy was also not anticipated. The following comments from the end-of-semester reflection sheets on students' advice to future students highlight how many came to see the philosophy as a cornerstone for their portfolios:

> Write [your] philosophy first and get real concrete ideas as to what you believe. Then formulate other ideas surrounding what you actually believe. REFLECT what you believe in your programme. Keep revising your drafts. (Gwen)

> Make the activities meaningful for both children's learning and your philosophy. Don't be afraid to delve into a topic you are unfamiliar with. It allows you to gain a new perspective. Keep going back to your philosophy and personal views. (Sally)

> Really think about your beliefs, the way you like to teach before you develop your portfolio. If you go back to your beliefs you can't go wrong, because you'll be talking about what you know. (Daisy)

Submission of Draft Portfolio Items

The ongoing feedback to students via class sharing of draft portfolio items and written comments from the lecturers was instrumental in assisting students to develop capacities for articulating and justifying their ideas (Frid & Sparrow, 2003). In fact, students noted almost unanimously at the end of the semester that the requirement on a fortnightly basis to have drafts ready to share with others and then submit them to the lecturer was essential for revising their portfolios to make them the best they could be:

> During the process of creating my maths portfolio I continually had to reflect on what I had done and what I liked and disliked about my portfolio items. This then allowed me to make changes that I felt were necessary, and while my portfolio is not perfect, I believe that the finished product is much better than the original. Through reflection I was able to make the appropriate amendments to my portfolio. (Elena)

> Begin with a goal for your mathematics learning and teaching. Keep up to date with drafts and ideas. Don't be afraid to change your ideas/presentation. Talk to others about ideas. (Tracy)

Class and small group discussion in the sharing sessions in relation to the content and depth and breadth of a portfolio item led the lecturers, during portfolio development in the first year, to develop what later came to be known as the *what-why-how-who else says so-framework*. This *what-why-how-who else says so-framework* was a tool designed by the lecturers in consultation with the students to emphasise that in presenting an idea about mathematics education practices, particularly concerning innovation, students would need to communicate *what* the idea is, *why* it is valuable to mathematics learning, *how* a teacher could put it into practice, and what the research and professional literature reports about the idea (*who else says so*). The framework, while having this practical focus for preparation of portfolio items, also served to support the reflective component of the students' learning as emphasised within an empowerment perspective of personal learning.

Mentoring

The ongoing feedback from the lecturers on draft items was a form of mentorship from a more experienced educator, especially when it extended to short class, hallway and office chats about ideas. Peer mentoring was also in place in the design of the unit, as students shared portfolio ideas in formal class sessions, helping each other to think further about ideas, their relevance, how they might be applied, and how they might be effectively communicated in visual ways as part of a portfolio. What needs to be noted in the context of this research is not the emergence of mentoring and making students responsible for their own and others' learning as a valuable support for portfolio development; this was not surprising. Rather, what was significant was that this process appeared to be a key factor for supporting the 'weak' students, with weak defined in relation to academic achievement and confidence. It was these weaker students whose comments on the reflection sheets focused strongly on the value they had found in group sharing and reflections:

> Group reflection also assisted in boosting confidence and esteem. … Start early – it requires a lot of hard work! Group discussion – share ideas with each other to articulate ideas and better shape your beliefs. Re-read what you have done to make amendments. (Isabel)

> Able to see what we need to work on as well as what is going well. Gain ideas from another person and develop our information as well as learn from others. (Leanna)

> Great experience for future use, for example interviewing … I feel very capable of discussing my views, strengths and ideas. Collaboration with a colleague/peer. This has given me the experience and skills to discuss issues with others. … [Isabel] and I were well prepared. We knew our own and each other's portfolios and had discussed the questions. Our discussions with the interviewers flowed and were meaningful. (Sally)

This last excerpt from the final reflection sheets mirrors what was observed during the last few weeks of the semester and during the final formal interviews with external assessors; many of the weaker students worked very hard with each other and with other peer mentors to consolidate and enrich their knowledge and build their skills for the interview process. Thus, there was a sort of 'interaction effect' within the whole portfolio process – all students demonstrated much professional learning, but some of those that made the most advancements were the academically weak ones.

Interviews

The last excerpt in the previous section highlights how the interviews acted as a catalyst for students to take responsibility for personal consolidation of what they had been learning throughout the semester. Their comments after the interviews clearly indicated how the process of interview preparation had served as an authentic professional context for focusing their ideas and energies, and in fact empowering them to see themselves as professionals:

> It wasn't as 'scary' as I first thought it would be. Very beneficial!! Being able to talk about our work shows we actually knew what we had developed. … The more I spoke about my 'issue' the more I felt I could really implement this into my classrooms. (Anna)

> Effective to be able to articulate the components of the portfolio and in linking it all together. It's nice to have important people 'interested' in our accomplishments. I learned how to link one thing to another and how to be a professional around other professionals. (Gwen)

> The interview was a valuable experience as it helped us to articulate what we had learnt and helped to consolidate our learning. … was also an introduction to the professional procedures that are used. (Tracy)

Conclusions and Implications

In summary, the mechanisms and processes that emerged as effective in supporting the reflective process inherent in portfolio development were: (i) development of a mathematics teaching philosophy, (ii) submission of draft portfolio items, (iii) lecturer and peer mentoring, and (iv) formal assessment interviews. Although some of these findings were 'hoped for' in relation to the targetted learning outcomes for the students, what is most significant is that they were achieved over a relatively short time frame (14 weeks) and were achieved in a way that demonstrated the potential of portfolios as a technology to empower pre-service mathematics teachers.

As a technology – a tool for addressing the problem of a lack of mathematics confidence and pedagogic knowledge – the use of portfolios showed much promise, particularly for empowering pre-service teachers to serve as change agents in reform

efforts in mathematics education. This claim is in evidence in the following excerpts from students' reflection sheets and related advice to future students:

> It helped me realise that I knew all my work and all I had to do was explain it in layman's terms. And I did! Cool! … That I am a professional (soon to be) teacher. That I will be imparting my innovative ideas about teaching, assessment and the curriculum framework and student outcome statements to future teacher colleagues. … Don't perceive yourself as a student in the interview. You are a beginning teacher and you know what you are going to do in maths and it's all there in your portfolio. (Natasha)

> I have become aware of many of my hidden strengths and have found that even my fear of maths, which I thought was a weakness, is actually one of my biggest strengths, as it helps me to plan, program and explore maths with a real purpose, knowing I will offer my children more than I was (Carla)

> … consolidate learning and gain a sense of ownership over the ideas placed in the portfolio. Choose a theme to run with and base your ideas around the theme. Assess your own beliefs and don't worry if you have to challenge them. Be willing to change and reassess. (Danielle)

> Through the development of this portfolio I also realised how much I do not want to be like one of those teachers who just gives children worksheets to complete. (Elena)

What this research has raised as issues for mathematics teacher education and related research, in relation to the development of teaching portfolios, are the following questions:

- ☐ How can the portfolio process be further developed to support pre-service teachers in their development of connections in and ownership of their professional knowledge, particularly in relation to mathematics teaching?
- ☐ What is the potential of a mathematics teaching portfolio developed across a longer time period within students' pre-service education?
- ☐ To what degree does the professional empowerment of pre-service teachers as identified in this study extend to empowerment to enact mathematics education reform after graduation?

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