

Primary Mathematics Teacher Education: Teaching at the Heart of Learning

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In this presentation we use the theme of teaching at the heart of learning to illustrate the opportunities for pre-service teacher learning. The presentation reports on the outcomes of classroom based inquiry in primary level mathematics education. The research involved pre-service primary teachers and teacher educators collaborating with classroom teachers and primary principals in two incubator schools in Limerick city. We found that engaging pre-service teachers in the design, implementation and evaluation of mathematics study lessons provides a vehicle for better understanding of the complexity of mathematics teaching at the primary level. The process highlights the need for strong subject matter knowledge, understandings of developmental and learning trajectories, the developmental nature of mathematics learning, appropriate pedagogical strategies and representations, insights into pupil responses and misconceptions, and the organization of classroom structures to support learning. Pre-service teachers reported that engaging in the process of looking at teaching had a more profound impact on their learning than their previous experiences of traditional mathematics teacher education modules.

INTRODUCTION

While national and international studies agree that many factors affect the standard of mathematics education, there is general consensus that the teacher is the most significant resource i.e. high quality teaching is vital (OECD, 2005; EGFSN, 2008). Effective mathematics teaching is a complex endeavour requiring knowledge about the subject matter of mathematics, the theory of mathematics, the way students learn, and effective pedagogy in mathematics (Beaton et al, 1996). Primary mathematics teacher educators face the challenging task of facilitating pre-service primary teachers to develop this range of knowledge domains. Within the Irish context factors exist which pose obstacles toward the development of the range of skills and dispositions which contribute towards good mathematics teaching. While the limited time available for mathematics education during pre-service preparation is a constraint, pre-service primary teachers' experiences and beliefs relating to mathematics also affect their openness to and interpretation of approaches and methodologies presented in the mathematics methodology courses. The *apprenticeship of observation* (Lortie, 1973) that prospective primary teachers experience i.e. traditional didactic approaches focused on rote learning of mathematics, result in limited personal experiences of methodologies they are expected to model (Hourigan, 2009) and lead to beliefs about mathematics that are debilitating and narrow (Szydlik et al., 2003). It is evident that the task of initial teacher training is onerous. It has been established that where 'traditional' experiences are not challenged in the course of initial teacher education, pre-service primary teachers have been found to 'teach as taught' (Becker and Settler, 1996; Smith and Sutherland, 2003; NCCA, 2006). In fact, there is a strong case to suggest that mathematics teacher education courses are a 'weak intervention' in affecting pre-service primary teachers' knowledge, beliefs and attitudes (Nesbitt Vacc and Bright, 1994; Feiman-Nemser, 2001; Shiel at al, 2006). Moreover, there is evidence to suggest that the effects of university teacher education are 'washed out' by school experience (Zeichner & Tabachnick, 1981).

It is possible to challenge and transform pre-service primary teachers' attitudes and beliefs (Peard 2007) through the provision of opportunities to reflect (Ambrose 2004) upon and critique prospective teachers' own experiences with mathematics. Supporting this proposed approach, Kahan (1992: 77) cited in Szydlik et al (2003: 255) asserts

If a program is to promote growth among novices, it must challenge them to make their pre-existing personal beliefs explicit; it must challenge the adequacy of those beliefs; and it must give novices extended opportunities to examine, elaborate, and integrate new information into their existing belief systems. In short, pre-service teachers need opportunities to make knowledge their own

It was with this in mind that the mathematics education area decided in 2006 to make 'Japanese Lesson Study' a core component of the curriculum specialisation elective taken by pre-service primary teachers in their final year of study. It was intended that the process of engaging in classroom based inquiry, guided by the Lesson study structure, would promote reflection upon critical components of mathematics teaching and facilitate participating pre-service primary teachers to '*learn*' from the act of '*teaching*'.

METHODOLOGY

Participants

While each year since 2006, 20-25 prospective teachers completed Japanese Lesson study, this paper focuses on the Spring 2010 cohort of 21 final year pre-service primary teachers who studied mathematics education during the concluding semester of their teacher education program. These participants had completed their mathematics education courses (three semesters) and all teaching practice requirements (at junior, middle and senior grades) and self selected into mathematics education as a cognate area of study. Seven students were male; the remainder were female. Two students were international Erasmus students.

Lesson Study

All pre-service primary teachers, and three mathematics educators, engaged in *Japanese Lesson Study* (Fernandez & Yoshida, 2004; Lewis, 2002; Lewis & Tsuchida, 1998). Lesson Study is an approach for studying teaching that utilizes detailed analyses of classroom lessons. Lesson study was used in this study to facilitate the examination of both the planning of lessons and the implementation of those lessons in primary classrooms and thus provided an avenue to design tools and sequences of instruction to support the development of algebraic reasoning with primary children.

The research was conducted over a 12-week semester. Participants were organized into groups of 5-6 to work collaboratively on the design and implementation of a study lesson. Four groups were formed and requested to design a lesson to engage primary level children in learning specific algebraic concept i.e. growing patterns, equality, functions, variables. All of the selected algebraic concepts, with the exception of variables, received little or no explicit mention in the Primary School Mathematics Curriculum (Government of Ireland, 1999). Initially the pre-service teachers associated the latter three concepts with their secondary school mathematics experiences.

The first phase of Lesson Study involved the *research and preparation* of a study lesson involving researching algebraic topics and the construction of a detailed lesson plan. The *implementation* stage involved one pre-service teacher teaching the lesson in a

primary classroom while the other group members and the researchers, observed and evaluated classroom activity and student learning. Group members then *reflected on and improved* the original lesson design through discussing their classroom observations and modifying the lesson design in line with their observations. The *second implementation* stage involved re teaching the lesson with a second class of primary students and *reflecting* upon observations. The second implementation was videotaped. The cycle concluded with in-class presentations of the outcomes of each of the four lesson study groups.

Data collection and analysis

The primary method of inquiry was collective case study (Stake 1995). The principal data collection technique was participant observation; the researchers were closely involved with the work of each group throughout the cycle. Data collection methods were closely intertwined with and ran concurrent with the lesson study cycle. Detailed description of the data collection tools and methods in addition to the data analytic strategies are outlined in Leavy (2010).

RESULTS

In this paper we are reporting specifically on the impact of Lesson Study on pre-service teachers' knowledge of algebra and beliefs about mathematics. This paper reports on two collective case studies – the reflections of participants in the 'Equality' and 'Growing Pattern' groups. As part of the Lesson study process, participants were required to partake in ongoing reflection throughout. More formally as part of the course assessment structure they were requested to complete structured reflections in response to prompts namely '*What I learned about algebra*' and '*What I learned about teaching algebra*'. Insights were also gained from group presentations at the end of semester (representing the final stage of the lesson study cycle) as well as anonymous course evaluations.

Reflection – Participants' Perceptions of Effect of Lesson Study Participation

On analyzing the responses, a number of common themes emerged. Analysis of the responses facilitated the researchers in drawing conclusions regarding the perceived effects of the participation. Due to the space limitation of the paper, it is only possible here to provide a 'taste' of findings.

Benefits of Collaboration

A number of the groups made reference to the fact that they had benefited from the opportunity to work as part of a group i.e. engaging in collaboration (Hiebert 1999). The following excerpts provide some insight into the reported benefits as perceived by the pre-service teachers:

'Working collaboratively in groups gave us the opportunity to benefit from each other's ideas and differing perspectives...' (Growing Pattern group presentation)

'I learned and heard lots of ideas I certainly wouldn't have thought of if I was planning the lesson on my own' (Equality group: Geraldine)

In the course evaluation, one student also categorised '*Sharing each others ideas and work*' as a '**strength**' of the course.

The Nature of Algebra and Mathematics

Analysis of the data suggested that participants' beliefs regarding the nature of algebra had changed over the Lesson study cycles e.g. *'I purposefully avoided teaching algebra in any of my teaching practices being under the illusion that it was too complex, abstract and unimportant and not a broad enough topic. After carrying out the lesson study, I found that this was not the case'* (Equality group: Tony)

A number of students reported that the experience had also affected their beliefs regarding the nature of mathematics generally:

'The lesson study has taught me that mathematics is not just a whole lot of rules that children must learn in order for them to progress in life.' (Growing Pattern group: Roy)

Mathematics Subject matter knowledge (SMK)

The majority of participants reported that engaging in classroom based inquiry made them aware that their SMK was weak and revealed the nature of their misconceptions:

'...I had a limited understanding of what the equals sign means...I understood the equals sign ...as 'is' (as in $3+5$ 'is' 8) not as 'is the same as' or the 'same value as', so I learnt something very important myself' (Equality group: Mia)

Participants reported that partaking in the lesson study developed their personal SMK.

'My own understanding of algebra has most definitely improved throughout the course of our Lesson Study Project....Before this, my knowledge was poor but now I am able to understand the background knowledge needed...' (Equality group: Sophie)

'I am glad to say that after completion of this lesson study assignment my concept of algebra has been vastly broadened' (Growing Pattern group: Ciara).

The development of 'deeper' understanding was reflected in the fact that a number of students focused on relationships within and between various areas of mathematics:

'I now realise that children who understand equality are well on their way to understanding relationships expressed by number sentences/equations' (Equality group: Mia)

'I also developed the understanding that in many cases algebraic reasoning is integrated with arithmetic' (Growing Pattern group: Donal)

Increased awareness of the benefits of specific teaching methodologies/strategies

While some students acknowledge the need for a variety of methodologies e.g. *'I have also learned the importance of using many teaching techniques which teaching algebra ...'* (Growing Patterns group: Donal), all students reported that they had gained insight into the benefits of specific teaching methodologies in the course of completing the lesson study project e.g. *'We learned the importance of working out problems with concrete materials before moving onto written problems, the value of story as a teaching method, the importance of incorporating images and colour into your materials, how to keep interest and motivation levels up by changing methodologies...'* (Equality group: Mia).

The experience also developed general pedagogical skills and decision making:

'It offered me insight into how effective group work is. I saw...that pupils teach each other and learn from others...' (Equality group: Valerie)

Many also reported developing appropriate questioning techniques:

'I think the main thing we learned...was to keep questioning as open-ended as possible...' (Growing Pattern group: Donal)

'I have realised that the child's responses should act as a catalyst for learning...' (Growing Patterns group: Ciara).

CONCLUSIONS

The data arising from this study emphasize the value of classroom based inquiry in supporting pre-service teachers in translating the theories presented in traditional lecture-style pedagogy courses to classroom based pedagogical practices. The benefits of 'looking at teaching' ranged from the development of general pedagogical skills (i.e. the management of learning, development of questioning skills) to revealing mathematical misconceptions and generating new understandings relating to subject matter knowledge (in this case, in algebra). While participants repeatedly acknowledged that completing lesson study was labour-intensive, consensus existed that the benefits far outweighed the demands: *'I feel lesson study while time consuming, its benefits are rich in facilitating teachers learning...'* (Growing Pattern group: Donal). In support of such sentiments one student wrote on the course evaluation: *'Hard work!! But totally worth it'*.

The extent of the reported impact was quite remarkable from a number of students:

'Finally, I would like to say that this lesson study experience has honestly taught me more about the art of teaching than any other activity I have undertaken in the last three years in Mary I...' (Equality group: Mia)

Despite having had pedagogy sessions previously on the respective algebra concepts students reported that participation in lesson study facilitated real understanding:

'...I am so glad I got to experience this before leaving college as I more than likely would have left with the wrong impression of algebra' (Growing Pattern group: Meg).

Examining 'real' teaching provided in-depth opportunities for active learning. Another feature common to lesson study which supported the development of understandings was the opportunity to emphasize how children learn (Fennema et al. 1996). Lesson study served as the vehicle wherein participants learned from engaging in and observing teaching; in contrast to traditional pedagogy courses where we just talk about teaching.

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