Use of the Internet for Teacher Professional Development and for Teaching Mathematics: Supports and Inhibitors

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This paper reports on a part of my ethnographic study about uses of the Internet for teacher professional development and teaching mathematics. Drawing on two case studies of teachers in Queensland, I analyse what factors (personal and contextual) support or inhibit mathematics teachers in making use of the Internet for teacher professional development and for teaching mathematics. The findings support the notion that teachers' knowledge and beliefs are key determinants in embracing technology as a tool for teaching and learning.

Introduction

Numerous studies have been conducted related to the educational potential of the Internet, including in relation to enhancing mathematics teaching (e.g., Moor & Zazkis, 2000) and teacher professional development (e.g., Gibson & Bonnie, 2004; Timmerman, 2004). However, the potential of the Internet for teachers to improve instructional practices has remained largely unexplored. Very little is known about how mathematics teachers use the Internet for their own professional learning and how this learning with the Internet would impact on the qualities of students' learning processes in the classroom. This issue is addressed by the ethnographic study reported in this paper.

The study firstly investigated a *High Use Internet (HUI)* teacher, that is, a teacher who intensively uses the Internet to sustain his/her professional growth as a mathematics teacher. It explored ways in which the HUI teacher used the Internet in teaching mathematics, reasons to integrate the Internet in teaching mathematics, the impacts of mathematics teaching using the Internet on students' learning and philosophical beliefs about teaching and learning using technology (Patahuddin & Dole, 2006a, 2006b).

In the second phase of the study I worked with a *Low Use Internet (LUI)* teacher, a teacher who had not made use of the Internet for those main goals but had a willingness to do so. This involved identifying the theoretical framework to work with the LUI teacher, developing a website and Blogs, exploring many websites recommended by the HUI, and familiarising myself with the potential of the Internet as a source of information, a means for communication, and a site for collaboration. My aim was to assist the LUI teacher to use the Internet for his professional development and for his mathematics teaching. The first phase of the study with the HUI teacher helped me in anticipating strategies to encourage the LUI teacher to use the Internet as a tool for learning and teaching mathematics.

My work with the LUI teacher was guided by five characteristics of effective professional development that were generated from analysis of relevant literature (Abdal-Haqq, 1995; Little, 1993; Putnam & Borko, 1997; Wilson & Berne, 1999): Effective professional development:

- is on-going;
- is collaborative and aims to promote and connect participants in learning communities;
- is student-oriented, focusing on student-centred approaches to teaching;
- takes into consideration the individual teacher and his/her context; and
- has as its prime focus the enhancement of pedagogical content knowledge.

In the process of analysing the data using this effective professional development framework, I found it difficult to explain a number of noticeable factors that facilitated or supported the LUI's attempts to use the Internet in his teaching and learning and a number of factors that interfered with or hindered change. Consequently, I turned to Goos's (2005a, 2005b) adaptation of zone theory in order to address the main research question that drove my study:

- What factors support and inhibit effective professional development for using the Internet as a tool for teaching and learning mathematics?

Three Zones of Influence in Teacher Professional Learning

The theoretical framework employed in this paper refers to the three zones of influence in teacher professional learning developed by Goos (2005a). This theoretical model adopts Valsiner's zone theory, an expansion of Vygotsky's Zone of Proximal Development (ZPD). The ZPD symbolises a space where a child's potential for learning will occur. It is the distance between what a person can do with and without help. In Valsiner's studies of child development, he introduces two additional zones, the Zone of Free Movement (ZFM) and the Zone of Promoted Action. The ZFM represents what actions the child is allowed, while the ZPA represents actions that the adult promotes as an attempt to influence the child's behaviour (Valsiner, 1997).

Goos extended the use of Valsiner's zone theory for several purposes: to understand the complexities of teachers' construction of identity (Goos, 2005a), to study interaction between students, technology and the teaching-learning environment (Goos, 2006), to analyse the pre-service and initial professional experiences of a novice teacher in integrating technologies into his classroom (Goos, 2005b), and to evaluate the effectiveness of the professional development (Goos, Dole, & Makar, 2007).

Goos (2007) proposed the zone theoretical model of teacher learning and development as follows.

> The first Zone [ZPD] represents teacher knowledge and beliefs, and represents the potential of development. This zone includes teacher's disciplinary knowledge and pedagogical content of knowledge.., and beliefs about their discipline and how it is best taught and learned. The second zone [ZFM] represents the professional context which defines the teaching action allowed. Elements of the context may include curriculum and assessment requirements, access to resources, organisational structures and cultures, and teacher perceptions of student background, ability, and motivation. The third zone [ZPA] represents the sources of assistance available to teachers in promoting specific teaching actions, such as that offered by a pre-service teacher education course, supervised practicum experience, professional colleagues and mentors in the school, or formal professional activities. (p.416-417)

Goos (2006) also stated that the relationship of the three zones "provides a useful way of analysing the extent to which teachers adopt innovative practices involving technology". She theorised that the development of teachers is determined by the relationship between all the elements of the three zones.

Design of the Study

The HUI and LUI teachers in this study were given the pseudonyms of Ann and Jack. Ann was observed in her normal school setting for two weeks and interviewed on several occasions over a four week period. Continued e-mail conversations between the teacher and the researcher occurred after the observational period. The study with Jack in his classroom was from February-August and November-December 2006.

An ethnographic approach was chosen for this study. It employed multiple data gathering methods: participant-observation, interviews, questionnaires, and written and non-written sources. In this study, the teachers completed several questionnaires, providing information about their professional background, how they use the Internet for professional development and for teaching and learning mathematics. Informal interviews with the teachers were held on several occasions, to clarify responses to questionnaire items and to verify my perceptions of what I had observed. I also accessed the Internet to find the teachers' favourite websites, as listed in their computers' bookmarks. E-mail communication was a part of the data collection method, and this occurred both during and after the fieldwork. Videotaped lessons also assisted in completion of the field notes.

Ann's Case Study

Ann was an experienced teacher who had been teaching at different grade levels from pre-school to Grade 7 at several different schools across Australia. She had many opportunities to attend various ICT workshops or conferences. Her professional learning about the uses of technology, including the Internet, started during the early years of the availability of the Internet for education in Australia. Ann stated that many PD programs she has attended have continued to inspire her to use the Internet in her teaching. They have triggered her curiosity to explore further uses of the Internet as a learning tool through using the Internet itself. The most exciting feature of the Internet, as identified by Ann, was how it easily it can be used as a communicative device. This has allowed Ann to learn from other teachers without the need to leave the school. Ann regards the Internet

as a rich living resource. One memorable comment that sums up Ann's feeling towards the Internet was: "If I didn't have access to the Internet, it would be like having my hand cut off".

Ann has a less than favourable environment since her classroom was a very crowded space and had limited resources. Even though she had six computers (including one very old computer that cannot save any work) in her classroom, only two were connected to the Internet. Things were difficult when her classroom had problems with the computers and there was not ICT support available in her school. Ann's students were very passive at the beginning of the year and often disengaged in learning for many reasons. However, Ann's perceptions of her students were very positive and she believed that her students had potential to think and to control their own learning.

Ann has a broad view about mathematics. She believes that mathematics is more than right or wrong, that it exists everywhere and as a tool to solve problems. Ann's belief about learning is that it is a process of constructing ideas by the learners and therefore teaching should engage students in their own learning. Because she stated her belief that "students are at the centre of learning" and every student has different levels of understanding and interest, her instructional practices cater for this diversity to make sure that every individual student is learning.

Ann's belief about ICT, including the Internet, is that ICT skills are important for a student's life and it is a powerful tool to enhance teaching and learning. Through compilation of interview data and classroom observations, I discovered that Ann's existing knowledge and beliefs about mathematics, teaching and learning mathematics are compatible with her beliefs about the Internet. Ann was already a *student-centred* teacher when she first used the Internet. She realised that the Internet is a powerful way to place the student at the centre of the learning process. Therefore Ann regards technology and including the Internet as vital to her learning and teaching style.

Interestingly for Ann, when the Internet first became available at her school (one Internet-connected computer available at the library in 1996), she immediately started using it in her teaching. In 2000, the Internet became available in her classroom and since that time, the Internet has become a part of her mathematics teaching. She particularly was keen to exploit the academic potential of the Internet as a communication tool to connect her students with other students from other schools in Australia or other countries. She has been continually experimenting with her students in using the Internet as a learning tool (Patahuddin & Dole, 2006b).

At the time of this research, Ann was implementing the new Queensland Mathematics Syllabus. This syllabus has a high emphasis on thinking, reasoning and working mathematically and emphasises the uses of communication technologies in teaching mathematics (Queensland Studies Authority, 2004).

Jack's Case Study

Jack is a beginning teacher who had commenced his second year of full-time teaching at the time of this study. In his first year, Jack taught Year 3 and in the second year he was teaching Year 2. During his first year of teaching, Jack attended several teacher professional development programs, but none of these related specifically to using the Internet for mathematics teaching and learning. He is a competent user of Microsoft Word, PowerPoint, Excel, and Kid Pix. He also knows how to make a website with FrontPage. Jack has access to the Internet both at school and at home, and uses the Internet for e-mail, banking, and shopping.

Jack's school was well-resourced. His classroom has a spacious feel. The desks for the 26 students are organised into five groups, leaving a large space for students to sit comfortably in a big circle on the carpet. His classroom has good access to four computers with a fast Internet connection. His school espouses support for use of ICT. The students were mostly from wealthy and well-educated families representing many cultures, and they were motivated and well-behaved. All these presented favourable opportunities to use the Internet for mathematics teaching and learning.

His words – "I want the students to have a good understanding of addition strategies, and the number facts" – and my observations suggest that Jack placed more emphasis on computational skills and less on mathematics thinking and problem solving than is suggested in the Queensland Mathematics Syllabus. Even though in some ways he said that he wanted to be student-centred, I have seen through my work with him that he preferred a teacher-centred approach. This is clearly indicated by the reason he gave for using the data projector instead of giving opportunities to students for more individualised instruction:

> … because I find it is easy with a data projector because you can do it for a whole class at once. And I think, they can all sit down, they can all see it rather than have them to use the computers. And then I think I prefer to do it that way then have the children back to their desks and doing an individual activity from there, like maths textbook or something from the board, as a consolidation because we only have four computers and I don't have time to supervise them all.

Unlike Ann, Jack's beliefs about the Internet for learning are very limited. He appeared to see the Internet as an "add-on". His claim that students look happy without the Internet reflects his beliefs that the Internet is just another tool and teachers do not necessarily have to use it.

While Ann sees the new Queensland Mathematics Syllabus as an opportunity to integrate technology into learning and teaching, Jack sees it as constraint. He did not use this new syllabus because he preferred to use the school program. At the beginning of the year, he told me that the school program was more practical for him than the new mathematics syllabus. Hence, he had not familiarised himself with the new mathematics syllabus and instead relied solely on the school program. Jack as a beginning teacher had rudimentary pedagogical knowledge as well as pedagogical content knowledge. Through my work with Jack, I discovered his difficulties in managing the students' learning. Jack's perception of the ability of his students was quite low; for example, I could see that he tended to pose simple problems to his students. He was very surprised when he found that one of his students could answer a non-routine and complex problem of the school enrichment test.

Time seemed a problem for Jack. Through interviews, I discovered that Jack often saw lack of time as a constraint to use the Internet. For example, he had not enough time to read emails. He lacked time to do some rotational activities that involved computer activities for one group. He gave up providing opportunities for students to access the Internet in their free time in the morning as it was the busiest time of day for him in managing his teaching plan. This might be because it was his first experience in teaching a Year 2 class. He worried about lack of time for teaching if students were involved in many group activities.

Analysis Using Zone Theory

Relationship between Ann's ZPD, ZFM, and ZPA

Ann attempted to enact her pedagogical beliefs (ZPD) by optimising the potential of the Internet. For example, she managed the classroom so that over time, students rotate through an activity to use the Internet. She took advantage of the limited resources to help her in assisting student's learning and to provide more individualised instructions.

The relationship between the curriculum element of Ann's ZFM (the new Queensland Mathematics Syllabus) and her ZPD (knowledge and beliefs) is very positive. This part of the ZFM appeared to afford teaching actions consistent with her beliefs about mathematics teaching and learning. The new syllabus is an affordance for Ann because it supports her preferred teaching approaches. From the interview, I discovered that she interpreted the recent syllabus as allowing her to teach investigation and problem solving and opening opportunities to incorporate the Internet into mathematics teaching.

There is a strong overlap between Ann's knowledge and beliefs (ZPD) and the kinds of professional development that she has sought out (ZPA). Her initial reaction to Internet related PD was positive because she could see how to use the Internet in ways consistent with her pedagogical beliefs (student-centred, investigative). The affordances of the Internet allowed her to continue her learning through virtual PD in her own time. Her beliefs about the Internet and her interest in its communicative potential led her to explore many learning and teaching resources as well as to involve herself in online professional forums. Also, the ZPA offered through the Internet (e.g., multiple representations) is compatible with Ann's beliefs about student-centred approaches. This positive relationship allows Ann to cater for the diversity of students' interests and abilities. For example, Ann used the Internet for remediation or extension or for "disengaged learners". As a result, Ann regards the Internet as an extension of herself as a teacher.

In summary, Ann looks at her professional context through the filter of her ZPD/ZPA relationship. The configuration of Ann's knowledge and beliefs, professional contexts, and sources of support came together to shape opportunities for her professional learning using the Internet.

Relationship between Jack's ZPD, ZFM, and ZPA

I was present in Jack's classroom as a participant observer to promote uses of the Internet for his learning and for his mathematics teaching without explicitly asking Jack to change his teaching direction. Ideas to support Jack had emerged as a result of my daily interactions with him. In this case, the researcher is one of the elements of Jack's ZPA.

All the approaches I used with Jack emerged, developed and proceeded at different times throughout my work with him. For example, I used e-mail communication, organised educational websites into Blogs, planned and designed mathematical investigations with Jack, showed him mathematical websites and worked with his students, and linked selected websites to his mathematics teaching program (see details in Patahuddin, 2007). Even though I continuously evaluated what I had done and thought carefully about the next type of strategy I could use, I often found it difficult to promote the uses of the Internet for Jack's professional development. Zone theory is useful for analysing matches and mismatches between influential factors in the three domains of knowledge and beliefs (ZPD), professional context (ZFM), and sources of assistance (ZPA). Two critical events from my work with Jack are selected to exemplify this analysis.

Because I discovered that Jack was unfamiliar with the new mathematics syllabus I decided to provide a table that linked a variety of websites (e.g., for remedial work, extension, hands-on activity, individualised instruction) directly to every topic in his mathematics teaching program. This strategy yielded positive outcomes in that it gave Jack more time to explore mathematical websites. He also began to ask: "How can we use all these great websites without using rotational activities?", which suggested that he had started to realise that his existing preferences and beliefs about teaching with data projector presentations (mentioned previously in this paper) was not compatible with his new notions about teaching with the Internet. Analysing this event through the lens of zone theory, we note that this aspect of the ZPA I offered was a good match for Jack's existing ZPD. Here, my strategy seemed successful in challenging Jack's ZPD. As Borko et al. (1997) explain, "… efforts to help teachers make significant changes in their teaching practices must also help them to acquire new knowledge and beliefs. At the same time, teachers come to understand new practices through their existing knowledge and beliefs" (p.272).

I took advantage of Jack's emerging dissatisfaction with his instructional practice by trying to change the way he organised classroom use of computers (Jack's ZFM). After observing that the computers were used very rarely by students, I suggested they might use the Internet as a part of their regular free morning activities. Jack was initially enthusiastic, but quickly gave up applying this idea because of other elements of his ZFM (only two computers were available as he kept two computers for teachers) and his ZPD (beliefs that students could not manage their learning using the Internet and that his teaching was effective without the Internet).

My attempt to bring Jack's ZPD and ZFM closer together was not entirely successful as I did not fully address Jack's existing ZPD. Apparent enthusiasm does not necessarily translate into confidence in use. Previous researchers (Borko et al., 1997; Borko & Putnam, 1996) inform us that changing beliefs usually takes a long time. Also, what teacher states as his/her belief does not necessarily mean that they own this belief.

Conclusion and Implications

Perhaps, most teachers in Australia would look at Ann's ZFM (poor resources, cramped space, and passive students) as constraints in achieving rich learning using the Internet. However, my study shows that Ann has agency to act on her environment. She works on shaping a classroom environment that will allow her to put her beliefs into practice. I argue that what really drives Ann in her teaching is her knowledge and beliefs (ZPD). This means that the Zone of Free Movement is not necessarily the real environment around teachers, but a way teacher see and interpret the environment (Goos, 2005). Thus one person can see a classroom like Ann's as a constraint, while another with different knowledge and beliefs might see the same classroom as an opportunity.

Jack's case study illuminated issues for a beginning teacher who was familiar with technology in his daily life but not yet integrating it into his own learning and teaching. While his ZFM was favourable, his preferred teaching approach and pedagogical beliefs (his ZPD) hindered optimal use of the Internet for learning. Jack views professional development through the filter of his ZPD/ZFM relationship. His beliefs and his professional context orient him towards seeking PD that will allow him to function more effectively in that context, for example, by providing ready-to-use resources he can use in whole class, teacher-centred lessons.

This core finding demonstrates that resources alone do not guarantee rich learning and successful teaching and supports previous findings that Internet availability in schools has not been optimised in teaching (Becker, 2000; Gibson & Oberg, 2004; Wallace, 2004). Governments in many developed countries (e.g., Canada, USA, England, Japan) have invested substantial amounts of money in technology and yet the potential for this technology to improve educational outcomes has not been achieved. The present study suggests that teaching resources are not the key to a technology-rich mathematical learning environment, as computers and the Internet are only tools that could either enrich or restrict learning.

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