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Using the Productive Pedagogies Framework to Build a Community of Learners Online in Mathematics Education

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Productive pedagogies (PP) is an influential framework for teaching and learning that has featured well in current reforms of teacher education. The present study was designed to examine principles of PP adopted by a cohort of beginning mathematics teachers. A networked online learning environment, WebCT™, facilitated the teachers' deliberations about PP. The uptake of PP by these new teachers was examined in the context of a collaborative activity in which the teachers were required to reflect on, critique, and share views with peers about a lesson on the teaching of multiplication. These online interactions are argued to provide opportunities for shared learning and activity. Qualitative analyses of the results show that participants espoused and embraced dimension of PP in varying degrees. The implications for using WebCT™ and similar online course management systems to support teacher reflections on best practice are discussed.

Introduction

Current debates about educational reform are concerned with the role of teachers in supporting the active and meaningful participation of learners. The characterization of a good teacher and how one becomes a good teacher continue to dominate these debates. A core issue here is the continuing professional development of teachers upon graduation from teacher training institutions. To this end, the use of information and communication technologies (ICTs) to support teachers in practice has been given increasing attention (Nicoll & Harrison, 2003).

There is an emerging consensus that ICTs provide alternative and innovative strategies to help practising teachers, as well as teachers who are in training. This

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trend is accompanied by a solid body of research that had examined the value of teachers reflecting on their own practice online. However, how this exercise really contributes to their growth as professional practitioners is less clear? Specifically, limited work has gone into answering this question by locating the issue of practice and pedagogy within a subject matter domain. That is the focus of the study reported here. The main research question was: How could WebCT™ be used to promote shared learning, activity, and reflection that are pedagogically powerful for mathematics teaching and learning? Judgements about participants' personal and evolving pedagogies were made against the principles of productive pedagogies (PP) (Hayes, Mills, Christie, & Lingard, 2006; Queensland School Reform Longitudinal Study, 1999).

Literature Review

Theoretical Framework

Current theories of learning have focused on the role of the learner in actively constructing meaning on the basis of inputs from other members who are involved in the social process. It is suggested that deep and meaningful conceptual understanding is better promoted by environments in which the learner is provided with tasks and skills that provide opportunities for reflection and verbal interactions with their peers (Vygotsky, 1978). The ensuing collaboration with other members increases the scope for learners to critique their own idiosyncratic perceptions and revise conceptions in the light of new information and alternative perspectives from their colleagues. Exploratory talk has been shown to be an effective mechanism for the promotion and maintenance of the cycle of discourse, reflection, justifications, and refinement of one's own thoughts (Littleton & Light, 1998).

In order to support the continuing development of teachers we need to recast their role as learners from the above framework of socio-constructivism. Thus, teachers as learners need an environment that fosters independent thinking and reflection about the subject matter they will be teaching and the pedagogies that undergird their teaching practices. In the case of mathematics, teachers who are new to their chosen profession need to develop an appreciation of the core content of primary school mathematics and ways to represent that content to young children. Thus, instruction for the continuing development of teachers of primary school mathematics needs to encourage them to initiate discussions, engage in critical reflections, and analyse authentic contexts for the development of numeracy. The articulation of their understandings in discussions can prompt new lines of thinking and help them acquire new strategies about teaching and learning mathematics among young children.

Online Discussion and Development of Recent Graduates

The above framework of social constructivism that underpins online discussion and collaborative learning suggests that there is considerable opportunity for instructors to utilize this medium to support the continuing professional education of recent graduates. While conventional undergraduate programmes provide practice-based learning, in the main, graduating students tend to have limited understanding of the expectations of their profession, including tensions that might exist between the knowledge gained from their tertiary studies and the actual application of this knowledge in practice. Graduates could better understand this tension if instructors could devise teaching methods that foster open communication and debate among the graduates who are commencing their professional work. It is here that online discussions hold great promise as tools of effective practice-based communication.

In the case of new teachers of primary school mathematics online discussions could provide a vital forum for sharing the dilemmas of practice in the context of real classrooms. The culture and policies of schools vary greatly and beginning teachers (BTs) are expected to translate formal theoretical knowledge into forms that children and the school community can understand. This body of knowledge and understanding is thus grounded in particular contexts. Primary school mathematics teachers need to be flexible and be able to transfer ideas from their tertiary studies in making sense of the needs of a particular school community. By sharing the problems and concerns of their own school context, teachers can better understand, anticipate, and develop potential solutions to the learning demands of children in their classroom.

BTs can learn mathematics and mathematical pedagogies through social interactions, meaning negotiation and shared understandings. As learners and practitioners, teachers who are new to the profession become acculturated by participating in discourses and cultural practices and appropriating contributions from other members of the community. The socio-cultural perspective of learning suggests that BTs can best learn how to critically reflect on practice online, where they have the opportunity to discuss practical problems with peers of greater and lesser experience (Schon, 1983). Encouraging practitioners to engage in discourses and studying the quality of such interactions has been argued to constitute an important area of study for mathematics teachers and researchers (Herbel-Eisenmann, 2005).

Learning that involves learners interacting with each other without the constraints of time is referred to as asynchronous learning (AL). AL environments have increasingly been used to conduct courses in the distance mode. In so doing, educators recognize the value of this medium to generate a critical mass for the engagement of a community of learners (Graham & Scarborough, 2001; Kofoed, 2004). In the current study a community of learners were engaged in the AL mode by sharing, reflecting and critiquing views expressed by members of a group of BTs within a course management system, WebCT™.

Productive Pedagogies and its Indicators

The nature of pedagogy that drives practice in the classroom has featured prominently in a number of reviews that have been conducted in Australia about teacher quality and student achievement (Australian Council of Deans of Education, 1998;

National Project on the Quality of Teaching and Learning, 1996; Ramsey, 2000). These reviews have identified a range of skills, knowledge, and understandings that are deemed to be desirable attributes of future teachers. Against this background, the framework of PP has been at the forefront of discussions about how we can situate teacher's actions and knowledge in classes that aim to cater for students' diverse cultural and ability needs.

The framework of PP, which had its genesis in a research study conducted in Queensland (Queensland School Reform Longitudinal Study, 1999), has generated considerable optimism and excitement within the education community for its potential to provide a solid basis in which to ground and make judgements about good teaching practices (Gore, 2001; Gore & Morrison, 2001; Hayes et al. 2006). PP has also provided an integrated alternative to the myriad frameworks that are available to teachers who are looking for something innovative in which to anchor their beliefs and practices. PP consists of a series of indicators that are grouped into four major dimensions: intellectual quality, relevance, supportive classroom environment, and recognition of difference (Table 1).

Mathematics Learning and Productive Pedagogies

The reforms suggested in PP directly address some of the principal concerns of mathematics teachers and educators. Recent thinking about mathematical pedagogy has placed an increased emphasis on building children's mathematical identities by inviting children to play an active role in learning and setting the agenda for learning (Putnam, Lampert, & Peterson, 1990). In so doing the social context in which children come to construct understandings is seen as important as the content that teachers anticipate children to learn. According to this line of thinking, becoming competent in mathematics is reconceptualized as inducting new learners to the discourse of mathematics that is practiced by the community of more mature members (Brown & Borko, 1992) such as teachers and parents.

For instance, how could PP be played out in the mathematics classroom where the focus is on the teaching of number systems? The topic of numbers and numeration is an important area within the K–6 syllabus. The character of the base 10 system as we know it today and the contributions made by different cultures to its evolution constitute a fascinating journey in the study of numbers, operations, "mystical" properties, and use of such numbers in the solution of children's day-to-day problems. Every dimension of PP can be activated during the course of teaching in ways that could problematize the above aspects of the number system, including the enactment of the relationship between, say, the base 2, base 5 and base 10 numbers systems.

Classroom practices that are consistent with the model of PP enable teachers to devise and implement learning strategies that are culturally sensitive and inclusive in that these allow the observation and evaluation of mathematics learning from the viewpoint of the learner, as opposed to measurement of learning against an externally developed set of criteria. Research work that has focused on the multidimensional

Table 1. Dimensions of PP and questions addressed

Intellectual Quality	
Higher order thinking	Are higher order thinking and critical analysis occurring?
Deep knowledge	Does the lesson cover operational fields in any depth, detail, or level of specificity?
Deep understanding	Do the work and responses of the students provide evidence of understanding of concepts or ideas?
Substantive conversation	Does classroom talk break out of the initiation/response/ evaluation pattern and lead to sustained dialogue between students, and between teachers and students?
Knowledge problematic	Are students critiquing and second-guessing texts, ideas, and knowledge?
Metalanguage	Are aspects of language, grammar, and technical vocabulary being foregrounded?
Relevance	
Knowledge integration	Does the lesson range across diverse fields, disciplines, and paradigms?
Background knowledge	Is there an attempt to connect with students' background knowledge?
Connectedness to the world	Do lessons and the assigned work have any resemblance or connection to real life contexts?
Problem-based curriculum	Is there a focus on identifying and solving intellectual and/or real world problems?
Supportive Classroom Environment	
Student control	Do students have any say in the pace, direction, or outcome of the lesson?
Social support	Is the classroom a socially supportive, positive environment?
Engagement	Are students engaged and on-task?
Explicit criteria	Are criteria for student performance made explicit?
Self-regulation	Is the direction of student behaviour implicit and self-regulatory or explicit?
Recognition of Difference	
Cultural knowledge	Is diverse cultural knowledge brought into play?
Inclusivity	Are deliberate attempts made to increase the participation of all students of different backgrounds?
Narrative	Is the teaching principally narrative or is it expository?
Group identity	Does teaching build a sense of community and identity?
Citizenship	Are attempts made to foster active citizenship?

aspects of mathematical meaning constructions and the role of the learner in knowledge creation support the traits of PP. For example, in a study about numbers Cronin and Yelland (2004) have found PP to be a powerful framework in assessing the positive numeracy outcomes of young Australian indigenous children. Numeracy refers to interpreting and using mathematical ideas to make sense of the environment and the development of solutions by the learner. In this enterprise it is the coming to understanding that is key. The various representations and models and the conjecturing that mediates these constructions should inform their assessment.

Design and the Learning Environment

In the study described in this paper a cohort of BTs were involved in web-based collaborative learning. The design of this learning environment was consistent with constructivist principles in which learning involves the internal construction of meaning. During this process the learner builds and reshapes personal knowledge of the world through the experience of interactions with the world (Jonassen, 1994, 1997), as opposed to learning being the transfer of knowledge from the expert to the novice.

The learning design that was developed for this study focused on 'Mathematical pedagogy for K–6 mathematics' (MPMIII), which is a core subject for BTs in the Bachelor of Teaching (Primary) programme at the University of Wollongong. MPMIII is taught in face-to-face mode for a period of 13 weeks. The teaching approach involves a combination of lectures and tutorials. The tutorials were used to explore ideas raised in the lectures. This is achieved through a series of mathematical activities where teachers are asked to analyse an activity, examine the core concepts that were mediated by the activity in question, and embed that activity in the course of a lesson. Following this, teachers engaged in discussions about pedagogical implications and possible extensions of the activities for their teaching. Because the students were practising teachers, the designer of the course aimed to provide a further forum for the teachers to share the actual impact of the activities as these were implemented in their own classrooms. WebCT™ was used to generate this forum. The face-to-face interactions and the discussions online were expected to complement and deepen teachers' understanding of the content and pedagogy underlying primary mathematics.

This forum helped to engender a virtual learning community (VLC) for the participating teachers, allowing increased interactivity with their peers, giving an opportunity for the construction of arguments, and providing constructive feedback without the constraints of time, pace, or place. The design was aligned to the model of a VLC proposed by Schrage (1991). According to Schrage, electronic environments such as WebCT™ offer the opportunity and context to support collaboration in which the learners conjecture and experiment with multiple representations of ideas in a mutually respectful manner. The participating teachers were expected to demonstrate a rich understanding of a central concept in primary mathematics and the teaching of that concept, namely multiplication. This called for a design that encouraged the participants to reveal the diversity of views about the concept of multiplication. McLellan (1997) suggested that Shrage's model is appropriate for instructional designs that aim to create VLCs online as it allowed learners to construct and demonstrate multiple forms of representation of concepts within rich domains such as mathematics.

This VLC was developed with a principal WebCT™ Course Management tool, namely Online Discussion. This tool allowed students to engage in threaded discussions about a hypothetical mathematics lesson. In order to scaffold the discussion, the investigator uploaded a number of connected electronic files onto the WebCT™ site for MPMIII using the File Management tools. The documents included lectures, tutorial activities, subject goals, and URLs for two web sites for MPMIII (http://www.boardofstudies.nsw.gov.au and http://www.curriculumsupport.nsw.gov.au). These sites provide information about syllabus requirements for New South Wales K–6 mathematics, assessment guidelines, and curriculum policies that impact on the teaching and learning of mathematics. The teachers were asked to visit these sites in order to update their knowledge of current curriculum developments as these impacted on the teaching of primary mathematics. The above information was expected to assist the participants to reflect more deeply on the lesson in question and thereby contribute to the quality of their inputs to the threaded discussions.

A critical component of the design for online discussion is the choice of tasks and resources that support learning and reflection (Berge, 1998; Oliver, 1999). While each learning design can provide affordances and constraints of its own, it is important to remember to use the tasks and contexts that are familiar to the student teachers. In the design for the current study the investigator developed a hypothetical lesson on the teaching of multiplication that acted as an authentic context for the participants to examine. This lesson was authentic in that it was reflective of commonly employed teaching strategies in primary classrooms. The focus concept for this context was the modelling of multiplication of whole numbers, a key strand of mathematics pedagogy in our primary curriculum. This lesson was uploaded onto the same WebCT™ site for MPMIII. More about this lesson is given in the Methods section of the report.

Method

Participants

The participants in the present study were 25 BTs who had graduated from our primary pre-service teaching degree, Bachelor of Teaching (Primary). Prior to the study these teachers had completed three mathematics methods subjects that emphasized socio-constructivist principles in primary and early childhood mathematics teaching and learning. They had to successfully complete eight weeks of teaching practice as part of the requirements for the degree. During the three years prior to the study the participants had also satisfied mathematics discipline requirements for the degree, including number, geometry, and algebra. All participants had been teaching in regular classes for at least six months before commencement of the study.

The teachers were enrolled on MPMIII, which is an elective subject for the Bachelor of Education (B.Ed.) programme. The B.Ed. is a graduate programme for practising teachers who had completed the Bachelor of Teaching (Primary) and wished to upgrade their qualifications. Participation in online discussions was a component of the assessment requirements for the subject. All of them had indicated that they had made use of computers during their courses and exhibited reasonable levels of facility with ICTs. The researcher was also the lecturer for MPMIII.

Material and Procedure

As mentioned in the design of the study, a hypothetical mathematics lesson plan was developed that would provide a starting point for the online discussions. The lesson focused on the teaching of the concept of multiplication to K–6 children. In this particular lesson the teacher's aim was to use objects to construct arrays as a means to represent and explore the concept of multiplication of numbers. The lesson and teacher's actions were posted online for participants to download and analyse. The lesson commenced with the teacher inviting students to look at a stack of cans that were placed on a table in front of the class. There were six stacks of cans with four cans in each stack, representing 4×6. The teachers used the stacks as a model to get students to talk about multiplication involving whole numbers.

During the first meeting with the researcher all participating BTs were given an opportunity to download the lesson from the WebCT™ site, analyse the lesson and raise questions. Following this meeting the participants were invited to engage in discussions via the Online Discussion tool from the relevant WebCT™ site for MPMIII for a period of 13 weeks. Participants were encouraged to reflect on comments posted by their peers and provide considered justifications for their views.

The following statements were provided to scaffold teachers' emerging reflections and responses:

- Think about how you have learnt the focus concept in the lesson.
- How do you think about the focus concept now?
- Think about how the lesson attempts to support children's building of understanding of multiplication.
- What are some of the tensions that you could anticipate in implementation of the lesson, and how would you respond to these?
- Try to integrate your personal understanding with the aims and expectations of the current syllabus.

The class as a whole clarified these statements with the researcher and this exercise formed an important part of their first two tutorial classes. Every comment or response was recorded as a threaded discussion in WebCT™. At the end of week 13 these comments were downloaded, collated, analysed, and coded.

A critique of a lesson could be undertaken in a number of ways, including comments about clarity of aims and objectives, appropriateness of the choice of teaching aids and sequencing of learning activities, assessment strategies, and extension work. In this study, however, the goal was to encourage the BTs to go beyond the above general comments and bring a deeper level of analysis to the lesson plan in question. While this analysis is somewhat hypothetical, it is enriched by the conversations the participants were allowed to have during the course of the study. Because they were practising teachers, the discourse and scaffolding for each other was also expected to bring a sense of reality to the views expressed about the lesson.

The exchanges among the participants included critical remarks about the lesson and how it might constrain or promote the active participation of children and its potential impact on the way children would understand multiplication. These judgements allowed the investigator to code segments as belonging to one or more of the dimensions of PP.

Results

The purpose of the study was to make judgements about the quality of learning that had taken place as a result of the online discussions among the BTs. The strategy for analysis was coding of comments as per the dimensions of PP (Table 1). In order to maintain the anonymity of the participating teachers, comments from each teacher are labelled BT1, BT2, and so on.

Participants' comments and responses to comments on the whole suggested a reasonable understanding of the focus concept, multiplication. All BTs had examined the concept of multiplication at varying degrees of complexity. The teachers had activated eight features of multiplication. The modelling of multiplication through the use of arrays had generated a high level of interest. The discussion seemed to focus on the arrangement of objects in rows and columns representing the multiplicand and multiplier, respectively.

Inputs that were posted at the beginning of the discussions tended not to have substantial elements of PP. However, as the discussion continued the participants began to ask more direct and searching questions about the efficacy of the lesson and its potential learning outcomes. This was directly related to their reflection about what other members of the group had to say. This "feeding off" effect, where one member builds on, or refines, the thoughts of others, constitutes a powerful scaffolding system. The consequence of this qualitatively enriched discussion was that the participants' comments became more sensitive to, and reflective of, the dimensions of PP.

Intellectual Quality (IQ)

The dimension IQ is concerned with learners developing a substantive understanding of multiplication via conversations and constructing other forms of representations, including the identification of patterns of relations that embody this operation. For instance, the BT comment below draws the attention of teachers to look for patterns in an array that reflects the commutative property of multiplication:

> BT1: I think that in order to promote further mathematical discourse among the students and allow the students to construct their own ideas and interpretations of arrays, each pair of students should join another pair and discuss how they solved the problem, what they did and what new mathematical features, if any, they have discovered, such as the commutative property.

The following input from one BT indicates the relationship between multiplication and division, the inverse property:

> BT2: The teacher could address the concept of division after the students have made arrays in the guided practice phase. The teacher could ask the students to take out 12 buttons (or another number with a few factor pairs), and divide or group them into an array. Then, I think it would be helpful to student learning if they had an opportunity to share their findings in small groups, perhaps table groups if they were seated that way.

Here is a response from one BT to comments from others about how the lesson could support deep learning:

> BT3: Deep learning may occur differently for all students, it may not only occur through questioning. This lesson has attempted to cater for a range of different learners that may be evident in the classroom, including visual, active and auditory learners.

Relevance

The category relevance is concerned with conceptual and other links that the learner could construct with multiplication. A large proportion of participants' comments tended to ignore the importance of assisting children to develop connected knowledge about multiplication. However, comments that were posted in the second and subsequent instances suggest an increased awareness of this important dimension of learning. The comments from BT4 exemplify the importance of connecting concrete and abstract understandings of children. This pattern of thinking also emerged as a key finding in a related study into teaching and learning about multiplication reported by Izsak (2004):

> BT4: A feature of this lesson that shows well-constructed teaching and learning practice is the initial use of concrete representations of multiplication to introduce the concept. The use of the cans and then the buttons, which students can manipulate, reflects the progression of children's conceptual development, moving from concrete to abstract.
>
> In this lesson, students move from the concrete representations of arrays to abstract representations using 2D space on the grid paper. The transition from concrete to abstract in this lesson takes place when the teacher feels they have a handle on the subject. This type of evaluation needs to be quite thorough, to fully understand whether students really understand the concept being taught.

Supportive Classroom Environment

Teachers' comments and deliberations about the environment that supports learning (supportive classroom environment) tended to remain relatively stable over the course of their interactions. There were a high number of comments posted during the first input, and this pattern did not increase significantly during the BTs' second inputs. In fact, there appears to be a tapering off effect the second time around. Concern with children's individual differences and learning styles did not appear to feature prominently in the teachers' discussions. Here are two comments on engaging students by providing alternative support structures:

> BT5: I believe that the activities provided by the teacher in this lesson plan are varying and interesting and chosen to cater to the individual learning styles of their class, as well as accommodate the semantic knowledge the children have. Not only has the teacher tried to engage students through trying to accommodate to all learning styles, but the use of stickers for the array for multiplication display is another technique used for student engagement.

> BT6: Through the Guided Practice part of the lesson, the teacher demonstrated different ways of writing arrays, i.e. 4 rows of 6 cans or 4×6, as well as how to use the flashcards, how to use the buttons to make arrays, how to draw arrays on grids, how to use the overhead projector and by showing how the students would be displaying their finished arrays.

In the following comment one of the BTs suggests that teaching should take a different entry point for developing and assessing student's understandings:

> BT7: It is important for students to make approximations or to have-a-go at reaching answers. In this way they are testing their knowledge and reaching their own conclusions.

Recognition of Difference

There were few instances of teachers' concerns with the cultural backgrounds of students and how this dimension of PP might impact on their interpretation of multiplication. This could be due to the fact that the participant's were discussing potential as opposed to real students in a classroom. Still, the general lack of focus on the cultural backgrounds that learners might bring to understanding the concept of multiplication constitutes an interesting outcome here. However, there was recognition of the need to cater for the individual learning styles of individual students, as shown by the following comments from BT8 and BT9:

> BT8: The students have displayed on board that implicitly communicates that numbers can be arranged in different groups to form larger numbers, called multiplication, however I think that this needs to be explicitly reflected on by the students in their own words.

> BT9: This class seems to be either an ES1 (Early Stage 1) or S1 (Stage 1) class (seeing as though they are only being introduced to multiplication) so their writing skills will probably be at a developing stage. This may place restraints on the way that they can express their ideas in a writing journal, so students should be encouraged to draw pictures, and approximate with mathematical and everyday language.

Discussion and Implications

The aim of the study was to ascertain the quality of a group of beginning primary teachers' pedagogies as they engaged their peers online. They were provided with a hypothetical lesson on multiplication as a context within which to explore their own pedagogies that underpin the teaching and learning of one area of primary mathematics. It was expected that the online discussions would provide an effective medium in which participants could draw on each other's remarks in order to gain deeper insights into their pedagogies.

This paper presents data relevant to the research question about BTs' evolving pedagogies vis-à-vis PP. However, the volume and richness of the data generated by WebCT™ suggests that this medium not only permitted greater insights into a complex pedagogical issue in mathematics teaching but also established a powerful learning forum. The ensuing learning community can be seen as important in promoting the growth of elaborate and sophisticated pedagogical content knowledge schemas among teachers. Such organized knowledge has been shown to be instrumental in advancing children's cognitions not only about multiplication, but mathematics in general (Schoenfeld, 1992). As the participants were teachers who were new to the profession, the results have significant implications for pre-service teacher education courses and in-service programmes for mathematics teachers.

The results of this exploratory study suggest that WebCT™ provided a convenient and non-threatening medium in which to generate and share rich descriptions and garner views about mathematics teachers' pedagogy. This is consistent with McConnell's (2002) investigation of problem-based analysis and sharing of information online by adults. Overall, the participants showed a level of interest and comfort in exchanging not only their own views but also constructing robust arguments in support of, or against, positions taken by fellow teachers through this medium. The learning community that was generated by this medium constitutes an important outcome and future studies of pedagogies need to examine its role further.

One related outcome of the study was the identification of a component of BTs' professional knowledge, namely their pedagogical content knowledge that is relevant to multiplication and the teaching of multiplication. Multiplication situations are complex in nature and appropriate modelling of this concept could be an effective strategy in not only helping young children acquire a meaningful understanding of the concept of multiplication, but also in examining connections to other operations involving whole numbers (Greer, 1992). It was evident that teachers with a greater repertoire of representations of multiplication and situations involving multiplication activated this knowledge during the discussions and in response to the views of their peers. This indicated the premium teacher's placed on developing a deep understanding (see Table 1).

A number of the comments from the participants indicated a limited understanding of the sub-concepts that are required for a deeper appreciation of multiplication by children. While they were knowledgeable about ways to use concrete material in the classroom, the participants were less forthcoming with regard to reasons underlying the use of such resources. That is, participating teachers were unable to justify the "cognitive scaffolding" that can be provided by the instructional materials that were put forward in the discussions. Taken together, this pattern of results can be interpreted as suggesting that this group of teachers need to think more deeply about how concrete materials can be used to represent and model the more interesting aspects of a concept. It would seem that as they were BTs, this component of their PP requires more experience and practice.

One of the most common responses from the teachers related to repeated addition and place value of numbers that are involved in multiplication. However, they could have extended this in a number of ways to demonstrate properties of multiplication, particularly with the aid of Internet-based resources. These results suggest that the teachers were more focused on showing that multiplication of two whole numbers could produce a third number that was larger than the initial two numbers. Repeated addition and its modelling indicated that student teachers viewed multiplication as a form of addition. The above approach could provide children with an opportunity to "see" the connection between numeration and the computational process that was considered to be pivotal in understanding numbers and operations (Hiebert & Wearne, 1992). Collectively, these comments related to the relevance dimension of PP.

A significant proportion of teachers' exchanges focused on the array model of multiplication. The portrayal of multiplication in the array form would help children develop elementary notions of algebra and the embedded relations (Greer, 1992; National Council of Teachers of Mathematics, 2000). The arrangement of the numbers involved in a multiplicative operation in rows and columns provides an effective alternative representation of multiplication. The participants reflected on the array model correctly to demonstrate commutative properties. Participants also alluded to the need to relate the numbers that were involved in the operation to real life situations. These instances reveal an important component of BTs' pedagogical schema for multiplicative structures (Vergnaud, 1988).

The identification of BTs' strengths and weaknesses was an important exercise in itself. Equally, the study demonstrated the power of computer-mediated communication to initiate and maintain a learning forum for mathematics teachers at all levels of expertise. Such a forum not only affords continuous learning from, and mentoring by, one's peers, but also has the potential to buttress others' ideas and understandings that they have acquired from their tertiary education courses, and help them continue on a productive journey as practitioners. The above role of WebCT™ in providing an asynchronous and rich learning environment is consistent with the views expressed by Murphy, Mahoney, Chen, Mendoza-Diaz and Yang (2005), that online instructors need to adopt a socio-constructivist approach in facilitating teacher reflections, learning, and mentoring by their peers.

One limitation of this study was that the participating BTs' deliberations and insights about the lesson might have been richer and more complete than is reported here had the lesson been implemented by them. However, the teachers' reflections do indicate a willingness to think critically through a particular course of teaching action. The suggestions also reveal that these teachers are flexible enough to change and adapt the learning conditions if the situation demands.

Note on Contributor

Mohan Chinnappan is a mathematics educator currently based at the University of Wollongong. His research interests include the investigation of mathematics concept development, problem-solving, and teaching that would scaffold deep mathematical understanding in K–12.

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