Supporting Learning in Early Algebra: A Model of Professional Learning

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This paper reports on a model developed to support 6 Year 1 teachers as they developed understandings of the new Patterns and Algebra strand in the revised Queensland Syllabus. Traditional Professional Development models are grounded in notions of teacher growth and change. This particular model was grounded in theories of learning, particularly those grounded in the socio-constructivist perspective. Teachers worked in pairs developing and implementing learning experiences for three differing aspects of the Patterns and Algebra strand. The results indicate that not only did the model offer positive professional learning experiences for the six teachers but also assisted them in becoming experts in their own right.

Introduction

The new Queensland Syllabus (Queensland Studies Authority, 2005) contains many changes that require teachers to embrace new content and pedagogy as it moves to outcomes based education. Of particular interest to this paper is the introduction of the new Patterns and Algebra strand at Levels 1 to 4 that requires students within the Primary context to think algebraically. This is the first time that such a strand has introduced outcomes for Year 1 through to Year 10 students. This area of mathematics is problematic for many elementary teachers. They commonly hold concerns about teaching mathematics let alone an area of mathematics that they themselves found difficult when attending school. This new syllabus also requires them to reconceptualise arithmetic focussing on two aspects, namely, products and processes. Previous experiences have predominantly been in arithmetic as computation rather than arithmetic as a mathematical structure in its own right. The purpose of this paper is to examine a model of professional learning used to support teacher learning in their practices, knowledge and beliefs of a new content area in the new Queensland Syllabus in 6 year 1 classrooms.

Models of Professional Development

Previous models of professional development described in the literature move from linear models (e.g., Guskey, 1985) to cyclical models (e.g., Clarke & Peter, 1993). Figure 1 illustrates the key elements of the linear model suggested by Guskey.

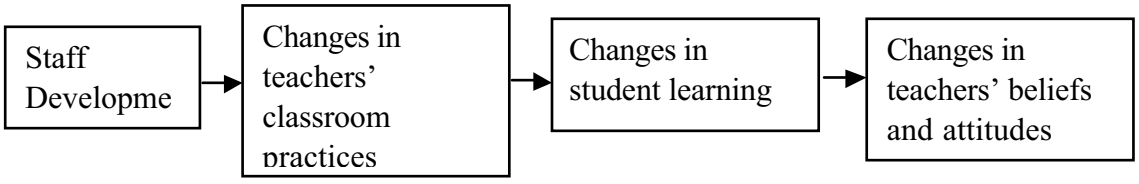

Figure 1 *Guskey's 1985 model of the process of teacher change*

This model suggests that student learning is a mediating factor in changing teachers' beliefs and attitudes. In this instance staff development is one off and the assumption is that it leads to changes in teachers' classroom practice, changed students' learning and

finally changed teachers' beliefs and attitudes. Clarke and Peter (1993) reconceptualised this model by (a) suggesting that professional learning is a cyclical experience, and (b) including the elements of classroom experimentation and sources of information, stimulus or support.

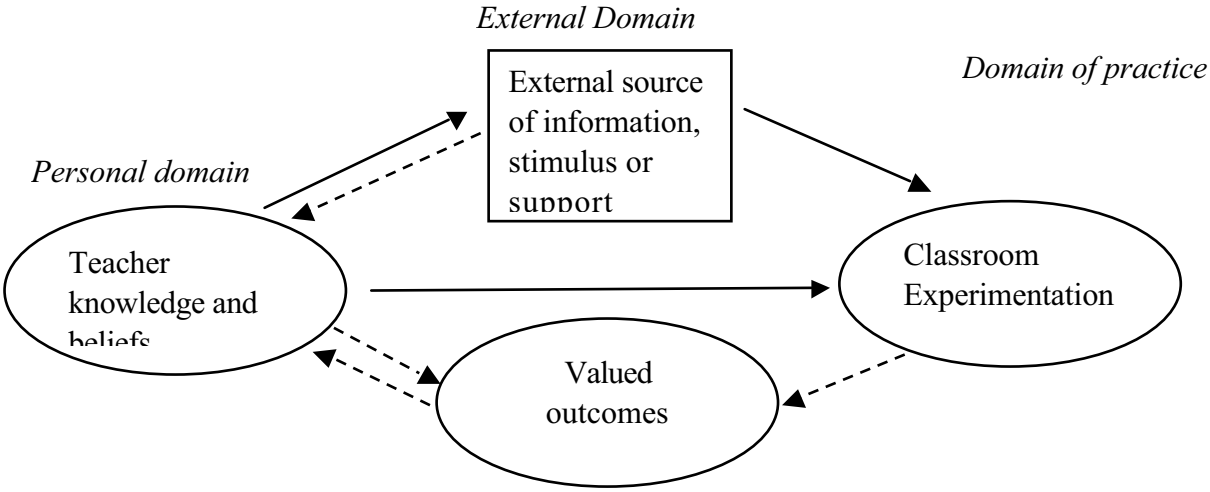

Figure 2 *Clarke-Peter model of professional growth*

In this model the personal domain is concerned with knowledge and beliefs that underpin practice. It is asserted that experimentation is always present in the classroom to some degree. This experimentation if it results in valued outcomes can lead to changed teacher knowledge and teacher beliefs. Teacher classroom practice and reflection may be influenced by outside sources including in-service programs and professional reading. It is suggested that the growth is cyclical with growth in one domain translating to growth in another.

The emphasis in both of these models is placed on teacher change and the factors that support such change. Many models in the literature reflect this focus. An important dimension that is absent is explicit theories about learning and how these theories can be utilised to support teacher professional growth. This paper summarises a model developed and implemented using this focus as its primary concern.

Theoretical Underpinnings

In Vygotskian perspective of learning, the Zone of Proximal Development is postulated as one's potential capacity for development through the assistance of a more knowing person (Vygostky, 1962/1934). This development is predicated by how this more knowing person scaffolds the task at hand. The quality of the interactions, in terms of their appropriateness and intellect, are conjectured to impact on the development of the ZPD. Valisner (1987) expanded Vygotskian theory of learning by including the notions of (a) the Zone of free action, what is allowed by the child by the adult, and (b) the Zone of promoted actions, what is being promoted by the adult, with no obligation for the child to accept what is promoted. Traditionally the Vygotskian theory is applied to support effective teacher – student interactions. The subtle abstraction of this perspective is its utilisation by a community of learners consisting of an expert (more knowing person) and 6 teachers. Many researchers have argued that meaning is constructed through discourse and

interactions and that the construction of knowledge does not occur in isolation but within a social and cultural context (e.g., Sfard, 1998; Wood , Cobb & Yackel, 1992). Learning is about knowledge construction, is knowledge-dependent, relies on current knowledge, and is highly aligned with the situation in which it takes place (Resnick, 1989).

Teacher knowledge, both content and pedagogical knowledge is viewed as key components of effective teaching (Bobis, Clarke, Clarke, Thomas, Wright & Young Loveridge, 2005). Teachers with more explicit and organised knowledge tend to provide instruction that features conceptual connections, appropriate and varied representations and active and meaningful student discourse. On the other hand teachers with limited knowledge have been found to portray the subject as a collection of static facts, to provide impoverished or inappropriate examples, analogies and or representations, and to emphasise seatwork assignments and or routinised student input as opposed to meaningful dialogue (Stein, Baxter, & Leinhardt, 1990). Many professional development models tend to focus on either content knowledge or pedagogical knowledge (e.g., White, Mitchelmore, Branca and Maxon, 2004), but rarely on both. Thus the model developed for this project contained specific elements that supported teachers learning about patterns and algebra, appropriate pedagogy that support students learning about patterns and algebra, and inbuilt structures that encouraged teachers to share with each other in the development of their construction of learning in particular focussed areas and the co-construction of learning across different focus areas. Figure 3 presents the key components of the professional learning model.

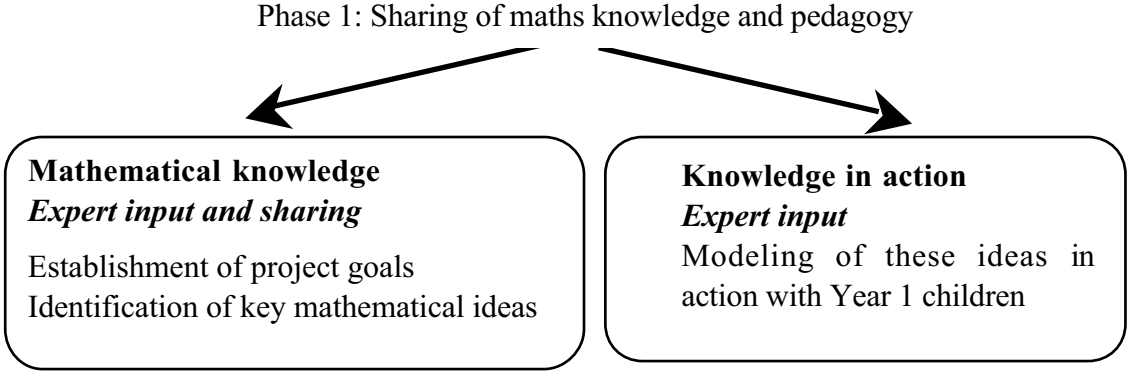

Figure 3. Phase 1 of the professional learning model utilised in the *project.*

In Phase 1 the teachers were considered learners with the more knowing person guiding and challenging the teachers as they constructed new knowledge and practices (Borko, 2004). The focus was on teacher learning in terms of both teacher's content knowledge and pedagogy and identifying activities and materials that encapsulate the core of knowledge and learning. The aim was to allow teachers initial access to the 'new knowledge'. The expert presented activities that assisted teachers to explore their knowledge and pedagogy of the patterns and algebra in an early years' context. In this instance a demonstration of the interaction between knowledge and pedagogy occurred by the expert teaching a lesson within the teachers' own classrooms. In this instance teachers were exposed to the experts Zone of promoted actions.

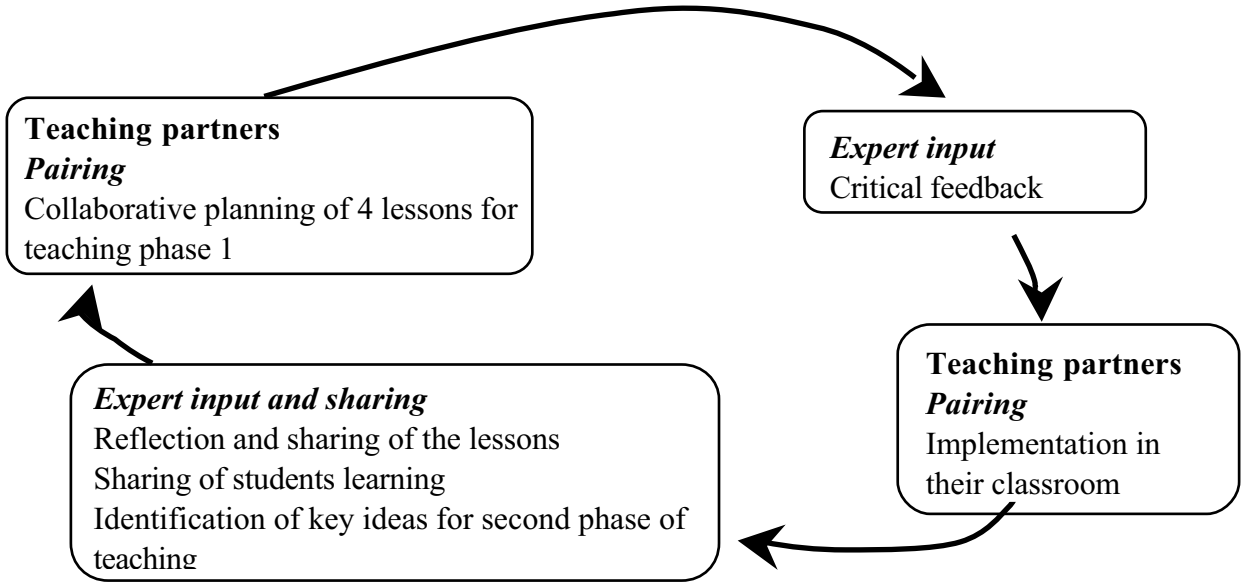

Figure 4. Phase 2 of the professional learning model utilised in the *project.*

In Phase 2 (the learning cycle) both the teachers and their students were considered as learners. Teachers in pairs, with the assistance of the expert, guided their students in the construction of new knowledge by collaboratively planning and implementing learning experiences. Specific structures were established to facilitate dialogue with others including the knowing person. The teachers then reflected on and shared their learning with the community of learners (the knowing person and the 6 teachers), and articulated appropriate learning experience for the next phase of the learning cycle. Each pair of teachers focussed on different content knowledge. Thus the model not only offered opportunities for teachers to learn but also allowed them to share their learning with others and thus take on the role of 'experts' in this phase of the model. The Zone of Free action was exemplified by allowing the teachers to undertake their own planning bounded by particular broad content and pedagogical goals, such as, develop hands on activities that supported mathematical thinking with regard to functions as rule to be followed, reversed and identified when given In and Out values. In the first round of the learning cycle they were required to do this without using number. In the second, they were required to map this thinking.

Methods

Participants

Three schools volunteered to participate in the Professional learning. Given that underpinning socio-constructivist theories of learning is the notion of ongoing dialogue as an important component of the learning process, each school was requested to select two Year 1 teachers on the understanding that they would be working together to collaboratively develop learning experiences for implementation in their classrooms. A total of six teachers participated in the project, two from each site. They were also aware that their learning would be fully supported by an 'expert' in the area and the outcomes of the project would be public.

Each pair of teachers was allocated a different dimension of the new patterns and algebra curriculum, namely, patterns, functions, and equivalence and equations with the later two consisting of new knowledge that is not commonly explored in the early years' classroom. During the teaching phase electronic contact was maintained between the pair of teachers and the expert. At the end of each teaching phase all participants met and shared their classroom activity, with the expert providing constructive feedback on the activities that occurred.

Data Sources and Analysis

To investigate the professional learning of teachers within the project data sources included (a) field notes, (b) videotape recordings, and (c) a teacher interview at the conclusion of the project. The data was collected to ascertain the effectiveness of the professional learning model and to identify changes in teachers' knowledge, beliefs and practices. Due to the space limitations of this paper, only the data pertaining to the concluding interview will be reported. Each interview was analysed using Grounded theory where themes were identified from the interview transcripts themselves. In the interview participants were asked to comment on the particular components of the model, namely the role of the expert, the use of pairing in the school situation and the opportunity to share with the other teachers who participated in the project proper. Incidental comments concerning their growth in knowledge and pedagogy and understanding of student learning were evident throughout their reflections. At no time were they specifically asked about these dimensions of professional learning as the purpose of the interview was to evaluate the usefulness of the professional learning model. The interview was open-ended allowing the respondents to direct the conversation with the interviewer prompting in depth reflections at appropriate phases. The interviews were conducted by a third party thus maximising the reliability of the comments proffered by the participants.

Results and Discussion

An analysis of the transcripts indicated that there were 6 broad categories that emerged from the interview, namely, the importance of ongoing dialogue with the expert, the benefits in seeing this person teach in their classroom, the advantages of working in pairs, the importance of sharing with others, and the benefits of the model for student learning. Tables 1 to 5 summarise the themes that appeared within these categories, together with representative quotes and the frequency of their occurrence.

Table 1
Ongoing Dialogue with a Knowing Person

Representative quotes	Themes and Frequency
It has changed the way I think in the classroom prior to this having been teaching 32 years I had thought that I had got things fairly down pat Mathematical thinking first time in 32 years, sad isn't it? Very knowledgeable and made us think so much more deeply So much information I was so excited when I came back to the classroom What we are doing is beneficial from Year 1 right up until Year 7 and how it can all connect in their later years	• Mathematical Knowledge (5) • Mathematical thinking (4) • Reflection on practice (4) • Connections across students development (2) • Simplification of mathematical ideas (1)

The three key benefits of ongoing dialogue with someone who has expertise in the area were the deepening of the participants' mathematical content knowledge, and the way that they thought and reflected on the teaching of mathematics. There were comments regarding the significance of this dialogue throughout all the stages of the Professional learning, not just the learning that occurred in Phase 1. In fact, two participants indicated that they would have appreciated further opportunities to discuss the teaching of patterning within their own context and believed that the sharing sessions with others were extremely beneficial.

Table 2
Benefits of Demonstration Teaching by Knowing Person

Representative quotes	Themes and Frequency
Made us realize I think that she wasn't expecting these perfect perfect lessons I was relieved to see that she used everyday items and not elaborate aids Just listening to the terminology she used and things like that really helped us Somebody else taking them so that was very insightful	• Use of mathematical language (2) • Use of every day materials (3) • Understanding of expectations(3) • See my class working with someone else

The demonstration lessons enabled them to 'see' that what was expected of them was within their capabilities in terms of expectations and materials used. It also appeared to provide credibility for the expert by demonstrating an understanding of how to enact that knowledge in an everyday classroom context, and in one instance served to significantly change the relationship between one of the participants and the expert.

Table 3
Benefit of Working in Pairs

Representative quotes	Themes and Frequency
Both of us had strengths and weaknesses balanced out very well The planning was very useful together Don't think I would have been able to do this by myself or perhaps not to the extent that we have done together	• Balanced out our strengths and weaknesses • Couldn't do this by myself • Feed off each others ideas (3)

The main benefit in working in pairs within their own context appeared to be the provision of a forum in which they could bounce ideas off each other. They also acknowledged that each 'fill in gaps' of knowledge of each.

Table 4
The Importance of Sharing with Each Other

Representative quotes	Themes and Frequency
The extra knowledge you gain….there were some great ideas Finding out that they were similar challenges to ours I have already taken some of their ideas and implemented them in the classroom.	• Knowledge from others (3) • Transferring of ideas, language • Changed whole way of thinking • Ordinary classroom teachers

You learn most either in a mentoring or sharing sense	sharing ideas (3) • Finding similar challenges (2)

Interestingly, one area that all of the participants valued was the opportunity to learn from each other. It was evident that as these teachers proceeded through the learning cycle of the second 'loop' of the project, they themselves were transforming into knowing people.

Table 5
Benefits for Student Learning

Representative quotes	Themes and Frequency
Even the weaker ones can go and get the counters…act it out, use concrete aids to find out what they want to know They have gained a deeper understanding number Made them think outside the square They can visualize a lot more because they visualize it going through the [function] machine	• Delivering correct ideas to students • Now thinking people (2) • Enjoyed ideas and activities (2)

While the teachers were not specifically asked about student learning they believed that the process assisted them in ensuring that the students were not learning incorrect ideas about mathematics, especially in terms of the convention of mathematics. Participants were also asked to provide feedback about the whole professional experience, including Phase 1 and Phase 2. Table 6 summarises the main themes that emerged from within this part of the data and the frequency of responses together with representative quotes for each theme.

Table 6
Comments about the Model as a Whole

Representative quotes	Themes and Frequency
Math's knowledge gained …very positive a great learning experience I can now see why I didn't understand it and where the teaching was going wrong for me I am thinking more deeply about the teaching of math Each time I walked away feeling very excited about the ideas	• Great learning experience • Enormously workable • Thinking more deeply • See where I was going wrong • Gained so much from the interactions

Overall, the model proved to fulfil its particular aim, that is, the aim of utilise learning theories to support professional learning outcomes.

Summary and Implications

The interviews indicated that the main focus of the teachers' comments were on learning, especially in terms of the knowledge gained concerning mathematics and learning mathematics. The role of the expert within this dialogue thus appeared two fold, first in terms of assisting these teachers access new knowledge and second in assisting these teachers become experts in their own right. The learning seemed to occur as a consequence

of four interactions, the first between the knowing person and the teachers, the second between the pairs of teachers, the third between the teachers and their students, and finally those between the group of teachers when they gathered to share their learnings. Interestingly, the main reflection these teachers had of the whole professional learning model was couched in the language of learning and knowledge rather than in the language of change and growth, common themes that currently appear in the literature of professional development. The model provided another unexpected outcome, that of the teachers developing their own expertise and 'standing' as experts or knowing people. It appeared that this began to occur as each pair of teachers shared their new knowledge with the four other teachers during the sharing days. They adopted the role of 'teachers' with the remaining four acting as 'learners'. This was as a direct result of each pair being allocated different content areas to explore. After the second round of the learning, they appeared more confident and could openly discuss the mathematics that they and their students had learnt. It can thus be conjectured that not only does the model offer positive professional learning for teachers but also opportunities for these teachers to develop into experts in their own right. The schools in which this project was based are currently in the process of utilising this model to promote new learning throughout their school communities with these teachers adopting the role of experts.

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