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PROFESSIONAL LEARNING: IMPLEMENTING NEW MATHEMATICS CONTENT

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This paper examines a model of professional development (PD) provided to support two, year 3 teachers while implementing new content incorporated within the new mathematics syllabus. The findings from this study suggest that the development of a professional learning community (PLC) extended the teachers' Zone of Enactment which inturn lead to teacher agency. Teacher agency was demonstrated by the teachers leading their own learning as well as that of their students.

INTRODUCTION

It is well recognised that teachers face an ongoing challenge in implementing mathematics reforms (e.g., Handal & Herrington, 2003). Consequently, to meet this challenge, there is a need to support teachers to develop their mathematics teaching skills. However, the provision of such support is highly problematic given that many elementary teachers are predominantly generalist teachers with little specialist expertise in mathematics education.

The purpose of this paper is to identify what professional development support teachers need when introducing new mathematics content, mental computation. In particular, this paper provides an account of a two year project in which teachers conducted a series of teaching experiments aimed at enhancing their content and pedagogical content knowledge in relation to introducing the new content area of mental computation. The following question provided the focus for this two year project:

> What supports do teachers need to enhance opportunities for a professional learning community to develop a sense of agency for learning?

TEACHER CHANGE AND PROFESSIONAL DEVELOPMENT

In designing this study, the researchers were mindful of the poor history of long term educational change. By tracing this history we came to appreciate that the 1960s was a period of wholesale "adoption" of innovations that were top down and followed a linear approach (Hopkins, Ainscow, & West, 1997). By the 1970s, the phase of adoption of innovations was widely viewed as a failure (Fullan, 1999). As a consequence, there was an effort to "teacher proof" innovations (Lieberman, 2005, p. 5). In addition, it was argued that greater structural and resource support should be given during the implementation phase of educational change. Moreover, theorists recognised that change was a process and the change process rested with the teacher (Miles, 2005). The 1980s saw a new phase of educational change when theorists identified the importance of meaning making within the implementation process (Fullan, 1999). In the 1990's, this thought was extended as these same authors focussed on the moral purpose of educational change with Fullan (2005a) noting that "moral purpose was a critical change theme … [and that] … moral purpose and change agentry made perfect partners" (p. 210). However, despite these theoretical developments, the challenge of educational change remains as "nothing tried so far really works" (Fullan, 2005b, p. 13).

As a way forward, contemporary theorists (see e.g., Earl, Levin, Leithwood, Fullan, & Watson, 2001) now argue that by building teacher capacity to implement reforms, it is possible to foster the development of school cultures that will sustain improved practices through teacher agency. Such

agency is linked to the teachers' belief in their "capacity to make a difference" (Frost, 2006, p. 20) and their capabilities in respect to implementing the education change (Durrant & Holden, 2006). This agency is discussed in the literature in terms of the "new professional" (McLaughlin, 1997) or the "activist professional" (Sachs, 2000). Moreover, for teachers to develop a sense of agency, it is argued that shared leadership must be possible and this is best reflected within a professional learning community (PLC) where teachers have the capacity to influence outcomes.

Extending this thought, Millett and Bibby (2004) advance a further theoretical perspective. This theory identifies the "Zone of Enactment" (p. 3), extending Vygotsky's (1978) theory on the Zone of Proximal Development and its application to the individual, to one that is extended to encompass the PLC. In short, this theory seeks to understand the teachers' capacity to change by examining the context and culture of the teachers' working environment including external influences such as the provision of PD, the impact of policy change, and the influence of the private and public sectors. Figure 1 depicts Millett and Bibby's (2004, p. 3) interpretation of the theory.

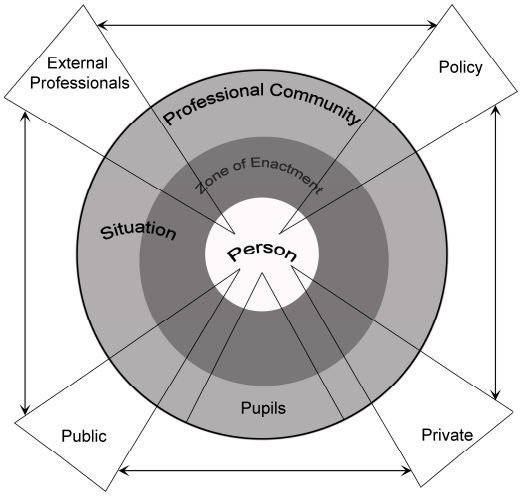

Figure 1. Theoretical model for discussing teacher change

According to Millett and Bibby (2004), sources of support that operate within this environment can stimulate a teacher's Zone of Enactment. This emergent theory is significant because it also contributes to the general trend identified throughout the literature that change occurring within the school is focused around the development of a community of professionals learning and working together. This theoretical model seems to offer a practical way to examine the PLC that combines professional development and teaching experiments which offer a supportive environment for educational change, teacher agency, and leadership for learning.

Millett, Brown, and Askew (2004) identified four conditions necessary for the realisation of Zones of Enactment through which PD may be promoted: time, talk, expertise, and motivation. They considered *time* for teachers to engage in discussion and reflection essential for the development of a PLC. Time allocated for the participants in the P-CAME project enabled them to work in an iterative framework of trial, reflection, discussion, modification, and retrial. Time has also been identified by other researchers (e.g., Clarke, 1994; Heid et al., 2006) as essential for teacher reflection in ongoing professional development. Millett, Brown, and Askew (2004) reported that as teachers in the P-CAME project were provided opportunities to observe each other's lessons, they were encouraged to *talk* with each other about these observations as a focus for reflection and discussion. *Expertise* in the P-CAME project came from within the school from other teachers and leading teachers, and external to the school from the university researchers. Expertise supported the teachers to reflect around theory and practice, and share expertise. *Motivation* appeared in several guises in the P-CAME project. Some teachers were motivated by internal feelings of interest in

mathematics, by a desire to improve their mathematics teaching, or from fear of mathematics teaching. External motivation was also a factor; for example, encouragement from colleagues, policy (curriculum changes), and external experts.

This concern for time, talk, expertise and motivation is further reflected in the literature. For example, external expertise was also identified by Joyce and Showers (1995) as an important factor in teacher support. They suggested that access to external professionals who support teachers' ongoing learning promotes ownership of their knowledge, where they can successfully design and implement lessons that reduce the gap between theory and practice. In addition, Hargreaves (2005) has suggested that the establishment of a collegial environment is important to support teachers in their pursuit of change.

It is important to acknowledge the widely listed elements necessary for successful teaching experiments, such as teacher identification of what they need to learn (Fullan, 2005b), a collegial environment (Hargreaves, 2005), and time to conduct the experiment (Heid et al., 2006). Moreover, access to external professionals who support teachers' ongoing learning promotes ownership of their knowledge where they can successfully design and implement lessons that limit the gap between theory and practice in research (Joyce & Showers, 1995).

With these theoretical developments in mind, this current project was designed to understand the supports that teachers need to enhance opportunities for a professional learning community to develop a sense of agency for learning.

THE STUDY

The context

In 2003, the first author worked with two, early years teachers to develop a program to enhance their students' mental computation. Mental computation did not feature in the old mathematics syllabus. The new syllabus (Queensland Studies Authority, 2004), which was in draft form at the time of the study, required a significant shift in beliefs and attitudes about teaching content and pedagogy. The instruction was therefore entirely new to the teachers as the old syllabus was limited to traditional algorithms. One aim of the study was to develop teacher content and pedagogical content knowledge to enhance their agency when implementing the syllabus. In 2004, some additional funding was available to continue the project. The two teachers volunteered to continue the project in their new classes.

Design

This research reported here adopted a case study design (Merriam, 1998) bounded by two early years teachers from one school. The teachers were also involved in teaching experiments that were focused on the new content of mental computation in the syllabus (Lesh & Kelly, 2000). These teaching experiments were supported by a PD program provided by the first author. It is this PD program that is the focus of this paper.

A teaching and learning environment that was collegial and supportive of teacher change was developed such that the teachers and the researcher collaboratively studied the philosophy and theoretical background of mental computation before planning the student instructional program. This environment was supported by the provision of teacher release time which allowed the teachers to focus on their learning of the new content.

The first author worked with two teachers, Pam and Sue, to prepare for and teach the new content of mental computation. The study was implemented in four phases (see Figure 2) over two years. Phases 1 to 3 were repeated in each of the two years.

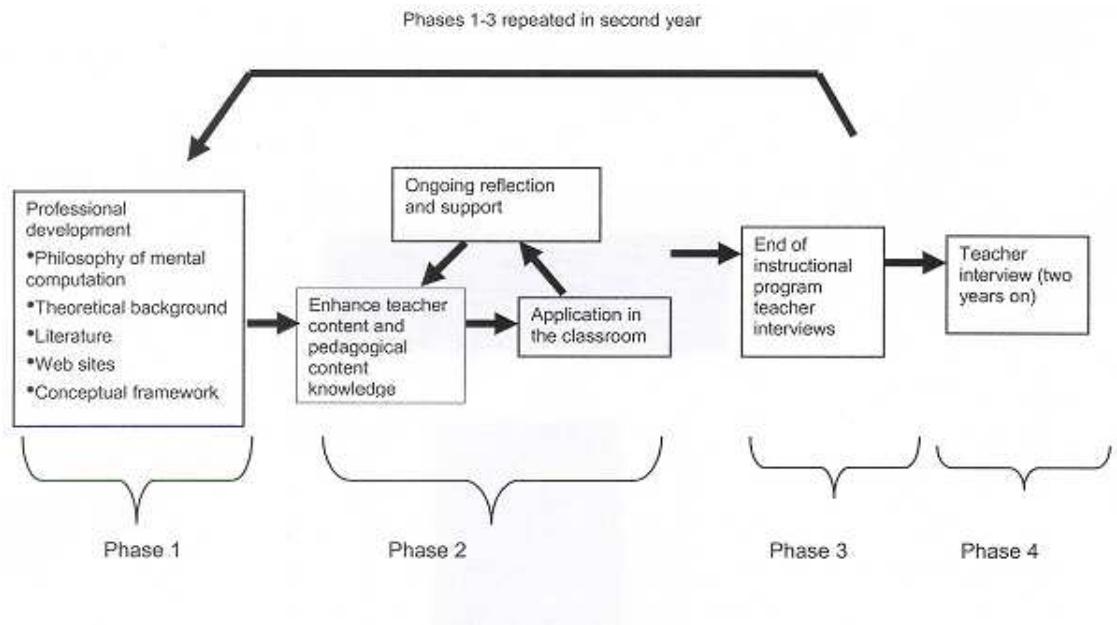

Figure 2. Phases of case study

As a way to orientate the reader each phase will be described. To address the research question, we report on phases three and four of the study. The data constituted teacher narrative interviews (Auerbach & Silverstein, 2003) conducted at the end of the instructional program and two years afterwards.

Phase 1: Professional development

The first author framed the professional development by the work of Askew, Brown, Rhodes, Johnson, and William (1997) who reported that effective teachers of numeracy had connectionist orientations to mathematics teaching and learning. In order to assist the teachers view mental computation as part of a connected whole, the researcher presented and explained a conceptual framework for mental computation, developed by Heirdsfield (2003a, 2003b). This framework explained the links between mental computation and related concepts and skills. Over two days, the first author provided background information for mental computation, including the project summary, relevant web sites, journal articles, the draft syllabus, explanations of mental strategies, and suggested activities to develop mental computation strategies and associated concepts. Pam and Sue studied the philosophy and theoretical background of mental computation before planning the student instructional program.

Phase 2a: Design and implementation of instructional program

Following the professional development sessions, the teachers and the first author designed the instructional program. While the teachers worked together to develop the program, it was implemented slightly differently in the two classes, because of individual teacher and class differences. The teachers assumed responsibility for implementing the instructional program. While the first author remained the "expert" in relation to mental computation, the teachers were considered "experts" in their classrooms. The implemented instructional program consisted of eight weekly, one-hour lessons in each year of the two years the project operated.

Phase 2b: Ongoing support and reflection

Ongoing support and reflection were integral parts of the implementation phase. During each lesson the researcher took field notes on the outcomes of the lesson as a way to inform subsequent teaching episodes. During end-of-lesson meetings, the researcher provided feedback on the content and management of the lesson, and suggested further activities. The teachers reflected on the student

outcomes, and discussed ideas for the subsequent lesson with the researcher. Discussions often continued among the teachers and researcher during mid morning recess. Here, teachers also shared their ideas with each other. Discussion and reflection between the teachers and researcher resulted in responsive and intuitive interaction through ongoing retrospective analysis, consistent with the methodology of Steffe and Thompson (2000).

Phase 3: End of project reflection

At the end of each year of the study, the teachers were interviewed to reflect on their learning over each year, and to identify the supports they believed enhanced their learning.

Phase 4: Follow up interview two years after completion of project

Two years after the completion of the project one of the two teachers was interviewed to discuss the long-term effects of the project and reflect further on the supports she believed enhanced their learning. The second teacher had left the school.

Data Collection

The data sources comprised the interviews, at the end of the two-year project and two years after the completion of the project (phases 3 and 4). Both teachers were interviewed for phase 3; however, only one teacher was available for the interview at phase 4.

Data Analysis

All interviews were transcribed and coded using a process of qualitative data analysis in accordance with the guidelines set by Auerbach and Silverstein (2003). Stage one involved the selection of relevant text, stage 2 the creation of themes from this text, and stage 3 the application of themes to theory. The interview data were analysed for two different phases of the project: (3) at the completion of the project, and (4) two years after the completion of the project. The interview data from phase 3 were interrogated to identify the efficacy of the professional development and ongoing reflection and support during the instructional program. The interview data in phase 4 were interrogated to identify the long term effects of these supports.

RESULTS AND DISCUSSION

The results for each of phases 3 and 4 are examined in terms of the support provided by the external professional in terms of the PD schedule and the change in the Zone of Enactment. Then, the results for phase 4 are interrogated to identify long term effects.

What supports do teachers need to enhance opportunities for a professional learning community to develop a sense of agency for learning?

According to Millett, Brown and Askew (2004), four conditions are necessary for realisation of Zones of Enactment – time, talk, expertise, and motivation. The analysis of the data is presented in terms of these four conditions.

Time

The teachers suggested that the PD provided at the commencement of each year of the project and the ongoing access to the researcher provided a very supportive structure through each of the first two phases of the study. But allocation of time was essential to permit the teachers to engage in this PD.

> Pam: The project provided a very beneficial PD program. But we needed the teacher release time to fit it all in.

This finding has been documented regularly (Durrant & Holden, 2006; Hargreaves & Evans, 1997; Heid et al., 2006), particularly when implementing new content and pedagogy (Lamb, Cooper, & Warren, 2007) or new policy directives (Millett & Bibby, 2004).

Although Pam and Sue spent time together reflecting on and discussing their lessons, they developed their lessons individually, as they believed their classes were sufficiently different from each other to warrant the development of separate lessons.

Sue: Pam has a different sort of class from mine. No, we had to develop our own lessons.

Pam: Yes, you know why. I think you can become a clone of the other person. It worked for them … But not your way. You're a different teacher. Your way of getting things across could be a bit different. Not that you don't learn from one another, but I think the talking, you know, "how would you do it?" Your personality is important…

The fact that the teachers had to plan individually may have supported their professional development. Rhodes and Millett (2004) questioned whether teachers who were not actively involved in the planning of lessons always had a depth of understanding they would have had, had they been partners in the process. "In some instances teachers believed that having sole responsibility for the planning… rather than sharing the planning was regarded as a PD exercise for individual teachers" (Rhodes & Millett, 2004, p. 120). Therefore, by having to develop their own lessons, the teachers in the present study appear to have acquired a sense of ownership of the lessons. Joyce and Showers (1995) also reported that successful teaching experiments occur when teachers have ownership of their lessons. Pam also discussed her preparation of lesson plans as supporting her construction of knowledge, again being responsive to her Zone of Enactment.

Pam: It forced me to become aware of the sequencing required to develop mental computation strategies.

Some aspects of time, as mentioned in Millett, Brown, and Askew (2004) were evident in this study – trial, reflection, discussion, and modification. However, retrial was not a factor, as Pam and Sue did not "retrial" lessons in following years, as they indicated that all classes are different from each other, and what works in one class in one year with one teacher might not necessarily work elsewhere. In fact, Pam and Sue trialled new things in following years, not as a "retrial", but in response to the new students in their classes.

Pam: I love the number board. I said I get to do a lot with the number board, but I said I have just taken off with the number line this year. And I think, and I'll tell you why I do – I bought one. It had never been done before, a lot of number line work has never been done [in this school], and this year I did something with the number line and they [the children] said to me, "but you didn't put the arrows in it." …Last year we did a lot of number line work. I said, "Right I'll do a bit more this year." I didn't have to start at scratch to teach number lines, as the children had been taught before.

Interviewer: But you did, before, didn't you.

Pam: Yes. You had to start at scratch and go through, this is the number line which way are you going to have to move? And that's the result of that of um, doing that number board because I did do that to death because I loved it.…um and I was confident in the number board. The following year, I did a whole lot of activities prelim activities on the number board, like cutting pieces out of the number board, yes. That sort of thing – where would I go, what would come

next but, give them the idea of placement on the number board. I could have done it on the number line if I was happy about it.

Unlike the teachers, reported by Millett, Brown, and Askew (2004), Pam and Sue did not believe that viewing each other's lessons and talking about their observations would have benefited them. They stated their classes were quite different from each other, and, therefore, observations would not have contributed anything to their understanding of their own classes. Instead, collegial reflection on the intent and outcomes of their lessons was more beneficial.

When asked to reflect on the PD and how it was structured Pam commented,

Pam: It really changed my way of thinking…We worked together collaboratively. That made our lessons more successful and we were very honest with each other… Even when [researcher] wasn't there we would actually just sit there and say what does this actually mean? Could we go further…are we just going to add on 9 or take 9? Or are we going to go to 19 or 39? All the talking helped us to get the language of mental computation to teach it…The readings and websites were good too but I tell you what was great. The concept map!

Researcher: Do you feel you had ownership of the process?

Pam: Yes I did. Sometimes I wished I didn't because I mucked up a few lessons. But I guess that is what happens when you do own it … and it's new.

While the teachers were appreciative of the time allocated for PD, and some planning, they believed that they needed additional time…

Sue: We would have liked more time reading. And we needed more time for planning for sequencing [of lessons].

The time allocated to the PD was important, and the ongoing provision of time throughout the project enhanced the commitment of the teachers.

Pam: I only feel sad that we didn't do more with the mental computation as a staff but then I guess staff change a bit, staff move on and I think the sad thing is that something takes place all the time. You know like one year it's mental computation and next year – this year it's grammar. You know, we never actually see something, see it through, practise with it, like we tell the teachers to do. Practise it and then we think we can do it by ourselves.

Researcher: But you had two years of it so that's better than…

Pam: Yeah, better than a lot of other people… So you can say that I was a bit …spoilt

<u>Talk</u>

Two aspects of talk appeared to be very beneficial for the teachers' learning: Teacher-researcher talk and teacher-teacher talk. At the end of each observed lesson, the researcher provided feedback on the conduct of the lesson. When probed about the reflective discussion at the end of each lesson the teachers were in agreement that this period of reflection supported their ongoing development.

Pam: And I'll tell you what else I found was the feedback we got after each teaching session.

Researcher: Did you feel you had a say in that discussion after the lesson?

Pam: Yeah, and you asked me why I did things.

A focus of these discussions was how to target the intent of the lesson and this usually involved encouraging the students to develop their own strategies. However, at the initial reflective

discussions in the first year, the teachers both expressed concern that the students were using a mental image of the pen and paper algorithms. Yet when the researcher suggested that all reference to the pen and paper algorithm be eliminated during any future instructional program, both teachers were hesitant as they believed their students still needed to learn the pen and paper algorithm.

The teachers also spent time reflecting together. They believed that this collaborative reflection enhanced their own understanding and helped focus their individual lesson development.

> Pam: Even when [researcher] wasn't there we would actually just sit there and say what does this actually mean? Could we go further…are we just going to add on 9 or take 9? Or are we going to go to 19 or 39? All the talking helped us to get the language of mental computation to teach it

Expertise

The researcher provided teachers with background information in the form of published research papers and web sites that detailed the philosophy and theoretical background of mental computation, mental computation strategies, and suggestions for the learning experiences aimed at promoting number sense. The teachers talked about the beneficial effects of the provision of appropriate literature, websites and suitable materials as a way to support their growth in content and pedagogy knowledge. The teachers' Zone of Enactment had been stimulated, leading to teacher agency and a belief that they had the capacity to make a difference.

> Sue: The PD has made us better teachers… and we gave better lessons as a result of having to plan the lessons ourselves.
>
> Pam: … and I tell you what I found interesting was those curriculum websites from … you gave us. … I go to [one of the sites] quite a lot now… So the websites helped, the readings helped.
>
> Researcher: What other things might have helped?
>
> Pam: I thought the concept map… you doing one with us. And I'll tell you what else I found was the feedback we got after each teaching session.

With the provision of the concept map, the teachers not only developed more connected knowledge, they also developed a connectionist orientation (Askew, Brown, Rhodes, Johnston, & William, 1997), as evidenced by their developing supporting lessons for topics related to mental computation.

> Pam: In other lessons, when you weren't there, we worked with the children on numeration, you know with MAB. And we worked on their number facts strategies. It all had to go together.

The researcher's expertise supported the teachers' content knowledge and pedagogical content knowledge. The teachers were empowered by the "materials" presented to them in the PD. Rhodes and Millett (2004) also reported teachers' enhanced knowledge as a result of having to access a wide range of materials.

Sue and Pam had mentioned the issue of sequencing in lessons. While they both believed that more (expert) assistance on the aspect of sequencing the teaching of this new content would have further assisted their learning.

The teachers, themselves, also developed expertise, as a result of discussing and reflecting.

> Pam: Now you take things on board that you feel confident with. And I felt confident with that so I did take that on board well.

Motivation

While external motivation in the form of curriculum change might have played a small part in the PD, internal motivation seemed to be the driving force for Pam and Sue.

Pam: And at the time I was looking for something a little bit different in professional development too. I mean I'm only going to be teaching a couple of more years, before retirement… You need to take the challenge. When the challenge goes out I'll retire.

In contrast, the other teachers in the school were not interested in pursuing PD in relation to mental computation, although mental computation was mentioned in the draft syllabus at that time.

Researcher: During the project, was there talk throughout the school about mental computation or was no one else interested?

Pam: No, no one was interested. The syllabus was only in draft form then.

External professionals coming into a school environment can adopt a range of different models. However, as this teaching experiment incorporated PD on new content, extra time during PD sessions was allocated to allow the teachers to understand that content allowing them to have ownership of their developed lessons and thereby leading the learning in their own classrooms.

Researcher: Overall how did you find that model of PD?

Pam: I think it's the way to do all PD…because you get taught something, you practise it supervised and then you learn from the reflection time…We talked about what we would do before you came back the following week…The process takes a long time… We had two years of it.

Researcher: How confident are you teaching mental computation now?

Pam: I don't think I would have actually taken it on board as well as I have because I knew something about it. Now you take things on board that you feel confident with. And I feel confident with this so I have taken it on board well.

What are the long term effects of the supports?

For the two years following the project Pam had continued to teach Year 3. There was evidence of long term changes. These teachers had begun to lead their own learning. However, this did not automatically extend to the whole school community.

Researcher: During the project, was there talk throughout the school about mental computation or was no one else interested?

Pam: No, no one was interested. The syllabus was only in draft form then.

As indicated by Millett and Bibby's (2004) theory, the majority of the teachers were only stimulated to learn because of new policy. Without the need to meet new policy requirements, most demonstrated no interest. However once accountability requirements were in place the project teachers had an opportunity to lead learning within the wider environment of the school's PLC.

Researcher: What about now, do the other teachers seek your advice?

Pam: Yes. They say, 'Oh now that mental computation is the name of the game, or, oh remember Pam when you did that project what did you do?' And I give them some advice, usually something very simple. It's hard to teach it all. They don't really have the time to learn everything from you.

Researcher: Should future projects be whole school based rather than year level based?

Pam: I think it would be lovely to have it as school based…I feel very sad that we didn't do more with mental compensation as a staff… You know we never actually see something through, and practise it like we tell the students to do.

Pam: …but I think all of them are doing some sort of um, mental computation now whether that's within the syllabus or the … , yeah, I would say that was the reason… It's in the syllabus.

During the two years of the teaching experiment, the teachers were moving towards a connectionist orientation to teaching mathematics (Askew et al., 1997). Two years later, Pam reported that she not only viewed mathematics with a connectionist orientation, she also viewed all learning this way. She still constructed concept maps before embarking on a new topic.

Pam: The concept maps ... have become part of my planning. Your concept map was used to identify where the children were at, and what each child needed. ..I now construct a concept map before I teach anything new. It helps me see the links. …I also think about the links between lessons in my planning.

Pam: Yes, it did um it changed my way of thinking. It's not so much thinking it made me more aware of why we teach certain things. They [concepts] don't come up in isolation …

Another long term change was the realisation that planning and sequencing are important for effective teaching.

Pam: By having to plan lessons in detail, we became aware of the importance of sequencing.

Pam: I continue to write more detailed lesson plans, and think about what the children need to know before teaching the new topic.

CONCLUSION

The project focused on finding an answer to the following question:

> What supports do teachers need to enhance opportunities for a professional learning community to develop a sense of agency for learning?

This project found that teachers need a range of supports to enhance opportunities for a professional learning community in order to develop a sense of agency for learning. The teachers in this study found that collaborative planning supported their professional learning as well as their agency (c.f., Rhodes & Millett, 2004). These teachers found lesson planning quite demanding; however, by actively participating in the PD sessions and through reading and further research, they believed that their planning became more efficient and effective. By sharing their experiences and expertise, they customised the planning of lessons for their own teaching styles and those of their students Rhodes & Millett, 2004). They became confident with their own knowledge and competent in their teaching. This finding is in line with Millet and Bibby's (2004) argument that the teachers'' "zone of enactment" (p. 3) was enhanced through participation in the PLC.

The project also highlighted the importance of time, talk, expertise, and motivation, the "four key conditions necessary for the realisation of rich zones of enactment" (Millet, Brown, & Askew, 2004, p. 250). Within this project, time and talk enabled trial, reflection, discussion, and modification (to the next lesson). External expertise was deemed to be essential to support teachers' learning with respect to new content knowledge and pedagogical content knowledge. It seemed that time, talk, and expertise complemented internal motivation, resulting in "deep change" (Millet, Brown, & Askew, 2004, p. 246-250). In a follow up interview, it was interesting to hear that the supports (i.e., time, talk, expertise, and motivation) offered during the conduct of the teaching

experiment had not been continued. The school has now only one of these teachers to draw on as the expert. No time is allocated for her to support her colleagues in the PLC that incorporates the whole school. While it was evident that external motivation did stimulate some interest by teachers after the introduction of the new syllabus, this was short lived. However, in order for collaborative knowledge construction to extend to the full school, external motivation is not sufficient, and time becomes the critical issue. In addition, these two teachers needed two years of ongoing assistance from the external expert to provide the necessary expertise for them to develop a sense of agency and to lead their own learning and that of their students in this new content area. In contrast, opportunities for talk to assist in leading the learning of colleagues appear to be restricted to staffroom discussions.

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