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EPMT PROJECT: A HYBRID MODEL OF PROFESSIONAL DEVELOPMENT FOR MATHEMATICS TEACHERS

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Enhancing the Pedagogy of Mathematics Teachers (EPMT) project is a hybrid model of Professional Development (PD) that reflects a gradual shift in the centre of gravity away from the University-based, "supply-side", "off-line" forms of knowledge production conducted by university scholars for teachers towards an emergent school-based, demand-side, on-line, in situ forms of knowledge production conducted by teachers with support from university scholars. The aims of the EPMT project were three fold: to provide teachers with training, to facilitate teachers' work (practice and feedback) at the school level and to enthuse and support teachers to contribute towards the development of fellow teachers. This paper presents one aspect of the project namely, teachers' work at the school level that advanced reasoning and communication in mathematics lessons.
Key words: mathematics teachers, professional development, hybrid model.

INTRODUCTION

Professional development of mathematics teachers in Singapore

Upon the completion of pre-service education, teachers in Singapore continue their learning journey through participation in many types of Professional Development (PD) programmes. For a long while the most common traditional type of PD activity in Singapore has been in-service courses of a type that focussed primarily on expanding teachers' repertoire of classroom activities or introduction to new initiatives of the Ministry of Education (MOE) with regards to curriculum implementation. These PD activities adopt the "give me a fish" approach. Such an approach provides teachers with knowledge for possible consumption and makes no attempt to engage them in creation of knowledge or support implementation of the knowledge in their classrooms. These PD activities may also be said to belong to what Matos, Powell and Sztajn (2009) describe as a "training model of professional development" (p 167). These activities in the form of courses are conducted for about 3 hours each day either for about 10 consecutive days or spread over a number of weeks. They are conducted by experts in the field and are "off-line" forms of knowledge production. After the completion of the course there is no follow up with the teachers about the use of the knowledge acquired and any impact that knowledge may have had on student achievement.

Many of these courses are ineffective as teachers are likely to reject knowledge and skill requirements when i) the requirements are imposed or encountered in the context of multiple, contradictory, and overwhelming innovations; ii) they are excluded from the development of the courses; iii) PD is packaged in off-site courses or one-off workshops that are alien to the

purposes and contexts of their work; or iv) they experience them alone and are afraid of being criticized by colleagues or of being seen as elevating themselves on pedestals above them (Hargreaves 1995).

Smylie (1989), in his survey of teachers' ratings of opportunities to learn in the US found that district-sponsored in-service workshops were at the bottom of the heap, ranked last out of 14 possibilities in terms of what teachers considered most valuable. Although such workshops are often accompanied by evaluations, seeking feedback on the duration, satisfaction, etc., efforts to measure what teachers learned have not been part of typical evaluation fare. In the same survey, Smylie found that teachers ranked direct classroom experience as their most important site for learning.

The goal of this paper

In contrast to traditional PD programmes in Singapore for mathematics teachers Enhancing the Pedagogy of Mathematics Teachers (EPMT) Project, which will be partly described in this paper, was a project that taught teachers how to fish. The goal of this paper is to describe how teachers in the project were engaged in implementing their learning in their classrooms, and did the teachers perceived their new knowledge impacting student learning. The research questions specifically explored in this paper are:

i) How did the project facilitate implementation of teachers' knowledge acquired during the PD training workshops in their classrooms?

ii) Did teachers perceive their new knowledge impacting student learning?

THE EPMT PROJECT

Enhancing the Pedagogy of Mathematics Teachers (EPMT) project, a school based project of the Centre for Research and Pedagogy at the National Institute of Education of Singapore, is a hybrid model of PD that integrates the "training model of PD" (Matos et al., 2009) with sustained support for teachers to integrate knowledge gained from the PD into their classroom practice. It exemplifies a critical development in the professional development of teachers in many parts of the world. This development reflects a gradual shift in the centre of gravity away from the University-based, "supply-side", "off-line" forms of knowledge production conducted by university researchers for teachers towards an emergent school-based, demand-side, on-line, in situ forms of knowledge production by teachers with support from university scholars.

The aims of the EPMT project were three fold. The first was to provide teachers with training on how to craft suitable learning tasks that engage students in reasoning and communication and teach for understanding during mathematics lessons. The second was to facilitate teachers' work (practice and feedback) at the school level by assigning them activities to carry out together with their fellow teachers who were also in the project. The third was to enthuse and support teachers to contribute towards the development of fellow mathematics teachers in Singapore.

Review of literature

The conceptual framework of the EPMT project draws on research findings, specifically the characteristics of effective PD programmes. High quality and effective PD programmes have been found to have a purpose as teachers are involved in shaping the foci of the programme that is related to their school work (Clarke, 1994; Hawley and Valli, 1999; Elmore, 2002). These PD programmes are part of coherent programmes of teacher learning and development that support their instructional activities at school, such as adoption of new standards (Stiff, 2002; Desimone, 2009) and focus on how to teach and what to teach – the substance and the subject matter- are key (Stiff, 2002; Desimone, 2009). Ball and Cohen (1999) have argued that "teachers' everyday work could become a source of constructive PD" (p 6) through the development of a curriculum for professional learning that is grounded in the tasks, questions, and problems of practice.

Such programmes include training, practice and feedback, and follow-up activities (Abdal-Haqq, 1995). Ball (1996) claimed that the "most effective professional development model is thought to involve follow-up activities, usually in the form of long-term support, coaching in teachers' classrooms, or on-going interactions with colleagues" (pp 501-502). Effective PD programmes are sustained (Clarke, 1994; Abdal-Haqq, 1995; Hawley and Vali, 1999; Elmore, 2002; Stiff, 2002; Borasi and Fonzi, 2002; Desimone, 2009) and embedded in teacher work (Clarke, 1994; Abdal-Haqq, 1995; Hawley and Vali, 1999; Carpenter et al., 1999; Elmore, 2002). Teachers learn best when observing, being observed, planning for classroom implementation, reviewing student work, and presenting, leading and writing (Stiff, 2002) and therefore opportunities for teachers to engage in active learning are certainly related to effectiveness of PD (Wilson and Berne, 1999; Desimone, 2009). In addition, collective participation by teachers from the same school, grade or department allow for powerful form of teacher learning through prolonged interaction and discourse (Wilson and Berne, 1999; Desimone, 2009; Stiff, 2002;). PD programmes that foster collaboration have been found to be effective (Clarke, 1994; Abdal-Haqq, 1995; Hawley and Valli, 1999; Elmore, 2002; Borasi and Fonzi, 2002).

Design of the project

The five significant features of the project were:

1. Content focus

The project had a content focus. It was specific to the pedagogy of mathematics. This focus was similar to that of most in-service courses conducted for mathematics teachers in Singapore as the main objective of such courses is to introduce teachers to new initiatives that arise from curriculum revisions.

2. Coherence

The project attempted to address the needs of the teachers in the following ways:

i)The revised mathematics curriculum of 2007 (MOE 2006a, 2006b) placed emphasis on reasoning and communication in mathematics lessons. As textbook questions were

inadequate for the purpose, there was a need for teachers to learn how to craft mathematical tasks that facilitate reasoning and communication during mathematics lessons.

ii)As teachers relied very heavily on textbooks for their daily work (Kaur 2010), there was a need for teachers to draw on textbook questions as starting points and craft tasks that would engage students in reasoning and communication.

iii)With the Teach Less, Learn More (TLLM) initiative of the MOE (MOE 2005) placing emphasis on teaching for understanding, there was a need for teachers to review and learn more about lessons that facilitate "understanding".

The university scholars who designed the project are actively involved in work at schools with teachers and so, were cognizant of their needs. Often in-service courses conducted for mathematics teachers are devoid of any input of teacher need by teachers but rather based on the provider's speculation as to what may be good for the teachers.

3. Duration

The project spanned 2 years and comprised three phases. Teachers attended training workshops for a semester, followed by a semester of school based work guided and monitored by the university scholars (PD providers), followed by another year (2 semesters) of self-directed school based work. The duration of the project was significantly longer than most in-service courses that mathematics teachers usually attended.

4. Active learning

The project engaged teachers in active learning – hands on work. They crafted mathematical tasks and planned lessons, worked in pairs to execute their lessons, video tape their lessons, critique lessons, and revise their plans, thereby engaging in iterative cycles of planning and implementing. In most in-service courses teachers are passive learners due to the nature of activities of the course, where dissemination of knowledge is the goal.

5. Collective participation

In the project there was collective participation at two levels – school and project. At the school level, at least 4 teachers with pairs of teachers teaching the same grade year and mathematics programme, participated. These teachers worked together during the training workshops and also at school when implementing their learning in their classrooms. At the project level, teachers also worked together building their knowledge by participating in sessions during which they critiqued their peer's work, shared their experiences and difficulties encountered during the implementation of their newly gained knowledge. In in-service courses teachers normally participate as individuals. Even if more than one teacher does participate from a school, they may not be able to work together for various reasons.

Implementation of the project

The project comprised of three phases spread over two school years. A school year comprises of two semesters, each of 20 week duration. Details of the phases are described in Kaur (2011). Specific to this paper only phase II of the project is described.

Phase II

The second phase of the project took place during the second semester of the school year (i.e. from July till December of the first year of the project). In this phase teachers were encouraged to infuse in their lessons their learning from the training workshops they participated in during the first phase of the project. Teachers were given specific assignments by the university scholars. They were assigned the following tasks to complete in their own time collaboratively with their fellow project participants in the school.

Plan, design and teach,

(i) [A] at least 1 lesson that infuse reasoning tasks and facilitate communication in your mathematics classrooms over a period of the next 10 - 15 weeks.

(ii) [B] at least 1 lesson that teach for understanding in your mathematics classrooms over a period of the next 10 - 15 weeks.

(iii) Video-tape anyone of the above lessons in A or B.

For all lessons, you must submit the lesson plan, samples of student work and your reflections about the lesson. A guide was provided for teachers to help them in their reflection of the lesson.

While teachers were working on their assignments, the university scholars' facilitated fortnightly meeting sessions during which teachers shared their work with the others and invited critique. It was during these sessions that teachers' shared with the rest of the project participants their tasks, lessons (through video-records), students' work and students' voices. They invited both applause and critique. We must say that after the first few sessions, the activity picked up momentum and teachers became more "welcoming" of critique. It was during these sessions that teachers were meaningfully engaged in the production of pedagogical knowledge, creating and testing their plans, most importantly taking into consideration their students' inputs like what made the lessons, enjoyable and meaningful. Using video records of their lessons they watched the performance of their students in class, reflected on their goals and evaluated their lessons. These actions led to revision / modification of plans for subsequent lessons. Towards the end of this phase teachers submitted their assignments. The assignments submitted by the teachers have led to the publication of the resource: Pedagogy for engaged mathematics learning (Yeap and Kaur 2010).

METHODOLOGY

Subjects

Table 1 shows the numbers of schools and teachers who participated in the project from January 2007 till December 2008. A requirement for participation in the project was that a group of at least 4 teachers per school participated. Every participant in the project had a buddy from his or her school such that they taught the same mathematics course and grade level.

Table 1: Number of schools and teachers in the project

	Primary	Secondary
Number of schools in the project	5	5
Number of teachers in the project for the 1st year	20	28
Number of teachers in the project for the entire duration	18	22

During the second year of the project 2 teachers from the primary schools were on maternity and child care leave respectively; 2 teachers from the secondary schools were also on maternity and child care leave respectively. In addition, another four teachers from the secondary schools moved schools at the beginning of the second year and hence were unable to continue with the project.

Sources of data

The data reported in this paper comes from two sources. The first is a narrative account of how teachers were engaged in implementing their learning in their classrooms. This is part of the implementation of the project. The second source of data is the post-intervention survey which was completed by participants during the last meeting session of Phase III of the project.

DATA ANALYSIS AND FINDINGS

In this section we first answer two analytical questions about how teachers were engaged in implementing their learning in their classrooms.

i) What were teachers assigned to do following the training workshops?

Teachers were given an assignment to do that required them to plan, design and teach at least one lesson that infused their learning {reasoning tasks facilitating reasoning and communication or taught for understanding}. They were asked to video tape the lesson and also subsequently do a reflection of the lesson.

ii) How were teachers supported in their attempts to infuse their learning in their classrooms?

There were at least four teachers from each school in the project, with pairs teaching the same grade levels. At the school level teachers worked together on their assignments. At the project level, teachers were supported in their attempts to infuse their learning in their classrooms via sharing of experiences during the fort nightly meetings organized by the university scholars.

From the answers of the two analytical questions about how the project facilitated implementation of teachers' knowledge acquired during the PD training workshops in their classrooms it is apparent that the method of the EPMT project which combined the "training model of PD" (Matos et al., 2009) and "sustained support for integration of knowledge gained from the PD into the practice of teachers" made it possible.

Next we examine the impact of strategies for reasoning and communication on student learning. A total of 33 participants of the project, 16 from primary schools and 17 from secondary schools completed the post-intervention teacher questionnaire of the project during the last meeting session of Phase III of the project. The overall response rate was 82.5%. The following is the data and analysis of the questionnaire item:

In what ways did the strategies for reasoning and communication help to improve student learning in your classrooms?

The qualitative responses to the above item were analysed using content analysis. They were first scanned through for common themes, following which codes were generated and the data coded. Inevitably "a progressive process of sorting and defining and defining and sorting" (Glesne 1999 p 135) led to the establishment of the final list of codes for the themes. Table 2, shows examples of the responses to the item and inferences made.

Table 2: Content analysis of data

Teacher code	Response	Inferences
P-2	Students were more engaged and they found the Math lesson interesting.	Lesson – interesting Students – engaged
P-11	I observed that students are more alert, more motivated to participated during lessons. More opportunities for pupils to share and explore their thoughts on the concepts or strategies.	Lesson – opportunities for pupils to explore their thinking and share Students – alert, motivated
P-14	Students could verbalise using the correct mathematical language (at most times). Students became more critical of their answers.	Students – verbalise thoughts; critical of their answers
S-8	It took their focus away from memorizing formula, and to how formulas are derived. The process makes them verbalized their thinking and increase retention of knowledge.	Lesson – shift of focus from rote learning to conceptual understanding Students – verbalise their thinking
S-11	The students were more engaged.	Students – engaged
S-17	It got them thinking through the tasks and they are able to grasp the concepts better. They had fun learning maths in a different way.	Lesson – got students thinking Students – fun learning

Table 3, shows the changes in the behaviours of students and likely cause inferred from the analysis of the survey data.

Table 3: Change in behaviour and likely cause

Primary students		Secondary students	
Change	Due to	Change	Due to
More alert, Motivated, Engaged	Lessons were fun and interesting because of activities designed by teachers	Motivated Engaged	Lessons had activities that were varied, fun, and thought provoking
Explored their understanding of mathematical concepts Explored alternative approaches to solve a task Verbalised their thoughts, often using mathematical language, and clarified their understanding	The nature of tasks they were given to do	Questioned their understanding of concepts Shift of focus from rote learning to how the formula/generalisation came about Verbalised their thoughts , clarified their understanding and increased retention of knowledge Increased use of logical thinking, analytical thinking Confidence of weak students improved	The nature of tasks they were given to do
Critical of their answers More aware of likely mistakes Were more reflective	Emphasis on nurturing good habits of mind	Self- assessed their learning Were more reflective	Emphasis on nurturing good habits of mind

From the qualitative data to the survey prompt, “In what ways did the strategies for reasoning and communication help to improve student learning in your classrooms?”, it is apparent from Table 3 that when teachers infused their learning about reasoning and communication students found lessons engaging. They found the lessons interesting, as the activities were more engaging, required them to “think about what they were doing”, talk about it with fellow classmates and present their work to the class. In so doing, they verbalised their thoughts, clarified their thinking and used mathematical language. Students in primary schools had the opportunity to explore various approaches to solve a task, in particular word problems. Students in secondary schools shifted their focus from “memorising the formulae” to how the formulae came about, were engaging in logical thinking and analytical thinking more frequently. Teachers also noted that the confidence of weak students improved when they worked in groups on tasks that demanded more “reasoning” than procedural work. Most importantly, there were signs that good habits of mind specific to the learning of mathematics were being nurtured, such as being reflective, aware of possible mistakes, being critical and regulation of learning through self- assessment.

CONCLUDING REMARKS

The EPMT project may be claimed to be unique in the context of PD for mathematics teachers in Singapore schools. It was a hybrid of the “training model of PD” (Matos et al. 2009) and “sustained support for integration of knowledge gained from the PD into the practice of teachers”. Ball and Cohen (1999) have argued that teachers’ everyday work could become a source for constructive PD, however in the case of the EPMT project teachers integrated knowledge they gained from the PD training modules into their everyday work so as to meet their needs and achieved this by working collaboratively with their fellow project teachers within their schools and also between schools that participated in the project.

References

Abdal-Haqq, I. (1995). *Making time for teacher professional development* (Digest 95-4). Washington, DC: ERIC Clearinghouse on Teaching and Teacher Education.

Ball, D.L. (1996). Teacher learning and the mathematics reforms: What do we think we know and what do we need to learn? *Phi Delta Kappan, 77*, 500-508.

Ball, D. L., & Cohen, D. K. (1999). Developing practice, developing practitioners: Towards a practice-based theory of professional education. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 3–32). San Francisco: Jossey-Bass.

Carpenter, T. P., Fennema, E., Franke, M. L., Levi, L., & Empson, S. B. (1999). *Children’s mathematics: Cognitively guided instruction*. Portsmouth, NH: Heinemann.

Borasi, R., & Fonzi, J. (2002). *Professional development that supports school mathematics reform*. Foundations series of monographs for professionals in science, mathematics and technology education. Arlington, VA: National Science Foundation.

Clarke, D. (1994). Ten key principles from research for the professional development of mathematics teachers. In D. B. Aichele & A. F. Coxford (Eds.), *Professional development*

for teachers of mathematics (pp.37 – 48). Reston, VA: National Council of Teachers of Mathematics.

Desimone, L. M. (2009). Improving impact studies on teachers' professional development: Toward better conceptualisations and measures. *Educational Researcher, 38*(*3*), 181–199.

Elmore, R. F. (2002). *Bridging the gap between standards and achievement: The imperative for professional development in education*. Washington, DC: Albert Shanker Institute.

Ginsburg, A., Leinwand, S., Anstrom, T. & Pollock, E. (2005). *What the United States can learn from Singapore's world-class mathematics system and what Singapore can learn from the United States: An exploratory study*. Washington, D.C.: American Institutes for Research.

Glesne, C. (1999). *Becoming qualitative researchers: An introduction* (2nd ed.). New York: Longman.

Hargreaves, A. (1995). Development and desire: A postmodern perspective. In T.R. Guskey & M. Huberman (Eds.), *Professional development in education: New paradigms and practices* (pp. 9−34). New York: Teachers College Press.

Hawley, W.D., & Valli, L. (1999). The essentials of effective professional development: A new consensus. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 127−150). San Francisco: Jossey-Bass.

Kaur, B. (2011). Enhancing the pedagogy of mathematics teachers (EPMT) project: a hybrid model of professional development. *ZDM – The International Journal on Mathematics Education, 43, 6/7*, 791-803.

Kaur, B. (2010). A study of mathematical tasks from three classrooms in Singapore schools. In Y. Shimizu, B. Kaur & D. Clarke (Eds.), *Mathematical Tasks in Classrooms around the World* (pp. 15–33). Sense Publishers.

Matos, J. F., Powell, A., & Sztajn, P. (2009). Mathematics teachers' professional development: Processes of learning in and from practice. In R. Even & D. L. Ball (Eds.), *The professional education and development of teachers of mathematics* (pp. 167 – 183). New York: Springer.

Ministry of Education. (2005). *Teach less learn more*. Singapore: Author.

Ministry of Education. (2006a). *Mathematics Syllabus – Secondary*. Singapore: Author.

Ministry of Education. (2006b). *Mathematics Syllabus – Primary*. Singapore: Author.

Smylie, M.A. (1989). Teachers' views of the effectiveness of sources of learning to teach. *Elementary School Journal, 89*, 543 – 558.

Stiff, L. V. (2002, March). Study shows high-quality professional development helps teachers most. *NCTM News Bulletin, 38*(*7*), 7.

Wilson, S. M., & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. *Review of Research in Education, 24*, 173–209.

Yeap, B.H. & Kaur, B. (2010). *Pedagogy for engaged mathematics learning*. Singapore: National Institute of Education.