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Exemplary Practices in the Primary Mathematics Curriculum - The Singapore Experience

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INTRODUCTION

Mathematics education in Singapore primary schools into the 21st century is still going through the period of change started in the early 1990's. There were calls for changes in emphasis from rote memorisation to meaningful understanding of concepts and problem solving; from a dependence on paper and pencil, manipulative computations and skills to mental calculations and thinking strategies; from teaching by telling to activity-based learning, group work and communication in mathematics. Since then a great deal of mathematics education literature, in-service workshops and programmes have been written and delivered on these essential areas for reform that schools should be incorporating into their classrooms. It was expected that teachers would be able to integrate those new initiatives into their lesson plans. A study by (Foong, Yap & Koay, 1996) revealed the concerns of Singapore teachers' about changes in the revised syllabus for primary mathematics. They recommended that within each school there should be collaborations among teachers through project activities that focused on how to incorporate changes proposed in the new curriculum. Teachers under the leadership of the head of department, could identify a particular problem or need, develop an action plan, acquire the knowledge, implement and then assess the outcome. The purpose of this paper is to present a collection of exemplary practices that were carried by the Mathematics Departments in some sixty schools to help their teachers, pupils and even parents in complementing the needs of a more engaging and relevant curriculum, sometimes beyond the classrooms.

EXEMPLARY PROJECTS FOR A MORE ENGAGING CURRICULUM

Since the year 2000, the author has been involved in teaching a module for the Diploma in Departmental Management (DDM) programme in the National Institute of Education (NIE). Participants enrolled in this module, entitled *Curriculum Area Leadership in Primary Mathematics*, are practicing Mathematics Heads of Departments (HODs) in their respective schools. For each cohort, the participants would be asked to list some of the constraints that they perceived as hindrances to the implementation of the intended aims stated in the MOE mathematics curriculum framework. Having identified and discussed the common issues across school systems, the participants were required to select one of the many projects that their Mathematics Departments had implemented in the past to address some of these problems for sharing with the other HODs. The objectives of this assignment where each HOD presents his or her school project are to promote community sharing of effective practices and for networking in future collaborations among HODs from the various school clusters.

Table 1: Categories of projects, their number of occurrences and some examples of practices

Category of Projects	No.	Examples of Practices
1.Problem Solving Schemes	13	Apply heuristics for non-routine problems; use "model-method" for challenging sums; A-Problem-A-Day; quizzes etc.
2.Activity-based Programmes	12	Use of IT for spatial creativity; Multiple-Intelligences (MI) lessons; "m*ultiplication-made-easy", "Math Boggles"*
3.Mathematics Games Day	10	Day Carnivals, Exhibitions and Math Trails to places of interests etc.
4. Grouping Pupils	11	Maths banding for P6 classes; peer-tutoring using Math Club members; buddy-system within class and across grade levels.
5. Maths Resources	5	Maximal use of resource room with pre-planned activities; School Maths Newsletters; Maths Webpage
6.Teacher Development	4	In-house workshop by teachers to upgrade on problem solving, mental sums; pupil assessment etc.
7. Parental Involvement	5	Workshops for parents; involvement of parents in children's learning activities

Total	60	

The sixty projects showcased by the HODs could be taken as a whole to represent what most schools were doing to address some of the constraints in the primary mathematics curriculum. The author considers these projects as exemplary practices that schools were doing to meet or supplement the essentials of the reformed curriculum. The variety and forms of the projects can be classified broadly into seven categories. Table 1 shows the categories and the number of projects shared by the HODs.

The following section provides brief accounts of the projects under each category:

Problem Solving Schemes

Thirteen schools had incorporated some form of schemes to integrate problem solving heuristics into the curriculum. Generally there were two schemes, one involving non-routine tasks and the other involved sums that required the "model-method" as a strategy. For the latter, although the use of the "model-method" for solving arithmetic word problems involving the four operations, fractions, ratios and percentages are stipulated in the syllabus, some schools found inconsistencies in the way their teachers presented the various types of model drawings and the solution steps to their pupils. To improve the situation, a few schools produced handbooks on the use of the "model method" for consistency amongst teachers so that when pupils moved from one grade to the next they would not encounter too many varieties. To prepare teachers who were not too familiar in the use of the model drawing for the more challenging problems in the upper primary grades, workshop materials in the form of booklets for the various grades were delivered. For those schools that developed such a scheme the motivation was more to help pupils who had difficulty in answering multiple-step word problems in the examination so that the school could improve on the national PSLE grade average. By upgrading the teachers' skills, more problem solving can then be incorporated into the classroom. All such resources were normally done by teams of teachers under the level Heads for the mathematics department.

For the non-routine types of problems needing other heuristic strategies such as *guess & check; listing; look for a pattern; working backwards etc.,* the HOD working with team of teachers would start collecting banks of such questions and their solutions. Although the curriculum stipulated that problem solving processes should be the focus of teaching and learning mathematics, teachers found a lack of non-routine problems to develop processes or problem-solving heuristics in the textbooks. At one school, non-routine problems were given out during assembly periods as quizzes to be followed up by classroom teachers to explore various strategies with their pupils. In this way teachers had to get involved in non-routine problem solving with their pupils. Another school had organized non-routine problems into "Young Mathematician" cards where co-operative learning was encouraged during enrichment classes. Other activities such as "A Problem-A-Day", term quizzes and on-line quizzes were opportunities for school to expose non-routine challenging questions to teachers and pupils. Two schools had successfully implemented structured scheme of work to incorporate teaching problem solving skills for non-routine questions into their curriculum time. It involved teachers' enthusiasm in sourcing for such problems and working on the solutions themselves. The mathematics department coordinated the compilation of the problems according to heuristics and levels, and also provided training for their teachers. One school started the scheme in 1998 across grade levels and was fully implemented by 2003 when non-routine questions became routine to all teachers and pupils in normal mathematics lessons.

Activity-based Programmes

One of the major aims in mathematics education is to provide pupils with the opportunities to be involved in meaningful and enjoyable maths activities. It is essential that these experiences also assist in the development of positive attitudes towards mathematics. Many teachers recognized the constraints in our local exam-oriented curriculum that has a syllabus with too much content. It leaves little room and time for hands-on activities to develop pupils, especially the weaker learners' motivation and confidence. These constraints tended to a prevalence of "chalk and talk" in the mathematics classrooms. Nevertheless there were schools that had made conscious efforts to inject regular activity-based programmes. They were conducted either in the classroom, mathematics room,

the assembly hall or even the canteen for pupils to experience some real and meaningful activities working with concrete materials which were familiar. At some schools, structured activity lesson plans were designed by teams of teachers for common usage at various levels.

For example, geometry lesson plans incorporating the use of IT were developed across the levels in one school where pupils' spatial creativity was enhanced when they produced designs in symmetry and tessellations. One school experimented to incorporate Multiple Intelligences (MI) into their primary one mathematics scheme. The aim was to provide teachers with structured lessons that would enhance co-operative learning and developing social skills of pupils. For this a team of teachers developed sets of activity-based mathematics lesson plans that integrated one or several of the intelligences such as logical, kinesthetic, visual/spatial, musical, naturalist and interpersonal as well as intrapersonal. At two other schools it was found that by P3 many of the pupils were lagging in their recall of the multiplication facts that would affect their learning of division and problem sums. One school developed a "multiplication-made-easy" programme with non-routine techniques using manipulatives; song and dance; and the other school conducted mass multiplication drills before school and during recess with the help of flash cards over a period of time. *Math Boggles* was another invention by a school to help pupils enhance their computational skills involving the four operations. It was basically adapted from the game *Boggle* where numbers were used instead of letters. The school developed several sets for all P1 to P5 pupils to play in groups during the *before school* period and in mathematics corners around the schools.

Mathematics Games Day

Mathematics Games Day would include an event within the school calendar, where a day or half a day is allocated for pupils of the whole school, sometimes at different levels, sometimes also opened to the public such as parents and residents in the neighborhood, to participate in fun-filled activities relating to the learning of mathematics and other subjects. Such events go by other names such as: *Maths At Play; Maths Fun Day; Funthematics; Maths & Science Fair; Math Carnival; Mathematics Festival, Mathematics Activity Day or Math Creative Day.* These were mostly held within the school compound, in the field, hall or the whole premises depending on the scale of the fair and booths were set up for the various game activities and challenges. Another popular event, *Math Trails* was organized often out of school at the Zoological Gardens and other places of interest such as the campus at the Nanyang Technological University in Jurong. One school organized a Math Trail at the Zoo for their P4 cohort and each pupil was encouraged to bring along their parents to work together with him or her on the mathematics trail questions. Organisation of these day-events is usually of two forms; one is where the school engaged an outside commercial agency to supply all the ideas, resources and logistics with some input from the teachers whose duty would be to help on that day to monitor pupils' behaviours. The other form of organization is where the teachers and pupils designed all the games and activities including manning the booths on the day itself. The latter is definitely more empowering for the pupils and teachers but it involved too much of teachers' time and resourcefulness.

On smaller scales working in teams, teachers had organized such events with the help of pupils for target groups. For instance, in two schools the upper primary pupils were given projects to design mathematics games and puzzles that were eventually used at a fair organized for the lower primary children. The upper primary pupils helped to run the booths organized in the canteen and this build up team spirit amongst pupils. One school organized a Math Activity Day for all the EM3 pupils and weak EM2 pupils where they experienced applications of measurement and number sense in real-life situations. They used measuring equipments and manipulatives for hands-on and problem solving. The P6 teachers and members of the mathematics committee were involved in planning and organizing the event. Another school did a major whole day event involving all teachers in the school, parents and relevant members of the community. There were lots of quizzes, competitions and even a Math Trail for both pupil and adult participations. Exhibitions of pupils' creative work such as mathematical art, 3-D geometric models, tessellations; connecting mathematics with the real world and projects on mathematical investigations were also displayed. It gave lots of publicity to the school when the media reported the event in the newspapers.

All such events have the aim of offering pupils a taste of the recreational side of mathematics and hopefully stimulate their interest in the subject. The games for such events were often designed to

reinforce basic concepts and skills previously used only when solving textbook problems. But at these events they got to use the mathematics in a fun way and at their own pace sometime in real-life context, whereby pupils can gain confidence as they could relate the abstract mathematics in a concrete way and in a different environment outside the classroom. They had opportunity to interact with pupils from other classes and also see other adults using the mathematics. For the teachers, such events brought out their resourcefulness and hopefully they could see the potential for using the games and activities in their own classrooms.

Grouping Pupils

In the primary schools, one of the challenges faced by teachers is coping with mixed-ability groups in a class. Classes were normally not streamed in the lower primary although some schools had practiced "banding" or "setting" for the lower end classes with respect to mathematics learning. Even after the P4 national streaming exercise, the range of abilities in mathematics within a class could vary substantially, especially so in the lower end of the EM2 stream. In *banding*, the pupils in each level are divided into classes according to the level of attainment in mathematics, while in *setting* the mathematics periods of 2 or 3 classes of a particular level are timetabled as a block where pupils are re-grouped according to their attainment in mathematics (MOE, 1994). In this way, the teachers will have more homogenous groups to teach according to the pupils' needs.

Among the eleven projects in this study on grouping pupils, three schools had practiced banding for their P6 classes so that the weaker classes were given more remediation with different teaching methods. One school had found the project a success that led to whole school implementation with a more structured after-school remedial programme across all the levels for the low ability in mathematics. The other projects showed attempts at peer tutoring or cross-age tutoring to help those pupils at risk. In one school, the teachers identified P1 and P2 underachievers through diagnostic tests and these groups of children were tutored by P4 and P5 Math Club members who were giving training as a buddy-cum-tutor to their charge. Besides one-to-one tutoring using work cards and manipulatives, CD roms, and games (created by the older pupils in another project) were also used. Graded work cards were prepared by teachers for this purpose. This project was conducted over 10 weeks in terms 2 and 3. Peer tutoring buddy system was used in the other projects where for example, pupils who scored above 85% in mathematics were paired with a classmate who scored below 35%. The value of such buddy system promotes interpersonal skills and in some way co-operative learning among pupils. For the weaker pupil, learning from a peer could be less threatening and for the better pupil it could enhance their own understanding of the mathematics that he or she is sharing with the other. In one project, the teacher required pupils to write in their journals, their reflections on learning under this buddy system.

Mathematics Resources

Maximizing the use of the Mathematics Resource Room available in their schools was the goal of two HODs' projects. They had set up a system where material resources like manipulatives were packaged according to the topics and the levels that teachers could use in their lessons. One of them attempted an open system where teachers had free access (unlike some common practices where most things and equipments are kept under lock and key) to the resources to encourage maximum usages and minimal hassle for use in their own classrooms. The resource room was also used a centre of mathematics learning with specially designed activity-based lessons and a roster set up for teachers to bring their pupils to experience these lessons. One school was especially proud of their Mathematics Room with specially designed furniture layout for co-operative learning and motivating mathematical posters and 3-D exhibits. Another HOD in her interest to promote the teaching of mathematics through children literature expanded her resource library with a wide range of story books that she searched from the internet. Many mathematical ideas and concepts are present in children's literature that teachers can tap. To showcase the activities of the mathematics programme in her school, one HOD and her team of teachers created their own Maths Webpage for the pupils, teachers, parents and the public. In another school a regular mathematics newsletter was published with teachers' and some pupils' input It was created to give opportunities for pupils to read interesting articles such as snippets on history of mathematics and mathematicians; interesting

mathematics problems as well as participate in the quizzes and fun activities on mathematics. This was another localized resource that teachers can tap to supplement the standard textbooks.

Teacher Development

The projects in the various categories discussed so far could be taken as forms of professional development of the teachers and HODs when they became involved in the planning, implementation and evaluation of the outcomes of each project. In this study there were four projects categorized specifically as teacher-development projects arising from an inquiry or problem. In one school, the HOD found that the existing practice of giving mental sums to pupils among her teachers were uncoordinated and there were some flaws in the way mental sums were carried out in the classrooms. Hence a workshop for the teachers was conducted to improve on the situation and at the same time update the knowledge of the teachers. At another school, the HOD found that there was variation in the attainment targets set by teachers for different classes in the same level. This was especially so among newly trained teachers who would set rather high or low targets that did not match pupils' ability. He initiated a project called *Math Thermometer*, where criterion sets of maths topical attainment tests were collated from teams of teachers to provide the appropriate targets for each level. Through this project, the teachers experience sharing and self reflection on their expectations of pupils' performance. Learning circles were formed in another school to identify pupils' weaknesses in solving of word problems at the various level and teachers then brain-stormed solutions to improve the teaching in this area.

Parental Involvement

Increasingly schools are beginning to see the advantage of engaging parents in the education of the children. Many parents had expressed concerns about the mathematics their children were learning that was so different from the times that they were students. Four schools had conducted workshops for parents across the grades from P1 to P5. Especially for the lower primary levels, the schools realized it was important to explain the mathematics curriculum to the parents and exposed them to the new concepts and the kind of problem solving methods like the model drawing that their children were taught. This can help parents to appreciate the mathematics that their children were doing and hence be able to support them in their homework. One school invited parents to join in a math trail at the zoo and another invited parents to contribute their help at their mathematics fair. In such ways parents had the opportunity to experience what their children were learning at these events.

CONCLUSION

In this sharing of the projects from sixty schools which range from development of curriculum schemes to involvement of parents, it points to an existence of a community of exemplary practices that can be generated and shared amongst schools. These various projects have been trialed and found to be beneficial to the pupils, the teachers and the mathematics curriculum. It also shows that schools are doing quite a lot to create engaging mathematical environments within their schools despite the isolation of teachers in their individual classrooms. The activities can be seen as extension of the conventional practices in the classrooms and pave the way for teachers to integrate more innovations into their own instructional practices. The network of HODs that has been formed in the DDM programme and their increased confidence through future collaboration is something valuable and should be encouraged. After all they are only a phone call away if more exciting projects and materials need to be shared. It is hoped that the positive impact of these undertakings as reported and shared amongst the HODs in this paper is not just for a *flavour-of- the-month* but for the long term.

References

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