Title The M^3 Project
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Source *Teaching and Learning, 17(1),113-119*
Published by Institute of Education (Singapore)

The M^3 Project

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Introduction

In line with current world-wide reforms in mathematics education, the Singapore Ministry of Education has revised the mathematics curriculum for primary and secondary schools in Singapore (Curriculum Planning Division, 1992). A framework that should guide teachers to conceptualise the revised curriculum has been suggested. Central to the framework is mathematical problem solving and major components that are believed to enhance students ability to solve mathematical problems are concepts, skills, attitudes, metacognition, and processes.

To realise the lofty ideas embedded in the revised curriculum, classroom teachers, who are the implementers of those ideas, need convincing evidence that those ideas can be implemented. One way of getting such evidence is for teachers to see that the ideas suggested in the revised curriculum have worked in classrooms similar to theirs. Another way is for the teachers themselves to try out those ideas in their own classrooms. The teachers should become researchers themselves. It is primarily in line with the latter option that the M^3 Project is being proposed. It is a classroom based research project aimed at investigating how to make mathematics meaningful to secondary school students, thereby helping to realise some of the aims of the revised mathematics curriculum in Singapore.

In the paragraphs that follow, I discuss briefly a theoretical framework that should guide the project, areas of research identified under the project, and the collaborators in the investigations.

Theoretical Framework for the M^3 Project

Evidence from research indicates that individual students learn mathematics by constructing meaning themselves (Davis, Maher, & Noddings, 1990). However, the individual construction of meaning is mediated by the social context within which students learn. In fact,

many educators believe that mathematical knowledge is socially constructed (Yackel et al, 1990; Vygotsky, 1978). Consequently, while focusing on students to make sense of mathematics themselves, teachers should endeavour to provide non-threatening classroom environments (NCTM, 1991). Thus, for carrying out investigations into areas identified under this project, the researchers should provide classroom atmospheres that will encourage students to interact with each other, with several activities, and with the teacher. Furthermore, students should be encouraged to share their ideas and should be assured that their ideas will be valued.

Areas of Research

The major focus of this research project is on ways to make mathematics meaningful to students. It is believed that conceptual understanding contributes a great deal towards the meaningfulness of mathematics. As such, emphasis in this article will be placed on some examples that help foster the development of conceptual understanding. Notice that other areas identified for investigation, although they may have different emphases, are all essentially aimed at making mathematics meaningful to students.

Teaching/Learning for Conceptual Understanding

Mathematics is made of several concepts and many of these concepts can be translated into formulas. However, for particular cases of a concept, there can be several variations in the formula. For example, particular cases of the concept of perimeter are rectangular and circular plane figures. To learn the concept of perimeter through the formulas, students will have to memorise $p = 2l + 2w$ as the perimeter for a rectangular plane figure and $p = 2\pi r$ as the perimeter a circular plane figure (see figure 1, a and b). So, for as many variations as there are, students will have to memorise all the formulas.

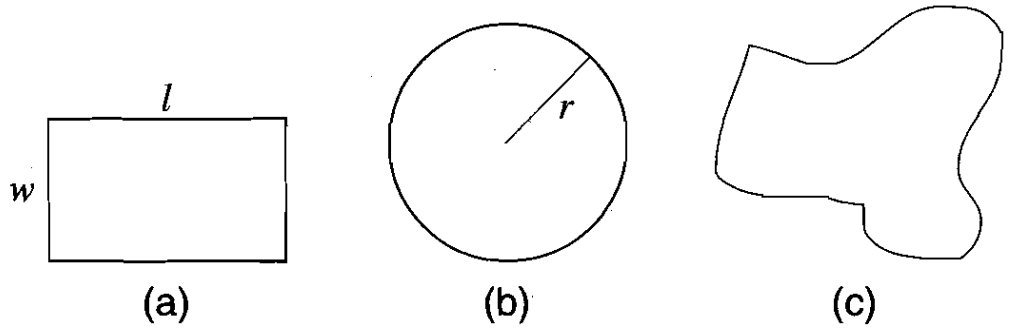

Figure 1

But do students have to memorise formulas of particular cases of perimeter to understand the simple concept of perimeter? And does memorising all the formulas help students extend their knowledge to make sense of the perimeter of figure 1c? Instead of students memorising all the formulas, the *sameness* underlying all the formulas, the sameness which is the essence of the concept of perimeter, is what should be emphasised and understood. This sameness is the distance around an object, starting from one spot and ending at the same spot. Armed with such understanding which I believe to be very powerful, students can conjecture how to find, and actually find, the perimeter of figure 1c, without knowing its formula. This way, students can extend this conceptual understanding to find the perimeter of even objects with no known perimeter formula. Furthermore, students can make better sense of known perimeter formulas, like $p = 2\pi r$ which is the circumference of a circle of radius r.

Notice, however, that emphasising conceptual understanding should not be construed to mean the neglect of formulas. Formulas help in representing and organising concisely the process of putting many ideas together (the underlying numerical relationships between sets of ideas), but conceptual understanding provides the *base structures* with which to advance knowledge (Noddings, 1990). With conceptual understanding, students should appreciate the manipulation of formulas so as to preserve the meaning of the formulas. For example, when students understand that 'derivative' $\frac{dy}{dx}$ is a one quantity limiting value, but not a ratio of two quantities, then they should not cancel dt in $\frac{dy}{dx} = \frac{dy}{dt} \cdot \frac{dt}{dx}$, the chain rule

for differentiation. For mathematics teachers, it should be of interest to know how to teach the various topics in the syllabus so that students can understand them conceptually. Whatever has been developed will have to be tried out by teachers so as to gather information on its effectiveness. Teachers will have to be conducting research in their classrooms.

Connections

Teachers can investigate how to make connections within mathematics topics, between mathematics and other school or non-school subjects, and between mathematics and real-life. Again, the focus should be on how these connections can help students to understand and appreciate mathematics.

Concepts Through Problem Solving

Since the focus of the revised curriculum is mathematical problem solving, one possible direction is to investigate how to use problem situations to develop mathematical concepts and processes. For example, how do students, through solving of real problems, make sense of matrix concepts and the Pythagorean theorem?

Modifying Textbook Exercises

Topics in mathematics textbooks are usually followed by numerous exercises that tend to be repetitive. How can these exercises be modified into mathematical investigations that promote the meaningfulness of mathematics? For example, as an exercise, students could be asked to find the area of the shape in figure 2 after a lesson on areas. However, the same exercise could be modified into a mathematical investigation by asking students to find the area of the grazing land available to a goat if it were tied at point A with a rope 50ft long.

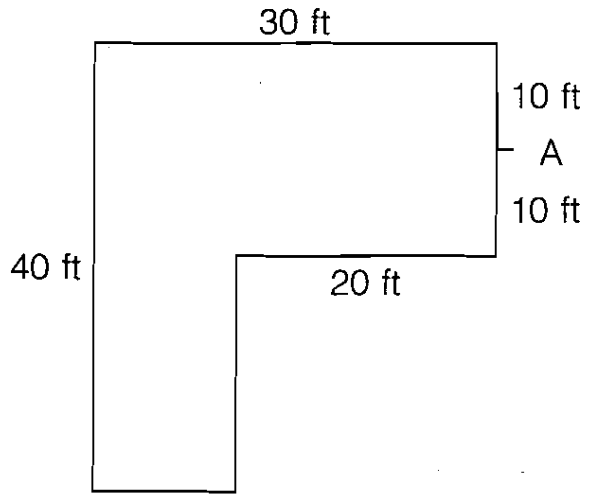

Figure 2

Using Small Groups

The benefits of using cooperative small groups to foster the teaching and learning of mathematics are well documented (Davidson, 1990; Webb, 1991). However, the cooperative groups do not *just happen*, they must be carefully planned and implemented. So, with the usually large class sizes in Singapore schools, the curriculum time available to teachers, and extensive materials to be covered, how can groups be organised and used effectively to make mathematics meaningful to students? Information on the effective use of small groups within the local context should be welcomed.

Use of Technology

Calculators and computers are impacting greatly on mathematics teaching and learning. How should mathematics classes be organised so that technology can make mathematics meaningful to students? *What* mathematics to teach or learn and *how* to teach or learn mathematics, need careful investigation by classroom teachers.

Assessment

It is a truism that what is tested and graded is what students perceive as valuable (see Wilson, 1994). Since tests are going to

remain within the revised mathematics curriculum, how should teachers be testing for understanding of concepts, attitudes, metacognition, and processes for gaining mathematical knowledge, *in addition to* the testing of skills? A lot needs to be investigated in this area.

Research Collaborators

Secondary school mathematics teachers, who are interested in pursuing a masters' degree, are to be identified for participation in the project. Teachers who have decided to participate in the project will use data gathered to write their masters' theses. So, while teachers gain in knowledge by researching into their own classrooms, they also benefit by obtaining a higher degree.

Conclusion

The M^3 Project should be seen as an on-going research into making mathematics meaningful to secondary school students in Singapore. The project draws on the revised mathematics curriculum in Singapore with the hope of contributing information on how to realise the ideals suggested in the curriculum.

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