Singapore Enactment Project

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The *Enactment Project* is a Programmatic Research Project funded by the Ministry of Education, Singapore, and administered through the Office of Educational Research, National Institute of Education, Nanyang Technological University. The project began in 2016 and its aim is to study the enactment of the Singapore mathematics curriculum across the whole spectrum of secondary schools within the jurisdiction. There were two phases in the project: the first involved in-depth examination of 30 experienced and competent mathematics to draw out characteristics of their practices; in the second phase, we study the extent of these characteristics through a survey of 677 mathematics teachers. A symposium was organised in MERGA 42 in 2019 where the foundational elements of this project were presented; we would like to share more findings of this project in this year's conference.

Paper 1: Berinderjeet Kaur *Models of mathematics teaching practice in Singapore secondary schools*

This paper revisits the models of mathematics teaching practice that were proposed by earlier researchers of the Singapore mathematics classrooms: Traditional Instruction (TI), Direct Instruction (DI), and Teaching for Understanding (TfU). The data from the survey in this project point to hybridisation of these models.

Paper 2: Tin Lam Toh *An experienced and competent teacher's instructional practice for normal technical students: A case study*

This paper presents a case of how an experienced and competent teacher engaged mathematics "low-attainers" in the learning of mathematics in a way that was responsive to their learning needs while upholding the ambitious goal of helping them acquire relational understanding of mathematical concepts.

Paper 3: Joseph Boon Wooi Yeo *Imbuement of desired attitudes by experienced and competent Singapore secondary mathematics teachers*

One of the components of the Singapore Pentagonal curricular framework is "Attitude". This paper presents findings of a survey that point to specific strategies used by Singapore mathematics teacher to imbue positive attitude towards mathematics in their students.

2021. In Y. H. Leong, B. Kaur, B. H. Choy, J. B. W. Yeo, & S. L. Chin (Eds.), *Excellence in Mathematics Education: Foundations and Pathways (Proceedings of the 43rd annual conference of the Mathematics Education Research Group of Australasia)*, pp. 65-66. Singapore: MERGA.

Paper 4: Yew Hoong Leong & Lu Pien Cheng *Singapore mathematics teachers' design of instructional materials*

Case studies based on the data in Phase 1 of the project revealed that the teachers crafted their own instructional materials based on modifications of reference materials. This paper summarises some of the moves teachers adopted when designing instructional materials for their lessons.

An experienced and competent teacher's instructional practice for normal technical students: A case study

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This paper presents a case study of an experienced and competent mathematics teacher's classroom instructional practice in a Normal Technical Mathematics course. The topic that was observed was Volume and Surface Area of a Pyramid, a subtopic within the mensuration topic in Secondary Two syllabus. The teacher used a video clip on the Egyptian Pyramids to integrate students' prior knowledge on pyramids, which raised their attention on the topic. This was followed by engaging the students in hands-on activity to understand the formulae.

The case study is part of the larger research project on enactment of the curriculum in the mathematics classroom as reported by this symposium.

Low Attaining Students

Studies have shown that low attaining students are generally visual and kinaesthetic learners (e.g. Amir & Subramaniam, 2007; Rayneri & Gerber, 2003). The mainstream education programmes worldwide are usually more theory-based than skill-based with ample hands-on opportunity for individual learners (Glass, 2003). Therefore, it is not at all surprising that this dissonance puts the low attaining students, who usually learn best through visual and physical engagement, at a disadvantage in the education system.

Low attaining students generally have little interest in academic subjects. They lack focus during lessons, have short attention span and hence tend to be restless in classes (Lui et al., 2009). Thus, typical teacher-centric teaching approaches might not be most appropriate for them. Myron and Keith (2007) stressed that in order for teachers to be more successful in working with the low attaining students, they must be more cognizant of the various learning styles of their students and attempt different teaching approaches for different groups of students.

Normal Technical Students in Mathematics

Singapore mathematics teachers are genuinely concerned about the performance in mathematics among the Normal Technical students (Toh & Lui, 2014). This concern is not unfounded as many of the Normal Technical mathematics students exhibit many of the characteristics of low attainers (Toh & Kaur, 2019).

Studies have also shown that Singapore teachers are not passively using traditional instructional materials and resource for teaching Normal Technical students. As the students' difficulties with mathematics and reasons for their lack of interest in the subject are various, teachers' effort to reach out to this group of students is also diverse. In addition to honing their pedagogical skills in the classrooms, teachers are also actively adapting less conventional instructional approaches and developing unconventional instructional material to address the learning needs of this group of students (Toh & Lui, 2014).

To have a first-hand glimpse into how mathematics lessons are conducted by a experienced and competent teacher in a typical Normal Technical class, the author (hereafter, first person pronoun) followed through one such identified teacher's lessons for two weeks on teaching a subtopic of mensuration in a Secondary Two Normal Technical

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mathematics class in a Singapore mainstream school. A few striking observations that were made will be reported in this paper.

Method

All the lessons that were observed in this study, the teacher interview, and the student interviews were video-recorded and transcribed. The video-recording, adapting the Complementary Accounts Methodology of Clarke (1998, 2001), used three video cameras to focus on: (1) the classroom as seen from the teacher's perspective; (2) the activity of two particular students in each lesson; and (3) the classroom from the perspective of an observer at the back of the classroom.

The teacher, Lucy-Marianne (pseudonym), was identified as an experienced and competent mathematics teacher by the mathematics education community. She was a Senior Teacher in her school, in her mid-forties at the time of our study, had more than ten years of experience teaching in the school and had been teaching mathematics in Express, Normal Academic and Normal Technical stream for more than fifteen years at the time when this study was conducted. In a discussion with her during the teacher interview, she expressed her passion in teaching the group of low attaining students. According to Lucy-Marianne, this group of students "deserved our attention more". She was trained to teach both Mathematics and Computer Applications.

Observation and Discussion

In unpacking teacher Lucy-Marianne's pedagogical practices from the entire set of video-recordings of her lessons, a very skilful scaffolding sequence to facilitate her students in understanding a complex concept was visible:

1. she first elicited her students' prior knowledge related to the concept;
2. she aroused her students' interest about the concept;
3. she built on their induced interest to further develop the mathematics concept;
4. she engaged her students in hands-on activities to "derive" the formula; and
5. she gave students ample opportunity to practise the application of the formulae.

During the teacher interview, she revealed that this was the constant sequence in teaching the other mathematical topics as well as to her Normal Technical students.

Eliciting students' prior knowledge

Her teaching of the subtopic on surface area and volume of a pyramid is the focus here. She built on her students' prior knowledge selectively for her lesson development, as illustrated by a portion of the dialogue below. Letters T and S denote the teacher and student participant.

Dialogue		Commentary
(after housekeeping matter)		
T:	Now let's move on to volume of pyramid – uh no, surface of pyramid [first]. OK by the way, let me introduce the word "pyramid". **What is [a] pyramid**?	*Teacher elicited her students' prior knowledge on pyramid.*
S:	A 3D.	
T	OK It's a 3-dimensional object... A pyramid is no longer flat [tapped the table],it's no longer flat [tapped whiteboard], but it's a 3-dimensional object. But **what does it look like and how does it look like…**?	*Teacher responded to a student's use of the term 3D (3 dimensional) by distinguishing between 3D and 2D objects (prior to this lesson, the students learnt mensuration of circle – a 2D object).*
S:	Cone.	

T:	It looks something like a cone. Oh, OK... "Looks something like" doesn't mean it's exactly the same. So later we are going to learn cone, today let's talk about pyramid. **Anyone can describe pyramid?**	*Teacher was careful to acknowledge the response that a pyramid looks something like a cone, but did not want to elaborate the concept of cone to avoid confusing the students (mensuration of a cone would be the next subtopic).*
	::::::::::::	
S:	Huh? Oh triangle.	
T:	Thank you … they (two students) are right... There are triangles on pyramids. So this is a pyramid like what you see in Egypt. Now, **if I were to look from top down, what do you think is on the ground?** What shape? S: I know, a square.	*Teacher elicited the responses of "triangle" and "square" from the students about their knowledge of pyramid. However, teacher did not further elaborate that the bases of pyramids can be made of other shapes at this juncture.*

Arousing students' interest and curiosity in the concept.

Teacher Lucy-Marianne skilfully related the geometrical figure of a pyramid to the Egyptian Pyramids at Giza. She discussed the historical function of the Egyptian Pyramids after showing a short video clip selected from YouTube about the Egyptian Pyramids. The content of the video clip raised students' awareness of mathematics in the real world; this is aligned to the Ministry of Education (MOE)'s desire to "prepare its citizens for a productive life in the 21st century" (MOE, 2012, p. 2). The selected video covered the students' responses: the sides of the pyramids (consisting of triangles), the plan view of the pyramids (squares), the dimensions and the historical functions of the pyramids. The use of videos in education is particularly useful for low attaining students, as it has the ability to reduce their cognitive load and facilitate their understanding of abstract concepts (Han & Toh, 2019)

Reinforcing the concept of the lateral side faces of a pyramid.

Teacher Lucy-Marianne emphasized the sides and base of a pyramid from different angles and by decomposing a three-dimensional pyramid into two-dimensional parts. Teacher Lucy-Marianne next used a worksheet (Figure 1) to reinforce the identification of the sides. Here, she unravelled the next part of the "truth" that the base of a pyramid is not necessarily a square or rectangle. She introduced pyramids with various polygonal bases. This was also the first time she insisted on the precise mathematics terminologies (lateral sides and base of a pyramid) illustrated in the dialogue below Figure 1.

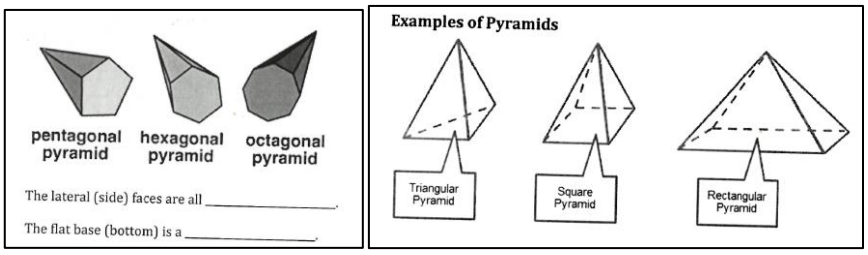

Figure 1. A portion of the worksheet used by Lucy-Marianne in introducing the faces of a pyramid

T: I want you to look at the word, the lateral side faces are? The word 'lateral' means side. Side means lateral. So the side faces are what kind of shape? … I will like to introduce a word, the flat base water missile, I call it 'polygon'. Polygon means it can be 3 sides, 4 sides, 5 sides, 6 sides, 7, 8, etc.

Deriving the procedure for calculating the total surface area of a pyramid.

The video clip and the identification the various parts of the pyramid led to the calculation of the surface area of a pyramid by considering the nets of a pyramid. She engaged her students in deriving the formulae using a hands-on approach by engaging them

to cut up a pyramid into its nets to identify the total surface area of a pyramid as the sum of the areas of the polygons in its corresponding net. This "experimental derivation" was observed in her lessons throughout this subtopic. In determining the volume of a pyramid in the succeeding subtopic, Lucy-Marianne conducted a "laboratory lesson" to demonstrate the relation between the volume of a pyramid and its related prism. The topic mensuration at the secondary level can be taught either in a very procedural manner, or one that engages the students with hands-on activities as proposed by Lim-Teo and Ng (2008). Teacher Lucy-Marianne had chosen the latter to better match the needs of her students.

Ample opportunity to practice. As in other observation of the Singapore classrooms, teacher Lucy-Marianne designed her worksheets to give sufficient structured and guided practice for her students. This will not be elaborated in this paper.

Conclusion

This is an episode of teaching mathematics to Normal Technical students by an experienced and competent teacher. While the teacher was cognizant of the importance of maintaining the rigor of the mathematics curriculum even for the low attaining students, the teacher was also skilful in engaging her students in activating their prior knowledge, exciting them with the mathematics in the real-world, and chunking up big group of mathematical content into manageable bites for her students. The teacher strove to develop in her students a relational understanding of the mathematical concepts through appropriate student engagement, while using video clip and storytelling to excite her students in the mathematical concepts. The lesson was evidence of her attempt at striking a balance between developing her students' cognitive and affective aspects of learning.

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