

# Mathematics Teacher Education for Future Ready Learners: A Singapore Experience

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## Abstract

This paper presents the readers with an alternative paradigm of teaching students mathematics not through the usual textbook approach, but using comics and the associated pedagogies. The author argues that it is more useful to equip students with the skills to acquire knowledge, by using contexts that they are likely to encounter in the future. The author further continues with the research experience in Singapore in using comics in teaching mathematics. As it started off with low attaining students in mathematics, there is room for extending this method to other groups of students.

## Introduction

To equip students with the knowledge and skills necessary for the adult working life later is no longer a suitable paradigm of teacher education today, as the world is changing very quickly. The amount of knowledge is increasing at an exponential rate, and what is learnt today will be quickly made obsolete by new technologies. The way a student understands the world today is so much different from a student's understanding of the world a decade ago. Projecting into the future, the way a student of the future understands the world is beyond our imagination at the current state. For example, the calculations of the position on the surface of the Earth by assuming the Earth as a sphere, has been made irrelevant by the current state of the Global Positioning System (GPS)! It is thus necessary to re-consider our paradigm of teacher education as one that prepares our students to be future ready.

## Threat versus Opportunity

From the evolution of education worldwide, educational programmes have evolved into one that is more theory-based than skill-based, and most of the instructional programmes tend to have an advantage for students who are visual and audio learners (Glass 2003). Students whose learning styles are classified as kinaesthetic learners tend to lose out in such educational programmes, and more often than not classified as "low attainers" (Amir and Subramaniam 2007; Rayneri et al. 2003).

A purely theory-based education programme might not be sufficient to equip students with the unknown future world. For example, the world today combines and presents information and

knowledge in different forms, including visual cues, rather than in textbook format. As an example, when I was presenting to a group of high school mathematics students a combinatorics problem involving “dictionary order” of arranging a series of letters, all the students were stunned as they had never used a dictionary in their life. Any information that they need are retrieved online via a search engine, or Wikipedia.

Teachers’ day-to-day experience with students also show that most of the so-called “low attainers” in schools are “street-smart” individuals who are able to decipher information in the real world more than the high achievers in schools. As such, teachers could view this as an opportunity to close the gap between students of different achievement levels. In the remaining of this paper, we discuss an effort in Singapore in the mathematics education to attempt to prepare students to be future ready, beginning with an attempt to reach out to the low attaining students through an innovative pedagogy of using comics for mathematics instruction.

### **A Singapore Experience: Start with Low Attaining students**

A survey was conducted by Toh and Lui (2014) on how Singapore teachers attempted to address the learning needs of their low attaining mathematics students. Toh and Lui (2014) found that the teachers were very concerned with the mathematics learning of their low attaining students, despite the fact that Singapore has performed very well in TIMSS and PISA. As an effort to help their students in coping with mathematics, there was much effort, though not well coordinated, among the mathematics teachers in devising their own creative teaching approaches to facilitate their students in mathematics. Among the many teaching approaches, storytelling, comics and cartoons were used by the teachers for mathematics instruction. After this survey, I assembled a team of researchers (hereafter, addressed as first person plural) from the Singapore National Institute of Education in proposing a research project to introduce the use of comics for mathematics instruction for the low attaining students. We worked with three Singapore mainstreams schools and which we eventually scaled up to 11 schools in total.

We began the whole process with designing sets of comics for selected mathematics topics from the lower secondary mathematics curriculum. As the research attempted to study the impact of comics on student learning and analyze the features of a comics mathematics lesson, we requested the participating schools to use the comics teaching package as an alternative teaching package in that the comics package should be used entirely to replace the current resources for these package. In other words, the comics teaching package should be used as a “replacement unit” (Leong et al., 2018).

In our design of our comics teaching package, the following items were developed:

The sets of comic strips which covered *all* the mathematical concepts for the selected topics of mathematics. We replaced most of the standard textbook features of exposition and worked examples by comic strips with storylines that explicated the concepts within the *context* of the comics. These storylines included humors within the context that the Singapore students were particularly familiar (e.g. Great Singapore Sales, the cultural heritage of Singapore etc.). In addition, the comics package were presented in two forms: hard copy version (in which the students could be given a printed copy of each set of comics); and the online version (in which the

students were provided with a password to log into the system). After the first cycle of implementation, we developed a parallel set of comics in which the readers were given the opportunity to complete the story by filling in the blanks in the comic strips. According to some teachers, they preferred their students to complete the story on the hardcopy instead of passively listening to stories during lessons.

Each set of comics was accompanied by sets of practice questions in order for teachers to reinforce the students' acquisition of the mathematical concepts. These practice questions consisted of those within the context of the comics, questions from other similar context, and also the typical examination-type questions. We hoped to ensure that students had sufficient practice of the questions and, more importantly, they were able to transfer their knowledge acquired across various contexts.

We also included classroom activities that promoted the development of higher order thinking skills among students. These questions stretched student thinking beyond the lower level tasks of understanding and application. In addition, we included open-ended tasks for students to use creativity to extend their understanding of the school mathematics.

In addition, we provided a set of suggested lesson outline in which we proposed how the lesson could be conducted using the comics package. In the first draft of this set of lesson outline, we proposed storytelling as the underlying pedagogy in conducting the lessons with the CIP. However, as we observed the lessons of the many teachers, we observed that they included many good practices (to be discussed below), which we eventually included in the lesson outlines for the second and later cycles of implementation.

### Our Observations

We (Toh, Cheng, Ho, Jiang and Lim, 2017) presented our observation in one mathematics lessons presented by one pair of mathematics teachers from a particular mainstream school. This was our first attempt to understand how a mathematics lesson using comics could possibly appear, and the features of such a lesson. We attempted to use the framework of the twenty-first century competency (21cc) model suggested by the Singapore Ministry of Education (Figure 1).



Figure 1. The 21cc framework of student outcome

We reported in Toh et al. (2017) that the teachers seized every opportunity provided by the comics to engage their students in the mathematical discourse. There were several instances in which the observed teachers attempted to use visual cues of comics to invite the students to decipher the meaning of the visual codes and interpret the context of the storyline of the comics. The teachers also infused various elements of civic literacy and global awareness in their lessons. The interview conducted with the students showed a positive gain among the students in the various soft skills that form part of the elements of the Singapore twenty-first century competency framework. Interested readers are encouraged to read the paper for greater details.

We (Toh, Cheng, Lim & Lim, 2018) further attempted to observe the comics mathematics lessons of several other teachers. We saw further that the comics mathematics lesson did not merely involve passive learning or comics reading by the teachers among the students, or monotonous narrating of the story by the teachers (as we had earlier proposed in the first draft of lesson proposals). The observed teachers seized the opportunities to engage students in active learning. The students in these classes were actively engaged in the mathematics discourse during the lessons. In particular, the teachers engaged their students in role-play in enacting the entire storyline of the comics, with various students playing the role of the fictitious characters of the comics. The other students were actively participating in the lesson by asking and answering questions during the interaction with the fictitious characters of the comic storyline. Not only that, the teachers engaged the students to participate in constructing the story of the comics by using comic strips with partially removed dialogues in mathematics.

All the above observations led us to further fine-tune our proposed lesson outline for the subsequent implementation of the comics research project. In this way, our research went through cycles of design – implement – fine-tune as shown in Figure 2.

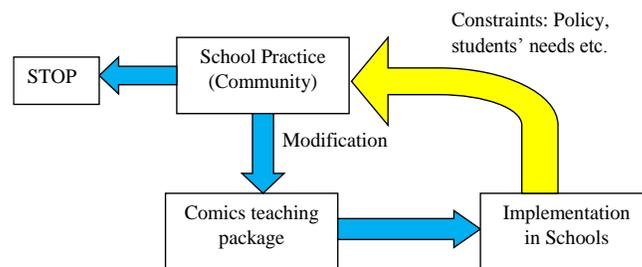


Figure 2. Design cycle of the comics research project.

## Next Step of this project

As the research is underway, we received interest from various schools in duplicating the studies at the upper primary level and also secondary level other than the low attaining students. According to the feedback given by the interested teachers, the design of the comics project is suitable not only to motivate the unmotivated students, but also it is a preparation for students to acquire knowledge beyond merely textbooks, but also from the real world context. Mathematics educators are moving away from heavily worded mathematical problems to those situations that involve a combination of different representations of information, usually involving a combination of graphics and words (Lowrie, 2012). Thus, it is not an exaggeration to say that the use of comics in education could reach an unprecedented status in preparing students to prepare for literacy in the future world.

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