HELPING NORMAL TECHNICAL STUDENTS WITH LEARNING MATHEMATICS – A PRELIMINARY SURVEY

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Abstract

Classroom anecdotes have shown that teachers find it challenging to teach Normal Technical [N(T)] students in Mathematics. The authors conducted a survey on a group of teachers teaching N(T) mathematics in July 2013 in an attempt to identify the N(T) students' learning difficulties in mathematics, and the strategies and resources that the teachers have used to help their students in learning the subject. This is a follow-up of an earlier research project on "Positive social climate for enhancing students' mathematics self-concept" that the authors have engaged together with several other colleagues from the Singapore National Institute of Education in the period 2002 – 2004. In the July 2013 survey, we found that teachers have identified several major factors in their students' learning difficulties, which can be broadly classified under three categories: cognitive, psychological and socio-emotional. The survey also indicates that teachers have resorted to the use of a variety of resources and strategies to help their students in learning the subject, ranging from manipulative developed by the Singapore Ministry of Education to a number of creative methods in teaching mathematics.

Keywords: Normal Technical; Low Attainers; Learning Difficulties; Teaching Strategies; Academic Self-concept

Introduction

In Singapore, the Normal Technical (which we will call N(T) hereafter) course was established in 1994. The rationale is to provide at least 10 years of general education for all Singapore students. Prior to the introduction of the N(T) course, it was estimated that about 15% of students dropped out from school after only 8 years of primary schooling. The Singapore government saw the need to equip these students who are less academically inclined with "the requisite skills and attitudes to enable them to contribute to the national economy" (Ng, 1993). With the introduction of the N(T) course, these students qualify for secondary school education (Ministry of Education, 2000). The intent of the Singapore Ministry of Education (hereafter, MOE) is to prepare these students for further vocational and technical training at the Institutes of Technical Education after their secondary education.

The MOE has identified that the needs of this group of students are quite different from the contemporaries from the other streams. Their curriculum in general is designed to focus more on practice-oriented learning, which is perceived to be more in line with N(T) students' approach to learning (MOE, 2000).

Teaching N(T) Mathematics

Anecdotes from the mathematics classrooms generally show that teaching mathematics in N(T) classrooms has been challenging for teachers. Why mathematics, in particular? Mathematics is an extremely powerful tool to represent the world. Its power comes from its abstraction. The theory of mathematics seems to develop without any particular context (Lui, Toh, & Chung, 2009). This is precisely why laypeople generally have the impression that mathematics is abstract. It is precisely because of this "abstractness" that mathematicians are enchanted with the "beauty" of the subject. However, this abstract nature of mathematics is the source of much of the difficulty for teaching this subject to students in general (Weissglass, 1990) and the low achieving students in particular.

Educational programmes worldwide have evolved to one that is more theory-based than skill-based. Furthermore, instructional programmes generally focus on students who are visual and audio learners (Glass, 2003). This has put the lower achieving pupils at a disadvantage, as they are generally kinaesthetic learners (Amir & Subramaniam, 2007; Rayneri & Gerber, 2003). It is thus understandable why the low achievers generally do not show interest or excel in the academic subjects or are perceived as lack of competence in these subjects.

Early research describes low achievers as those students who fall into the bottom 20%of mathematics attainment in their age group in national examinations (Denvir, Stolz & Brown, 1982). Haylock (1991) used the term "low attainers" to define students who attain very much less in mathematics when compared to their contemporaries. In this paper, we choose the word "low attainers" over several other terms like "slow learners", "at-risk students", "special needs students", "under-achievers", and so on. We agree that the use of the term "low attainers" does not make any judgment about the reasons for low attainment in mathematics (Kaur, Koay, Foong, & Sudarshan, 2012).

At this juncture, we would like to caution the readers that although the N(T) students have been categorically been classified as the academically weakest students, there is much diverse ability among the students in N(T) classrooms, with wide range of learning abilities across different subjects. We are not denying that there are N(T) students who have performed as well or even better than their peers in the Express or Normal Academic courses, (for example, Channel NewsAsia, 2012; Wong, 2014; to cite only a few)

Characteristics of Low Attainers

In this section on literature review, we refer to studies associated with "low attainers", as the concept of N(T) is unique to Singapore, and not much literature exists related to N(T) course in Singapore.

Generally, the literature identifies several broad attributes of low attainers. They can be classified as (1) cognitive and metacognitive; (2) affective; and (3) social attribute.

Cognitive and metacognitive factors

Low attainers generally lack metacognitive strategies (Cardelle-Elawar, 1995; Krutetskii, 1976; Mercer & Mercer, 2005; Verschaffel & De Corte, 1995) and suffer "cognitive overload" and they usually have short-lived memory for mathematical procedures (Keijzer & Terwei, 2004; Mercer & Mercer, 2005). Also, these learners lack the ability to apply the appropriate heuristics for different situations (Nelissen & Tomic, 1998; Verschaffel & De Corte, 1995), or to apply domain-specific knowledge flexibly (Kraemer, 2000). Further, they lack appropriate background or pre-requisite knowledge (Mercer & Mercer, 2005). In addition, the low attainers usually have difficulties in using more sophisticated representations such that schemata and models or in considering numbers as formal objects (Karsenty, Arcavi, & Hadas, 2007; Kraemer & Janssen, 2000).

Affective factors

Low attainers generally show negative attitude towards learning mathematics. Some signs of negative attitude includes feelings of fear, stress, anxiety and resentment towards the subject (Haylock, 1991; Karsenty, 2010; Karsenty & Arcavi, 2004; Lehr & Harris, 1988; Mercer & Mercer, 2005). They have low self-concept (Karsenty & Arcavi, 2004; Kaur & Ghani, 2012; Mercer & Mercer, 2005). Students' disruptive behaviour in classrooms could be influenced by their attitude towards the subject, and that the experiences that students acquire plays a significant role in the formation of their attitude. Thus, it is not surprising that researchers have explored the affective domain of low attainers (see, for example, Kaur & Ghani, 2012).

Social factors

Studies have also shown that many low attainers have social problems and they lack social skills (Haylock, 1991; Lehr & Harris, 1988).

Preliminary Study – A Survey

This section reports a preliminary survey that the authors conducted in July 2013 following a workshop conducted for the N(T) mathematics teachers. This survey was developed by the researchers as an attempt to understand N(T) mathematics teachers' perception of their students' lack of interest and perceived learning difficulty in mathematics, and the strategies that the teachers had used to engage their N(T) students. The participants were allowed to indicate their name and contact details, or to leave the personal particulars anonymous if they did not wish to be contacted for further follow-up. A copy of the survey is attached in Appendix A.

A total of 25 teachers attended the workshop. They were encouraged to participate in the survey. As the participation in this survey was entirely voluntary, the authors only received responses from 19 participants from eight different schools in Singapore.

Teachers' perception of why their students got 'stuck' in mathematics

The participants have indicated the following reasons as to why they think their students got 'stuck' in mathematics. These reasons can be classified under three broad categories: (1) cognitive; (2) psychological; and (3) other factor.

Table 1

Teachers' Perception of the Reason Their Students Got 'Stuck' in Mathematics

Reasons	No. of responses	Percentage
Cognitive Factors		
Unable to understand the question	4	19.0
Poor understanding of mathematics concepts	4	19.0
Poor foundation in primary school mathematics	2	9.52
Confused by multi-step problems	1	4.76
Need more worked examples to learn	1	4.76
Difficulty in memorizing formulae	1	4.76
Lack of perseverance	1	4.76
Unable to see the relevance in life	2	9.52
Affective / Psychological Factors		
Easily distracted	1	4.76
Not interested	3	14.3
Other Factor		
Dyslexic	1	4.76

Teachers' perception of why their students were not interested in Mathematics
The reasons of the teachers' perception of their students' lack of interest in Mathematics can be classified under three broad categories: (1) cognitive; (2) affective; and (3) other factor.

Table 2
Teachers' Perception of the Reasons for Their Students' Lack of Interest in Mathematics

Reasons	No. of responses	Percentage
Cognitive Factors		
Mathematics is difficult	6	37.5
Not relevant to daily life	4	25
Too complicated	1	6.25
Affective / Psychological Factors		
Boring	1	6.25
Never passed mathematics before / Lack of success since Primary school	2	12.5
Too far behind their peers	1	6.25
Other Factor		
Family problem	1	6.25%

Teachers' use of strategies and resources to help their N(T) students learn mathematics
The teachers' responses to the survey shows that they had used a wide spectrum of resource and strategies to help their N(T) students learn mathematics. This wide range can be broadly classified under several categories: (1) mathematical manipulative; (2) ICT; (3) Media; (4) Modification of Pedagogy; (5) Psychology; and (6) Alternative Pedagogy. The detailed description of the items in these categories is shown in Table 3 below.

Table 3
Strategies and Resources to Help N(T) Students Learn Mathematics

Strategies And Resources	No. Of Responses	Percentage
Category 1: Manipulative		
Manipulative (alge-discs and other standard manipulative)	5	11.63
Tasks to discover mathematical formulae experimentally	1	2.33
Category 2: Information and Communications Technology		
Online learning platforms	5	11.63
Content Websites	2	4.65
Mathematical tools	1	2.33
Category 3: Media		
Videos	5	11.63
Category 4: Modification of Pedagogy		
Adopt a slower pace of lesson	1	2.33
Individual explanation of concepts	1	2.33
Peer coaching	2	4.65

Engage students to share interesting mathematical ideas	1	2.33
Use more examples to illustrate a concept	1	2.33
Use appropriate form of language	2	4.65
Small group consultation	1	2.33
Relate the mathematics to everyday life	1	2.33
Use of hands-on activities	2	4.65
Category 5: Psychology		
Build up students' confidence / allowing small successes	3	6.98
Category 6: Alternative Pedagogy		
Storytelling	2	4.65
Cartoons	4	9.30
Games	3	6.98

Table 3 shows that teachers used a wide variety of strategies and resources to enhance their N(T) students' learning of mathematics. These include the current practice: effective use of manipulative (Category 1) to the innovative approach of Alternative Pedagogy (Category 5). Tables 1 and 2 show that cognitive factors were perceived by teachers as the biggest reason behind their students' getting stuck and their lack of interest. According to Appleton, Christenson, Kim, and Reschley (2006), motivation is crucial for students' engagement and active involvement in a task. Students' lack of interest arose mainly due to motivational problems (mathematics is difficult, 37.5%; not relevant to daily life, 25%) hence leading the students to not engage. Categories 5 and 6 will discuss further methods combating motivational problems and developing students' interests in mathematics via raising their self-confidence and use of alternative pedagogies such as comic books.

In contrast, students' getting stuck was not largely attributed to motivational issues (lack of perseverance, 4.65%; unable to see the relevance in life, 9.52%). Instead, it was attributed mostly to a poor foundation in mathematics (Unable to understand the question, poor understanding of mathematical concepts, poor foundation, confused by problems, total 52.58%). Categories 1 through 4 thereby discuss methods to develop mathematical concepts and strengthening their foundation.

Category 1: Use of manipulative

The use of manipulative to enhance the teaching of mathematics has been recommended in the Singapore mathematics curriculum since 1980s. All prospective mathematics teachers going through pre-service teacher education have been introduced to various approaches of using different manipulative to facilitate their students' learning. In the latest recommendation by the MOE, algebra discs (or alge-discs) have been recommended as a model to help students construct meaning and make sense of abstract algebra symbols and processes (MOE, 2013). Classroom anecdotes might show that teachers have the tendency to reduce the curriculum time in using manipulative and leave more time to prepare students to solve problems occurring in high-stake national examinations. It is also heartening to observe in this survey that a sizeable number of participants have resorted to using manipulative in their teaching. Not only that, one participant explicitly indicated on the use of discovery task to discover mathematical formulae experimentally. This is an indicator of teachers moving away from the traditional chalk-and-talk to pedagogically sound practices when teaching becomes challenging.

Categories 2 and 3: Information and Communications Technology (ICT) and Media
Students should work with concrete material before they develop abstract mathematical concepts, according to the work of Bruner and Piaget. Thus, ICT provides "semi-concrete" (Wong, 2008) experiences to bridge the gap between concrete experiences and abstraction. Of the four modes of ICT that Wong (2008) proposed that could be used in mathematics education, the teachers seem to resort to the *tutor* mode (online learning platforms and content websites) and the *tool* mode (open tool for exploration). Based on the survey, the *tutee* and *co-learner* modes did not seem to be much explored. Five participants identified the use of videos as resources and strategies to help their N(T) students with learning mathematics.

Category 4: Modification of Pedagogy
The participants generally attributed the students' learning difficulty and lack of interest in mathematics to their poor foundation in the subject since the primary school foundation or in language skills. It is thus not surprising that it appears a relatively long list of pedagogical strategies to discuss. These can be seen to consist of several sub-categories:

4.1 Poor foundation in mathematics

This sub-category consists of the strategies

- Adopt a slower pace of lesson
- To explain concepts to individual students
- Peer coaching
- Small group consultation
- Use of hands-on activities
- Use more examples to illustrate a mathematics concept

4.2 Poor foundation in language

It was also raised in the participants' responses that some students were hindered by their language competency in understanding the mathematical problems or concepts that were conveyed by the language. For example, students generally were not able to solve word problems which were presented at great length in complex sentences. The remedial effort proposed by the participants was to use the language appropriate to their students.

4.3 Emotion of students

It was also interesting to observe that teachers have appealed to the effort of relating mathematics to everyday life, in order to make the subject more relevant and interesting to their students. Inviting students to share interesting ideas about mathematics could also be seen as an attempt of teachers to empower their students in the process of learning, thereby making them excited about the subject.

Category 5: Psychology
The participants have also revealed their awareness of the psychological aspect of their learners from the N(T) courses. These students might not have a sound foundation or a good academic self-concept. Building up students' confidence and (by) allowing for smaller successes in classrooms are the strategies they used in their classrooms.

It is interesting to note that although studies have found that prior academic self-concept is highly correlated with subsequent academic achievement, the reverse relationship was not found. That is, prior academic achievement was not correlated with later academic self-concept. However, Marsh, Byrne, and Yeung (1999), and Marsh and Craven (2006) proposed that efforts to improve academic self-concept can lead to attainment of higher academic achievements, which in turn higher academic self-concept is linked to better academic achievement.

In the longitudinal study by Seaton, Parker, Marsh, Craven, and Yeung (2013) in Australia, the separate models indicating reciprocal relations between mathematics self-concept and achievement and mathematics performance approach goal orientation and achievement were established. There was little evidence of reciprocal relations between a mastery approach goal orientation and achievement. When all the variables were included in a single model, only self-concept had significant reciprocal relationships with achievement.

Category 6: Alternative Pedagogy

It is exciting to the authors to note that alternative pedagogies such as storytelling and use of cartoons and comics, which were usually seen as "enemies" of the schools decades ago in Singapore, have been used as strategies and resources to help students learn mathematics. While twenty years ago students caught reading comics in schools were likely to be sent to be disciplinarily dealt with, today, some teachers are beginning to view them as potential educational tools, as a way to arouse students' interest in academic subjects (Cleaver, 2008), and also an avenue to improve their students' academic literacy (Tilley, 2008). While these might never approach the complexity of reading 'real' texts, compared to reading 'real' books, this may appear to be a simple task and compared to reading no books, such an approach might be preferred. Research has provided evidence that cartoons, comics and storytelling might have particular attraction among school age children (see for example, Wright & Sherman, 2006).

Conclusion

This paper reports a preliminary survey on the perception of N(T) mathematics teachers' perception of their students' learning difficulty and lack of interest in the subject, and the strategies and resources that they have used to help their students learn mathematics. As part of the effort to help their students learn mathematics, the teachers have resorted to the use of a wide variety of approaches (we have broadly classified under five broad categories). In 2013, the Singapore Ministry of Education introduced a developmental project named *Improving Confidence and Numeracy* (ICAN) for N(T) mathematics teachers. In this programme the teachers are developed professionally by their project co-ordinators and external mentors including MOE-based ICAN workshops in various aspects of pedagogy and sound teacher pedagogical practices. In fact, this preliminary survey shows that, in fact, teachers have identified even a broader spectrum of strategies, including psychology and alternative pedagogy.

As a caution to the readers, this preliminary survey might not be exhaustive as the number of participants is relatively low. Thus, the list in Tables 1, 2 and 3 would certainly not be exhaustive. But the authors hope that this should be sufficient to serve as a springboard for further research towards helping the low attainers learn and *enjoy* mathematics.

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APPENDIX A

No. of years in teaching service: _____

No. of years teaching NT mathematics: _____

1. In your past 3 years' teaching service in NT classes, have you come across any students who have low motivation or low self-concept in learning Math? If yes, how many and which level?

_____

_____

2. Based on your observation, why did they get 'stuck' in Math?

_____

_____

3. Based on your observation, why were they not interested in Math?

_____

_____

4. Describe one or two effective strategies you have used in helping them.

_____

_____

5. What resources did you use to teach Math in NT classes?

_____

_____

6. Any suggestion to share with fellow colleagues and education researchers?

_____

_____