Mathematics Attitudes and Achievement of Junior College Students in Singapore

Lim Siew Yee
Hwa Chong Institution
<tohsy@hci.edu.sg>

Studies that investigated students' attitudes toward mathematics and its relationships with achievement are scarce in Singapore. To address this issue, the mathematics attitudes and achievement of 984 junior college students were measured. Results indicated that students had positive attitudes toward mathematics but lacked intrinsic motivation to do mathematics. Students were extrinsically motivated to study mathematics, but the relationship between extrinsic motivation and achievement was weak. However, there was a significant positive correlation between intrinsic motivation and achievement. This is contrary to the beliefs of many educators and parents in Singapore who believe in extrinsic rewards and punishments to encourage better achievement. This study suggests that Singapore educators and parents should focus more on how to motivate students intrinsically.

Positive attitudes toward mathematics is a key intended outcome of mathematics learning in Singapore (Ministry of Education, 2008). However, the few studies that investigated Singapore students' attitudes toward mathematics could not produce conclusive results (Ang, 2009). Moreover, many of these studies did not measure motivation even though it is a key dimension of attitudes (Tapia, 1996). In addition, even though the relationships between attitudes and achievement in mathematics have been widely studied (Ma & Kishor, 1997), such studies are scarce in Singapore (Fan et al., 2005).

This study investigated Singapore students' attitudes toward mathematics, as a multi-dimensional construct with motivation as a key dimension, and investigated the relationships between attitudes toward mathematics and achievement in mathematics. The results of this study can potentially highlight to educators the domains of attitudes that students are weak at, and help educators decide the domains of attitudes to focus on in their interactions with students.

Literature Review

Attitudes toward Mathematics

Attitudes are defined as positive or negative emotional dispositions (Aiken, 2000; McLeod, 1992). However, the exact definition of attitudes toward mathematics varies (Akinsola & Olowojaiye, 2008). Zan and Martino (2007) suggest that the definition of attitudes is dependent on the problems that the researcher is dealing with, and is linked to the choice of the measuring instruments, which are discussed in the Methodology section.

Motivation in Mathematics

Motivation is a key domain of attitudes which is often insufficiently addressed in studies on attitudes toward mathematics. According to self-determination theory (Deci & Ryan, 1985), motivation can be categorised into three broad categories, namely amotivation, extrinsic motivation and intrinsic motivation. These three categories of motivation exist on a continuum according to the level of self-determination underlying the

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motives behind behaviours. Figure 1 illustrates this continuum which is adapted from Deci and Ryan (2000).

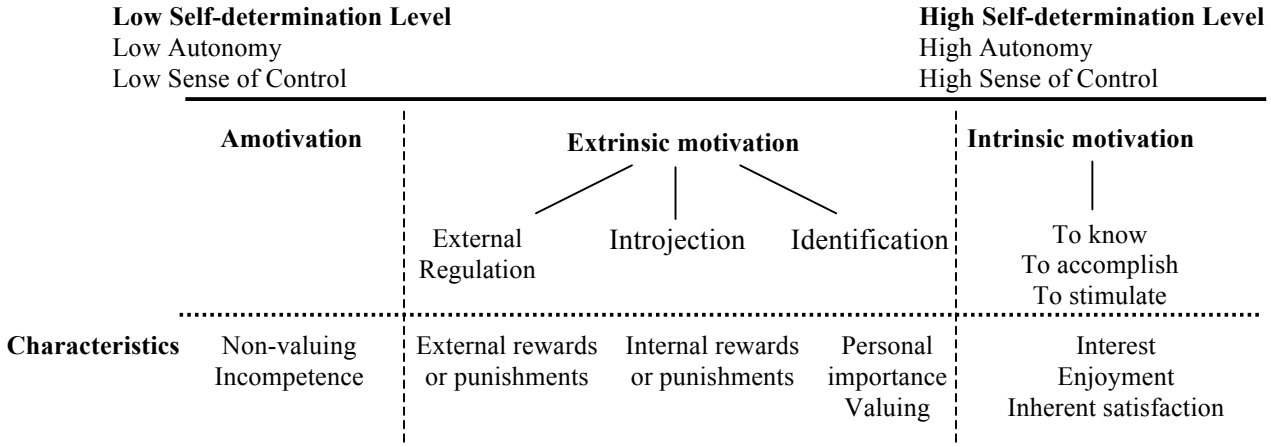

Figure 8. Self-Determination Continuum.

Amotivation lies on the extreme left of the self-determination continuum and occurs when individuals feel that an activity has no value, do not feel competent to complete a task, or do not expect any desirable outcome from the activity (Ryan & Deci, 2000).

Extrinsic motivation refers to the desire to engage in an activity because it leads to an unrelated outcome (Deci, 1972; Spaulding, 1992). On the self-determination continuum, extrinsic motivation is further categorised, from lower to higher level of self-determination, into external regulation, introjection and identification (Vallerand et al., 1992). External regulation is caused by externally imposed rewards or punishments (Vallerand et al., 1992). Introjection takes place when individuals internalise the reasons for their behaviours and impose their own rewards or constraints (Hayamizu, 1997). Finally, identification occurs when an individual identifies with the reason for behaving in a particular manner. The behaviour is valued by the individual and occurs because the individual chooses to do so. Identification differs from intrinsic motivation because pleasure or satisfaction may not be derived in the process of completing the task (Hayamizu, 1997).

Intrinsic motivation lies on the extreme right of the continuum, which is characterised by high autonomy and sense of control (Deci & Ryan, 2000). It refers to an inner desire to accomplish a task, and pleasure is derived in the process (Berlyne, 1965; Deci, 1975). Vellerand et al. (1992) further categorise intrinsic motivation into intrinsic motivation to know, to accomplish things, and to experience stimulation.

Singapore Students' Attitudes Toward Mathematics

There are very few quantitative studies that investigated students' attitudes toward mathematics in Singapore. Lim-Teo, Ahuja and Lee (2000) provide one such study on 388

students from seven junior colleges in Singapore. This reported that about half of the participants have negative attitudes toward the learning of calculus. Specifically, 70% of the participants found calculus difficult and almost 50% did not enjoy learning calculus.

Similar results on secondary school students in Singapore were reported by Fan et al. (2005). Data collected from 1215 students in eight secondary schools indicated that only 49% of the participants liked to spend time on mathematics. This suggested that almost half of the participants were not intrinsically motivated in mathematics (Gottfried, 1985).

The above results must be interpreted with care. Some aspects of Lim-Teo, Ahuja and Lee (2000)'s experimental design, such as how the participants were chosen, was not documented in detail. In Fan et al. (2005)'s study, threats to external validity were decreased by using a stratified random sampling method to select both above average and below average schools in terms of mathematics ability. However, selection bias might still exist as participants from the chosen schools were not randomly selected.

Methodology

This paper presents the findings of a pilot study that forms part of a larger study on Singapore junior college students' attitudes and achievement in mathematics. Data from 1044 students from a top junior college in Singapore was collected for this pilot study. After omitting data with missing or multiple entries, 984 sets of completed data were used.

Students' achievement in mathematics was measured using a three-hour paper that was equivalent to the GCE 'A' level 9740 H2 mathematics examination in terms of content and difficulty level. Five teachers, each with at least five years of teaching experience assessed the content validity of the paper.

Popular attitudes scales with established psychometric properties were used to measure attitudes toward mathematics. The Attitudes Toward Mathematics Inventory (ATMI) (Tapia & Marsh, 2004) consists of 40 items that measured four factors, namely enjoyment, general motivation, self-confidence and value. Validity and reliability have been established for high school (Tapia & Marsh, 2004) and college students (Tapia & Marsh, 2002). As the ATMI does not measure anxiety, which is an important domain of attitudes toward mathematics (Hyde, Fennema, Ryan, Frost, & Hopp, 1990), the mathematics anxiety subscale in the Fennema-Sherman Mathematics Attitudes Scales (FSMAS) which consists of 12 items, was added to the list of statements that was used for this study.

In addition, the ATMI measures only motivation in general. There is a need for another instrument that measures motivation as a multi-dimensional construct such as the Academic Motivation Scale (AMS) (Vallerand et al., 1992). The AMS is made up of seven subscales that assess amotivation, extrinsic motivation (external regulation, introjection and identification) and intrinsic motivation (to know, to accomplish, and to stimulate). This is in line with the definitions used in this study. Reliability and validity for the AMS have been established for college students (Vallerand et al., 1992). However, the AMS is not constructed to measure motivation for particular subjects and needs to be adapted for mathematics learning before it can be used in this study. The original AMS asks the question "Why do you go to college?" This question was changed to "Why do you study mathematics?" Statements were also adapted. For instance, the statement "Because I experience pleasure and satisfaction while learning new things" is changed to "Because I experience pleasure and satisfaction while learning new things in mathematics".

An exploratory factor analysis performed on the modified AMS showed that the factor structure of the original AMS was retained. However there were cross loadings on the intrinsic motivation to know, to accomplish, and to stimulate. This result was expected as

these three factors are not differentiated on the self-determination continuum in Figure 1. Hence, these three factors were collapsed to form a single factor.

Before the administration of the ATMI, the FSMAS Anxiety subscale and the modified AMS, participants were assured that the results of the pen-and-paper survey would not affect their school grades in any way, and they could choose to remain anonymous or opt out of the study at any point in time.

Results and Discussion

Table 1 shows the means and standard deviations of the various domains of attitudes. All the instruments used in this study use a five-point Likert Scale that ranges from strongly disagree (one point) to strongly agree (five points).

Results from ATMI

This study showed that in general, the participants had positive attitudes toward mathematics. They enjoyed mathematics (M = 3.30, SD = 0.77), were confident about their ability to do mathematics (M = 3.34, SD = 0.79) and saw the value of mathematics (M = 3.49, SD = 0.70). These results are different from the results reported by Lim-Teo, Ahuja and Lee (2000) due to a number of possible reasons. First, Lim-Teo, Ahuja and Lee's study was on the learning of calculus which may be more challenging than other topics in the junior college mathematics syllabus. Second, the participants of this study come from a top junior college, while the participants from Lim-Teo, Ahuja and Lee's study come from seven different colleges. Third, Lim-Teo, Ahuja and Lee used a self-constructed attitudes test that had not been sufficiently tested for validity and reliability. Finally, this study reported on means and standard deviations, while Lim-Teo, Ahuja and Lee presented their findings using percentages of participants who agree or strongly agree to the statements in the attitudes test. To obtain more conclusive results, data will be collected from five other junior colleges once the author receives permission from the Ministry of Education, Singapore.

Results from FSMAS and the Modified AMS

The participants scored a mean of less than three points in the following domains of attitudes measured using FSMAS and the modified AMS: (1) anxiety (M = 2.80, SD = 0.74), (2) amotivation (M = 1.97, SD = 0.92), (3) introjection (M = 2.82, SD = 0.89), and (4) intrinsic motivation (M = 2.82, SD = 0.90). The first two results are expected as the participants come from a top junior college and studies have shown that mathematics anxiety and amotivation correlate negatively with achievement (Betz, 1978; Karsenti & Thibert, 1995). Table 2 shows that these negative correlations are supported in this study (r = –0.53 and r = –0.42 respectively).

On the other hand, the participants were generally motivated by external rewards and punishments (external regulation: M = 3.03, SD = 0.95) and could identify with the reasons for studying mathematics (identification: M = 3.31, SD = 0.90). These results are supported by Spaulding (1992) who reported that educators tend to rely on external rewards and punishments to motivate students and neglect the importance of intrinsic motivation.

Gender Differences in Mathematics Attitudes and Achievement

Table 3 shows the results of a *t* test performed to compare males' and females' achievement and attitudes toward mathematics. The test failed to show a statistically reliable difference between males' and females' achievement in mathematics ($t(982) = 1.419$, $p > 0.1$) but showed that males were more confident about their ability to do mathematics than females ($t(982) = 1.419$, $p < 0.05$) These results are supported by Caplan and Caplan (2005) who did a meta-analysis and found that most studies showed no gender difference in mathematics ability, but males tend to feel more confident about their own mathematics ability than females. There is also a statistically reliable gender difference in mathematics anxiety ($t(982) = 3.59$, $p < 0.001$), and this is supported by Pajares and Kranzler (1995) who found that females tend to feel more anxious about mathematics than males.

Correlations between Attitudes and Achievement

Table 2 shows that achievement correlated positively with all the domains of attitudes, except for anxiety ($r = –0.53$), amotivation ($r = –0.42$) and external regulation ($r = –0.05$). Among the various domains of attitudes, self-confidence correlated most positively with achievement ($r = 0.60$). These results are supported by other studies (Leung, 2002; Samuelsson & Granstrom, 2007). Specifically, studies have shown that achievement is positively related to self-confidence (Fennema & Sherman, 1977; Leung, 2002), value (Aiken, 1974; Fennema & Sherman, 1977, 1978) and enjoyment (Aiken, 1974). Moreover, results from the Trends in International Mathematics and Science Study suggest that self-confidence and value are positively related to mathematics achievement in Singapore (Martin & Mullis, 2007).

This study also shows that the relationship between achievement and extrinsic motivation was almost non-existent and this is in line with the findings of Ryan (1982) who highlighted that there is no clear relationship between extrinsic motivation and achievement. This is contrary to the beliefs of many educators and parents in Singapore who believe in extrinsic rewards and punishments to encourage better achievement (Sharpe, 2002).

On the contrary, there was a positive correlation between achievement and intrinsic motivation ($r = 0.36$). This result is supported by studies in various countries (Gottfried, Fleming, & Gottfried, 1994; O'Dwyer, 2005; Shen, 2002; Uguroglu & Walberg, 1979). As the participants of this study were not intrinsically motivated to study mathematics ($M = 2.82$, $SD = 0.90$), there may be a need for educators and parents in Singapore to focus more on motivating students intrinsically.

Conclusion

This study sought to investigate Singapore students' attitudes toward mathematics and the relationship between attitudes and achievement in mathematics. Results show that students had positive attitudes toward mathematics, but more can be done to motivate students intrinsically. Deci (1975) suggests that student's intrinsic motivation can be enhanced by creating opportunities for students to have control over their learning environments and increasing students' perceived competence in completing tasks.

In addition, the relationship between extrinsic motivation and achievement was almost non-existent. This implies that extrinsic rewards and punishments may not be useful in improving students' achievement in mathematics. While self-confidence is found to be

positively correlated with achievement, it may not necessarily imply a cause-and-effect relationship. A cyclical relationship may exist between achievement and self-confidence where good achievement leads to high self-confidence, which in turn leads to greater achievement. The converse may also be true and further studies are required to establish these relationships. In addition, further studies will be conducted in other junior colleges in Singapore to generalise results as the sample for this pilot study comes from only one junior college.

Table 1

Means and Standard Deviations of Domains of Attitudes

		Enjoyment	General Motivation	Self-confidence	Value	Anxiety	Amotivation	External Regulation	Introjection	Identification	Intrinsic Motivation
(Instrument)		(ATMI)	(ATMI)	(ATMI)	(ATMI)	(FSMAS)	(AMS)	(AMS)	(AMS)	(AMS)	(AMS)
Female (N = 500)	Mean	3.29	2.93	3.27	3.46	2.88	1.91	2.92	2.82	3.27	2.76
	SD	0.76	0.88	0.78	0.63	0.73	0.89	0.93	0.87	0.87	0.87
Male (N = 484)	Mean	3.30	3.15	3.40	3.52	2.71	2.02	3.16	2.83	3.36	2.88
	SD	0.79	0.87	0.79	0.77	0.74	0.95	0.95	0.92	0.91	0.94
Total (N = 984)	Mean	3.30	3.04	3.34	3.49	2.80	1.97	3.03	2.82	3.31	2.82
	SD	0.77	0.88	0.79	0.70	0.74	0.92	0.95	0.89	0.90	0.90

Table 2

Correlations between Domains of Attitudes and Achievement

Variables	1	2	3	4	5	6	7	8	9	10	11
1. Achievement	–										
2. Anxiety	-0.53*	–									
3. Enjoyment	0.48*	-0.73*	–								
4. General Motivation	0.47*	-0.73*	0.87*	–							
5. Self-confidence	0.60*	-0.92*	0.76*	0.76*	–						
6. Value	0.31*	-0.49*	0.68*	0.69*	0.51*	–					
7. Amotivation	-0.42*	0.55*	-0.63*	-0.62*	-0.61*	-0.56*	–				
8. External Regulation	-0.05	0.03	0.02	0.10*	-0.01	0.27*	0.02	–			
9. Introjection	0.09*	-0.18*	0.32*	0.29*	0.22*	0.35*	-0.11*	0.46*	–		
10. Identification	0.16*	-0.28*	0.38*	0.43*	0.31*	0.67*	-0.32*	0.55*	0.39*	–	
11. Intrinsic Motivation	0.36*	-0.57*	0.80*	0.76*	0.60*	0.64*	-0.50*	0.46*	0.50*	0.16*	–

Note. N = 984, *p < 0.01.

Table 3

Gender Differences in Mathematics Attitudes and Achievement

	Achievement	Enjoyment	General Motivation	Self-confidence	Value	Anxiety	Amotivation	External Regulation	Introjection	Identification	Intrinsic Motivation
t	-1.419	0.20	3.90	2.60	1.29	-3.59	1.84	3.99	0.22	1.60	2.03
p	0.156	0.84	0.00	0.01	0.20	0.00	0.07	0.00	0.83	0.11	0.04

Note. Degree of freedom = 982, α = 0.05.

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