The Mathematics Educator
1999, Vol. 4, No.1, 15-33

TERTIARY AND JUNIOR COLLEGE STUDENTS' ATTITUDE TOWARDS MATHEMATICS[1]

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Abstract

A research project entitled "Calculus Education at the Junior College and Tertiary Levels in Singapore" was begun in 1996 to study the current status of teaching and learning of calculus in Singapore. As part of the project, a survey was carried out to determine the general attitude of Junior College and Tertiary students' attitude towards mathematics in general and towards calculus in particular. This paper reports the findings of the part of the survey dealing with student attitude towards mathematics. In general, tertiary and junior college students who do Mathematics have a positive attitude towards mathematics in that very few of them have mathematics anxiety and majority enjoy mathematics. However, some of the findings of the students' view of mathematics and their approaches to learning mathematics give cause for concern.

Introduction

Attitude is a learned predisposition or tendency on the part of an individual to respond positively or negatively to some object, situation, concept, or another person (Aiken, 1970). A proper attitude is important for achieving excellence in learning process or whatever we wish to do in our daily life.

A proper attitude of teachers and students towards teaching and learning mathematics is a critical factor for quality mathematics education, that is 'Mathematics Education of the First Rate' (Ahuja, 1994). It is generally believed that positive attitude towards mathematics will lead to greater effort and hence to higher achievement in mathematics.

[1] This research was funded by the Academic Research Fund, National Institute of Education, Nanyang Technological University, Singapore, RP 5/96 OPA

Attitude towards mathematics has several dimensions: like –dislike, easy - hard, useful – not useful, fun – no fun, remember – forget, desire – no desire are the most common. Not only does attitude affect achievement in mathematics but achievement also affects attitude (Neale, 1969). In fact, many researchers found that there is a strong relationship between attitude towards mathematics and achievement in mathematics: *See* Steinkamp (1982), Kloosterman (1991), Randhawa & Beamer (1992), Minato & Yanase (1984), and others. A student's attitude towards mathematics is important in determining whether he or she elects to take courses in mathematics, engage in mathematical activities, and perseveres in these efforts once he or she has begun (Aiken, 1972). Foong (1987) observed that some of the highly anxious, poor mathematics achievers, in their moments of frustration or resignation, feel that taking mathematics is a waste of time.

As part of the research project "Calculus Education at the Junior College and Tertiary Levels in Singapore", which is to study the current status of teaching and learning of calculus in Singapore, a survey was carried out to determine the general attitude of Junior College and Tertiary students' attitude towards mathematics in general and towards calculus in particular. More details of the project are given in Ahuja, Lim and Lee (1998,1999). This paper reports on the part of the survey dealing with student attitude towards mathematics.

Research methodology

The survey was carried out among students of tertiary institutions and junior colleges in Singapore. This self-reporting survey questionnaire was used to gauge the students' responses to various statements related to students' attitude towards mathematics and their practices in learning the subject.

Sample

All four polytechnics in Singapore participated in the survey and in each polytechnic, the survey forms were given to about 100 students from 5 or 6 intact tutorial groupings. These polytechnic students were second year engineering students who had undergone one year of Engineering mathematics. Overall, 397 completed forms were returned from the polytechnics.

The university students were second year students from the two universities in Singapore. These students had completed the first year university mathematics, which included a substantial amount of Calculus. A total of 147 forms were returned.

For the junior college sample, 7 junior colleges were selected from the 14 junior colleges in Singapore. Three were from the top band of five junior colleges, two from the middle band and two from the below average band. In the Singapore junior college system, students could study a single Mathematics subject called Mathematics C or they could study two Mathematics subjects, Mathematics C and Further Mathematics. The latter are usually very strong in mathematics and are all in the Science stream whilst the single mathematics students are from Science, Arts and Commerce streams. Each junior college was asked to administer the questionnaire to two or three intact tutorial groups from specified groups and streams. The 388 junior college students were thus from 15 tutorial groups each having between 20 to 30 students. The breakdown is as follows:

Table 1: Breakdown of student sample from junior colleges

Subject Combination	Further Mathematics	Mathematics C		
Stream	Science	Science	Arts	Commerce
Number of students	140	133	71	44

Instrument

The instrument used was a self-report survey questionnaire wherein students rated their agreement on statements pertaining to their view of mathematics or their practices in learning mathematics. The main part of the questionnaire consisted of 25 items, with 15 items on the attitude towards mathematics and 10 items on attitude towards calculus. In this paper, we only report the findings on the attitude towards mathematics section.

Besides the above-mentioned 15 items, there was a preliminary question in the questionnaire where the students were asked to estimate the amount of time they spend per week on mathematics outside classroom time. There was also a final open-ended question asking for their general comments on their feeling towards mathematics.

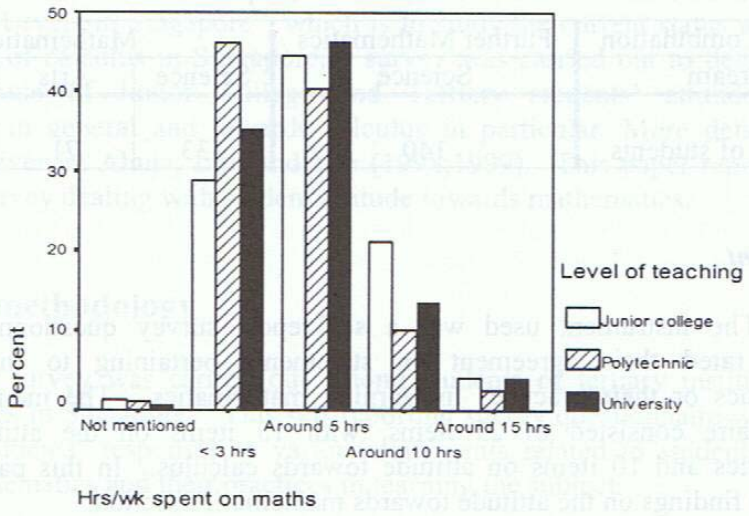
The 15 items on attitude towards mathematics can be grouped into six categories as shown in Table 2 below. For each item, the students had to rate their agreement with the statements along a four point scale, indicating strongly agree (SA), agree (A), disagree (D) or strongly disagree (SD). The neutral or no opinion options were not included, as we wanted to encourage students to make a choice.

Findings regarding hours spent on mathematics outside the class

Students were asked to estimate the amount of time spent per week outside class time doing mathematics homework, revision or other mathematics work during term time. The categories given were: (a) less than 3 hours a week, (b) around 5 hours a week, (c) around 10 hours a week, and (d) around 15 hours a week or more.

The distribution of responses is given in bar graph below.

Bar Graph of Responses on Time Spent on mathematics



It can be seen that the modal class for university students and junior college students is around 5 hours a week whereas for the polytechnic students, the mode is less than 3 hours per week. Overall, the estimated median hours spent on mathematics per week outside class time is about 5 hours.

The main findings

In this section, the results of the survey pertaining to students' attitude towards mathematics are reported through the use of frequency tables of the students' responses to the various statements. In each table, corresponding to each

statement, the count and percentage of responses for each of the various choices strongly disagree (**SD**), disagree (**D**), agree (**A**) and strongly agree (**SA**) as well as that for missing responses (**MR**) are given.

Before examining the findings for individual statements, Table 2 below shows the description of all the items as well as the summary of the findings regarding the students surveyed. In this table, each statement under the various categories is given and against each is specified whether the majority falls under agree/strongly agree (denoted as agree) or disagree/strongly disagree (denoted as disagree). The percentage of this majority is also indicated in brackets.

Table 2: Description of items and summary of findings on attitude towards mathematics

Category	Item Number	Statement	Majority
Enjoyment of mathematics	1	Working Maths problems is fun.	Agree (77%)
	11	I enjoy Maths because I don't have to work hard at it compared to other subjects.	Disagree (66%)
Self-concept with regards To Maths	3	I generally understand what is going on in Maths class.	Agree (53%)
	4	Maths is my best subject.	Agree (82%)
	6	I find Maths concepts hard to understand.	Agree (53%)
	7	I am good at solving Maths problems.	Disagree (58%)
	12	I find it easy to remember most of the things I learn in Maths.	Agree (57%)
	13	When I do Maths, I'm unsure if I'm correct unless I check answers/solutions with textbooks, teachers or friends.	Agree (81%)
Motivation	2	I do more Maths problems than those set by the lecturer/teacher.	Agree (64%)
	5	I often read ahead in our Maths textbooks.	Disagree (72%)
	9	I have a strong desire to understand and learn Maths concepts.	Disagree (89%)

Table 2 (... cont'd)

Category	Item Number	Statement	Majority
View of Maths	10	If I don't see how to work a Maths problem quickly, I will not be able to do it.	Disagree (65%)
	15	The way to score in Maths is to practise routines more than to understand concepts.	Agree (63%)
Anxiety	14	I feel a great sense of unease when the class discusses Maths concepts.	Disagree (83%)
Rationale for taking Maths	8	The main reason for taking Maths is that I can score high grades in it.	Disagree (54%)

Enjoyment of mathematics

Under the category "Enjoyment of mathematics", Tables 3 and 4 give the distribution of responses to the statements 1 and 11. These tables suggest that majority (78%) of the students find working mathematics problems fun while their enjoyment of mathematics is NOT due to not having to work hard at it compared to other subjects.

Table 3: Frequency distribution of responses to the statement: *Working mathematics problems is fun*

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	5	1.3%	1	0.3%	1	0.7%	7	0.8%
SD	12	3.1%	23	5.8%	2	1.4%	37	4.0%
D	62	16%	76	19.1%	26	17.7%	164	17.6%
A	263	67.8%	235	59.2%	103	70.1%	601	64.5%
SA	46	11.9%	62	15.6%	15	10.2%	123	13.1%

Table 4: Frequency distribution of responses to the statement:
I enjoy Maths because I don't have to work hard at it.

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	0	0%	1	0.3%	1	0.7%	2	0.2%
SD	68	17.5%	67	16.9%	37	25.2%	172	18.5%
D	178	45.9%	193	48.6%	75	51.0%	446	47.9%
A	113	29.1%	106	26.7%	28	19.0%	247	26.5%
SA	29	7.5%	30	7.6%	6	4.1%	65	7.0%

It is interesting that overall, only about a third agreed or strongly agreed with the statement that they enjoyed mathematics because they did not have to work hard at it and that this proportion is even lower for the university mathematics.

Self-concept with regards to mathematics

The second category of statements deals with the students' self-concept with regards to mathematics. This category seeks to find out their own assessment of their ability in learning mathematics. It is interesting to note that almost half regard mathematics as their best subject, as can be seen from Table 5 below.

Table 5: Frequency distribution of responses to the statement:
Mathematics is my best subject

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	1	0.3%	0	0%	4	2.7%	5	0.5%
SD	60	15.5%	53	13.4%	13	8.8%	126	13.5%
D	116	29.9%	135	34.0%	55	37.4%	306	32.8%
A	135	34.8%	144	36.3%	48	32.7%	327	35.1%
SA	76	19.6%	65	16.4%	27	18.4%	168	18.0%

On the question of understanding mathematics concepts and skills, it is heartening to find that more than 81% are able to understand in mathematics classes (from Table 6). However, about 40% find mathematics concepts hard to understand (from Table 7). From the sub-groups in Tables 6 and 7, it can be seen that the percentage of those who understand in mathematics classes decreases from 87% for junior colleges to 83% for polytechnic students to 66% for university students. Confirming this, the percentage of those who find mathematics concepts hard to understand increases from 30% of junior college students to 37% of polytechnic students to 60% for university students. This is reasonable, as university mathematics is more abstract and hence conceptually harder to understand whereas mathematics at lower levels tends to concentrate more on skills and routines.

Table 6: Frequency distribution of responses to the statement:
I generally understand what is going on in Maths classes

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	1	0.3%	1	0.3%	0	0%	2	0.2%
SD	4	1.0%	12	3.0%	8	5.4%	24	2.6%
D	45	11.6%	55	13.9%	42	28.6%	142	15.2%
A	301	77.6%	279	70.3%	95	64.6%	675	72.4%
SA	37	9.5%	50	12.6%	2	1.4%	89	9.5%

Table 7: Frequency distribution of responses to the statement:
I find Maths concepts hard to understand

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	0	0%	1	0.3%	2	1.4%	3	0.3%
SD	22	5.7%	38	9.6%	5	3.4%	65	6.9%
D	249	64.2%	211	53.1%	51	34.7%	511	54.8%
A	111	28.6%	130	32.7%	77	52.4%	318	34.1%
SA	6	1.5%	17	4.3%	12	8.2%	35	3.7%

With regards to whether they were good at solving mathematics problems, there was not much variation among the different groups. About 40% of the students felt they were good at solving mathematics problems while 60% felt they were not (see Table 8).

Table 8: Frequency distribution of responses to the statement:
I am good at solving Maths problems

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	3	0.8%	2	0.5%	1	0.7%	6	0.6%
SD	17	4.4%	25	6.3%	5	3.4%	47	5.0%
D	201	51.8%	208	52.4%	85	57.8%	494	53.0%
A	160	41.2%	150	37.8%	53	36.1%	363	38.9%
SA	7	1.8%	12	3.0%	3	2.0%	22	2.4%

From Table 9, it can be seen that overall, about 60% of the students found mathematics easy to remember while 40% of them did not. Here there was some variation among the different groups with only 51% of university students agreeing with the statement, compared to 62% for the junior college students and 56% of the polytechnic students.

Table 9. Frequency distribution of responses to the statement:
I find it easy to remember most of the things I learnt in Maths.

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	3	0.8%	3	0.8%	1	0.7%	7	0.8%
SD	16	4.1%	30	7.6%	4	2.7%	50	5.45
D	127	32.7%	141	35.5%	67	45.6%	335	35.9%
A	211	54.4%	197	49.6%	66	44.9%	474	50.9%
SA	31	8.0%	26	6.5%	9	6.1%	66	7.1%

The last statement in this category dealt with the students' confidence in their own solutions of mathematics problems. A large majority (80%) of students is unsure of their own solutions and tended to check with textbook answers or with others. Among the groups in Table 10, the university students are more confident with 73% agreeing with the statement followed by junior college students with 79% agreeing while 87% of the polytechnic students agreed with the statement. A significant percentage of polytechnic students strongly agreed with the statement and this shows a lack of confidence in their own mathematical ability.

Table 10. Frequency distribution of responses to the statement: *When I do Maths, I'm unsure if I'm correct unless I check answers/solutions with textbooks, teachers or friends.*

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	4	1.0%	0	0%	1	0.75	5	0.5%
SD	3	0.8%	9	2.3%	2	1.4%	14	1.5%
D	75	19.3%	44	11.1%	37	25.2%	156	16.7%
A	237	61.1%	220	55.4%	89	60.5%	546	58.6%
SA	69	17.8%	124	31.2%	18	12.2	211	22.6%

Motivation

The next category had three statements, which dealt with student motivation as reflected by their own desire to learn mathematics and their practices of reading ahead or doing more problems than those assigned by the teacher.

It was revealing that although about 65% of the students surveyed claimed that they had a strong desire to understand and learn Maths concepts (see Table 11), this desire was not translated into practice. Students tended not to be independent learners with only a quarter doing more problems than assigned (Table 12) and only 10% reading ahead (Table 13). Observe that there is a swing from the agreement to the first statement on desire to learn to disagreement with practices, which indicate independent learning.

Table 11: Frequency distribution of responses to the statement:
I have a strong desire to understand and learn Maths concepts

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	0	0%	1	0.3%	1	0.7%	2	0.2%
SD	10	2.6%	20	5.0%	3	2.0%	33	3.5%
D	135	34.8%	121	30.5%	44	29.9%	300	32.2%
A	214	55.2%	217	54.7%	88	59.9%	519	55.7%
SA	29	7.5%	38	9.6%	11	7.5%	78	8.4%

Table 12: Frequency distribution of responses to the statement:
I do more Maths problems than those set by the teacher.

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	1	0.3%	0	0%	1	0.7%	2	0.2%
SD	54	13.9%	68	17.1%	14	9.5%	136	14.6%
D	234	60.3%	217	54.7%	85	57.8%	536	57.5%
A	84	21.6%	102	25.7%	42	28.6%	228	24.5%
SA	15	3.9%	10	2.5%	5	3.4%	30	3.2%

Table 13: Frequency distribution of responses to the statement:
I often read ahead in our Maths textbooks

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	0	0%	0	0%	3	2.0%	3	0.3%
SD	121	31.2%	91	22.9%	22	15.0%	234	25.1%
D	245	63.1%	244	61.5%	110	74.8%	599	64.3%
A	17	4.4%	56	14.1%	11	7.5%	84	9.0%
SA	5	1.3%	6	1.5%	1	0.7%	12	1.3%

Anxiety

From the students' responses to the item on unease during Mathematics discussion, only a minority are uncomfortable with class mathematics discussions. However, this minority reaches about 20% for students from tertiary institutions. The results are exhibited in Table 14.

Table 14 : Frequency distribution of responses to the statement:
I feel a great sense of unease when the class discusses Maths concepts.

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	3	0.8%	0	0%	1	0.7%	4	0.4%
SD	60	15.5%	56	14.1%	19	12.9%	135	14.5%
D	278	71.6%	263	66.2%	97	66.0%	638	68.5%
A	41	10.6%	61	15.4%	23	15.6%	125	13.4%
SA	6	1.5%	17	4.3%	7	4.8%	30	3.2%

View of mathematics

Items 10 and 15 of the survey were designed to reflect students' perceptions of mathematics. If students agreed with the statement in Item 10 that "*If I don't see how to work a Maths problem quickly, I will not be able to do it*", then they regarded mathematics as a subject which did not require perseverance in problem solving. From Table 15, it is noted that the majority of students disagreed with the statement. polytechnic students showed the greatest percentage (40%) who agreed with the statement, followed by university students (35%) and lastly, junior college students (26%).

In Item 15, agreement showed that students view mathematics (or more precisely assessment in mathematics) as mainly applying routines that they had to practise well. Here, a majority of polytechnic students (76%) agreed with the statement while about 60% of junior college students also agreed. Among university students, this percentage dropped to 36%. The figures are presented in Table 16.

Table 15: Frequency distribution of responses to the statement:
If I don't see how to work a Maths problem quickly, I will not be able to do it.

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	5	1.3%	5	1.3%	5	3.4%	15	1.6%
SD	40	10.3%	44	11.1%	14	9.5%	98	10.5%
D	244	62.9%	188	47.4%	77	52.4%	509	54.6%
A	89	22.9%	134	33.8%	45	30.6%	268	28.8%
SA	10	2.6%	26	6.5%	6	4.1%	42	4.5%

Table 16: Frequency distribution of responses to Statement:
The way to score in Maths is to practise routines more than to understand a concept.

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	1	0.3%	0	0%	1	0.7%	2	0.2%
SD	30	7.7%	24	6.0%	22	15.0%	76	8.2%
D	122	31.4%	72	18.1%	71	48.3%	265	28.4%
A	150	38.7%	142	35.8%	39	26.5%	331	35.5%
SA	85	21.9%	159	40.1%	14	9.5%	258	27.7%

Rationale for taking mathematics

Item 8 examined whether the students' rationale for taking mathematics was the ability to score well in mathematics relative to other subjects. Although the distribution for all students was roughly 55% disagreeing and 45% agreeing, there was a great difference between groups. The tertiary students had around 60% disagreeing with the statement whilst almost 60% of the junior college students agreed that their choice of taking mathematics was motivated by high grades. The responses are shown in Table 17.

Table 17: Frequency distribution of responses to the statement:
The main reason for taking Maths is that I can score high grades in it.

	Junior college		Polytechnic		University		Total	
	Count	%	Count	%	Count	%	Count	%
MR	0	0%	0	0%	1	0.7%	1	0.1%
SD	31	8.0%	50	12.6%	15	10.2%	96	10.3%
D	126	32.5%	204	51.4%	77	52.4%	407	43.7%
A	181	46.6%	114	28.7%	43	29.3%	338	36.3%
SA	50	12.9%	29	7.3%	11	7.5%	90	9.7%

Findings on general attitude

In this section, the findings from the last open-ended item of the questionnaire are summarised. Students were asked to include any comments they had concerning their feeling towards mathematics. In general, the comments could be grouped under the following points:

(a) 25 respondents used very positive comments towards mathematics such as "mathematics is fun and interesting"; that they found the subject challenging and that it stimulated their minds. Others mentioned that mathematics was very important and foundational to science.

(b) 12 respondents offered very negative comments towards mathematics. Two students used strong words such as "I hate mathematics" and "calculus is hell".

(c) 4 junior college students commented that they enjoyed mathematics and found the subject challenging.

(d) One of the more frequently occurring points (28 respondents from the various groups) can be summarised as a call for more real application of the mathematics they learned to either their future work or to other subject areas. Three of the university students and one junior college student said that they found mathematics/calculus useful and challenging when they applied it to many real life situations or to Physics. However, most of the other junior college students (16 comments in all) felt that much more could be done to explain the practical uses of calculus while the polytechnic students (11 comments) thought that the mathematics they did

was not related to working life and that examination questions could also be more practical.

(e) There were 20 students (from various groups) who mentioned the importance of practice in order to do well in mathematics and the cliché "Practice makes perfect" was often used.

(f) There were also 12 students (11 from junior colleges and 1 from university) who were concerned with the assessment process and this is linked with the previous point concerning practice. They felt that the demands of examination questions and the drive to score have resulted in the subject becoming uninteresting. According to them: (i) "At higher level, mathematics is becoming more and more a dead subject, students do not usually understand concepts, yet can score high grades merely by practicing real hard"; (ii) "Maths can be interesting when we do not focus on just solving standard exam questions"; and (iii) "Much more can be done to make Maths a more likely [he probably means likeable] subject rather than just plain routines and routines of practices so as to get an 'A'. Perhaps projects can be done or to encourage new methods of teaching." The above three comments show that these students do NOT have a negative attitude but are asking for assessment to put more stress on concepts and on thinking rather than on the ability to score through repeated practice of routines and standard questions.

(g) Another group of comments centred around suggestions for teaching. Besides the calls for more practical examples as given above, the rest (32 students from all three groups) asked the lecturers to (i) make their lectures more interesting, (ii) proceed at slower pace, (iii) to challenge students with more interesting "situation" questions, (iv) provide more examples, (v) include history of the development of the topic (vi) hold remedial or preparatory classes (vii) use visual aids or other interesting teaching approaches.

(h) The final group of open comments was from those who found mathematics particularly difficult. They had difficulty in the more conceptual nature of mathematics and 6 university students mentioned that mathematics was getting harder for them as they progressed in their mathematics education. Comparatively, only two polytechnic students and two junior college students wrote that mathematics was difficult although the sample for these categories was much larger.

Summary and discussion of results

On the whole, most mathematics students of junior colleges, polytechnics and universities reported spending around 5 hours a week outside class time on their mathematics. The university students and junior college students had a mode of around 5 hours whereas the polytechnic students spent the least time among the three groups with mode of less than 3 hours and comparatively fewer spending a great deal of time at the high end.

The difference among the groups of students is reasonable. The junior college student sample consisted of 140 out of 388 who are doing double Mathematics C and Further Mathematics while the others did the single Mathematics C. Since almost half of the junior college sample do two mathematics subjects out of their 4 'A' level subjects, they are expected to spend much time on homework and other mathematics work. As for the university students, mathematics would be one of their two or three main academic subjects they are reading and they should hence spend more time on reading, understanding and preparing for tutorials. The polytechnic students, on the other hand, are taking mathematics more as a service subject in their engineering diplomas and hence mathematics should not occupy so much of their preparation and study time.

The following is a summary and discussion of the findings regarding the attitude of the students surveyed[2]:

(a) They had a generally positive attitude towards mathematics: they enjoyed doing mathematics and the reason for this was not that they found it particularly easy. About 64% had a strong desire to understand and learn mathematics. The students comprehended what was taught in mathematics classes (a comfortable 82%) although the majority felt that concepts were hard to understand. About 57% of them found it easy to remember what they had learnt in mathematics and around 40% felt that they were good at solving mathematics problems. Around half felt that mathematics was their best subject. Also, majority did not take a defeatist non-persevering attitude in giving up quickly if they could not do the mathematics problem in a short time.

[2] Please refer to the data presented in Table 2 on page 19.

(b) However, majority of the students (81%) lacked confidence in their own solutions and tended to seek external verification of correctness. There was also a lack of initiative in working more problems than set by the teacher and in reading ahead in mathematics textbooks. It appears that Singapore students even at higher levels are not independent learners of mathematics.

(c) Although the majority of 54% did not choose mathematics because it gave them high grades, this is a small majority and 46% agreed with this statement. Among the junior college students however, the majority went the other way and 59.5% actually agreed that they chose mathematics because they could score high grades in the subject. This is somewhat borne out by the fact that very good mathematics students do not necessarily continue in mathematics since our pragmatic Singaporean students see high grades as stepping stones to their careers in other areas.

(d) For comparison between groups of students, the findings show that more university students find it difficult to understand what is going on in mathematics class as well as find concepts hard to understand. This is reasonable as university mathematics tends to be far more conceptual and abstract whereas mathematics at polytechnics and at 'A' level concentrate more on application of routines and procedures. This also showed up in the ease with which students remembered what was learnt: fewer university students find it easy to remember the mathematics they learnt.

(e) However, although the majority of university students were also unsure about their solutions, this majority of 73% was lower than that of junior college students (79%) and polytechnic students (87%). This is also an expected finding since the university students are generally stronger in mathematics and should therefore have more confidence as well as more understanding of how to ascertain correctness. Furthermore, the independent learning style at universities as well as lack of provided solutions might have contributed to such differences between the groups.

(f) Another cause for concern is the students' view of assessment in mathematics. Overall, 63% agreed that the way to score in mathematics was to practise routines more than to understand concepts. The discrepancy between groups is especially high for this item: 76% of polytechnic students and 60% of junior college students agreed with this statement but only 36% of university students agreed. This again reflects the conceptual nature and abstract nature of university mathematics

Conclusion

The findings show that in general, the Singapore students who are in tertiary institutions have a positive attitude towards mathematics. However, there is cause for concern because of the following areas:

(a) In general, junior college and polytechnic students do not see understanding of concepts as important for scoring in mathematics. There is a slight change in attitude in this aspect as students encounter university mathematics.

(b) Some university students have reported difficulty in learning mathematics, especially when learning becomes more concerned with concepts, definitions, theorems and proofs.

(c) From the open-ended question at the end of the survey, some of the written comments suggest that teachers and lecturers should use more interesting ways of teaching calculus.

(d) A high majority of students in tertiary institutions as well as junior colleges lack confidence in their mathematical learning and are largely dependent rather than independent learners of mathematics.

In conclusion, we ask for and seek answers to the following questions:

✓ How do we reconcile the different objectives of mathematics education as held by the different stakeholders (teachers, students, the education system, and society)?

✓ Should teaching approaches emphasise the conceptual or the procedural? Can we do both?

✓ What are desirable learning practices and how do we foster these?

✓ How do we make mathematics lessons more interesting and inspiring?

Finding the answers to the above questions are important, as they will determine the direction mathematics education should take to bring us into the next millennium.

References

Ahuja, O. P. (1994). Quality Mathematics Education in Papua New Guinea and its role in National Development. In: *Quality Mathematics Education in Developing Countries*, Ed. Ahuja, O. P. et al, UBSPD Publishers' Distributors Ltd., 73–103.

Ahuja, O. P., Lim-Teo, S. K. & Lee P. Y. (1999). Teachers' Perspective on Non-traditional Approaches in Calculus Teaching. *Australian Senior Mathematics Teachers* (To appear).

Ahuja, O. P., Lim-Teo, S. K. & Lee P. Y. (1998) Mathematics Teachers' Perspective of their Students' Learning in Traditional Calculus and its Teaching Strategies. *Journal of the Korea Society of Mathematical Education Series D: Research in Mathematical education. 2(2)*, 89-108.

Aiken, L. R. Jr. (1970). Attitude Towards Mathematics. *Review of Educational Research* 40 (1970), 551-96.

Aiken, L. R. Jr. (1972). Research on Attitude Towards Mathematics. *Arithmetic Teacher, 19*, 229-234.

Foong, P. Y. (1987). Anxiety and Mathematics Performance in Female Secondary School Students in Singapore. *Singapore Journal of Education*, *8(2)*, 22 – 31.

Kloosterman, P. (1991). Beliefs and Achievement in Seventh-Grade Mathematics. *Focus on Learning Problems in Mathematics*, *13(3)*, 3-15.

Minato, S. & Yanase, S. (1984). On the Relationship Between Students Attitude Towards School Mathematics and Their Levels of Intelligence. *Educational Studies in Mathematics*, *15*, 313-320.

Neale, D. C. (1969). The Role of Attitude in Learning Mathematics. *Arithmetic Teacher, 16*, 631-640.

Randhawa, B. S. & Beamer, J. E. (1992). *Gender Similarities in a Structural Model of Mathematics Achievement.* Unpublished manuscript. University of Saskatchewan, Saskatoon, Canada.

Steinkamp, M. W. (1982, April). Sex-Related Differences in Attitude Towards Science: A Quantitative Synthesis of Research. *Paper presented in the annual meeting of the American Educational Research Association*, New York.