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STUDENTS' ATTITUDES TOWARD CALCULUS: A PRELIMINARY STUDY AMONG DIPLOMA STUDENTS AT UNIVERSITI PUTRA MALAYSIA

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Abstract. A preliminary study was conducted among 62 diploma students at Universiti Putra Malaysia (UPM) to (1) assess their attitudes toward Calculus, (2) determine the difference in attitudes scores between males and females and (3) assess the relationship between students, attitudes toward Calculus and their prior Mathematics achievement. Attitude was measured in cognitive, affective, and behavioural domains. The findings showed that a high percentage of students did not have positive attitudes toward Calculus. There was a statistical significant difference in the mean scores for males and females in the Calculus attitudes scale. Specifically, statistical significant differences were detected between males and females in two attitude domains: cognitive and behavioural. The correlation between students' attitudes toward Calculus and Mathematics grade was low and not statistically significant. In general, this study revealed that diploma students in UPM have different levels of attitudes toward Calculus. This information would be helpful to Mathematics lecturers when they conduct their lectures.

Keywords: Attitudes, Calculus, diploma students

Abstrak. Satu kajian awal telah dijalankan di kalangan 62 orang pelajar-pelajar diploma di Universiti Putra Malaysia (UPM) untuk (1) menilai sikap mereka terhadap Kalkulus, (2) menentukan perbezaan dalam skor sikap di antara pelajar lelaki dan perempuan dan (3) menilai hubungan di antara sikap pelajar terhadap kalkulus dan pencapaian pelajar dalam Matematik sebelum ini. Sikap diukur dalam domain kognitif, afektif dan tingkah laku. Dapatan kajian ini menunjukkan peratusan pelajar yang tidak menunjukkan sikap yang positif terhadap Kalkulus adalah tinggi. Terdapat juga perbezaan yang signifikan dalam skor min sikap terhadap Kalkalus di antara pelajar lelaki dan perempuan. Secara spesifik, perbezaan signifikan dikesan di antara pelajar lelaki dan perempuan dalam dua domain sikap iaitu: kognitif dan tingkah laku. Korelasi di antara sikap pelajar terhadap Kalkulus dan gred Matematik adalah rendah dan tidak signifikan. Kajian ini menunjukkan bahawa pelajar-pelajar diploma di UPM mempunyai tahap sikap yang berbeza terhadap Kalkulus. Secara amnya, maklumat ini adalah berguna kepada pensyarah dalam mengendalikan proses pengajaran-pembelajaran di dalam kuliah.

Kata kunci: Sikap, Kalkulus, pelajar diploma

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1.0 INTRODUCTION

There have been some recent concerns on Mathematics achievement among students in Universiti Putra Malaysia (UPM). For Semester I 2002/2003, Semester I 2003/2004, Semester II 2003/2004 and Semester I 2004/2005, 79.7, 63.8, 42.7 and 66.4% of students at the diploma level scored grade C+ and below for Mathematics respectively, where approximately 70% of this course is made up of Calculus. This trend is worrying as it shows that the majority of students are performing poorly in Mathematics.

Calculus is an important component of Mathematics. In all Malaysian universities, most Engineering and Science students study a Calculus courses as it is considered as the foundation for many majors (Faridah Basaruddin, Siti Fatimah Ahmad Zabidi & Mohd Zamri Yusoff, 2003). Therefore, we can conclude that Calculus is an important paper for every Science and Engineering students. However, many students perform poorly in Calculus courses (Faridah Basaruddin *et al*., 2003; Zhang, 2003) and lecturers have little confidence in undergraduates' coping abilities toward such courses (Roselainy Abdul Rahman *et al*., 2003). Chen *et al*. (2003) found that one reason for such poor performance is because students do not understand the underlying concepts of Calculus. Chen *et al*., (2003) stated that as a result, many students perform poorly. Students are distressed as they have to face with the abstraction of definition in Calculus (Byun, *et al.*, 2003). The problem is further compounded by students' little understanding of the symbolic algorithms when using Calculus in more advanced Mathematics courses (Tucker & Leitzel, 1995).

The studies above seemed to indicate that poor performance in Calculus is related to students' weak foundation in the topic and their failure to master the basic concepts. This issue has to be considered seriously. There are studies that have shown the relation ship between the attitude and performance variables (Thondike-Christ, 1991; Gallagher & De Lisi, 1994; Shashaani, 1995; Tapia & Marsh 2001). Positive relationship is always obvious between Mathematics achievement and attitudes towards Mathematics (Papanastasiou, 2000). According to Papanastasiou (2000), students with positive attitudes toward Mathematics tend to do well in the subject. Therefore, it is important to address students' poor foundation in Calculus, as equal as to assess students' attitudes toward Calculus.

2.0 THEORETICAL FRAMEWORK

Studying attitude is important because it can predict an individual's response to an object (Ajzen and Fishbein, 1977). Attitudes guide behaviour and "favourable attitudes predispose positive responses to the object and unfavourable attitudes predispose negative responses" (Ajzen and Fishbein, 1977). Attitude is generally classified according to three categories of attitude responses which are affect, cognition and behaviour or behavioural intention (Breckler, 1984; Ajzen, 1988; Eagly & Chaiken,

1998). Brown *et al.* (2002) agreed that these three components capture the meaning of attitudes accurately.

The Tripartite Model developed by Rosenberg and Hovland (1960) postulates that attitude is a response to an antecedent stimulus (Breckler, 1984). The antecedent stimulus can be the independent variable. Affect, behaviour and cognition are classified as the response to that stimulus (Breckler, 1984). According to Ajzen (1988), affect is related to the evaluation of the feelings toward the attitude object while cognition reflects the perception of information about the attitude object and lastly, behavioural or behavioural intention are commitments, and actions toward the attitude object.

In the context of attitudes toward Calculus in this study, affect refers to positive or negative feelings toward Calculus. Cognition refers to how students perceive Calculus, such as perceiving the usefulness of Calculus in their lives or relating Calculus to their daily lives, while behaviour reflects how students react to Calculus.

It is possible that students have developed some attitudes toward Calculus because it is a subject that has been made compulsory for almost all Engineering and Science based courses in the university, where the study was conducted. Therefore, consistent with Ajzen and Fishbein (1977), if attitudes toward Calculus are understood, it would be possible to predict Calculus related behaviour or performance.

3.0 REVIEW OF RELATED RESEARCH

Studies on attitudes toward Calculus per se are scarce as indicated by the search returns in databases such as Eric Reproduction Service, Proquest Education Journals and Ebscohost. However, the search returns indicate that there are many studies related to Mathematics. As Calculus is a topic taught in Mathematics (Microsoft Encarta Online Encyclopedia, 2004), therefore, it would be worth to examine the research related to Mathematics.

Performance on Mathematics has been shown to be significantly related to positive attitudes toward Mathematics (Gallagher & De Lisi, 1994). Shashaani (1995) found that attitudes toward Mathematics is an important factor in determining the achievement and participation of students in Mathematics. Thondike-Christ (1991) stressed that Mathematics course grades are related to students' intention to continue studying advance Mathematics courses.

Tapia and Marsh (2001) stated that there is a pertinent need to recognize the importance of attitudes. Therefore, attitudes should be assessed. Linn and Hyde (1989) stressed that changes at the affective and achievement levels have greater effect on Mathematics participation compared to the cognitive level. The learning of Mathematics is related to attitudes or the affective level (Meyer & Koehler, 1990). An attitude is paramount in preserving students' interests in pursuing higher level of Mathematics courses (Tobias, 1987). For these reasons, there is an urgency to create positive attitudes among students in the classroom (Steinback & Gwizdala, 1995). Mc Leod (1992) further suggested that

> "affective issues play a central role in Mathematics learning and instruction. When teachers talk about their Mathematics classes they seem just as likely to mention their students' enthusiasm or hostility toward Mathematics as to report their cognitive achievements. Similarly, inquiries of students are just as likely to produce affective and cognitive responses; comments about liking (or hating) Mathematics are as common as reports of instructional activities. These informal observations support the view that affect plays a significant role in Mathematics learning and instruction". (p.575)

Haladyna *et al*. (1983) highlighted several reasons why positive attitudes are important. The reasons are listed below:

(i) a positive attitude is an important school outcome in and of itself;
(ii) attitude is often positively, although slightly related to achievement;
(iii) a positive attitude toward Mathematics may increase one's tendency to select Mathematics courses in high school and college and possibly ones' tendency to elect careers in Mathematics or Mathematics related fields.

The importance of studying attitudes is reaffirmed in the new millennium when Ajzen and Fishbein (in press) stated that attitudes toward behaviours enable researchers to predict behaviours from the attitude construct.

It may seem that attitude is an important variable to look into, however, studies by Leder (1994), Huang and Waxman (1993), and Hollowell and Duch (1991) stressed that gender is one of the intervening variables that must be looked into. Through a meta-analysis study, Elsey and Snetzer (1998) found that gender differences in student attitudes toward Mathematics exist. Male students showed more positive attitudes toward Mathematics compared to females. However, the differences were small. Marsh and Tapia (2002) reported that positive attitudes toward Mathematics is not gender related but is more likely related to either individual or personal experiences.

Odell (1998) found that there were significant differences in students' attitudes toward Mathematics in a business college. It was also found that attitudes could be used to predict grades. Males are found to be more confident when it comes to their ability to solve Mathematics problems (Frost, Hyde & Fennema, 1994). They also found that males generally have more positive attitudes toward Mathematics. When it comes to performance, there are studies which found that females outperformed males. According to Harris and Carlton (1993) and Linn and Kessel (1996), girls excel better on routine Mathematics problems usually taught in class while males outperform females on nontextbook-like problems. It seems that females and males perform differently when they are given distinct kind of Mathematics problems to be solved. Linn and Kessel (1996) explained that such differences exist because of female students' tendency to use standard problem solving strategies taught in textbooks and classrooms while males use unconventional methods which are not taught in class to solve problems.

For these reasons, it is therefore, pertinent to examine students' attitudes toward Calculus as previous studies showed that attitudes and students' performance are closely related. There is also a need to examine the relationship between gender and performance.

4.0 OBJECTIVES OF THE STUDY

The objectives of the study are to:

(i) assess students' attitudes toward Calculus;
(ii) determine the differences in attitudes scores between males and females; and
(iii) determine the relationship between students' attitudes toward Calculus and prior Mathematics achievement.

5.0 METHODS

Sixty two students from two diploma programs at UPM took part in the survey. The instrument used in this study was developed specifically to suit the participants. Each item was measured against a five point Likert-type scale ranging from strongly disagree (1) to strongly agree (5). Fifteen items were developed for the instrument by the first author who has taught Calculus for almost seven years at both the matriculation and diploma levels. The second and third author of this paper validated the content and clarity of the instrument. The instrument was developed in Malay language. The instrument was pilot tested on 34 students who were not involved in the actual study. The reliability of the attitude score of the pilot test as ascertained by Cronbach's alpha was .82, while the alpha level for the actual study was .85.

6.0 PARTICIPANTS' BACKGROUNDS

The participants consisted of 43 females and 19 males (n= 62). The mean age of the participants was 19.7 years old (SD= 2.9). Sixty of them were from the Diploma in Human Development program while the remainings were from the Diploma in Farming. Thirty nine of the participants had taken Additional and Modern Mathematics while 23 of them had only modern Mathematics background. Out of the 39 students who took Additional Mathematics, 35 revealed their grades.

7.0 RESULTS

The results reported in this section were mainly based on the quantitative data obtained from the Likert-style items. Descriptive statistics (means and standard deviations) were used to report the data gathered through Likert-style items. T-test was used to determine

the attitude difference between males and females while MANOVA was carried out to determine the differences between males and females in terms of the three domains (affective, cognitive and behavioural) of attitudes.

7.1 Attitudes Toward Calculus

Results of participants who answered the final version of the survey form are shown in Table 1. Final items included in the instrument are shown in Table 1, with the means and standard deviations. The overall mean was 3.36.

Based on the Tripartite Model, five items were developed according to the affective, cognitive and behavioural domains respectively. The participants' attitudes toward Calculus were assessed with 15 Likert-style items. The participants would need to state their preferences from five choices (5 points=strongly agree, 4 points=agree, 3 points=not sure, 2 points=disagree, 1 point=strongly disagree and vice versa for negative items). All except for three items were in the positive form. The negative items were reversed scored before further analysis was carried out.

The cumulative scores of their attitudes toward IT were between 19 and 70 with a mean of 50.52 (SD= 8.47). Attitude was categorised into four levels: negative, moderately positive, positive and highly positive according to the 25th, 50th and 75th percentile. The findings showed that 50% of the participants had negative (22.6%) and moderately positive (27.4%) attitudes while the remainings had positive (19.4%) and highly positive (30.6%) attitudes toward Calculus.

Seven items in Table 1 are above the overall mean (3.36). The statement: "I need to do a lot of Calculus exercises" has the highest mean (4.48) while the second highest mean for the statement "Learning Calculus is a waste of time" suggests that participants disagreed it was not worth to spend time learning Calculus. The lowest mean is 2.97 (It is important that students learn Calculus every semester). The next lowest two items with a mean score of 3.00 each are statements about the application of Calculus in their daily lives. This shows that students disagreed with both statements.

When the analysis was split according to gender, the results in Table 1 show that females scored higher then males in all items except for two items. The male candidates tended to agree more with the statement "I enjoy learning Calculus if more time is allocated for the subject". However, the difference between both sexes was very small. When asked whether they had any topic preferences when they did their revision, the males tended to agree more with the statement: "I revise more on Calculus topics compared to other topics". The item "I need to do a lot of Calculus exercises" recorded the highest mean score for both males and females. Female participants seemed to have better attitudes toward Calculus compared to the males based on the mean score of each item. The authors, however, could not assume that the differences were significant because only descriptive analyses were carried out at this stage.

Next, the items were summed up to arrive at an overall score for each construct (affective, cognitive, behavioural). The higher the mean scores means that the

Table 1 Items for attitudes toward Calculus

Item	Females		Males		Total	
	M	SD	M	SD	M	SD
I need to do a lot of Calculus exercises***	4.49	.77	4.47	.70	4.48	0.74
Learning Calculus is a waste of time*	3.91	.92	3.74	1.05	3.85	0.96
What I learn in Calculus will be important when I further my study at the degree level**	3.95	.79	3.53	1.31	3.82	0.98
I will do extra Calculus exercises than the ones already given in lectures***	3.84	.90	3.05	1.03	3.60	0.99
I learn Calculus well*	3.53	.77	3.37	1.01	3.48	0.84
I enjoy learning Calculus if more time is allocated for the subject*	3.40	1.16	3.42	1.02	3.40	1.10
What I learn in Calculus is useful outside lectures**	3.51	.88	3.16	1.02	3.40	0.93
I always ask the lecturer when I do not understand a Calculus topic***	3.56	.99	2.53	1.02	3.24	1.09
I revise more on Calculus topics compared to other topics***	3.47	.98	4.58	1.12	3.19	1.09
Calculus is boring*	3.05	1.05	3.00	.88	3.03	0.99
Calculus is not related to the field that I will be involved in**	3.02	.86	3.00	1.11	3.02	0.93
I learn the Calculus topics first before attending lectures***	3.19	.88	2.63	.96	3.02	0.93
I try to relate Calculus with my everyday life**	3.09	.90	2.79	1.03	3.00	0.94
When I learn Calculus, I will use it in my everyday life**	3.07	.99	2.84	1.02	3.00	0.99
It is important that students learn Calculus every semester*	3.05	1.19	2.79	1.03	2.97	1.15

Mean of means=3.36 *= affective **= cognitive ***= behavioural

participants' attitudes were more positive. Table 2 presents the participants' means scores with the standard deviations of the three subscales. The participants scored the lowest on the cognitive subscale and highest on the behavioral subscale. This indicated that the participants reacted positively toward Calculus but did not perceive it to be important in their lives.

Table 2 Means of affective, cognitive and behavioural constructs

Subscale	Mean	S.D.
Affective	16.74	3.45
Cognitive	16.24	3.38
Behavioural	17.53	3.26

7.2 Difference in Attitudes Toward Calculus

An independent-samples t-test was conducted to find out if there is a significant difference in attitudes of males and females students toward Calculus. There was a significant difference in the mean scores for males (M= 46.89, SD= 9.16) and females [M= 52.12, SD= 7.72; t(60)= -2.318, p=.024]. The differences of the means were small (eta squared= 0.082).

Further analyses were carried out to determine if differences exist between male and female students in the affective, cognitive and behavioural domains. A MANOVA test was conducted for this purpose. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices and multicollinearity, with no serious violations noted. There was a significant difference between males and females on the combined dependent variables: F(3,58)= 7.65, P< .0005; Pillai's Trace= 0.716, partial eta squared= 0.28. When the results for the dependent variables were considered separately, the mean scores for two domains reached statistical significance using the Bonferroni adjusted alpha level of .017 (Table 3).

Table 3 Differences between males and females

	Males		Females				
Dependent variables	**Mean**	**S.D.**	**Mean**	**S.D.**	**F**	**P**	**Partial eta squared**
Affective	16.32	3.38	16.93	3.51	.41	.523	.007
Cognitive	15.32	3.83	16.65	3.13	2.09	.154	.034
Behavioural	15.26	3.21	18.53	2.76	16.71	.000	.218

* Significant at p< .017

The domains were cognitive [F(1,60)= 2.086, P= .154, partial eta squared= 0.034] and behavioral [F(1,60)= 16.71, P< .0005, partial eta squared=.218]. The mean score for the affective domain was not significant [F(1,60)= .41, P= .523, partial eta squared= 0.007]. This suggested that female participants had more positive perceptions with more favourable reactions toward Calculus when compared with the males. However, there was no significant difference between them when measured in terms of their feelings toward Calculus.

7.3 Relationship Between Attitudes Toward Calculus and Prior Mathematics Achievement

Prior Mathematics achievement was measured in terms of the students' Additional Mathematics grades achieved in the SPM examination. The highest grade that a student can achieve is A1 and the lowest grade is F9. A total of 35 students indicated their grades. A correlation analysis was conducted to determine the relationship between

students' attitudes and Mathematics achievement. According to Cohen (1988), the correlation between both variables was small (r= -.265, p= .124) and not significant. This suggested that the relationship between students' attitudes toward Calculus and Mathematics grade was negligible.

8.0 DISCUSSION

Three major findings have emerged from this study. First, the results of this study revealed that there is a high percentage of students categorised as those with negative and moderately positive attitudes toward Calculus. This finding has to be taken seriously because it is possible that students with such attitudes would find Calculus boring. Maybe they also fail to relate and use Calculus in their daily lives. It seemed that students were aware that Calculus involved a lot of practice to excel in. They were also willing to do extra exercises other than the ones given during lectures. Most also agreed that they were able to learn the subject well and would enjoy it more if more time was allocated for Calculus for both the lectures and tutorials. They also agreed that Calculus was a useful topic to be learned. In other words, this meant that students were able to identify Mathematics within everyday activities. Generally, most of the students who participated did not feel learning Calculus was a waste of time and saw the importance of it when they pursued their study.

The results also revealed that students did not ask their lecturers when they did not understand what has been taught in class. They did not place Calculus as a priority subject when they did their revision. Calculus was also perceived as a boring subject. There could be several reasons for this, as indicated in Table 1. There was a possibility that students were bored as they were not able to relate it to their everyday lives. They also did not see the connection between Calculus and the areas that they would be involved in the future. They also indicated that they did not learn the topics beforehand. Second, the comparison of mean scores between males and females for each item suggested that females tended to have more positive attitudes in general. The t-test analysis confirmed that there was a significant difference between females and males in terms of their attitudes toward Calculus. The results seemed to contradict the findings by Frost *et al.* (1994) and Elsey and Snetzer (1998) who found males to have more favourable attitudes toward Mathematics. The results from MANOVA test revealed that male and female participants differed significantly in terms of how they perceived Calculus. Statistically significant difference was also found between both groups in terms of how they reacted to Calculus. When compared in terms of their feelings, no significant difference was detected suggesting that gender did not have an effect on their feelings.

Third, prior Mathematics achievement when measured in terms of their grades (Additional Mathematics), did not seem to relate to students' attitudes. This suggested that students who scored good grades in their additional Mathematics paper did not necessarily have more positive attitudes toward Calculus.

9.0 CONCLUSION

The result of this study was preliminary in nature but provided some insights that may be deemed useful especially to those who teach Calculus at the tertiary level. The results indicated that diploma students had differed levels of attitudes toward Calculus. A high proportion of diploma students had negative and moderately positive attitudes toward Calculus. This could possibly be due to the way Calculus is taught in UPM. Calculus is currently taught using the traditional approach. Teaching is done in lecture halls, accommodating at least 60 students at one time where course instructors deliver lectures by transmitting knowledge in a one-way mode while the students watch, listen and take notes passively.

The result of the study also suggested gender should not be ignored. Female students were found to have more positive attitudes toward Calculus. Specifically, females tended to perceive Calculus as more important in their everyday lives when compared to males. They were able to see the connection between Calculus with what they do in life. Female students also put in more effort, such as doing more Calculus exercises than those given by lecturers throughout the Calculus course. This is shown by the highest mean scores achieved in the behavioural domain. In other words, females would most likely perform better than males in Calculus because of their more positive attitudes, and they probably have higher tendency than males to choose Mathematics related jobs.

To conclude, when students have more positive attitudes toward Calculus, it is likely that they will perform better in Calculus assessments. The likelihood of them taking more Advanced Mathematics courses in later semesters or at degree levels is enhanced. This is true because measures of attitudes are good predictors of behaviours (Ajzen, 2001; Brown, Manogue & Rohlin, 2002).

10.0 LIMITATIONS OF THE STUDY

It should be noted that this study was preliminary and exploratory in nature. All data collected were based entirely on the honesty and how the participants perceived their attitudes toward Calculus. However, this study only involved diploma students from one public university that had volunteered to take part in it. Therefore, caution must be taken when generalizing any findings for the entire population at the university where this study was conducted.

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