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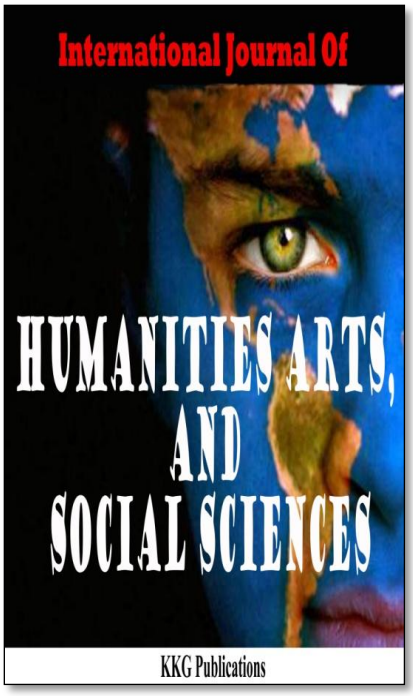

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A STUDY OF STUDENTS' PERFORMANCE IN CALCULUS AND THEIR ATTITUDES TOWARD THE COURSE USING A TRIPARTITE MODEL

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Abstract. Facey-Shaw and Golding (2005) found that attitude plays an important role in students' academic performance. In this study we use a tripartite model, according to which attitude has a cognitive, an affective, and behavioural components (Eagly & Chaiken, 1998). Using this model, we have constructed an appropriate Calculus Attitude Questionnaire I (CAQ I). We used equivalent forms to measure the reliability of this questionnaire. This instrument was administered to 82 randomly selected engineering students from different faculties at Universiti Malaysia Pahang (UMP). After collecting the data, we analyzed it using SPSS software. In this paper we present and discuss relationship between students' performance in Calculus and their attitudes toward Calculus in these three categories.

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INTRODUCTION

Any student aspiring to major engineering is required to complete at least one semester of Calculus at most universities in the world. Calculus plays an important role in learning and degree completion requirement of university- level engineering course. Students are denied access to other courses required by the engineering programs unless they pass the Calculus course – Calculus seems to be a gatekeeper course to engineering programs. Calculus indeed is very important to every engineering student who wishes to complete the engineering program successfully.

Many calculus lecturers and instructors are very much concern about the performance of the students enrolling in the course. They are seeking techniques and methods to assist their students in understanding the concepts of Calculus and also to motivate them. In some cases where the failure rates of Calculus are high, the lecturers or instructors are very much concern, to find ways and solutions to reduce the failure rates. The expression below is an example of concern of a mathematics lecturer. "My main concern is to facilitate student success. I am looking for a solution to the problem of high failure rates in first semester Calculus. I want to know "what works", which adds pragmatism to my worldview" (Creswell, 2007: 22). The same scenarios happen at Universiti Malaysia Pahang which is one of the newest public universities in Malaysia. There are nine faculties at Universiti Malaysia Pahang, out of which six faculties are engineering faculties. The lecturers teaching mathematics, particularly Calculus is very much concern about the students' performance in Calculus since we believe that to be good in engineering courses, students must be good at mathematics, especially Calculus. In this preliminary study, we have constructed Calculus Attitude Questionnaire I (CAQ I) to enable us study the students' attitudes toward Calculus. In this article, we would like to share our findings as well as to discuss the reliability and validity of the questionnaire.

Theoretical Background

According to modern trends of research in mathematics education, attitude towards mathematics is a very important construct to interpret students' behavior. It also plays an important role in students' academic performance (Facey-Shaw & Golding, 2005). In any case, it is crucial that any investigation of attitudes be assessed with an instrument that has good technical characteristics if research conclusions are to be meaningful. A lot of research has been done on attitude towards mathematics, but theoretically the concepts need to be developed. Several authors (e.g. Di Martino & Zan, 2001; Rufell, Mason & Allen, 1998) have pointed out that attitude is an ambiguous construct, it is often used without proper definition, and it needs to be developed theoretically. The most obvious problem with attitudes is the discrepancy between espoused and enacted attitudes. Moreover, attitude measures need substantial refining (Ma & Kishor, 1997). Di Martino and Zan (2001) distinguish two basic approaches to defining attitude towards mathematics:

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1. A 'simple' definition describes it as the degree of affect associated with mathematics; i.e. attitude is the emotional disposition toward mathematics. This kind of definition ignores the cognitive element in attitude. However, even those who use this kind of definition, often rely on paper and pencil test, which makes it hard to distinguish emotional disposition from beliefs
2. A three-component definition distinguishes emotional response, beliefs, and behaviour as components of attitude. This second approach seems incompatible with the widely accepted view (e.g. McLeod, 1992; DeBellis & Goldin, 1997) of attitude, emotions and beliefs as long to the affective domain.

There is another definition in which behaviours do not appear explicitly (Daskalogianni & Simpson, 2000) attitude towards mathematics is therefore seen as the pattern of beliefs and emotion associated with mathematics. This definition is referred to as a bi-dimensional definition.

Kulm (1980) suggests that 'It is probably not possible to offer a definition of attitude towards mathematics that would be suitable for all situations, and even if one were agreed on, it would probably be too general to be useful'. In this way, the definition of attitudes assumes the role of a 'working definition' (Daskalogianni & Simpson, 2000). This position views the attitude construct as functional to the researcher's self-posed problems: in these terms, we consider it to be useful in the context of mathematics education, as long as it is not simply borrowed from the context in which it appears, i.e. social psychology, but it is rather outlined as an instrument capable of taking into account peculiar problems in mathematics education. This is in line with the position of Ruffell et el. (1998) who see attitude as an observer's construct.

The definition of 'positive' or 'negative' attitude towards mathematics clearly depends on the definition of attitude itself. The characterization of an individual's attitude as positive/negative is in most cases, simply the result of a process of measurement, performed through instrument such as the Thurstone or Likert attitude-scales or the semantic differential technique (Di Martino & Zan, 2001). Since in most questionnaires used to assess attitude the items range from those related to emotions to those related to beliefs, to those related to behaviour, an answer can be characterized as 'positive' by referring to different meanings of the word 'positive' itself. More precisely, this meaning varies depending on whether 'positive' refers to emotions, beliefs, or behaviour.

Students' beliefs and attitudes toward Calculus influence how they approach Calculus. If a student does not believe that Calculus is useful or that it is too difficult, then the motivation to spend time working on Calculus will decline. Additionally, beliefs about Calculus can influence confidence, which, in turn, can affect performance. Thus, a common assumption held by many researchers is that there is a relationship between attitudes and academic achievement (Kloosterman & Cougan, 1994; Kloosterman & Stage, 1992).

Students need to recognize Calculus is not about following predetermined steps and getting a single answer. If students, however, believe that Calculus is simply about following a sequence of steps to get to the solution, then they do not have the ability to think critically about Calculus.

Research Objectives and Research Questions

The main objective of this preliminary study is to construct Calculus Attitude Questionnaire I (CAQ I) and use it as an instrument to analyze the students' attitudes towards Calculus at Universiti Malaysia Pahang. Other objectives are:

1. To analyze the reliability and the validity of CAQ I
2. To analyze the attitudes of students with high performance (good students)
3. To analyze the attitudes of students with low performance (poor students)

Since we are using a tripartite model, according to which attitudes have a cognitive, an affective, and behavioural components, we have identified and categorized the items in our questionnaires in these categories. Our research questions are:

1. How reliable and valid are the items in those categories?
2. Do the 'good' students possess 'positive' attitudes?
3. Do the 'poor' students possess 'negative' attitudes?

From this pilot study, we would like to identify the shortcomings of CAQ I so that we can modify it for our future project. We would like to know in which categories we need to focus more. We hope we can construct a better questionnaire in our next project.

METHODOLOGY

Development of Mathematics Attitude Questionnaire I

Calculus Attitude Questionnaire I (CAQ I) was developed based on several Mathematics and Calculus attitude inventories. From these inventories, we had identified and chosen questions that could provide information about students' attitudes in three categories, namely their beliefs about Calculus and self beliefs, their behaviour regarding Calculus and their emotions towards Calculus. After some modifications, we finally had an inventory which consists of five sections and we named it as the Calculus Attitude Questionnaire I (CAQ I).We used Likert scale in CAQ I, ranges from 1 (strongly disagree) to 5 (strongly agree).

About CAQ I

CAQ I consists of five sections; Section I consists of questions about students' demography, Section II is about students' beliefs about mathematics and the other three sections consist of questions which can provide information about students' behavior, self beliefs and feelings (emotions) towards Calculus.. In each section, there are randomly distributed positive and negative questions and the number of questions varies.

Pilot Test

A pilot test was administered by three lecturers in Semester III (2008/2009 Session) to 82 randomly selected students from different faculties at Universiti Malaysia Pahang (UMP). The

questionnaires were collected and analyzed. From the questionnaires, we had identified 59 'good' students and 23 'poor' students based on their answers in Section I of CAQ I. 'Good' students are the students who got 'good' grades (C or higher) in Calculus and 'poor' students are those got 'poor' grades (lower than C). We had also identified positive and negative attitudes in those three categories. We used SPSS to analyze the reliability and validity of CAQ I and find the mean score of positive/negative attitudes for the 'good'/'poor' students.

FINDINGS AND DISCUSSION

Statistical Analysis

Reliability of Measurement

Reliability refers to the consistency of a measure. A test is considered reliable if we get the same result repeatedly. For example, if a test is designed to measure a trait, then each time the test is administered to a subject, the results should be approximately the same. Since it is impossible to calculate reliability exactly, we can just estimation reliability. There are several different methods to estimate reliability such as test-retest, equivalent forms and split-half. Test–retest reliability requires that respondents to answer the identical questions at two or several different times (with a suitable time lapse in between). After that, the original and retest answers are compared. Equivalent forms reliability relies on the similar aspect of the definition of reliability and uses equivalent forms of questions typically embedded in the same questionnaire. Split-half reliability requires that the researchers separate the total sample into two groups and compare one group's response to the other's responses. Measurement reliability can be improved by revising questions, collapsing scales, and throwing out respondents. In this study, we used equivalent forms to measure the reliability of this questionnaire. We analyze the collected data by using SPSS software. Since we used equivalent forms to measure the reliability, we preferred to use Crobach's Alpha Model in analyzing our data.

Validity of Measurement

Validity refers to the degree to which a study accurately reflects or assesses the specific concept that the researcher is attempting to measure. There are several types of validity, such as face validity, criterion related validity, content validity, predictive validity and discriminant validity. However, in this study, it is impractical to validate a concept unless there is a theoretical network that surrounds the concept.

The Reliability of Equivalent Form

From the equivalent form's method and Crobach's Alpha Model, we produced each of the sections results and presented it in Table1.

TABLE 1
Cronbach's Alpha Results

Category	Cronbach's Alpha
About Mathematics	0.875
Behaviour	0.669
Belief	0.672
Emotion	0.566

Referring to the Table 1, the values of Cronbach's Alpha are equal or greater than (0.7) in three categories, namely categories of About Calculus, Behaviour and Belief which indicates that the reliability of those categories are trustworthy. However, improvements still need to be made on Behaviour and Belief categories. While for Emotion category of Cronbach's Alpha value is less than (0.7) which indicates that this category is less reliable and much improvement need to be made to make it trustworthy.

Overall Scores of Positive and Negative Attitudes

By calculating the mean score for each category of each item, we obtained results and is represented in Table 2, Table 3, Table 4 and Table 5.

TABLE 2

Mean Score of Behaviour, Belief and Emotion Categories

Sample		Behaviour		Belief		Emotion	
		Mean Score		Mean Score		Mean Score	
N	Positive	Negative	Positive	Negative	Positive	Negative	
1	3.62	3.06	4.17	4.01	3.50	2.17	
2	3.68	3.61	4.23	3.11	3.74	3.06	
3	3.87	2.84	4.17	2.62	3.78	2.93	
4			4.15	3.10	3.54		
5				2.72	3.48		
6				2.51	3.61		
7				3.26			
Mean	3.72	3.17	4.18	3.05	3.61	2.72	

TABLE 3

Mean Score of Behaviour Questions and Students' Categories

Questions	Mean Score	Good Students (59)	Poor Students (23)
Positive Behaviour	3.72	3.88	3.32
Negative Behaviour	3.17	3.14	3.26

Table 3 shows the relationship between positive and negative behaviour questions in terms of mean scores and students' categories (good and poor students). The overall mean score for positive questions is (3.72), where the mean scores for the 'good' students and 'poor' students are (3.88 and 3.32) respectively. On the other hand, the overall mean score for the negative behaviour is (3.17). The mean score for the 'good' and 'poor' students are (3.14 and 3.26) respectively. These results indicate that 'good' students possess positive behaviours and the degree is much better than the 'poor' students. On the other hand, the 'poor' students possess more negative behaviours compared to the 'good' students.

TABLE 4

Mean Score of Belief Questions and Students' Categories

Question	Mean Score	GoodStudents (59)	Poor Students (23)
Positive Belief	4.18	4.2	4.13
Negative Belief	3.05	2.98	3.2

Table 4 shows the relationship between positive and negative Belief questions in terms of mean score and students' categories (good and poor students). The overall mean score for positive belief is (4.18) where the mean score for the 'good' and 'poor' students are (4.2) and (4.13) respectively. Meanwhile the overall mean score for the negative belief is (3.05) where the mean score for the 'good' and 'poor' students are (2.98 and 3.2) respectively. These results reveal that 'good' students have positive beliefs and the degree is better than the 'poor' students. On the other hand the 'poor' students have more negative belief compared to the 'good' students.

TABLE 5
Mean Score of Emotion Questions and Students' Categories

Question	Mean Score	Good Students (59)	Poor Students (23)
Positive Emotion	3.61	3.15	3.38
Negative Emotion	2.72	2.69	2.88

Table 5 shows the relationship between positive and negative Emotion questions in terms of mean score and students' categories (good and poor students). The overall mean score for the positive emotion is (3.61) where the mean score for the 'good' students is only (3.15) compared to the mean score for the 'poor' students. Nevertheless the mean score for the positive emotion of the 'good' students (3.15) is much higher than the mean score for the negative emotion (2.69) in its own category (good students' category). The overall mean score for the negative emotion is (2.72) where the mean score for the 'poor' students (2.88) is much higher than the mean score for the 'good' students (2.69). This indicates that although many 'poor' students possess positive emotion towards mathematics, their negative emotion is greater than those possessed by the 'good' students. These results should be accepted with caution due to the low reliability in the emotion category where the Cronbach's Alpha value is only (0.566).

LIMITATIONS OF THE STUDY

This pilot study was performed during Semester III (2008/2009) during which not many mathematics courses were offered and the enrollment of students was very low. Many of the students were repeating the courses and their achievement in Calculus was not so good. The sample size was small (82) and the number of 'good' and 'poor' students was not equal or at least about the same. There was no balance in the number of positive attitudes and negative attitudes, questions in those three categories namely, belief, emotion and behaviour categories. We hope we can modify our questionnaire and get a larger sample in a normal semester (Semester I or Semester II) to obtain a more valid and reliable results.

CONCLUSION

In this preliminary study, we have found that students with good performance had positive attitudes towards Calculus and students with low performance had a more negative attitude towards Calculus but the poor students' emotion towards mathematics was still high. Again, we have to be a little bit cautious when interpreting this since the reliability of the questions in this category (Emotion) is very low.

These findings are important to the educators and administrators of the University so that appropriate actions can be taken to improve the students' attitudes towards Calculus with the hope that it will improve their performance in Calculus.

Educators and parents alike need to become active change agents in fostering positive attitudes in students or children in order to enhance their interest and achievement in Calculus. They should be more motivated, more empathic and sensitive to their students' and children's needs.

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