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Mathematical Learning of Engineering Undergraduates

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Abstract

Much research has been conducted on the teaching and learning of mathematics for engineering undergraduates. This paper reports on a preliminary study in an investigation on the mathematics curriculum of engineering students, a study of engineering students and lecturers' perceptions about the mathematics curriculum, teaching and learning that have been carried out. The research instrument was a set of questionnaire that the respondents consist of lecturers and students from engineering faculties of UTM in Johor, Malaysia. The information highlights issues of concern in the development of the mathematics curriculum for engineering students based on data of implemented curriculum as compared to the desired curriculum.

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Keywords: mathematics curriculum; mathematical skills; engineering undergraduate

1. Introduction

Mathematics is a difficult subject and students have difficulty because of different perceptions of mathematical words and concepts. There are some various factors that influence students' performance (Ihejieta, 1995). These factors are:

- i. Students' lack of eagerness to mathematics may stem from psychological incidences such as fear, tolerance threshold, and perseverance and associated factors.
- ii. The mathematics curriculum may not be relevant to real life.

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- iii. Mathematics instructors were not keen on teaching the course and did not help their students by catering individual differences.
- iv. Other references such as text books were missing from both schools and homes.

Moreover the mathematics curriculum for engineering is presented by identifying the comprehensive list of topics in mathematics (Roselainy et. al. 2005). The engineering students are expected to find out the importance of mathematics in their future carriers (Sazhin 1998). As a result, what mathematical skills are expected and what mathematics topics and where in the engineering curriculum these skills and topics are gained are considered very important. While there were many suppositions regarding these issues in engineering faculties at UTM, such identification had not been formally carried out or documented. The current study is based on the mathematics curriculum in the undergraduate degree program and tries to link the mathematics curriculum to the mathematics is used by engineering students.

Mathematics skills are considered as a part of required mathematics courses in UTM. In addition the difficulty of certain mathematical topics which have caused some problems among students is described in this study. The feedback and input was sought from engineering faculties.

2. Problem Statement

In UTM, some effort at improving students' understanding and enhancing their mathematical thinking has been carried out as well (Yudariah & Roselainy 2004). However, there has been research (Willcox and Bounova 2004) that has identified that there is poor interaction between the faculties of mathematics and engineering in coordinating and consolidating the mathematics needed in engineering education (Roselainy, Yudariah & Mason 2002). The communication gaps of knowledge sharing between mathematics and engineering faculty were identified.

Mathematics was taught as service subjects in UTM with the expectation that the engineering students should have sufficient skills in mathematics so that they were capable of solving problems in engineering. However, it is realized that the engineering students had not achieved the proficiency as expected in the usage of the skills and the transfer of the mathematical knowledge. This paper which is a part of a doctoral study of the mathematics curriculum for engineering undergraduates, aims to describe mathematical topics that are considered difficult by the students and mathematics lecturers; also, the relevancy of each mathematics topic to the understanding of the engineering core and elective courses. The survey consists of questions that look at the utilization of mathematics courses that are derived from engineering lecturers. Part B of this questionnaire is attached in appendix.

3. Methodology

This study is an initial study on the students and lecturers of three engineering faculties in UTM namely; Electrical Engineering (FKE), Civil Engineering (FKA) and Mechanical Engineering (FKM). Some issues are explored by using questionnaires based on the students' and lecturers' conceptions of mathematics. Three sets of questionnaire (see Appendix A) for this study were designed according to previous researches such as Willcox work in 2004. The difficulty, relevancy and the application of mathematics subjects and their subtitles, has been described according to students' and lecturers' view. As well as, the participants were asked which mathematics topics need to be re-taught or reviewed for engineering courses.

The three sets of questionnaire for this investigation were handed out to three groups of respondents consisting of mathematics lecturers teaching mathematics subjects to engineering students, engineering undergraduate

students, were addressed by one set, and engineering lecturers teaching subjects with a significant need of mathematics were asked by another set. All three sets consisted of two parts in which, Part A is about the profile of participants working as lecturers in different fields of engineering and using mathematics in their engineering courses and their academic background. However, Part B aims to investigate the utilization of mathematics knowledge by selecting the courses mentioned in a list. 27 items were listed in a table based on difficulty and relevancy of mathematics topics to engineering courses. For example, some of the topics such as matrices, differentiation, integration, series, and vectors were covered.

The questionnaire is designed for engineering lecturers aims to elicit information about which mathematical topics needed to be re-taught during the course, which topics needed to be reviewed and it also elicit information for investigating the utilization of each mathematics subject in identified engineering courses. In addition, four open-ended questions are designed at the end of part B. The data which is gathered from 4 open-ended questions at the end of questionnaire is to identify the mathematical skills needed in the courses and the expectations of engineering lecturers towards the mathematics courses.

Most of the lecturers generally face with difficulties and challenges in the classroom so question number 1 enquired participants' perceptions towards the difficult skills of mathematics for engineering students. The next question identifies the lecturers' perspectives about engineering students' problem solving skills. An open-ended question number 3 was designed to investigate these difficulties among undergraduate students. The aim of question 4 is to determine how teaching mathematics can be formed according to the needs of the engineering curriculum. Question number 5 is an open ended question that enquires participants' suggestions for improving the teaching of mathematics to engineers. In order to qualify the analysis, listing the problems encountered by students in their explanation was analysed from the written responses of the students.

The questionnaire was distributed to 80 respondents made up of mathematics lecturers and both engineering students and lecturers. The questionnaires were distributed to a total of 30 students from the engineering departments. A total of 25 students, submitted their responses. Finally, the semi-structured questionnaires were given to a total of 30 engineering lecturers and 30 mathematics lecturers. 25 engineering lecturers and 25 mathematics lecturers returned the questionnaires.

The software SPSSPC has been used to analyze some of the data. The statistical analyses were expressed frequency, percentage, reliability index. The reliability index (Cronbach α) for all respondents equaled 0.92.

The data that is extracted from the questionnaire would enhance mathematics lecturers' awareness of where the mathematics is used and the views of their engineering colleagues about students' mathematical difficulties.

4. Findings

From the data obtained by questionnaires it was inferred which topics are difficult for learning and understanding. Figure 1 illustrates the percentage of difficulty of each mathematics subject in the perspective of undergraduate engineering students in UTM. Based on this figure on statistical information, it can be inferred that in students' point of view the courses which are arranged from Differential Equations, Mathematics engineering 1, to Mathematics engineering 2 are the most difficult subjects in learning.

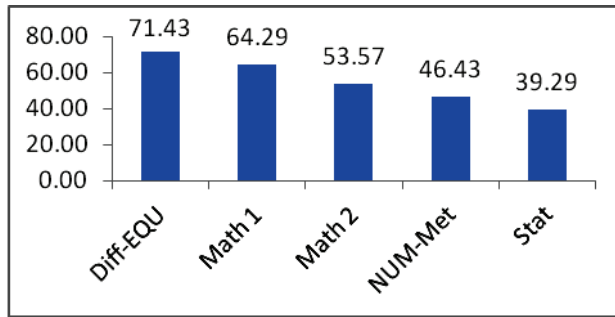


Fig. 1. Mathematics Subjects Difficulty according to Students' point of view

As can be observed in the above figure, 71.43 percent of students considered that the Differential Equations is the most difficult subject, while 64.29 percent of students selected Mathematics 1 as the difficult course and 53.57 percent of students believed that Mathematics 2 is the difficult subject for learning.

Figure 2 presents the difficulty of each Mathematics subject in the perception of Mathematics lecturers.

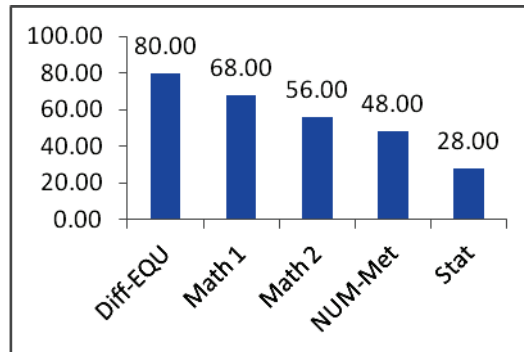


Fig. 2. Mathematics Subjects' Difficulty according to Mathematics Lecturers' point of view

Mathematics lecturers have similar views to the students about topics that they thought were difficult. 80 percent of the mathematics lecturers considered that 'Differential Equations' is the most difficult subject. 68 percent of the mathematics lecturers selected 'Mathematics I' as the most difficult subject; while 56 percent of them considered that 'Mathematics II' is very difficult for learning.

In general sense, based on what is extracted from three groups of respondents, two of them including, mathematical lecturers and engineering lecturers considered that Differential Equations course as having a higher level of application. Moreover both mathematics lecturers and students out of three groups of respondents agreed that 'the relevancy of Mathematics II' is quite high to engineering courses.

According to the result obtained from the questionnaire of engineering lecturers which is shown in figure 3 it was demonstrated that Differential Equations, Mathematics I and Mathematics II have 88.89%, 70.37% and 55.56% percentage of application in engineering courses respectively.

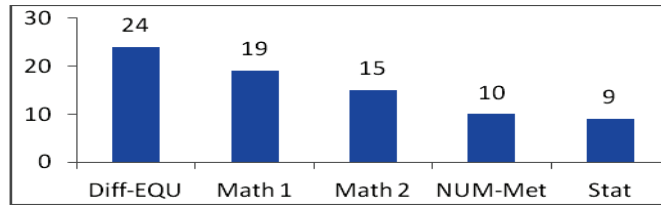


Fig. 3. Utilization of Mathematics subjects from Engineering Lecturers point of view

Note that vertical axis is the number of respondents out of total 30 engineering lecturers who were participant in this survey. For instance 24 engineering lecturers were agreed 'Differential Equations' is the most difficult subject for engineering students to learn and understand.

According to the engineering lecturers:

- 1) Some of the sub-topics in Engineering Mathematics I need to be reviewed by the curriculum designers which is shown in followed figure (Figure 4):

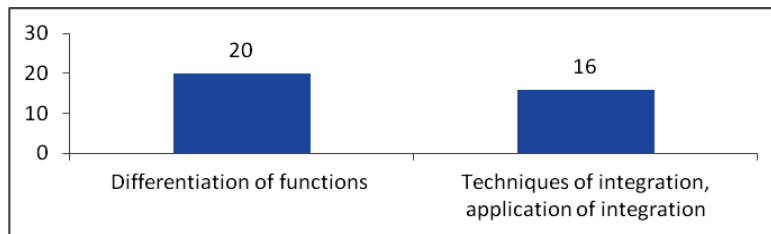


Fig. 4. Mathematics I subtopics which need to be reviewed during engineering courses

Figure 5 showed the application of subtopics of Mathematics I according to engineering lecturers' point of view. The vertical axis shows the amount of respondents who said their opinion about the utilization of each mathematics topic. The horizontal axis shows mathematics topics are included in Mathematics I.

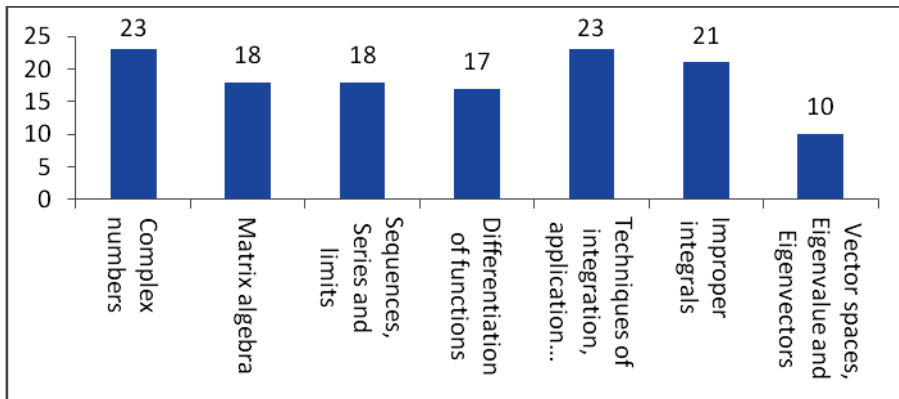


Fig. 5. Utilization of Mathematics I subtopics according to Engineering Lecturers' point of view

- 2) Some of the sub-topics in Mathematics II should be re-taught by the lecturers. The subjects such as: Fourier Series, surface and volume integral, Multiple Integral of Real Functions and partial derivatives are in a group of subjects which should be pay strong attention according to the utilization of each subtopic in this subject which is shown in the following figure (Figure 6):

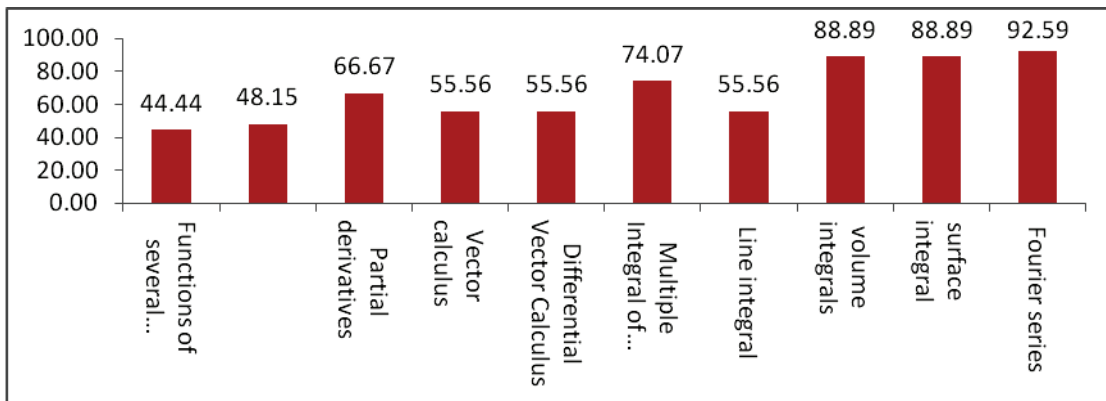


Fig. 6. Utilization of Mathematics II subtopics according to Engineering Lecturers' point of view

Note that the vertical axis is the percentage of respondents to the application of mathematics subtopics through engineering courses this comes out of Utilization column of questionnaire.

The open-ended questions come at the end of questionnaire indicate the difficulties of learning and the teaching methods for engineering students and what they ask for betterment based on their point of view in the questionnaire. The Questionnaire also tried to ask what kind of mathematical difficulties were on the way of engineering students. To answer these questions lots of students blamed the vast number of formulas as one of the difficulties. Some blamed the difficulty of understanding the mathematics itself. Careless mistakes made by students were another difficulty. Calculating probability of certain events and also not sufficient teaching hours of mathematics were considered as other factors by some students.

What students suggested about improvement of learning process were: Using software to aid the mathematical problems we face, doing a lot of exercise and assignment, dedicating more time for math class, understanding the concepts, laws and principles of the mathematics, application of mathematical issues in other subjects and so on.

The answer to the question of what skills are the most useful one in mathematics in the eye of students were: Problem solving, translation, modelling and formulating and so on.

Last but not least was the question of what students expect to receive from mathematics. Some students believed that the most important role of mathematics offered in the curriculum is to be useful and the more applicable it is the more interesting it would be for them. Some other expected to put mathematical calculation into practice in the real life and others were keen on learning mathematical skills. "Mathematics has to be able to solve the problems with minimal references." One student said according to the students answers to the above open-ended question.

5. Discussion and Conclusion

According to the above discussion on the difficulty of Mathematics subjects in the perspective of the lecturers, it should mentioned that the time of subjects which offered should be added to make it possible to students for better comprehension in the subjects. Apart from this, it suggests that the lecturers should use the effective method of teaching such as; using student-centred activities with the aim of improving the level of understanding and decreasing the difficulties of learning in the students.

The findings of this paper are helpful for suggesting a decent and proper curriculum to cover the mathematical needs of engineering students via distribution of questionnaire and in order to do so, rather than what is discussed in this paper, one should consider other aspects such as students' post-graduation issues to be an eligible engineer in the future. As noted by (Henderson and Broadbridge 2007), "Students have a higher satisfaction rating where there is regular consultation between Math and Engineering faculties on curriculum planning and where space and time are provided for drop-in assistance."

The results show that the perception and understanding of engineering courses are related to learning the mathematical subjects both before and during the learning of engineering courses and they are not separated from each other and have a great deal of importance. The paper also tries to show the link of mathematics which is included in the engineering faculties' curriculum to the mathematics which is required in engineering courses.

It should be noted that learning the mathematical courses also is related to some variables. Such as the difficulty levels of learning issues which is not identify in this research also the teaching method, and the learning inclination of students and in higher level the curriculum of mathematics which includes all the aspects of teaching and learning in order to get the most out of it.

Acknowledgements

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4.5 Eigenvalue Problems										
4.6 Numerical solution of ordinary differential equations										
4.7 Partial Differential Equations										
5. Mathematics Engineering II										
5.1 Functions of Several Variables										
5.2 Graphs of Functions of Two Variables										
5.3 Partial Derivatives										
5.4 Vector Calculus										
5.5 Differential Vector Calculus										
5.6 Multiple Integral of Real Functions										
5.7 Line Integral, Volume Integrals, Surface Integral										
Series and sums: Taylor, Fourier										

Additional Questions

- What mathematics skills students should have?

<input type="checkbox"/> Modeling	<input type="checkbox"/> Decision Making	<input type="checkbox"/> Representing	<input type="checkbox"/> Communication	<input type="checkbox"/> Justification
<input type="checkbox"/> Validating	<input type="checkbox"/> Visualization	<input type="checkbox"/> Formulating	<input type="checkbox"/> Problem solving	<input type="checkbox"/> Translation

Others (please specify):

- What are the mathematics difficulties that your students face with?
(Specify the skills please)
- Do you have some suggestion on how to improve students’ mathematical skills?
- What are your expectations in the teaching of mathematics?