Comparison between Level of Students' Responses toward Cooperative Learning in Mathematics Engineering Courses at UKM

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Abstract: -

Mathematics is a crucial language in all engineering courses and researches where mathematical modeling, manipulation and simulation are used extensively. But Engineering Mathematics courses are regarded as uninteresting and difficult courses in engineering curriculum. This is reflected in engineering students' performance at the end of each semester for these courses. This paper presents the implementation of cooperative learning at Faculty of Engineering and Built Environment (FKAB), Universiti Kebangsaan Malaysia (UKM); which aims at introducing an innovative teaching and learning methodology. It is emphasized the use of cooperative learning (CL) as an alternative technique in order to enhance learning in Engineering Mathematics courses. In implementing CL in the teaching and learning of Engineering Mathematics courses, it is important to have a better understanding on students' reflection on CL; which is a key component in the development of learning and teaching process and also students' generics skills. This paper emphasized on the individual students' respond toward CL activities and how they coping with free-rider in Engineering Mathematics courses. A set of Likert scale questionnaires was given to two groups of students from two difference courses at FKAB, UKM; Engineering Mathematics I: Vector Calculus (consist of 41 year one students) and Engineering Mathematics III: Differential Equation (consists of 60 year two students); and the data were analyzed, rank and compared. Data ranking was used to show differences in the views of year one and year two students on their respond toward CL activities and coping with free-rider. Data shows that students' respond positively toward CL and development of teamwork skills shown while attending to the free-rider issues. Thus, this learning method do helped engineering students to understand better in their learning process and enhance their generic skills, in which it assisted to increase their interest toward the learning of Engineering Mathematics courses.

Key-Words:- Cooperative learning; students' response; cooperative learning structure; mathematics engineering

1 Introduction

In all levels of education, the traditional method of teaching is lecture-based teaching. Mauri *et.al* (2008) [9] discussed the description of a lecture conducted using this traditional method. Even though this method is able to deliver knowledge to students and produce graduates, but majority of the students hardly move beyond this type of learning that is superficial and focused on the development of exam-passing abilities as the ultimate goal [8][9]. Meanwhile, Danko *et.al* (2009) [4] studied the implementation of student-centred learning approach in large engineering classes. This approach, which involved active and collaborative learning activities, developed and

enhanced engineering students' skills and aptitudes.

Mathematics is a fundamental subject for all engineering courses and researches, where mathematical modelling, manipulation and simulation are used extensively. Saleh (2004) [12] discussed experiences in teaching Engineering Mathematics courses at third level engineering students and, subsequently, found that these students encounter some difficulties and act indifferently toward these learning method. The students regarded Engineering Mathematics courses as uninteresting and difficult in engineering curriculum. Moreover, this was reflected in their performance at the end of each semester. Undoubtedly, an engineer should have good command of the fundamental mathematics knowledge. Sazhin (1998) [13] described that the objective of teaching mathematics to engineering students is to find the right balance between practical applications of mathematical equations and in-depth understanding of living situation. On the other hand, Cardella (2008) [2] mentioned that the impact of mathematical thinking skills on an engineer will enable them to use mathematics in their practice. Attitudes of engineering undergraduates toward mathematics was studied by Miika *et al.* (2008) [10] and this provides us with better understanding to engineering students' actual knowledge and the lack of knowledge in mathematics. However, it is believe that in practice it is not enough just to have good basic mathematics knowledge. An engineer is also required to have good generic skills such as a good communication skill, positive thinking, able to work independently, and others.

It is well known that Universiti Kebangsaan Malaysia (UKM) is a nation's contributor of engineering graduates. To produce quality graduates, the Faculty of Engineering and Built Environment (FKAB) of UKM started implementing an outcome based educations (OBE) approach beginning with the first year courses in the 2005/2006 academic session. Programmes Outcomes (POs) were established in order to implement OBE. POs describe what students are expected to know or able to do by the time of graduation from the programme. Thus, in preparing the students to become successful engineers of tomorrow, the faculty is encouraging active learning techniques, especially as cooperative learning (CL) and problem-based learning (PBL). In relation to that, in the first semester 2010/2011 academics session, the FKAB of UKM started implementing CL method in Engineering Mathematics I (Vector Calculus) and Engineering Mathematics III (Differential Equation).

In implementing CL in Engineering Mathematics courses, it is important to acknowledge students' respond and perception toward CL. Does this method help student to understand better in their study? Thanh-Pham, Gillis and Renshaw (2009) [15] found that more than fifty per cent reported that CL was no better and worse than the traditional lectured-based teaching method in term of increasing students' academic achievement. Zakaria *et al*. (2010) [18] studied the effects of CL on students' mathematics achievement and attitudes toward mathematics. The study revealed that the CL methods have a positive effect on the formation of the attitudes toward mathematics among students. This paper attempt to provide an overview of how CL has been conducted in Engineering Mathematics courses in FKAB, UKM, how students respond and perceive this method to learning [1][11].

2 Cooperative Learning In Engineering Mathematics Courses

Cooperative Learning can be characterized as a social process in which knowledge is acquired through the successful interaction between the group members [3][16]. Cooperative learning refers to a variety of teaching methods in which students work in small groups to help one another learn academic content [14].

Cooperative learning is a successful teaching strategy in which small teams, each with students of different levels of ability, use a variety of learning activities to improve their understanding of a subject. Each member of a team is responsible not only for learning what is taught but also for helping teammates learn. It is also an approach to team work that minimizes the occurrence of those unpleasant situations and maximizes the learning and satisfaction that result from working on high-performance team [5]. There are five elements as important aspects to CL [6][7][16]; which are individual accountability, social skills, face-to-face interaction, positive interdependence and group processing. Subsequently, cooperative efforts result in

participants striving for mutual benefit so that all group members:

- gain from each other's efforts
- recognize that all group members share a common fate
- know that one's performance is mutually caused by oneself and one's team members
- feel proud and jointly celebrate when a group member is recognized for achievement.

Faculty of Engineering and Built Environment, UKM consist four major departments: the Department of Electrical, Electronic & System Engineering, Department of Civil & Structural Engineering, Department of Chemical & Process Engineering and the Department of Mechanical & Materials Engineering. In the first two years of the engineering programme, students have to take engineering core courses regardless of which program or specialization they eventually pursue. A common curriculum makes up a high percentage of the first three semesters of all the engineering undergraduate programs. This stresses on subjects like mathematics, engineering sciences, together with computer programming, engineering drawing and English.

In engineering mathematics courses, CL was implemented in Engineering Mathematics I (Vector Calculus) and Engineering Mathematics III (Differential Equation) in order to enhance generic skills. A few types of CL have been implemented such as Jigsaw, Think-Pair-Share, Round Robin and Three-Minutes Review (Mapping). Table 1 shows the explanation on each structure.

Table 1 Cooperative Learning Structure

Cooperative Learning Structures	**Explanation**
Jigsaw	Groups with five students are set up. Each group member is assigned some unique material to learn and then to teach to his group members. To help in the learning students across the class working on the same sub-section get together to decide what is important and how to teach it. After practice in these "expert" groups the original groups reform and students teach each other
Think-Pair-Share	Involves a three step cooperative structure. During the first step individuals think silently about a question posed by the instructor. Individuals pair up during the second step and exchange thoughts. In the third step, the pairs share their responses with other pairs, other teams, or the entire group
Round Robin Brainstorming	A question is posed with many answers and students are given time to think about answers. After the "think time," members of the team share responses with one another round robin style. The recorder writes down the answers of the group members. The person next to the recorder starts and each person in the group in order gives an answer until time is called
Three-Minutes Review (Mapping)	Teachers stop any time during a lecture or discussion and give teams three minutes to review what has been said, ask clarifying questions or answer questions

3 Objectives

The aim of this study is to share the reflection from 60 first year students and 41 second year students who have participated in CL during their mathematics lecture. Two sets of questionnaires contain questions on the implementation of CL during lecture, which including individual response towards CL and coping with free-riders, were given to the students based on their courses, i.e. Engineering Mathematics I (Vector Calculus) for first year students and Engineering Mathematics III (Differential Equation) for second year students. The questions are all the

same for both courses. This paper particularly aims to

i. determine students respond toward CL, whether CL help them on gaining better understanding on their study and their generic skills,
ii. focus on students' perception on free rider in their learning activities, and
iii. identify the most important criteria on individual response.

4 Methodology

The questionnaire was designed to obtain the individual response of CL and coping with free-riders from FKAB students' perspective. 101 students of first and second year were randomly selected for the survey. The questionnaire requires them to assess quantitatively on the each identified responses of CL and attribute of coping with free-riders. Each attribute was measured using a five-point Likert-scale representing different levels of agreement of attribute. The responses "1" indicates "Strongly Not Agree", "2" indicates "Not Agree", "3" indicates "Neutral", "4" indicates "Agree" and "5" indicates "Strongly Agree". The data collected was analyzed using simple statistical method to scrutinise demography data and using multi-attribute value technique to analyze level of agreement on each attribute.

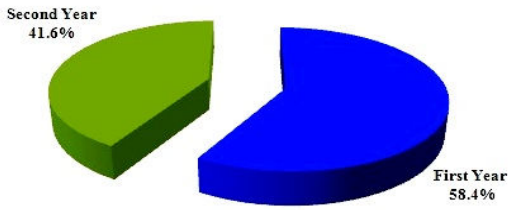

Fig. 1 Percentage of Respondents

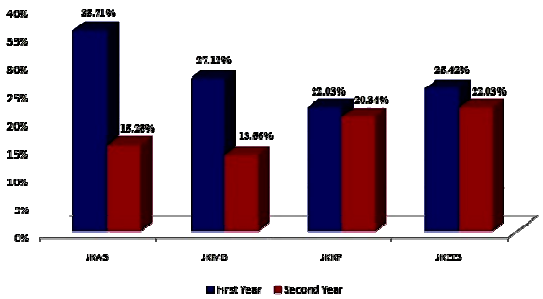

Fig. 2 Percentages of Respondents across Department

5 Data Analysis

Cooperative learning was implemented in Engineering Mathematics courses to measure generic skills as well as to improve students' academic performance.

Evaluation on the individual response toward cooperative learning is based on:-

i. *t*-test

In this study, the t-test is employed in order to determine as to whether the mean is significant or otherwise. The hypothesis for *t*-test as following:

H_O: Non-existence of difference mean between first year and second year student towards cooperative learning.

H_1 : Existence of difference mean between first year and second year student towards cooperative learning.

In the event of non-existence of difference mean between first year and second year student, this means that the students' response for both years is the same. Then, there is a failure to reject the null hypothesis. Fail to reject the null hypothesis if the *p*-value is more than α, and otherwise.

ii. Rank of Individual Response and Coping with Free-Rider.

The questionnaire asked the respondents on the individual response and coping with free-rider on a rating scale of 1 to 5. Using the multi-attribute value technique, the first step was calculating the arithmetic mean, $\bar{x}_{ij}$, of these ratings for each criterion using (1), followed by calculating the weighted mean ratings for each attribute using (2) and (3).

$$\bar{x}_j = \frac{\sum_{i=1}^{n} x_{ij}}{n} \quad (1)$$

$$\bar{X} = \frac{\sum_{k=1}^{m} \bar{x}_j}{m} \quad (2)$$

where $\bar{x}_j$ = arithmetic mean for each criterion; $\bar{X}$ = arithmetic mean for general individual response; x = rating given by respondent; n = number of respondent; m = numbers of criteria; and j = range of criteria.

The responses to these questions were then used to calculate the mean ratings for level of requirement in each criterion in the same way as for the response. The index of each criterion response was calculated in order to prioritise the criterion within the response and to rank the level of requirement of the criteria within the response. Equation (3) is used to calculate index of criterion.

$$\bar{x}_j = \frac{\bar{x}_{ij}}{Max\left(\bar{x}_{i1} : \bar{x}_{ij}\right)} \qquad (3)$$

for $1 \le j \le 5$ (individual response), and $1 \le j \le 4$ (coping with free-riders). Using equation (3), the weight and index for each criterion were calculated.

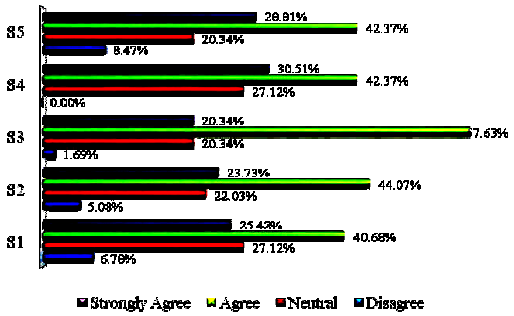

Fig. 3 Percentage for first year students based on individual response.

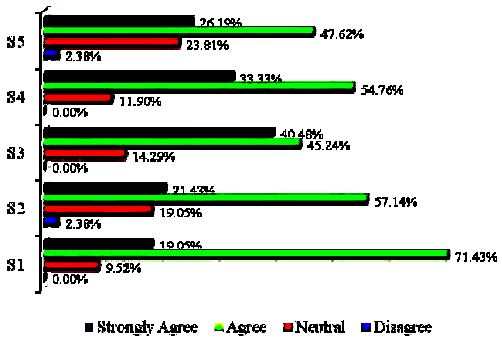

Fig. 4 Percentage for second year students based on individual response.

6 Result And Disscussion

The results of the report are divided into three sections. The first section is the frequency of individual response for first year and second year, the second section is the *t*-test based on individual response for first year and second year engineering students and last section will cover the rank of each criterion for individual response and coping with free-rider responses by first year and second year.

6.1 Frequency

As illustrated in Figure 3 and Figure 4, the percentages of individual response for first year and second year were presented. As in Figure 1, the highest percentage (57.63%) belongs to the S3, which is student agreed that through CL, communication in the team is clear, direct and respectful. However, the study revealed that CL tutorials are not a useful learning aid in preparing for assessment (S4). Figure 2 showed that second year students feel safe and supported in the team environment (S1) by giving highest percentages which is 71.43%. For three attributes (S1, S3 and S4), none of the students disagree with the statement.

6.2 T-Test

As illustrated in Table 2, by using *t*-test, there is no significant difference response between first and second year student towards cooperative learning. It is found that only one attribute (Communications within the team is generally clear, direct and respectful; S3) has significant difference response between first and second year student towards cooperative learning if we compare *p*-value with $\alpha = 0.05$.

6.3 Rank of Individual Response And Coping With Free-Rider

Table 3 and Table 4 summarises the individual response on CL and students' perception on free rider in their learning activities between first year and second year student. In general, the result indicates the mean score for first and second year student towards individual response is 3.91 and 4.10 respectively. The index shows in Table 3 designate that three most highest criteria on individual response for first year student are "*I find CL tutorials a useful learning aid in preparing for assessment*", "*Communications within the team is generally clear, direct and respectful*"

and "*I find textbooks a useful learning aid in preparing my assessment*".

Table 2 *t*-test and *p*-value based on individual response

	ATTRIBUTE	t-test	p-value
S1	I feel safe and supported in the team environment	-1.614	0.11
S2	I have forged close relationships with my fellow team members.	-1.15	0.253
S3	Communications within the team is generally clear, direct and respectful.	-2.103	0.038*
S4	I find CL tutorials a useful learning aid in preparing for assessment.	-1.245	0.216
S5	I find textbooks a useful learning aid in preparing my assessment.	-0.35	0.727

*$\alpha = 0.05$

Whilst, for second year student, their three most highest criteria are "*Communications within the team is generally clear, direct and respectful*", "*I find CL tutorials a useful learning aid in preparing for assessment*" and "*I feel safe and supported in the team environment*". Overall, comparing on the responses toward CL between first and second year students, we can concluded that there exist improvement in the students' communication and teamwork skills during the learning activities for the senior students.

Table 4 provides a summary of comparisons on students' priorities based on criteria for coping with free-rides between first and second year students. The result indicates that the two highest criteria for first year students are "*They were confronted and asked to explain themselves. The situation was resolved by listening to their problems and then helping them to overcome these problems*" and "*We confronted the person involved to try and understand and discover what problems he was facing*".

Table 3 Comparisons on students' priorities based on individual response toward CL between year one and year two student.

Attribute	FIRST YEAR				SECOND YEAR			
	Mean	STD	Index	Rank	Mean	STD	Index	Rank
INDIVIDUAL RESPONSE TOWARDS CL	3.91	0.87			4.10	0.68		
I feel safe and supported in the team environment	3.85	0.89	0.95	4.00	4.10	0.53	0.96	3.00
I have forged close relationships with my fellow team members.	3.76	1.04	0.93	5.00	3.98	0.72	0.93	4.00
Communications within the team is generally clear, direct and respectful.	3.97	0.69	0.98	2.00	4.26	0.70	1.00	1.00
I find CL tutorials a useful learning aid in preparing for assessment.	4.03	0.76	1.00	1.00	4.21	0.65	0.99	2.00
I find textbooks a useful learning aid in preparing my assessment.	3.92	0.92	0.97	3.00	3.98	0.78	0.93	4.00

Table 4 Comparisons on students' priorities based on coping with free-riders between year one and year two student.

Attribute	FIRST YEAR				SECOND YEAR			
	Mean	STD	Index	Rank	Mean	STD	Index	Rank
COPING WITH FREE-RIDERS	**3.54**	**0.91**			**3.82**	**0.73**		
I don't feel that we had any free-riders. We did have teething problems initially, but we discussed them as a group and were able to improve the way we worked as team.	3.52	0.78	0.95	3.00	3.81	0.67	0.95	2.00
We confronted the person involved to try and understand and discover what problems he was facing.	3.54	0.95	0.96	2.00	4.00	0.62	1.00	1.00
They were confronted and asked to explain themselves. The situation was resolved by listening to their problems and then helping them to overcome these problems.	3.69	0.90	1.00	1.00	3.81	0.74	0.95	2.00
We didn't have any free-riders.	3.41	0.98	0.92	4.00	3.67	0.85	0.92	4.00

While, the top criteria for second year students is "*We confronted the person involved to try and understand and discover what problems he was facing*". However, the criteria "*I don't feel that we had any free-riders. We did have teething problems initially, but we discussed them as a group and were able to improve the way we worked as team*" and "*They were confronted and asked to explain themselves. The situation was resolved by listening to their problems and then helping them to overcome these problems*" are the second highest index choose by second year students. Comparing the criteria of coping with free-rider from Table 4, both first and second year students seem to agree that there exist free-rider in CL activities but it was the least important criteria. On the other hand, this result also revealed that students show their maturity in handling learning issue after experienced two years of CL in FKAB, where they work as a team in addressing the problems and the decisions are made by consensus. Thus, this study acknowledge the CL activities in engineering mathematics courses at FKAB, UKM have developed and improved communication and teamwork skills

7 Challenges and Conclusion

Cooperative learning is a method where work were done by students team in order to produce a product such as problem solutions, project report and etc. under conditions that satisfy five criteria of CL. Extensive research has shown that properly implemental CL leads to greater learning and superior development of communication and teamwork skills (such as leadership, time management and conflict resolution skills). This technique has been used and considered to be very successful in all scientific discipline, including engineering mathematics. On other hand, there are various challenges in implementation of CL [17][18] such as fear of the loss of content coverage. It means that cooperative learning methods often take longer than lectures and many lecturers conclude that it is a waste of time.

This study revealed that, for the first year students, CL tutorials is a useful learning aid in preparing for assessment while second year student agreed that communications within the team is generally clear, direct and respectful. Even tough, they agreed with different attribute, based on t-test, engineering students at FKAB, UKM still give positive response towards CL. Therefore, the comparison study on this paper revealed that CL learning methods, implemented in Engineering Mathematics courses in FKAB, UKM, have improved the generics skills (that is, communication and social skills) of the engineering students when they gained more experiences in CL learning activities. Consequently, team building and teamwork are integral part for this learning activities.

The benefits of CL are not automatic, however if it is not properly implemented, it will create considerable difficulties to the lecturers, most notably dysfunctional teams and student resistance or hostility to group work. This paper shared some views and perceptions of the students who are participated in CL throughout the semester during their lecture. All the views and comments are very important in order to improve the implementation of CL in these courses because through this technique the lecturer can significantly help prepare their students for their professional careers.

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