

The Impact of Blended Learning on Communication skills and Teamwork of Engineering Students in Multivariable Calculus

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Abstract

Graduate engineering students need the skills and abilities other than those related to the discipline they studied. Effective communication and teamwork are two important generic skills requirements for successful engineers. In this study, we used blended learning environment based on mathematical thinking and Creative Problem Solving to support students' communication and teamwork skills in the learning of multivariable calculus. The main goal of this paper is to identify the impact of the blended learning multivariable calculus course on engineering students' communication and team-working skills. One class consisted of 62 first year engineering students participated as a case study where instruction was provided in a blended learning format. Results indicated that the blended learning multivariable calculus course has positive effects on students' communication skills. However, the scores of both pre and post-test for students' teamwork skills remained virtually the same.

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1. Introduction

Institutes and industries agree that many engineering students, upon graduation, suffer from a lack of generic skills such as communication and teamwork. The need to communicate with vendors, customers, managers, technicians and other engineers is something engineers become aware of early in their careers (Baren and Watson, 1993). Being able to work effectively in teams is an important generic skill for engineering students in their future careers. Consequently, engineers are not only required to be competent in their technical abilities but must also master generic skills such as communication and teamwork to complement current industrial needs (Hoddinott and Young, 2001; Watson, 2002; Pauw, Oosthuizen, and Westhuizen, 2006; Soo, 2007). The lack of effective communication skills and teamwork can be related to the engineering curriculum. Because undergraduate engineering courses are mathematically and technically oriented, it is very difficult to find space within a full timetable for the development of communication skills and teamwork (Baren and Watson, 1993). Offering the integration of these skills within engineering, science, and mathematics is an important approach to developing skills within the curriculum.

Mathematics is one of the most important courses for engineering students as it is offered as pre-requisite course to other advanced mathematics or even engineering courses. The inability to understand basic mathematics concepts may hinder the understanding of other concepts or even subjects. The importance of learning mathematics for engineering students is to enable them to work with several mathematical ideas and various representations and also use this knowledge in their engineering fields (Roselainy, Yudariah, and Sabariah, 2007). However, for most engineering students, mathematics is one of the most difficult courses to study.

There are methods to support students in the learning of mathematics on one hand and generic skills on the other. Some researchers endeavour to support students in the learning of mathematics by promoting mathematical thinking with or without the use of computers. On the other hand, Creative Problem Solving (CPS) as a problem solving framework can be used to support students' generic skills in engineering, science, and even mathematics courses.

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However, not much has been studied about supporting effective communication and teamwork in mathematics courses, specifically multivariable calculus, by CPS and computer tools.

In this study, we used a model that conceptualized a framework for supporting students' learning and generic skills such as communication and teamwork through a blended learning environment. The purpose of this study is to determine the impact of using blended learning in multivariable calculus course on students' communication skills and teamwork, both before and after the course.

2. Communication and Teamwork Skills through Blended Learning

Blended learning as the combination of face-to-face formats and web-based formats (Black, 2002; Aycock, Garnam, and Kaleta, 2002; Graham and Valsamidis, 2006) identify a sufficient environment to support students' generic skills and thinking powers in the learning of multivariable calculus (Kashefi, Zaleha, and Yudariah, 2012a). In fact, blended learning environment is rich with tools to support the students' generic skills. The blended learning environment will give students the opportunities to benefit from both the face-to-face and the e-learning instruction.

In a study of multivariable calculus, Kashefi, Zaleha, and Yudariah (2012a, b) used a blended learning mathematics model to support students' generic skills and mathematical thinking powers. Classroom tasks, Assessments, Computer and web aide, and Strategies were the elements of the model of blended learning mathematics which was used as a guide to classroom instruction. Modular Object-Oriented Dynamic Learning Environment (Moodle) as a Course Management System (CMS) used to develop and implement of blended learning multivariable calculus course. By designing tasks and assessments in special manner based on mathematical thinking and CPS, they tried to support students' generic skills by technology. Moreover, social forums and journals in e-learning as an important element of blended learning model were some sufficient tools to support students' communication and teamwork skills.

In this method, designing prompts and questions are being used in order to initiate mathematical communication between the students and lecturer. Students were encouraged to use verbal and written prompts and questions as guide. Furthermore, synchronous and asynchronous web communication facilities such as chat, email, and discussion board can also support the students' oral and written communication. Moreover, by doing group assignments and presentations as a team, not only they can support the students' team work but they can also encourage discussion and sharing of ideas among the students. Working in pairs, small group, critical thinking and problem solving, students' own examples, doing assignments, reading and writing in the face-to-face and web environment are other strategies of this method.

By using the web environment, the resources is prepared in the most sufficient ways for it to be used in face-to-face class and in laboratory session (as online and offline). It will also help the students in their study at home. In this environment, students can have access to lecture notes, web-based interactive educational tools, animations, videos, forums module, chat module, journal module, assignments, assessments, survey and feedback. In addition, it will also help the students to find more information about content and questions, and to submit assignments, projects and laboratory reports.

3. Method

One class of 62 first year students enrolled in a multivariable calculus was selected for this study at Islamic Azad University of Kermanshah (IAUKSH) in Iran in the fall semester of 2010. The first-named author with more than 8 years experience of teaching in multivariable calculus course taught this class. The multivariable calculus offered by IAUKSH is a three credit undergraduate course and covers functions of several variables, partial derivatives, multiple integrals, vector functions and vector calculus. These topics were taught over a period of 14 weeks with 3 meeting hours per week consisting of 2 hours face-to-face and a 1 hour laboratory session. In the lecture session, the mathematical concepts were introduced to the whole class. After the students had established a general idea of the concept, they then proceeded to the laboratory session. In the laboratory session, online activities, students were directed to perform interactive mathematics tasks, and to post messages and questions on the discussion board. The

instructional design of the textbook was based on researchers' methodology to inculcate mathematical thinking and CPS. Thus, we designed prompts and questions based on mathematical thinking and CPS to increase the students' understanding, teamwork, and communication by organizing the contents in the specified manner. In addition, a course discussion board was used to foster student-student and student-instructor communication during the course providing a collaborative and shared space for a global community.

A survey was developed to assess students' communication skills and teamwork before and after the blended learning multivariable calculus course. The survey was comprised of two sections in order to identify students' communication and teamwork skills. The scale that was used to measure students' communication skills and teamwork by considering effective classroom discussion in face-to-face and web were adopted from the literature review (Rovai, 2002; Gunasagaran, 2006; Alper, 2008; Wan Azlinda Wan Mohamed and Mime Azrina Jaafar, 2009). In the communication subscale, request help, get information in web, willing to speak openly, ask online question, easy in asking, learn by classroom discussion, confidence, listen and respect the ideas of others were the summaries of the items. Whilst, study with peers, share the ideas with others, increase ability to solve problem, compute with others, relying on others in solving mathematics problems, finding errors, losing time, help to teammates were the items of teamwork sub-scale. A 5-point Likert scale rating ranging from strongly disagree to strongly agree was used in the statements. At the beginning of the first week of the term, before the start of lectures, and at the end of the final week of the term, all students were invited to complete the questionnaire. The post-test was distributed online.

The pilot study was carried out at the Faculty of Engineering at IAUUKSH in the beginning of the fall semester of 2010. The participants were 28 first year students in a multivariable calculus that was selected by using simple random sampling among all multivariable calculus classes. The survey was distributed among students and the data was collected. The Cronbach Alpha Coefficients for communication subscale was 0.718 and for teamwork scale was 0.733. So the all the constructs have reliability of more than 0.70; therefore, it implies that all the items from the constructs are statistically reliable and none of the items should be deleted. It is concluded that the reliability of the instrument is high (DeVellis, 2003).

The null hypotheses that are related to the research questions of this study indicated that there is no difference between the students' communication and teamwork skills before and after experiencing the blended learning multivariable calculus course. The Wilcoxon signed ranks test was used to test the change in the students' responses to the generic skills scales in communication and teamwork skills before and after the course. The Predictive Analytics SoftWare (PASW 18) was used to analyze the quantitative part of this study.

4. Findings and Discussion

A high proportion of students (69%) claimed that they ask somebody for help when necessary. Only eleven students (18%) preferred to get information about the course from the web. Almost half (45%) did not have the desire to speak openly. There was an exceptionally high agreement (77%) on not asking question about mathematics from lecturer or peers through either email or online chat. Furthermore, not much less than half (44%) thought that they should only get help when they have a question. A high proportion (65%) also preferred to learn mathematics through classroom discussion with peers and lecturer. The lack of confidence when knowing that the instructor is observing them during the discussion of the problem with their peers was a difficulty for a great majority of the students (74%). Almost half (45%) believed in respecting the ideas of others.

The data revealed that a minority of the students (18%) preferred to study with peers in a group and only nine students (15%) preferred to share their ideas with others. Four students (6%) preferred to compute with others to solve the problem, while more than half (55%) believed that studying with peers caused them more disadvantages. Almost half of the students (50%) did not have any preferences of other items.

Looking at the responses in detail after the implementation of blended learning multivariable calculus course, it was found that a vast majority of students (77%) asked somebody for help only when necessary. Not much less than half of the students (44%) preferred to get information about the course via the web. A considerable minority of them (38%) indicated that they did not have the desire to speak openly. However, a high proportion of students

(61%) have asked the lecturer or peers questions about mathematics through email or online chat. More than half (55%) believed that it is easy to get help when they have a question. That might be the reason as to way a majority of the students (69%) preferred to learn mathematics through classroom discussion with peers and lecturer. A high proportion of students (61%) also felt lack of confidence when the instructor was observing them during the discussion of the problem with their peers. Half of them (52%) believed that they have to listen to and respect the ideas of others.

After the implementation of blended learning multivariable calculus course, a considerable minority of students (37%) preferred to study with peers in a group. Majority of students (81%) did not like to share their ideas with others; however, half of them (52%) believed that working in team increased their ability in solving problem. Only eight students (13%) preferred to compute with others to solve the problem. These responses indicated that half of the students (50%) felt that they could rely on others in solving mathematics problems. In contrast, half of them (52%) believed that they could not help their group in finding errors and mistakes. A quarter of the students (29%) believed that studying with peers brought about more disadvantages to them. However, more than half of them (56%) believed that they were able to help their teammates in learning the material in the course.

A comparison of pre and post of the blended learning multivariable calculus course revealed that the students have improved on all items of communication skills. However, the aspects such as: asking question from lecturer or peers via email or online chat, and their confidence during discussion with peers and lecturer when being observed by lecturer, did not improved for majority of the students.

The Wilcoxon Signed Ranks statistic, converted to a z-score, is equal to -6.618 with significance (*p*-value) equal to .000. Thus, it can be concluded that communication skills changed significantly during blended learning multivariable calculus course. See Table 1. These results serve to reject the null hypothesis that there is no difference in the overall communication skills between the pre and post-test as a result of the students' participation in the blended learning multivariable calculus course.

The null hypothesis tested in the blended learning multivariable calculus does not improve students' teamwork skills. It has no effect on the team working skills. Table 1 also represents that when using the .05 level of significance and a two-tailed test with significance (*p*-value) equal to .097, the critical values of *z* are -1.96 and +1.96. Because the obtained value of *z* (-1.661) does not exceed these values, thus, the null hypothesis cannot be rejected. It can be concluded that the blended learning multivariable calculus has no effect on the teamwork skills.

A comparison on the students' responses to pre and post-test also revealed that students' opinion about all items did not improved much, except for items that share the ideas with others and studying with peers means losing. Students' responses on sharing their ideas with others strongly decreased while their opinion on studying with peers means losing, increased from almost half to a quarter of students.

Table 1. Wilcoxon Signed Ranks test for the communication skills

Test Statistics ^b		
	PostCommunication - PreCommunication	PostTeamwork - PreTeamwork
Z	-6.618 ^a	-1.661 ^a
Asymp. Sig. (2-tailed)	.000	.097

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

5. Conclusion

The hypothesis that the blended learning multivariable calculus course affects on students' communication skills was supported by the results. A statistically significant difference was found between the pre and post-test for the communication skills. The results revealed that all items improved. Specifically asking question from lecturer or

peers via email or online chat and students' confidants during discussion with peers and lecturer significantly reversed and improved.

It means that students were actively supported in discussing, verbalizing, and writing out their understanding of mathematical ideas and concepts. In blended learning multivariable calculus course, students' written and oral communications were supported by discussions between students and instructor based on different strategies such as prompts, questions and also CPS that supported their level of confidence. Using different technologies such as forums module, chat module, journal module, and discussion boards played important roles in supporting students' communication with each other and also with instructor. In different modules and discussion forum, the students' lack of ability in typing mathematical formula caused them to feel reluctant to discuss further about mathematical concepts and had also led them to refuse sharing some general ideas and information. However, in some cases, students tend to use word file to communicate with each others.

The results of the pre and the post-test confirmed the hypothesis that there is no significant difference between the students' teamwork skills before and after experiencing the blended learning multivariable calculus course. Result revealed that almost the scores of both pre and post-test fell in the moderately low level and remain virtually the same. However, students' opinion about the effectiveness of sharing their ideas with others decreased sharply.

In the blended learning multivariable calculus course, different strategies such as working in pairs and small group based on CPS in the class and also worksheet problems, group assignment, and presentation were used to support students' team work. Although the instructor used some strategies such as presentation and submission of assignment by each student individually, it seems that the method was still not enough to support the students when working in team. Results confirmed the need of new strategies to support and encourage the students to share their ideas.

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