Outcomes of blending project-based and traditional lecture-based teaching approaches in engineering education at the United Arab Emirates University

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CONTEXT

Over the years, several teaching approaches are trialled, practiced and modified. While a direct flow of information from academic staff to students is the central view of traditional approach, the project-based learning (PBL) approach considers an active and deep learning through engaging students in a real world issue in a collaborative environment. Both approaches have their own advantages and disadvantages, and majority of engineering programmes in the world still apply traditional lecture-tutorial approach. This study investigates the outcomes of a blended model (mix of PBL and traditional) in teaching some engineering courses at the United Arab Emirates University, with the aim of eliciting the advantages of both approaches.

PURPOSE OR GOAL

This study investigates the use of blended approach (mix of PBL and traditional) with the aim of eliciting the advantages of both approaches to enhance student learning outcomes. Constraints of PBL implementation in engineering education are their resource intensiveness, reluctance of teaching staff to embrace it and differences in students' learning styles, beliefs and expectations. On the other hand, traditional approach is generally considered as a passive, surface learning and exam-focused teaching approach. Therefore the outcomes of blended approach of teaching are analysed and presented in this paper.

APPROACH

Two courses were selected, an undergraduate course GENG 315 (Engineering Practices and Entrepreneurship) and a post-graduate course GENG 602 (Environmental Impact Assessment: Principles and Applications). Assessment items for both courses included class participation, quizzes, assignments, midterm exam, project report (with presentation for the post-graduate course) and final exam. Students' group projects consist of 15% and 40% of the total marks for the undergraduate and post-graduate course, respectively. Learning resources and controlled information were provided to students with a brief outline of the project and its requirements. Students were encouraged to freely set out the direction, range and timing of activities that facilitate them to reach the best learning results. They were allowed to choose their study team of 4 or 5 mates by themselves. At the end of the semester, students were handed out a questionnaire to assess their achievement in intended course outcomes in a scale from 1 (very low) to 5 (very high). In accession to this, students performed the course evaluation at the end of the semester. The data were then analysed to find out how the blended approach helps students to achieve their course outcomes.

ACTUAL OR ANTICIPATED OUTCOMES

It was found that the blended approach of teaching in the selected engineering courses was very successful in terms of achieving students' actual course performance, students' evaluation of the course and their achievement in intended course outcomes.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Carrying out of blended model of teaching in engineering courses can help to minimize the problems of both the standalone traditional and PBL approaches. Even so the blended model needs to be designed appropriately and carefully so that it is well matched with the learning styles of students.

KEYWORDS

Project-based learning, traditional learning, blended model, course outcomes.

Introduction

Over the years, several teaching and learning approaches are trialled, practiced and modified. Broadly, these techniques can be grouped into traditional and modern methods. Traditional teaching involves conventional lectures followed by tutorial and/or laboratory sessions - a direct flow of information from academic staff to students in isolated time segment (Nepal and Jenkins, 2011a). Except taking notes, students are considered cognitively active, but physically inactive. According to Cangelosi (2003), most students cannot maintain such attention and behaviour for a long period of time. The method lacks sufficient interactions between the students and the academic staff and among students, and considers students as passive learners (Nepal and Jenkins, 2011b). On the other hand, modern methods are cognitive science based and encourage students to construct knowledge rather than taking it in as it is disseminated (Cross, 1998, 1999). Modern teaching method involves contemporary teaching and learning practices using project and program based learning, work integrated learning, and integrating learning approaches. Students are encouraged to use real world concepts, tools, experiences and technologies; they work in groups to identify, acquire and share knowledge to solve real problems. Among modern methods, the project based learning (PBL) is widely acknowledged as a collaborative, progressive, student-centred, interactive, active and deep learning approach, particularly for engineering education. Benefits of the PBL approach in engineering education are well described in several previous studies (Mills et al., 2005; Ribeiro and Mizukami, 2005; Perrenet et al., 2003; Gibson, 2003; Mills and Treagust, 2003).

Both approaches of teaching, possess their own advantages and disadvantages. Some engineering students dislike the PBL approach as they need to adopt a self-directed learning strategy to complete often unclear and open-ended tasks. Their individual learning styles and needs may be different than the team learning needs. The challenges involved in implementing a successful PBL are related to time and efforts, instructor's content knowledge and lack of experience of instructors and students, and the need to develop specialized materials for off-campus studies (Yam and Rossini, 2010). It is acknowledged that PBL approach is resource intensive. In some cases, students evaluate the PBL approach lower than the traditional approach in spite of their improved learning and course performance (Nepal and Stewart, 2010; Nepal and Panuwatwanich, 2011). These drawbacks of PBL approach can be minimized by motivating students and creating a classroom environment favourable for students' learning (Yam and Burger, 2009). Collaboration among the students, academic staff and community are significantly important in PBL so that knowledge can be shared and distributed among the stakeholders. University teaching requires the emergence and development of teaching methods consistent with the learning techniques of students (Ewell, 1997). Knowledge of students' learning styles is therefore significantly important for developing a successful PBL in engineering education. Still now, the majority of engineering courses is taught by traditional lecture-tutorial-based approach. A complete shift from traditional approaches to PBL approach, is therefore, sometimes difficult because of current institutional practice towards traditional method. Implementing a blending approach, i.e. a mix of traditional and PBL approaches can be an alternative, which can elicit merits of both methods.

This study investigates the use of blended approach (mix of PBL and traditional) with the aim of improving the advantages of both approaches to enhance student learning outcomes. Constraints of PBL implementation in engineering education are their resource intensiveness; the reluctance of academic staff to embrace the approach and differences in students' learning styles, beliefs and expectations. On the other hand, the traditional teaching approach is considered as passive, surface learning and exam-focused. A blended

teaching approach was followed in two engineering courses at the United Arab Emirates University (UAEU) and the students' actual performance, their course outcomes and evaluation were analysed and presented in this paper. Comparison of students' learning outcomes between the traditional and blending approach was also made in this study. This research was conducted to answer the following research questions:

1. What are the outcomes of the blending of PBL and traditional teaching approach on the students' actual performance in two engineering courses at UAEU?
2. What is the effect of the blending teaching approach to students' evaluation of course and study outcomes compared to the traditional teaching approach?

The study is considered to be an experimental field study in which one independent variable was examined to find out if it has an effect on the two dependent variables. The independent variable in this study is the delivery approach which has two levels; named blending of PBL and traditional approach and the traditional approach. Two dependent variables focused on this study were students' actual performance and students' evaluation of course and study outcomes.

The UAEU is a public university located in the city of Al Ain, UAE. The University consists of nine academic colleges (schools) along with the University General Requirements Unit (UGRU) as a foundation level program within the university. The College of Engineering (COE) was inaugurated in 1980 and there are five academic departments (civil, mechanical, chemical and petroleum, architectural and electrical engineering). The enrollment at the COE is about 9.5% of total students (more than 15,000). The percentage of male and female students at the COE is about 53% and 47%, respectively. About 90% of total students at the UAEU are generally considered as the first generation university students, whose parents have no college or university experience (Bielenberg, 2005). Like many other universities in the region, UAEU does not follow a co-education system.

The undergraduate course GENG 315 (Engineering Practices and Entrepreneurship) focuses on basic concepts and principles of engineering practice and entrepreneurship, including cost estimation, cash flow analysis, comparing alternatives and their application to engineering design and projects. The course was conducted in the Fall (August to December) and Spring (January to June) 2012-2013 academic semesters applying the blending of PBL and traditional teaching approach. Each semester was 14 weeks long and there were two lectures (2 hours long each) in a week for the course. In the first seven weeks, lectures were conducted based on a traditional approach. Topics covered during traditional lectures were principles of engineering economic analysis, cost concepts and design economics, present economy study, time value of money and money-time relationships. At the eighth week, after the midterm examination, a lecture on entrepreneurship, business and financial plan was delivered and students were asked to form project groups of four or five students and choose an entrepreneurship project of their choice. An excel spreadsheet for financial analysis was provided to students. Students were motivated to work independently on their project and their progress was regularly monitored during the scheduled lecture periods. After the eighth week, scheduled lectures were divided into two segments, first half time was employed for traditional lecture and the second half was kept for students' group work. Students were asked to submit their project report on 14th week, before the final examination. Every student in a group was motivated to take part in the project and each member was needed to complete a peer evaluation of their group member's participation in the task. Every student in a group obtained the same grade for their project work. Though 15% marks was allocated to the project work, a question about their project work was also included in the final examination. Students' actual performance in the course and their evaluation and outcomes were compared with the outcomes of Fall 2008-2009 semester where a traditional teaching approach was followed.

The blending teaching approach was applied in a newly offered post-graduate course GENG 602 (Environmental Impact Assessment: Principles and Application), in order to see the consequences. The course was delivered in the Spring (January to June) 2011-2012, Fall (August to December) 2012-2013 and 2013-2014 academic semesters, and there was only one lecture (3 hours long) in a workweek. At the beginning of the semester (first and second weeks), students were asked to form groups of four or five students of different disciplinary backgrounds. They were required to pick out a real infrastructure development project in the United Arab Emirates for conducting an EIA study. Students were requested to follow the national EIA guidelines (Environment Agency Abu Dhabi EIA guideline, for example) to prepare their study report. Every lecture was split into two parts, the first part involved traditional lectures and the second part involved group work session. In the group work session, students seated together as a group and discussed themselves about the project. The function of the instructor was to facilitate their work and to monitor their progress. In the last week (14^{th} week), every group presented their project. Every student was asked to complete a peer evaluation of their group member's participation in the project. Every student in a group obtained the same mark for their project report, but a different mark for their presentation and answers to questions.

Research method

Assessment details for both courses included class participation, quizzes, assignments, midterm exam, project report (with presentation for the post-graduate course) and final exam. Students' group projects consist of 15% and 40% of the total marks for the undergraduate (GENG 315) and post-graduate course (GENG 602), respectively. For the undergraduate course, group project involved development of a business and financial plan for an entrepreneurship of their choice. In the post-graduate course, the project involved the accomplishment of an Environmental Impact Assessment report for a real world development project in United Arab Emirates. Controlled information was provided with a brief outline of the project and its requirements. A list of learning resources was provided and students were asked to search out the required information by themselves. Students were encouraged to freely set out the direction, scope and timing of activities that help them to achieve the best learning outcomes. Students were allowed to choose their study team of 4 or 5 mates by themselves. For the post-graduate course, a multidisciplinary team was promoted. At the end of the semester, students were distributed a questionnaire to evaluate their achievement in intended course outcomes in a scale from 1 (very low) to 5 (very high). In accession to this, students performed the course evaluation in a scale of 1 (strongly disagree) to 5 (strongly agree). The data were then analysed to see how the blended approach helped students to achieve their course outcomes. The 2-sample t test was performed using the MINITAB software to analyse whether course outcomes and evaluation scores from different semesters differed significantly at the 95% confidence level. Table 1 shows the questions involved in the evaluation of the courses. Tables 2a and 2b provide the intended course outcomes for the GENG 315 and GENG 602 courses respectively.

Table 1: The questions involved in the course evaluation (CE) of both courses, students were asked to assign their scores in a scale of 1 to 5, where 1, 2..,5 indicates strongly disagree, disagree, neutral, agree and strongly agree, respectively.

[CE-a]. The course objectives were clearly explained.
[CE-b]. The course outline was consistently followed.
[CE-c]. Expectations for learning in this course were clearly communicated.
[CE-d]. There was close agreement between the stated course objectives and what was actually covered.
[CE-e]. Evaluation methods were clearly explained (rubrics/marking schemes given in

advance of the assignment and explained to the students).
[CE-f]. The evaluation methods used in this course were fair and appropriate.
[CE-g]. The assignments in the course were clearly related to the course objectives.
[CE-h]. The requirements of the course (projects, papers, exams) were adequately explained.
[CE-i]. The course materials were presented in an organized manner.
[CE-j]. Students were invited to share their ideas and knowledge.
[CE-k]. The general climate in this course was good for learning.
[CE-l]. In general, the level of difficulty in this course was appropriate.

Table 2a: The intended course outcomes (CO) of the GENG 315 (Engineering Practice and Entrepreneurship) course, pupils were required to assess their achievement in these intended outcomes in a scale of 1 (very low) to 5 (very high).

[CO-a]. Student will understand the two components of engineering practice related to technology and economic aspects.
[CO-b]. Introduce students to the concepts of entrepreneurship.
[CO-c]. Student will be able to describe some of the basic cost terminology and concepts widely used in engineering practice.
[CO-d]. Student will understand the price-demand analysis of the product.
[CO-e]. Students will be able to discuss the integrated approach and describe selected Techniques used in cost estimation.
[CO-f]. Students will understand the difference between simple and compound interest.
[CO-g]. Students will be able to solve problems related to basic equivalence methods such as
Present worth, future worth, annual worth and IRR.
[CO-h]. Students will be able to evaluate project risk using payback period.
[CO-i]. Students will be able to measure project performance having the same useful life using one of the equivalent worth or benefit cost (B-C) ratio methods.
[CO-j]. Students will be able to measure project performance having a different useful life using annual worth or B-C ratio methods.
[CO-k]. Students will be able to discuss different elements of a business plan.
[CO-l]. Students will be able to build a financial plan of a project.

Table 2b: The intended course outcomes (CO) of the GENG 602 (Environmental Impact Assessment: Principles and Applications) course. Students were asked to evaluate their achievement in these intended outcomes in a scale from 1 (very low) to 5 (very high).

[CO-a]. Understand law, policy and institutional arrangement for conducting an Environmental Impact Assessment (EIA) of a proposed activity or project
[CO-b]. Understand and apply the local, regional and international guidelines for EIA study (e.g. Environment Agency Abu Dhabi EIA guideline)
[CO-c]. Undertake different steps of an EIA study (screening, scoping, baseline study, impact Analysis and mitigation & monitoring)
[CO-d]. Understand and able to conduct public participation in different steps of EIA study
[CO-e]. Effectively communicate and apply their knowledge in a multi-disciplinary EIA study team.
[CO-f]. Prepare an EIA study report on a proposed or existing project.
[CO-g]. Able to present an EIA study report efficiently.
[CO-h]. Express their ideas more effectively during classroom discussion.

Data analysis and results

Course performance

In different semesters, the actual course performance of enrolled students in both courses is shown in Figure 1. In the undergraduate course (GENG 315), about one fourth (25%) students achieved the highest grade (A grade) and about 20% students achieved the second (B+ grade) and third (B grade) highest grades separately. The rest of the students (35%) mostly achieved the C+ and C grades. In comparison to the traditional approach in Fall 2008-2009 semester, it is observed that students actual performance in achieving the highest grade (A) is increased, but decreased for the average grade (B). In the post-graduate course (GENG 602), about 50 to 60% enrolled students achieved the highest grade (A grade) and the rest of the students mostly achieved the second highest (B+) grade. Reasons that more than 50% students in the post-graduate course achieved the A grade are their strong motivation to perform better in the group project (40% of total marks) and their talent because only selected high-profile students are enrolled in the post-graduate program. In both courses, students' actual course performance were found very satisfactory after application of blending of PBL and traditional teaching approach.

Course evaluation

Average scores of the students' evaluation of the course are shown in Figure 2a and 2b for the under-graduate and the post-graduate course, respectively. In the undergraduate course (GENG 315), average scores for all criteria are above the scale 4 compared to the below 4 scores in the Fall 2008-2009 semester where a traditional teaching approach was followed. This indicates that the course evaluation was very satisfied after application of blending approach.The 2-sample t test showed that course evaluation scores of blending teaching approach significantly differed (improved) at the 95% confidence level from the traditional approach. Among the blending approach course evaluation scores, Fall 2012-13 scores were found significantly differed from the Spring 2012-13 sections.

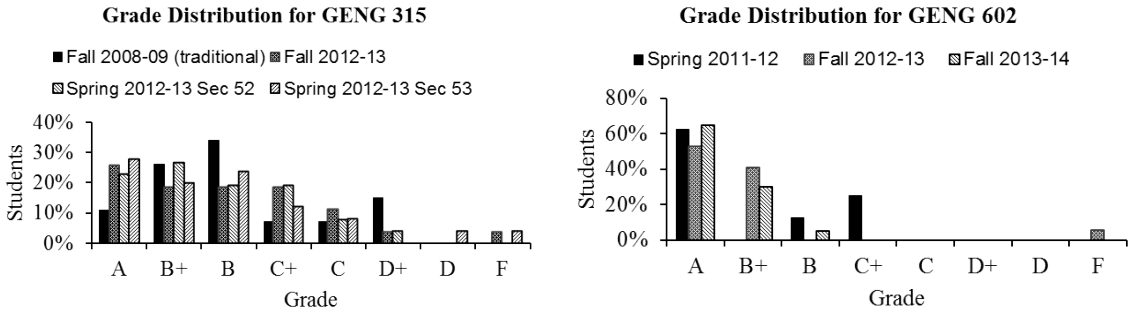

Figure 1: Actual grade distribution in the undergraduate GENG 315 and post-graduate GENG 602 course in different semesters, except the Fall 2008-2009 semester for the GENG 315 where a traditional teaching approach was followed, a blending approach was employed for all other semesters.

For the post-graduate course, except for the CE-f (the evaluation methods used in this course were fair and appropriate), average scores for all criteria are above 4 in scale. It is clear from the course evaluation that the project mark (40% of total marks) distribution technique to individual students need some improvements. This can be achieved by confidential student assessment of their group member's contribution and by assigning some particular tasks of the project to each student and their individual contribution to the project will be evaluated. The 2-sample t test showed that the Spring 2011-12 scores were significantly differed from the Fall 2012-13 scores at the 95% confidence level. The cause for the difference may be linked for students' preference for different learning styles.

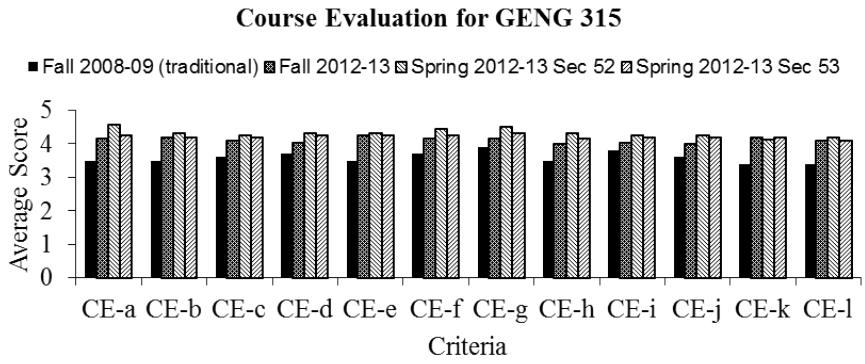

Figure 2a: Course evaluation of the undergraduate course GENG 315, number of respondents were 18 out of 24, 19 out of 27, 15 out of 25 and 18 out of 26 students in the Fall 2008-2009, Fall 2012-2013, Spring 2012-2013 (section 52) and Spring 2012-2013 (section 53) semesters, respectively (description of course evaluation questions is shown in Table 1), a traditional approach was followed in the Fall 2008-2009 semester.

Course outcomes

Scores on students' achievement in intended course outcomes for the undergraduate course are shown in Figure 3. Average scores for all outcomes are about or more than 4 in comparison to below 4 for the traditional approach (Fall 2008-2009). Standard deviation of scores falls below 1 for all outcomes. This represents very satisfactory results on intended course outcomes. Students' achievement in course outcomes reflects their actual course performance shown in Figure 1. The 2-sample t test confirmed that course outcomes of the blending teaching approach significantly differed (improved) at the 95% confidence level from the traditional approach. It was also found that course outcomes between sections 52 and 53 (Spring 2012-13) differed significantly at the 95% level where a blending approach was used in both sections. This difference is very obvious considering differences in students' preferred learning behaviour.

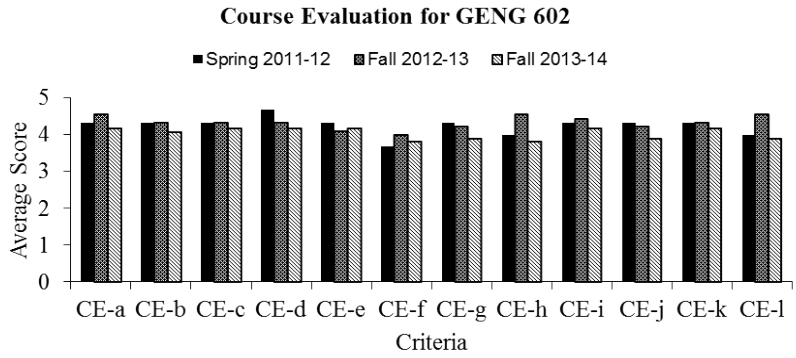

Figure 2b: Course evaluation of the post-graduate course GENG 602, number of respondents were 6 out of 8, 9 out of 17 and 11 out of 20 students in the Spring 2011-12, Fall 2012-13 and Fall 2013-14 semesters, respectively (description of course evaluation questions is shown in Table 1).

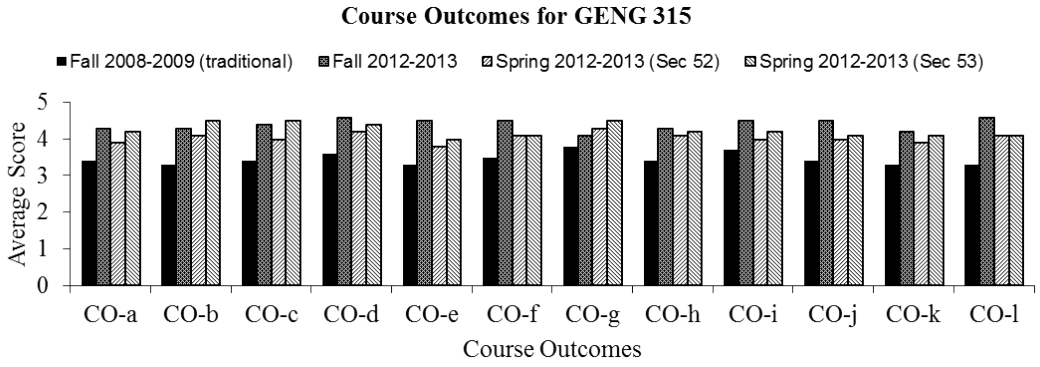

Figure 3: Evaluation of course outcomes; number of respondents were 18, 17, 14 and 19 students in the fall 2008-2009, Fall 2012-2013, Spring 2012-13 (Section 53) and Spring 2012-13 (Section 52) courses, respectively (description of course outcomes is shown in Table 2a).

Conclusion

The results discussed in this paper show that the blended method of teaching, if designed appropriately and carefully, can help to minimize the problems of both standalone traditional and PBL teaching approaches. The observed performance in terms of students' actual grade achievement, evaluation of the course and achievement of intended course outcomes shows that the implemented blended teaching approach was successful. In the post-graduate course where 40% marks were allocated to project work, project mark distribution technique to individual students needs some improvements. This can be minimized by assigning particular tasks to each student in a group and their contribution to the project will need to be supervised carefully. Students' evaluation of the course is considered as one of the key performance criteria for academic staff, therefore a blended teaching approach is more favourable.

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