Full Paper

Introduction

Deep learning environment is important for engineering studies as it helps students become motivated and challenged and look forward to better learning. Motivated students try to apply what they learn in one subject area to other situations and relate their classwork to real life. Therefore, they are able to acquire indispensable set of knowledge, skills, and beliefs. In engineering, skills such as critical thinking, team work, self-directedness, case based learning and problem solving are highly valued (Edward and Ran, 2006). However, which learning methods help them to achieve these skills is unexplored.

There is a growing consensus that the most important problems facing engineers will require producing new knowledge and that engineers must be educated differently (Ellis et al. 2010). It is expectation from the employers that engineers will have passion, systems thinking, innovative and will have an ability to work in complex and dynamic environments. New globally competitive workplace demands that engineers should have interdisciplinary skills, communication skills, leadership skills, an ability to adapt to changing conditions, and the eagerness for life long learning. In solving new problems and working out complex designs, engineers will need to be able to participate in intense brain storming and team work (Ellis et al. 2010). Engineering education needs to equip students for this kind of knowledge (Karim, 2010a).

Student learning in higher education has been the subject of intense research. A conclusion that may be drawn from this large body of research is that learning is a complex human activity. The factors that can impact on students' success in higher education are diverse, but they are sometimes categorized as being either personological factors (e.g. age, prior experiences, learning styles) or contextual factors (e.g. teaching and learning activities, assessment procedures) (Karim, 2010b). However, there seems to be insufficient literature on exploring the link between learning practices and deep learning experience in engineering education. Present study attempts to overcome this gap.

This study was conducted for securing a deeper understanding of the factors that help deep learning and student engagements in engineering courses. A questionnaire survey was conducted among the mechanical and civil engineering students at Queensland University of Technology (QUT), Brisbane, Australia. Among 160 civil and mechanical engineering major students approached, 105 students responded in the survey resulting in a response rate of 66%. Results of this study is reported in this paper.

Research method

A number of researchers have discussed empirical research methodology in education research. Although surveys are common in empirical education research, a number of other designs, including single and multiple case studies, panel studies and focus groups, may also be used, depending on the problem being studied (Eisenhardt, 1989; Yin, 1994). Based on the type of research, one or a combination of these methods is used. Next step is appropriate sample selection and collection of data. One method, or a combination of several data collection methods, should be used in conjunction with the research design. Once data is collected, the next step is the processing and analyzing of the data.

A systematic approach of empirical research was used in this study. The research problems and broad areas of investigation were first formulated from the literature. A pilot investigation was then carried out to identify different effective learning practices. The questionnaire was then designed based on the literature and pilot study. The response scale varied; most were in Likert scales (1-5 point scales), some of the questions were of binary type with yes/no response and other were descriptive. The questionnaire was easy to understand and complete for the respondents. Similar questions were grouped together to make it easier for the respondents. The respondents were asked to mention their demographic details like gender, country of origin, discipline and GPA for our reference and for better analysis. Objectives of a survey can be achieved only if the right target population was screened. A total of 160 engineering students studying in two different engineering majors (mechanical and civil engineering) were randomly selected. The questionnaires were handed in the class room after respective classes. Of the 160 questionnaires distributed, 105 responses were received from the survey with an effective response rate of 66%.

Results and Discussion

Reliability of the survey instrument

Reliability (internal consistency) of the measurement instruments is important to ensure that the outcomes from a study are reliable. A widely practiced procedure to statistically determine the instrument reliability is the determination of Cronbach's coefficient alpha (Karim et al., 2005). Moreover, data reliability requires that instruments measuring the same construct should be sufficiently different from other instruments. That means, although the questions should be consistent, they should not be repetitions of the same questions. The *F*-test in reliability analysis is used to measure the uniqueness of the variables. Significant *F*-values indicate that each of the variables employed to measure a concept is unique and not a repetition of another variable. Statistical analysis was performed by SPSS for Windows.

Reliability tests were conducted for the variables studied as a measure of the internal consistency of the research instruments employed to measure the concepts. Results of the reliability tests are presented in Table 1. Exceeding a minimum α value of 0.60 for variables means that the variables are internally consistent and are good measures of the concept studied (Nunnally, 1978). All the variables have significant *F* values ($p<0.05$) and all the variables have α values greater than 0.6. The results indicate that the variables studied are internally consistent and each of the variables is unique and not a repetition.

Table 1: Reliability of the survey items

Items	**Reliability**		
	α	**F**	***p***
Factors that influence deep learning in engineering units	0.841	13.17	0.000
Assessment methods that enhance student attitudes and understanding	0.853	12.3	0.000

Demographic characteristics of the respondents

Among the respondents, 89 respondents or about 85% were male and 16 respondents or 15% were female students. Country of origin of the respondents is shown in Figure 1. It can be seen that 80% students are local Australians and rest 20% are from 14 different countries. In terms of GPA achieved, 14%, 39%, 43% and, 4% students achieved GPA within 6-7, 5-6, 4-5 and 3-4 respectively (Figure 2). About 53% respondents are from civil engineering major and 47% are from mechanical engineering major.

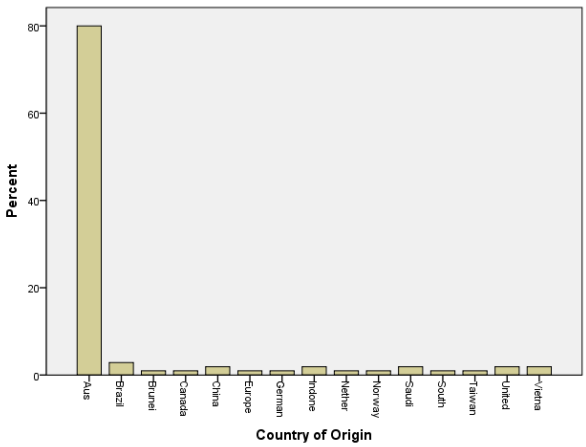

Figure 1: Country of origin of respondents

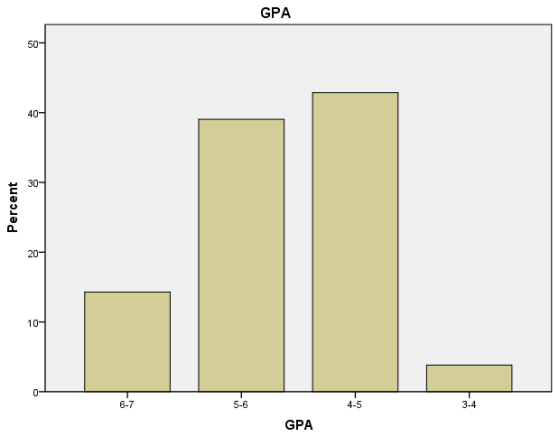

Figure 2: GPA of respondents

Factors impact deep learning in engineering units

Results of the survey regarding student opinion about factors affecting deep learning in engineering units are presented in Table 2 (mean value) and Table 3 (proportion of respondents supporting each item). In Table 3, for clearer interpretation, ‘strongly agree’ and ‘agree’ are combined into ‘agree’ and similarly ‘strongly disagree’ and ‘disagree’ are aggregated as ‘disagree’. It can be seen in Table 2 that efforts by the teaching staff to make the units interesting (mean 4.37) and availability of necessary resources (mean 4.19) are considered two main factors that contribute to deep learning. About 83% and 78% respondents respectively agreed with this factors and only 1% disagreed. Other factors that got mean value of more than 4 are learning environment in the university, flexibility in teaching and learning (lecture and assessment) and effective assessment strategy. These factors are supported by more than 75% respondents. It is interesting that factor like peer learning, real life examples and videos, group learning/ tutorials, involvement of industry people in lectures, and field trips/industry visit, which are usually considered very effective for deep learning received low scores from students. This study shows that field trip/ industry visit is considered as least preferred method for deep learning as can be seen in Table 3. Only 38% respondents supported agreed that Field Trips/ Industry visit helps deep learning. A critical analysis can reveal that factors that have most effect on deep learning are internal factors and very relevant to university staff and environment. The least effective factors are mostly related to ‘external’ of ‘personal’ factors.

Table 2: Factors that influence deep learning in engineering units

Factors	**Mean**	**Std Dev**
Efforts by the teaching staff to make the units interesting	4.37	0.79
Availability of resources	4.19	0.79
Learning environment in the university	4.12	0.75
Flexibility in teaching and learning (lecture and assessment)	4.12	0.84
Effective assessment strategy	4.05	0.98
Peer learning	3.94	0.94
Real life examples and videos	3.93	1.10
Deep understanding/explanation of theories	3.78	0.95
Group learning/ Tutorials	3.77	0.97
Involvement of Industry people in lectures	3.74	0.96
More choice and more voice for student	3.59	0.96
Field Trips/ Industry visit	3.28	1.13

Table 3: Proportion of respondents supported factors of deep learning

Factors	Disagree (%)	Neutral (%)	Agree (%)
Efforts by the teaching staff to make the units interesting	1	16.3	82.7
Learning environment in the university	1	19.6	79.4
Flexibility in teaching and learning (lecture and assessment)	4.1	17.3	78.6
Availability of resources	1	20.6	78.3
Effective assessment strategy	7.1	17.3	75.5
Real life examples and videos	11	19.5	69.5
Peer learning	5.2	25.8	69.1
Group learning/ Tutorials	8.4	29.2	62.5
Deep understanding/explanation of theories	7.6	32.5	60.1
Involvement of Industry people in lectures	8.6	32.1	59.3
More choice and more voice for student	7.3	42.7	50
Field Trips/ Industry visit	22.2	39.5	38.3

Assessment methods that enhance student attitudes and understanding

It is established in the teaching and learning literature that there must be a strong alignment between assessment and learning activities to engage students in learning. Literature also established that assessment methods are vital for learning. Assessment practice is an important part of the teaching/learning process as it provides critical feedback to students about their learning. Developing appropriate and challenging assessment standards is, therefore, critical in making learning effective and efficient. Through meaningful and challenging assessment tasks students can be engaged in deep learning process. Opinions were sought on the assessment methods that enhance student attitudes and understanding. Results are shown in Table 4 (mean value) and Table 5 (proportion of respondents supporting each item). It can be see that students consider problem based assessments (mean value 4.21) are the best way for student learning. About 80% students supported this concept. It is evident that open book assessments are more preferred than close book

assessments. As can be seen, next two popular assessments are open-book in class problem solving and open book final examination. On the other hand, least popular assessments are close-book in class problem solving and close book final examination. Less than half of the respondents think that close book assessments can enhance student learning and understanding.

Table 4: Assessment methods that enhance student attitudes and understanding

item	Mean	Std Dev
Problem based assignment	4.21	0.84
Open-book in class problem solving	4.14	0.95
Open book final examination	4.04	1.00
Multiple-choice question test	3.64	1.06
Seminar/ Presentation	3.61	1.01
Close-book in class problem solving	3.27	1.17
Close book final examination	3.23	1.27

Table 5: Assessment methods that enhance student attitudes and understanding

item	Disagree	Neutral	Agree
Problem based assignment	3.2	17	79.8
Open-book in class problem solving	5.4	19.4	75.3
Open book final examination	7.6	18.3	74.2
Multiple-choice question test	11.7	31.9	56.4
Seminar/ Presentation	12.7	33	54.3
Close-book in class problem solving	24.5	29.8	45.8
Close book final examination	24.5	29.8	45.7

Impact of lecture recording

Many universities in Australia and overseas started recording lectures for students. Queensland University of Technology introduced lecture recording in 2013 and made it compulsory for all units. There have been a lot of debates about the effectiveness of this video recording of lecture on student learning. In this study, students were asked whether they think that lecture recording helped their learning. It can be seen lecture recording is highly supported by students as 88% of the students found it helpful for their learning (Figure 3).

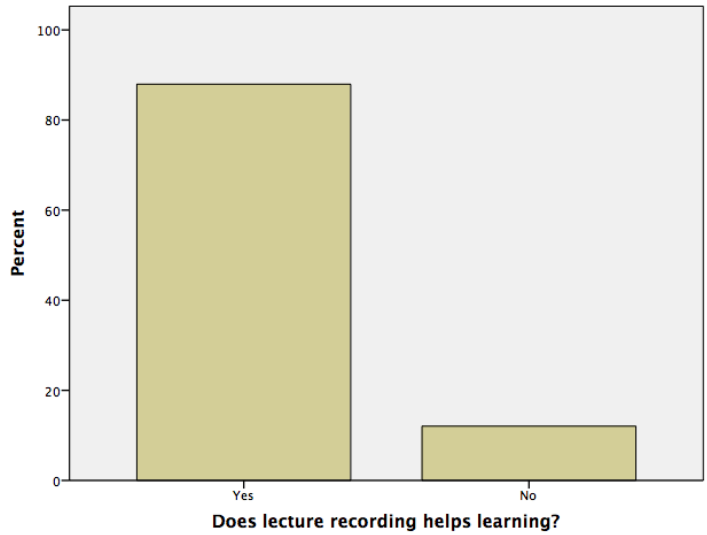

Figure 3: Impact of lecture recording on learning

Does availability of lecture recording deter students joining the lecture classes?

One of the major concerns raised by the academics about lecture recording that lecture recording will significantly impact the class attendance. In order to investigate whether this was a true concern, students were asked whether they feel not joining the lecture classes due to the availability of lecture recording. It can be seen that only 1 in 4 (24%) students feel that they can skip the lectures as recorded lecture was available. This finding should remove the main concern academics have regarding lecture recording.

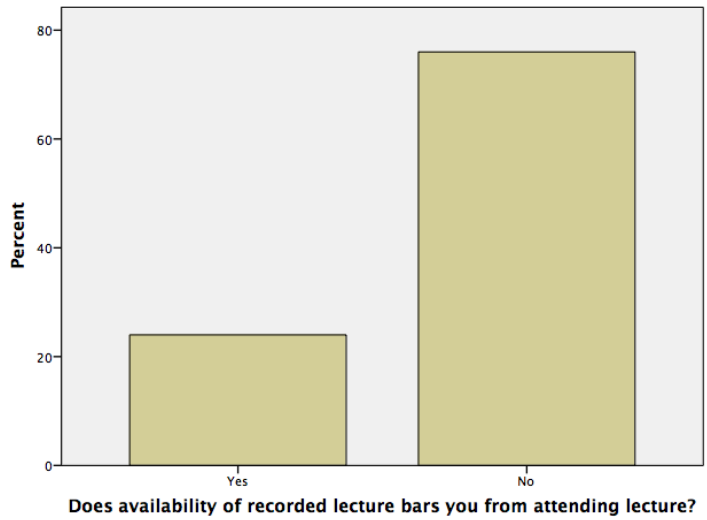

Figure 4: Impact of lecture recording in class absence

Conclusion

Engineers are concerned with the process of obtaining and utilising resources to produce useful goods and deliver services so as to meet the goals of the organisation. Unlike other subjects, content of these units could be very wide, vast and complex. The content sometimes becomes boring to the students and therefore difficult to engage the students in

the learning process. This study investigated the factors that facilitate deep learning and the assessment items that help student learning and understanding for engineering students. A survey among students showed that more than 80% students suggested that efforts by the teaching staff to make the units interesting is the main factor for deep learning. About 80% students said that learning environment in the university and flexibility in teaching and learning are also very important. They also suggested that field trips/ industry may not be considered very useful for learning. In assessments, student like open book assessments over close book assessments and found problem based assignments are the best way of engaging students. Finding of this study will significantly help engineering academics in designing their course and assessments to ensure deep learning of their students.

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