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EVALUATION OF CURRENT PRACTICES IN ENGINEERING LABS: COMPARING TEACHER-CENTERED APPROACH AND LEARNER-CENTERED APPROACH

Husam Arman*   **Mahmoud Abdulwahed****

Abstract

Traditional teaching approaches are still dominating the Palestinian higher education with some exceptions. Engineering education is one of the key and attractive disciplines for students. This sets the challenge to improve engineering education. This paper reports on an assessment of student learning in Labs in the largest Faculty of Engineering in Palestine. The second part of the study involved an experiment comparing the impact of a new student-centered approach in teaching Labs with the traditional approach. The objectives of the new intervention were to test the impact of using learner-centered approach in the industrial engineering Labs on the performance and the motivation of students learning using a sample of three experiments as part of safety Lab. The students were randomly divided into two groups experimental and control which were designed to be equivalent in terms of number, age, gender and academic achievement. The students of the experimental group have achieved better than the control group students in the final marks. Furthermore, the feedback showed significant engagement and learning stimulus by students of the experimental group students.

Key Words: *Engineering education, laboratory education, learner-centered, teacher-centered*

* Dr., Industrial Engineering Department, An-Najah National University, Nablus, Palestinian Territories, husma.arman@najah.edu
** Dr., College of Education, Qatar University, P.O.Box: 2713, Doha, Qatar, m.abdulwahed@qu.edu.qa

I. INTRODUCTION

Teacher-centered approach is considered as a classical teaching which refers to passive delivery of knowledge whereby teacher is the center of the process as opposed to constructivist pedagogy, which is a learner-centered, whereby the student is the center of the process. In this context, teachers controlled and disseminated knowledge and skills to students who generally worked alone and remained passive. Classical teaching methods have been the norm of educational practice for thousands of years, at least since the times of ancient Egypt and Assyria (Abaté & Cantone, 2005). When theorizing pedagogy started in the 19th and 20th century, early pedagogical theories such as Behaviourism reflected classical approaches. However, trends in teaching and learning have historically been in shift from Behaviourism (Pavlov, 1927; Skinner, 1953; Thorndike, 1913), passing through cognitivism (Atkinson & Shiffrin, 1968; Kulhavy and Wager, 1993) , towards Constructivism (Kolb, 1984; Richardson, 2003).

Constructivist pedagogy is a modern paradigm that has been significantly impacted by cognitivism (Hergenhahn and Olson, 2004); however, it holds a holistic approach to pedagogy and learning as opposed to the microscopic focus of cognitivism on the internal mechanisms that underline learning processes. Constructivism perceives learning as a process of constructing knowledge by individuals themselves as opposed to the passive teacher-student model (Kolb, 1984; Brown et al., 1989]. Learning should focus on concepts and contextualization instead of instructing isolated facts (Brooks and Brooks, 1993). In the process of knowledge creation, students link new knowledge with their previous knowledge. Consideration should be given to the student's preferred learning style (Kolb, 1984).

Some of the main pillars of constructivist pedagogy (Richardson, 2003; Savery and Duffy, 2001) are: 1- learning is a student-centered process, students' autonomy should be fostered; 2- learning should be contextualized and associated with authentic real-world environment and examples; 3- social interaction and discourse is an important part of learning; 4- the taught elements should be linked with the learner's previous knowledge; 5- it is important to facilitate continuous formative assessment mechanisms, self-esteem and motivation; 6- teachers should act as orchestra synchronizers rather than speech givers; and 7- teachers should consider multiple representations of their teachings.

One of the main characters of modern constructivist pedagogy is its emphasis on student's social interaction with peers and the teacher during the learning process, e.g. social learning (Bandura, 1971). The introduction of new media and social networking online tools (normally referred to as Web 2.0) during the last decade has led to the emergence new models for implementing constructivist pedagogy (McLoughlin and Lee, 2008; Lu, 2010). For instance, Facebook could facilitate more social constructivist learning among students of one campus; furthermore, it would enable virtual social constructivist among geographically distributed students in different countries or campuses, which otherwise was impossible before. The new forms Web 2.0 integrated social constructivist pedagogy is sometimes referred to with term Connectivism (Siemens, 2005). Constructivist or connectivist pedagogy are not yet the norm, classical teaching methods still prevail in large number of educational institutions worldwide. However, many of the successful investigations for improving engineering education have embraced constructivist principles; empirical findings have in general revealed enhanced outcomes and learning experiences (Moor and Piergiovanni, 2003). These findings would encourage engineering colleges to revise their ways of delivering engineering education.

II. BACKGROUND OF THE STUDY

In Palestine, practices associated with a teacher-centered model of instruction appeared to prevail based on a recent study (Cristillo, 2009). Although the Palestinian academic institutions are growing rapidly in terms of quantity (both number and capacities) nevertheless the quality of teaching practices and its link to learner outcomes in higher education are not progressing as such. One of the key and attractive higher education disciplines for Palestinian youth is engineering. These factors have raised significant pressure on local engineering colleges to provide competent engineering education that would produce skilled and employable engineering graduates on regional and international scales. One cure of this problem is to move from classical teaching approaches into modern constructivist methods.

One of the key components of engineering education is laboratory experience. Significant portion of engineering graduates will end-up in a career that requires high hands-on and experimental skills. The main aims of laboratory education in engineering curriculum are to link theory with practice, and to equip students with enhanced hands-on skills. Laboratories importance in engineering education has been emphasized. However, the aimed impact of laboratory education on the students' learning is often not realized (Hofstein and Lunetta, 2004). It has been noticed that less attention has been paid for laboratory education, particularly during the last 30 years (Feisel and Peterson, 2002). Revisiting the methods of teaching and learning of laboratories has been emphasized in many recent studies.

In this paper, a constructivist model of conducting laboratory education was investigated at the Industrial Engineering Department, Faculty of Engineering, An-Najah National University (ANU) in Palestine. The impact of the constructivist approach was compared with the outcomes of the classical approach which is normally followed in engineering schools. The new model has been built based on a number of constructivist pedagogy principles; new media and social networking tools have been utilized in the implementation process.

III. METHODOLOGY

Both quantitative and qualitative educational research methods have been utilized in the methodology of approaching this investigation. This included students' assessment survey, controlled experimentation, hypothesis test, semi-structured interviews, and observations. The methodology involved two main parts: A- Large-scale assessment of students' satisfaction with current practices of laboratory education; and B- Small-scale controlled investigation on one of the labs.

1. Large-scale assessment of students satisfactions

The large-scale assessment survey targeted all engineering departments of the Faculty of Engineering at ANU in order to examine the current situation of students' satisfaction with the laboratory teaching. A questionnaire was prepared consisting of 12 questions to measure students' perception. A statistically representative sample was randomly selected using stratified sample in order to make sure all 10 departments in the faculty are represented. This meant surveying 284 from the 2660 students. To evaluate the general satisfaction of the engineering students, they were mainly asked about the appropriateness of the current teaching practices in linking applications to theory as this is the objective of the Labs.

2. Small-scale controlled investigation

One laboratory at the industrial engineering department was selected for the small-scale investigation. Students of the lab were randomly divided into control and experimental groups for investigation; this has been accompanied- and/or followed- with hypothesis tests of learning outcomes of both groups, semi-structured interviews of the experimental group, and observations of in-lab performance. The control group followed a classical teaching approach, while the experimental group followed a constructivist pedagogical approach, where students were actively engaged before, during and after the Lab session unlike the traditional approach. For example, supporting materials sent to the students before the experiments, quizzes, take home exercises, videos and games were used. Furthermore, continuous communications and feedback was achieved after the session remotely using a dedicated online page on Facebook. Three Lab experiments were used as a sample study in order to assess the impact of the constructivist approach on students' performance and motivation to learn. The control and experiment groups were equivalent: 10 students each, age is (22 years old), gender (2 female in each) and academic achievement (average GPA of the control group was 73.1% and 73.2 for the experimental group).

3. Student-centered approach development

The new proposed approach including both the theoretical and practical part was designed in an attempt to be driven by the student-centered approach. The enhanced activities introduced at three stages, before, during and after the class in order to make sure maximum interaction and formative feedback are attained.

Before the class: The students were requested to do a good preparation of the experiment from a modified handout. Dedicated videos were developed in-house to demonstrate specifically how to use the instruments and conduct the experiment. Homework, games, and extra exercises were assigned. Moreover, the students had the chance to communicate with the teacher and other students before the experiment using Facebook. Various website links and general videos were posted as well.

During the class: Quizzes before and sometime after the theoretical explanation were conducted and the students were informed of that as part of their preparations. This has ensured effective interaction for learning purposes and proper preparation. The results of the home exercises were discussed in addition to the principle of instrument which was demonstrated before the class. Moreover, group exercises inside the class were conducted to reflect and elaborate on students understanding and learning. This included mini projects used to demonstrate the experiments outside the lab. For example students were asked to use the instruments to assess air quality in the university buildings.

After the class: Feedback from students about the experiment was shared at the end of class and on the Facebook page and in the next sessions as well.

The experiments chosen were: 1- Muscle Fatigue Test; 2- Flue Gas Test; and 3- Air Quality Assessment. Those experiments are well established and were selected for demonstration purpose as they represent typical sample. Therefore, any improvement is attributed to the teaching approach implemented itself. . Figure 1 shows the major differences of the newly developed approach taking the example of the muscle fatigue test.

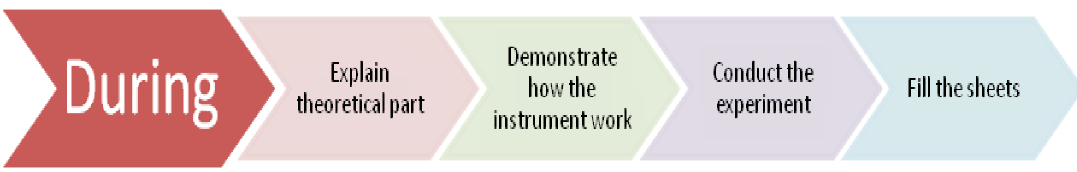

Figure 1 A. The traditional approach

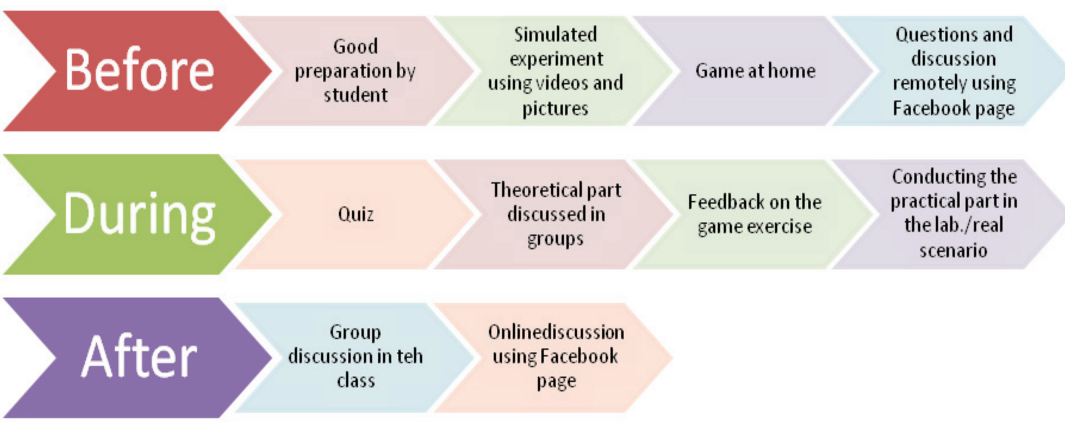

Figure 1 B. The new approach

IV. DATA ANALYSIS AND FINDINGS

1. Quality of education in the engineering Labs

The assessment of the quality was measured quantitatively using a survey that was statistically representative using stratified sampling technique to guarantee all departments were considered. The sample size of each department was calculated based on the weight of the department in terms of number of students (see Figure 2). The survey has targeted the students only, therefore any judgment is from the students' perspective. This is due to the fact that the

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student is the center of the learning process and measuring his/her satisfaction is essential. The other purpose of the survey was to use its findings as an input for the selection of the case study in part two of the research study

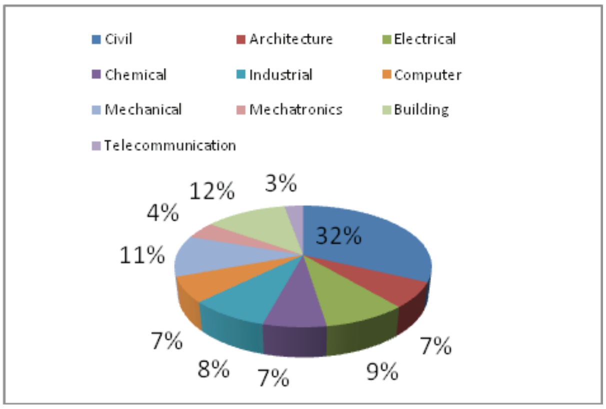

Figure 2. The selected sample in the Faculty of Engineering

The general satisfaction of the students who said (agree + strongly agree) was 63.7%, but it was different across the 11 departments, for example civil department scored 76% while electrical 42% and industrial 50%. Moreover, half of students in the sample were unsatisfied of the way teaching is carried out. Finally 43% of the student cannot see the benefit of the Labs in connecting the theory and making use of it in real life.

Majority (61%) of the students agree on the appropriateness of the teaching materials which confirms the results obtained with regard the issues that make the highest impact on their learning. The teaching methods were one of the key issues. Moreover, 63.4% of the students believe the current assessment methods are not appropriate and depend heavily on theory. The accessibility to the tutor, which can provide ongoing feedback for students, lacks based on the student's observation as shown in Figure 3.

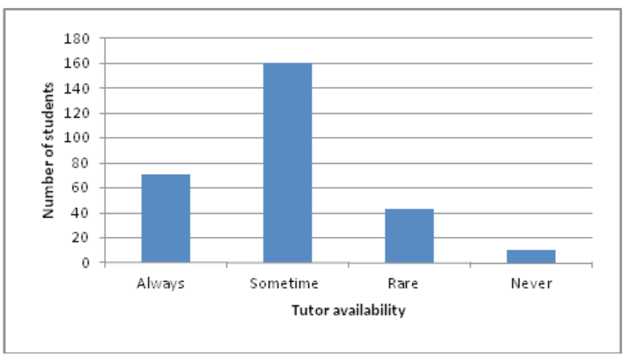

Figure 3. The availability of tutor outside the class

Part of the problem is the fact that the student's motivation to prepare for the Lab. is poor, as shown in Figure 4. This is attributed to the teaching style and the very summative assessment methods used. Finally, the survey showed that 85% of the students will welcome interactive exercises, and additional active learning materials and resources such as practical group projects, videos games, etc.

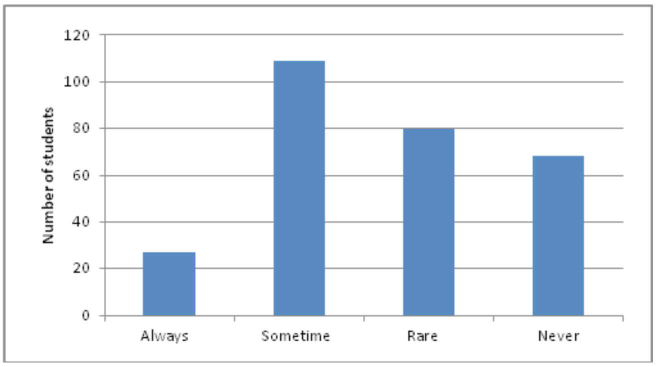

Figure 4. Number of students who prepare the experiments

2. Teacher-centered approach vs learner-centered approach

In order to assess the impact of the new approach, three measures were considered. The first measure (M1) is a quantitative one present the comparison between the marks for both groups. The second and third measures were qualitative and on the experimental group only. The second measure (M2) was interviews while the third measure (M3) was only observation and continuous feedback during the sessions.

M1: Comparing the marks of both groups

M1 was investigated using hypothesis testing and statistical analysis. Statistical hypothesis testing is usually achieved through defining a “Null Hypothesis” that contains the opposite of what researcher is trying to test (Conover, 1999). The null hypothesis is normally rejected if the statistical test has resulted in a significance probability of 95% or more. This is expressed by significance value (p-value) of 0.05 or less. If the threshold of the p-value is lowered, i.e. to 0.02, this will result in higher confidence of accepting or rejecting the null hypothesis test results minimizing a so called Type I error when the null hypothesis is rejected when it is indeed a true one. However, such low p-values may result in a so called Type II error when the null hypothesis is not rejected when it is indeed false. If the sample number is very small, e.g. less than 15, a Type II errors is very likely to occur at a threshold value of 0.05; hence it is recommended to raise it to 0.1 (Cohen, Manion & Morrison, 2005). In this study, the threshold of 0.1 is admitted due to the small sample number of the control and experimental groups. The null hypothesis in this case states that: “There is no statistically significant difference between the learning outcomes (measured by tests) in between the control and the experiment group as a result of the student- centered approach”.

A midterm exam was conducted and the results of the t-test, as shown in Table 1, depict statistically significant difference between the two groups p-value = 0.059 < 0.1.

Table 1. Summary of the t-test (<0.1)

	Variable 1	*Variable 2*
Mean	83.6%	76.6%
Variance	6.236111	8.622222
Hypothesized Mean Difference	0	
P(T<=t) two-tail	0.05967	

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M2: Feedback from the experimental group using a short survey

Based on the short interviews conducted after the study was concluded with the experimental group, several findings were discovered. Most students think that the new approach (more active learning oriented) of teaching and learning helped them to understand and apply the Lab experiments. Moreover, they found it easier to remember the information and all the students were very satisfied in the way the three experiments were taught. Students commented their performance in the exam was better in those three experiments and they felt more confidence about how the relate to practice. These conclusions were based on an analysis of the transcribed text for the narrative text reported in the semi-structured interview.

M3: Qualitative observations and continuous feedback

The informal feedback and observations demonstrated great benefit to the researchers to grasp the various challenges and issues related to the way the students appreciate and learn best. For example, the interaction between the students themselves and the teacher was very effective and enjoyable. This is due to the flexibility and accessibility provided through the communication medium used employing the Facebook. The method of teaching was continuously altered to adapt to the preferred approaches the students felt pleasant to learn.

V. DISCUSSION AND CONCLUSION

The main focus of this paper was on assessing the current practices of delivering the Labs and discusses an attempt to introduce some simple concepts based on the student-centered approach. The first part looked at the current teaching practices of one of the most important modules in the Faculty of Engineering (i.e. the Labs). The most important finding of this part was underlining the significance and the value of the teaching methods as seen by the students. The majority see it the most influential factor in the learning process as compared to the teacher or the student roles. Driven by the first part, the second part of the study was conducted to change few sessions in the Lab and make them more interactive and closer towards the student-centered approach. This intervention was a small pilot that can be used to build upon to carry out a large scale empirical study. The results showed relatively fine indications, whether the quantitative or the qualitative measures, when the students are more involved and embedded in the learning process extensively. Utilizing relevant games at home in advance to the class to introduce the subjects were very effective. Designing projects based on the subjects proved to offer more insights and enjoyable experiences as it was more project-based learning (PBL). Moreover, the formative type of assessment used enhanced the ability of the student to be in contact with the material and engaged constantly.

Finally, utilizing the multimedia prior, during and after the class ascertained the role and the significance of the social media enhanced learning system in the context of higher education. For example, the Facebook account created for this experiment was very successful in various aspects. The students were content that they are enabled to add accessible content and were motivated to follow up all the announcements and the videos uploaded by the teacher. Moreover, the use of familiar tool and already majority subscribed users made the adaptation quick and easy. This issue was apparent when other unfamiliar social media was introduced and drastically failed once used before by the teacher. The general positive feedback on the way the Lab was conducted had inspired both the students and the teacher to adopt in other Labs. However, such a step change can be a demanding and time-consuming activity and it often requires a subtle balance of teaching, research, admin, and other commitments from the teacher side. As these are considered additional activities and needs extra preparation which may take a back seat to other, more pressing obligations.

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