Borneo International Journal eISSN 2636-9826; Vol. 1 (1); 2018; 9-14
Published by *Majmuah Enterprise*
www.majmuah.com

Implementation of Problem Based Learning Component for Open-Ended Engineering Laboratory: Early Comparison on Students' Performance

R. P. JONG*, K. F. TAMRIN
Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS), 94300 Kota Samarahan, Sarawak, MALAYSIA
Email: jprudiyanto@unimas.my | Tel: +60198548547 | Fax: +6082583410 |

Received: July 1, 2018
Accepted: August 3, 2018
Online Published: September 10, 2018

Abstract

Problem based learning has been adopted worldwide in several disciplines of education particularly in medicine. The opportunity for implementation of problem based learning component was observed with the implementation of open-ended laboratory in engineering education. Achievements of students in two cohorts were compared to assess the effectiveness of the problem based learning component implementation component in Engineering Laboratory 4. The results shows promising improvement in students' achievements.

Keywords: PBL; fully open-ended; engineering laboratory

1. Introduction

The opportunity to implement problem based learning component in engineering laboratory was observed with the difficulty of students in relating the problem statement of the open-ended laboratory with the fundamental engineering knowledge prior to the commencement of the experiments. The consequence was that most students were unable to apply reasoning based on engineering principles to their analysis of the findings in the experiments. The outcome was reflected in their laboratory reports and of course in their score of the course.

As an effort to increase the effectiveness of the open-ended laboratory implementation, the component of Facts, Idea, Learning Needs and Actions in problem based learning was utilized to enhanced students' prior knowledge before attempting the experiments. It is the objective of this study to compare between the achievements of students between prior and after the implementation of the problem based learning component in the open-ended laboratory modules. The comparison shall be useful to gauge for the effectiveness as well as for further planning on the improvement in the engineering laboratory courses.

Problem based learning (PBL) has been adopted worldwide in medical schools since its first implementation at the medical school of McMaster University of Hamilton in Canada (Aldarmahi, 2016). In a previous study, PBL was compared with example-based learning (EBL) with the finding that EBL was more effective in enhancing students' learning performance with the characteristic of EBL that represent the complete required knowledge (Sern & Salleh, 2015). However, PBL has its own advantage with the enhancement of students' knowledge retention due to the active involvement of the students' during the learning process (Clyne & Billiar, 2016).

Open-ended laboratory has a benefit of enabling students to design and conduct experiments as well as analyze and interpret data for a valid conclusion based on their prior knowledge (Desai, Hungund, & Desai, 2015). It was proven that students understood the experiment concept better with open-ended laboratory as compared to the traditional guided laboratory practice (Haron, Mohammad, & Sam, 2013). Students are being exposed to the aspect of design in the early years of their study through the open-ended laboratory but the reasonable workload is still maintained for the students (Hastie & Haelssig, 2016).

2. Methodology

The study was conducted on Engineering Laboratory 4 course for the Bachelor of Engineering (Mechanical and Manufacturing Engineering) offered by the Faculty of Engineering, Universiti Malaysia Sarawak. The adoption of Facts, Ideas, Learning Needs and Ideas (FILA) table was implemented for the first time in semester 2 of 2017/2018 for Engineering Laboratory 4. The implementation however was limited to only two out of four modules of the experiments

Borneo International Journal eISSN 2636-9826; Vol. 1 (1); 2018; 9-14
Published by *Majmuah Enterprise*
www.majmuah.com

available in the course. In Engineering Laboratory 4, there are a total of five modules to be completed by the students within the semester. The brief details of each module are displayed in **Table 1**.

Table 1: List of laboratory modules for Engineering Laboratory 4

Module	Topic	Laboratory Type
Module 1	Principle of Flow Measurement	Fully open ended
Module 2	Orifice and Free Jet Flow	Fully open ended
Module 3	Flow of Real Fluid	Partial open ended
Module 4	Turbomachinery - Turbine	Partial open ended
Module 5	Turbomachinery - Pump	Partial open ended

Two modules were selected for the implementation of PBL component as a trial which were Module 1 on Principle of Flow Measurement and Module 2 on Orifice and Free Jet Flow. The selection of those two modules were based on the nature that the modules were fully open-ended laboratory that make them the most suitable candidate for the implementation of PBL component in the learning process.

Fully open-ended laboratory modules require students to understand the problem statement and design experiments as the solution or investigation effort for the problem statement. Hence, FILA table will be most useful in the initial step of the fully open-ended laboratory to enhance students' prior knowledge for understanding on the problem statement and related knowledge for the next steps in the experiments.

The implementation of FILA Table in the laboratory modules was initiated in the semester 2 of 2017/2018 session. It was made as a requirement for the students to show their FILA Table before being allowed to proceed with the experiments. Students were interviewed on the understanding of related topics and the elements stated by them in the FILA Table. **Figure 1** shows the process in Engineering Laboratory 4 prior to the implementation of PBL component. The prior process possesses a major weakness that cause the students hard time to relate the problem statement with their prior knowledge, hence making them unable to relate the significance of the experiments with the acquired knowledge. Hence, the outcome on their laboratory reports show high similarity to the previously submitted laboratory reports by the previous cohorts. The similarity of the reports was detected because invalid experiment designs as the laboratory concept was changed from fully guided to fully open-ended for the 2016/2017 cohort.

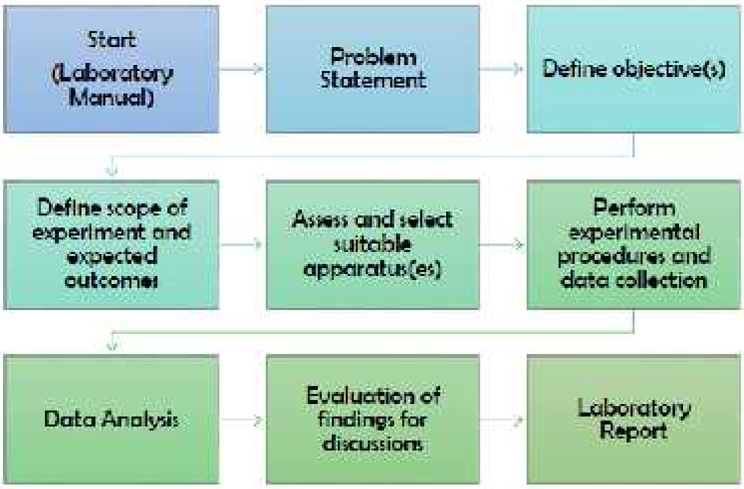

Figure 1: Engineering Laboratory 4 process prior to implementation of PBL component in semester 2 of 2016/2017

In the efforts to overcome the issue in the previous laboratory process, changes were made to the laboratory process by introducing additional components with the goal to assist students in acquiring intended outcomes of the open-ended laboratory. **Figure 2** is showing the revised process for Engineering Laboratory 4 for students of 2017/2018 cohort. The most important addition to the process is the fourth component which is "Identify Facts, Ideas, Learning Needs and

Borneo International Journal eISSN 2636-9826; Vol. 1 (1); 2018; 9-14
Published by *Majmuah Enterprise*
www.majmuah.com

Actions". This component is the FILA table that have been used in PBL all this time. Additional requirement on presentations at two stages of the process gives the opportunity to the students to verify their works before proceeding the next stage.

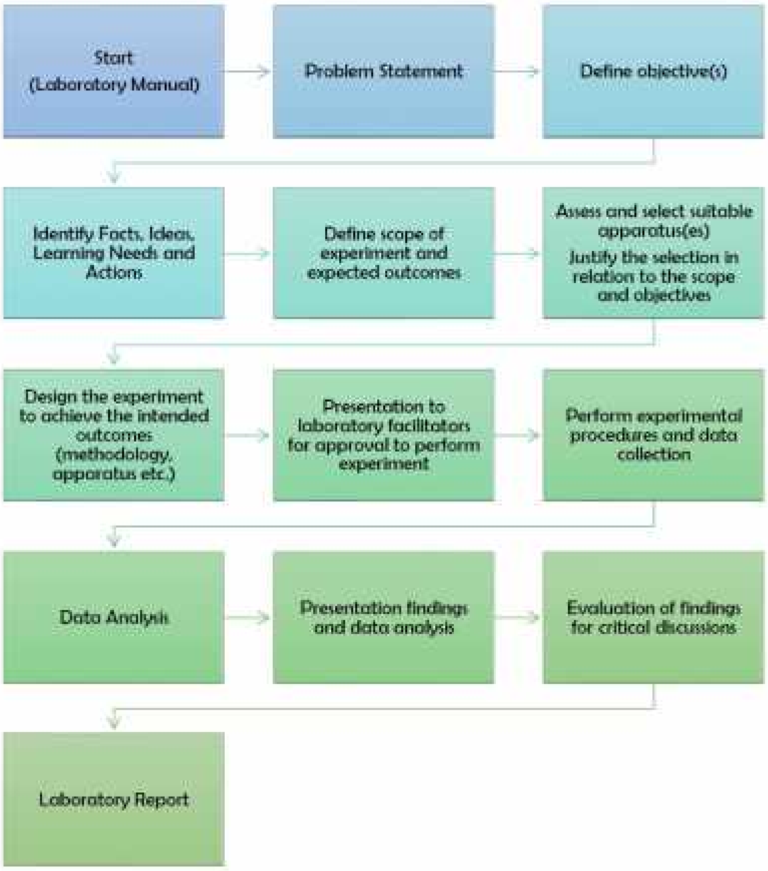

Figure 2: Engineering Laboratory 4 process with the implementation of PBL component in semester 2 of 2017/2018

The study was conducted on two cohorts of students. The first cohort was prior to the implementation of the PBL component in the Engineering Laboratory 4 in semester 2 of 2016/2017, while the second cohort was the students who undergone the laboratory sessions with the requirement on PBL component as part of their modules in semester 2 of 2017/2018. These two cohorts were selected due to the fact that both cohorts were experiencing transition period; from fully guided laboratory to open-ended laboratory, and implementation of PBL component in fully open-ended engineering laboratory.

The performance for both cohorts involved in this study was measured based on their score of the selected modules in the laboratory course. Students' scores were group based on the following: (i) 90-100, (ii) 80-89, (iii) 70-79, (iv) 60-69, (v) 50-59, and (vi) less than 50. The students' scores below 50 are not significant because the of the minimum passing mark is set at 50%. The overall performance was assess based on the percentage of students in each group of the score. Each group represent the achievement of students and their acquisition of intended skill in the laboratory practice.

3. Results and discussion

Figure 3 and **Figure 4** show the distribution of students' performance in semester 2 of 2016/2017. There were large percentages of students in the bottom two groups of scores; 50-59 and less than 50. The large percentage is more obvious in the Principle of Flow Measurement Module with about 74% of students were in the bottom two groups. The scores between 50-59 allow students to pass the course but not necessarily achieve the intended course outcomes. This the main reason on the importance to shift the number of the students in the bottom two groups to at least score in the group of 60-69.

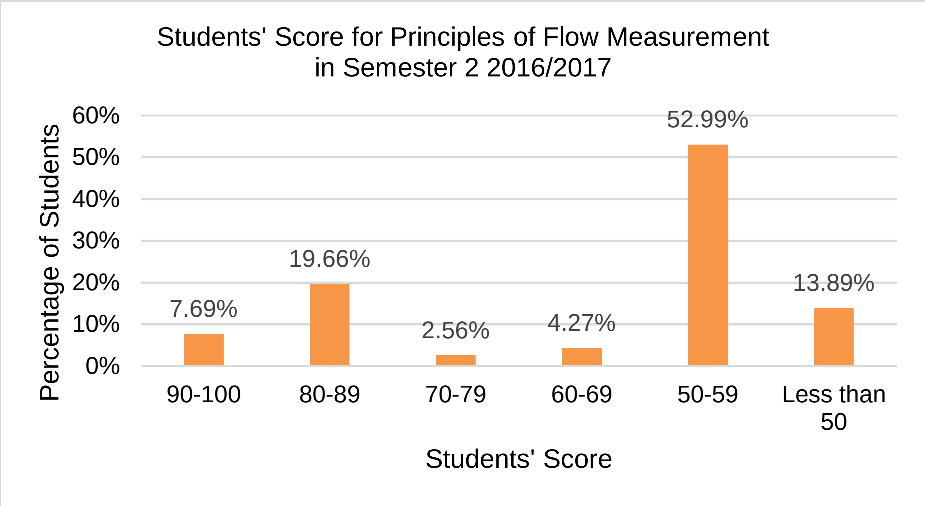

Figure 3: Students' Performance for Principle of Flow Measurement Module in Semester 2 of 2016/2017

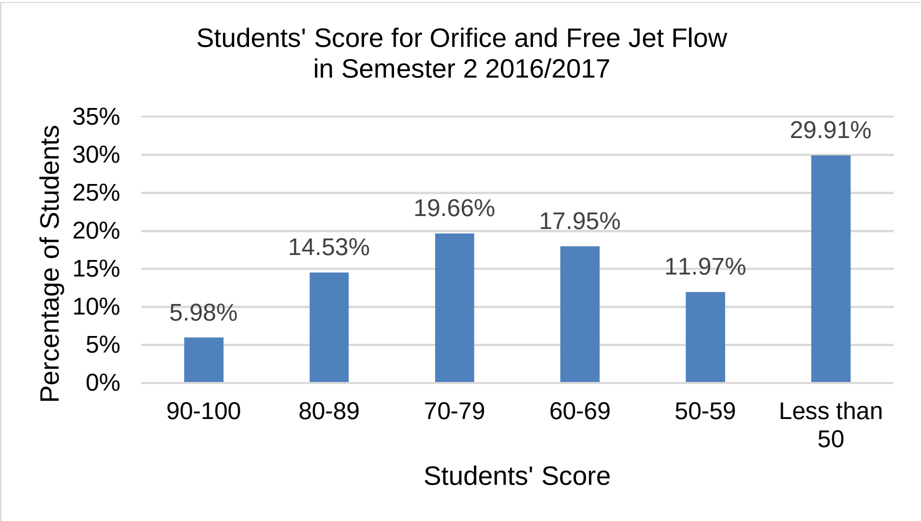

Figure 4: Students' Performance for Orifice and Free Jet Flow Module in Semester 2 of 2016/2017

The Orifice and Free Jet Flow Module recorded about 30% of the students' scores below the minimum passing mark. This is as bad as the situation for the Principle of Flow Measurement Module but for this case, it was a definite of non-achievement on the intended outcome of the experiment.

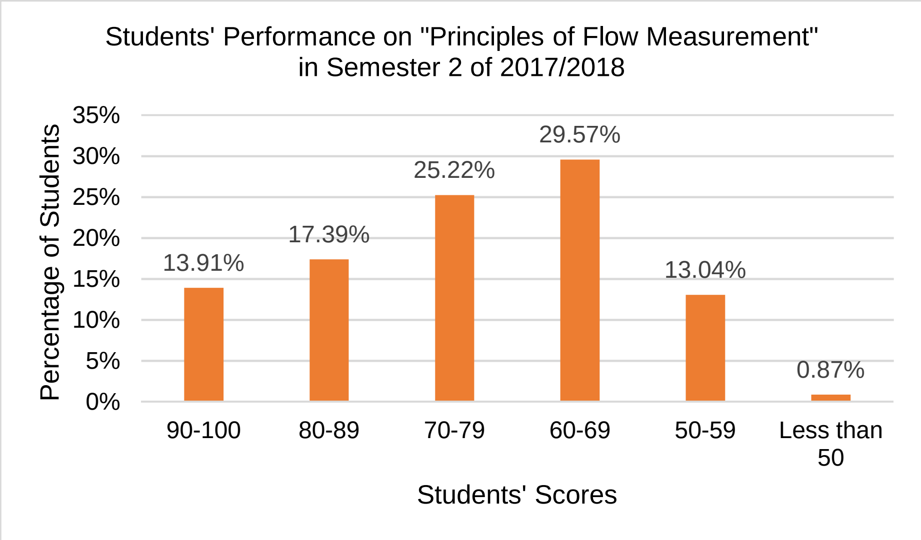

Figure 5: Students' Performance for Principle of Flow Measurement Module in Semester 2 of 2017/2018

In the following session, with the implementation of PBL component in the fully open-ended laboratory, the students' scores show significant shift towards the higher group of scores. The performance for Principle and Flow Measurement Module in semester 2 of 2017/2018 shows a reduction of the total percentage of about 53% for the number of students in the bottom two groups. The significant shifts out of the bottom two groups shows promising positive early outcome that hopefully will continue to improve in the next session.

In **Figure 6**, improvement is significant with the shift of 22% students from the bottom group of Less than 50 to the higher group of scores. This contributes to the shift of the numbers of non-achievers to the partial achievers or full achievers in the intended learning outcomes of the module.

Both of the fully open-ended module showed significant improvements on the students' scores distribution particularly in the groups of bottoms two. In addition to the said improvement, the trend of the students' scores distribution shows a bell curve distribution which significantly differentiate between excellent, average and poor output of the laboratory practice through the assessment of reports and presentation. Note that in the previous session (2016/2017), students' achievement was assessed solely on the laboratory report without the element of progressive assessment. The improvement can be considered as the initial success on the implementation of PBL component in the fully open-ended laboratory modules for Engineering Laboratory 4.

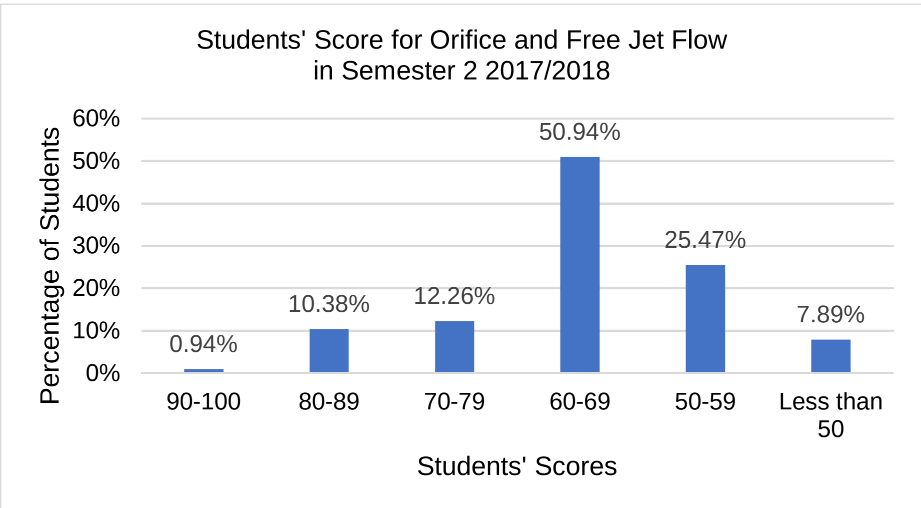

Figure 6: Students' Performance for Orifice and Free Jet Flow Module in Semester 2 of 2017/2018

4. Conclusions

The early study on the implementation of PBL component in fully open-ended laboratory for Engineering Laboratory 4 shows a promising improvement in students' performance with the reduction on the percentage of students in the bottom two groups of scores. This can be considered as an early success of the implementation of PBL component in Engineering Laboratory 4. The study shall be continued in the next few cohorts for a stronger evidence of the success in the implementation of this PBL component. In addition to the assessment based on students' achievements, students' opinion shall also be considered for variation in angle of views of the effectiveness in the implementation. With the additional few components of the study to be carried out in the future, a firm evidence shall suggest for better improvement on the existing process so that the benefits shall continue to affect the students learning.

References

Aldarmahi, A. A. (2016). The impact of problem Based Learning versus Conventional education on Students in the Aspect of Clinical Reasoning and problem Solving. *Education in Medicine Journal, 8*(3).

Clyne, A. M., & Billiar, K. L. (2016). Problem-Based Learning in Biomechanics: Advantages, Challenges, and Implementation Strategies. *Journal of biomechanical engineering, 138*(7), 070804.

Desai, S. S., Hungund, B. S., & Desai, S. D. (2015). *Assessment of Program Outcome by Open-Ended Experiment in Enzyme Technology Laboratory Course.* Paper presented at the Proceedings of the International Conference on Transformations in Engineering Education.

Haron, Z., Mohammad, S., & Sam, A. R. (2013). The Implementation of an Open-Ended Experiment in the Civil Engineering Laboratory. *Procedia-Social and Behavioral Sciences, 102*, 548-559.

Hastie, M., & Haelssig, J. (2016). An open-ended design-based lab exercise for a first thermofluids course. *Proceedings of the Canadian Engineering Education Association (CEEA).*

Sern, L. C., & Salleh, K. M. (2015). Comparison of Example-Based Learning and Problem-Based Learning in Engineering Domain. *Universal Journal of Educational Research, 3*(1), 39-45.