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Assessment of Affective Domain by Open Ended Laboratory Approach in Structural and Material Laboratory Course

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ABSTRACT

The objective of this study is to improve the development of affective domain among students with the introduction of the Open-Ended Laboratory (OEL). This enables students to design and conduct experiments, as well as to analyze and interpret data in a groups. By conducting the laboratory exercises in a group, students shall develop the ability to function effectively as a leader, as well as an effective team member. The present paper describes the assessment of the affective domain in OEL of Structural and Material Laboratory course for Diploma Program. This study involved a group of second-year students of Diploma of Civil Engineering for March-July 2019 semester who enrolled in the Structural and Material Laboratory course. There were ten groups involvesd in this study with the total number of 233 students; 98 male and 135 female.The attainment of affective domains among students in the evaluation rubrics was investigated in discovering the effectiveness of the course assessment. Not many differences in affective domain attainment between genders are reported; females shows better performance in punctuality and discipline attributes as compared to males. The outcome of this study is to observe that the OEL approach creates positive impacts in developing student generic skills such as leadership, communication, and teamwork. This attribute is expected by the industry, thus this also contributes to the overall students' learning experience.

Keywords: *Open-Ended Laboratory (OEL), affective domain, assessment, rubric.*

1.0 INTRODUCTION

The laboratory component course is designed to provide hands-on experience to inculcate the experimental skills during assembling the equipment, planning and preparing for the laboratory procedures. Today one of the required criteria for accrediting engineering programs is improving engineering education. There is an increasing concern in trying to make learning more effective for engineering students. Numerous techniques of innovative teaching may be applied in the teaching and learning process such as Project-Based Learning (PBL), Project Oriented Problem Based Learning, Active Learning, Cooperative Learning, Independent Learning and others (Azinoor Azida et al., 2018). According to Bloom et al. (1956), assessment of educational learning known as Bloom's taxonomy categorised the educational objectives into three domains; cognitive domain, psychomotor domain, and affective domain. Learning domains have always played an important role in evaluating the students' knowledge and skills. The learning domains can be incorporated while designing the course outcomes for all courses in an educational programs (Kasilingam et al., 2014).

One of the important objectives of engineering education is to produce graduates who possess the appropriate level of engineering knowledge and skills, such as the ability to solve engineering problems and produce new knowledge. These two skills are mainly the learning outcomes for the cognitive domain (Gondim & Mutti, 2011). Other than that,engineering education is also intended at producing students who are competent in the other two domains, the psychomotor, and affective domain. One of the examples of psychomotor skills that could be adopted through a the learning process is the ability to conduct experiments for civil engineering fieldwork. Besides that, Atsumbe & Saba (2008) stated that engineering students do not have the ability to learn but also to have the ability to be empathetic, self-starters, critical and creative thinkers that reflects individual values, motives, and interests. These attributes are categorized under the affective domain.

In order to provide students with engineering practice prior to their graduation, open-ended laboratory (OEL) courses or practical work can be integrated into the curriculum. It is found that this alternative method has successfully developed independent learning amongst students during the conduct of the experiments (Azinoor Azida et al., 2018). Salim et al. (2013) stated that a laboratory is a proper learning environment for developing and enhancing students' knowledge, practical skills, and attitudes which cover the learning domains of of cognitive, psychomotor and affective. A number of published papers have reported on psychomotor implementations in laboratory work. One such previous paper by Baharom et al.

(2015) investigates the implementation of psychomotor skills assessments in the teaching and learning process in concrete laboratory experiments. A combination of traditional and problem-based techniques of teaching was used, including lectures, flip demos, lab work, reports, and surveys. The comparisons were made between the results obtained through psychomotor assessment and the final examination marks. They proved that the psychomotor domain of each student was successfully measured.

2.0 AFFECTIVE DOMAIN

Other than that, the affective skills component can also be assessed through the observation approach which involves the evaluation of students' generic skills in the areas of communications, leadership, teamwork, work ethics, attitudes, professionalism, critical thinking, problem-solving and decision making in the open-ended laboratory. However, Strobel et al. (2011) found that the affective domain of learning tends to be more widely incorporated in social science research in comparison with engineering education research. This is because engineering students are often perceived as being more object-oriented than people-oriented. Assessment of affective skills was seen as being less important than the assessment of psychomotor and cognitive skills. Thus, the objective of this study is to discuss the assessment of affective domain by open-ended laboratory approach in structural and material laboratory course for the Diploma Program at the Faculty of Civil Engineering, Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus. Besides, the attainment of affective domains among students is also investigated to know the effectiveness of the course assessment.

3.0 METHODOLOGY

Students are required to attend the laboratory session and conduct all the experiments and laboratory works assigned to them as complied with the designated lesson plan. The instructor (lecturer and lab assistant) give optimum and minimal guidance as follows to the requirement of the experiment. The presence of an instructor is compulsory throughout each laboratory session so that the observation can be conducted smoothly. All elements as stated in the rubrics need to be observed; current performance are assessed and awarded marks are recorded in a proper format. Data collected was analysed using descriptive statistics.

3.1 Students' Demographic Information

This study involved second-year Diploma of Civil Engineering students, Faculty of Civil Engineering, UiTM Johor Branch, Pasir Gudang Campus for March-July 2019 semester who enrolled in the Structural and Material Laboratory course. There were ten groups involved in this study with the total number of 233 students; 98 are male and 135 are female as shown in Table 1.

In this course, students were exposed and introduced to the standard laboratory procedures for conducting the testing for basic mechanics of structures such as torsion, reaction, bending moment and shear force, influence lines, deflection, suspension cable, semi-circular arch, buckling of structs and pin-jointed truss. In addition, the course also covers the testing of standard consistency, setting time and fineness of cement, fresh concrete, steel tensile test, and concrete mixing and testing.

Table 1: Numbers of the student according to the group

Group	Gender		Total
	MALE	FEMALE	
4A	12	13	25
4B	10	16	26
4C	14	10	24
4D	11	13	24
4E	8	16	24
4F	3	22	25
4G	12	11	23
4H	12	11	23
4I	8	16	24
4J	8	6	14
TOTAL	98	134	233

3.2 Teaching and Learning Approach

The teaching method adopted for this course as stated in the course information is a face-to-face guided and non-guided approach. During the semester, it is compulsory for the students to attend the laboratory session according to the timetable. The designated contact hour for this course is 1 one hour per week. The time allocated for each laboratory session in a week is two hours. Thus, the

total hours for students need to attend a face-to-face laboratory session for one semester is 28 hours. The course consists of eleven main experiments that covered the aspects of structural and materials properties. The face-to-face guided and non-guided interaction among students and instructor (lecturer and laboratory assistant) conducting the open-ended laboratory has been conducted as per designed in the lesson plan and complying with the course information guideline. Through the open-ended laboratory approach, students directly and indirectly are exposed to the complex engineering activity which will assist the students to enhance their understanding of this course.

This study inolved 233 students. Each student needs to work in a group of a maximum four people which consists of both male and female. The grouping approach is to ensure that students have the opportunity to play a role as a leader and a team player. This enhances students' abilities to brainstorm, discuss and communicate among them about the task which relates to the method and procedure of conducting the experiment and laboratory works. Students needs to participate and show commitment to the group during pre-preparing, preparing, executing and finishing stage of the laboratory activity.

3.3 Course Assessment Method

This course adopted formative assessment in which the evaluation is carried out continuously throughout the enrolled semester. The assessment is classified into three types; namely, laboratory activity, laboratory observation, and practical test. Overall, each assessment is designed to measure specific domains such as psychomotor and affective. Table 2 shows the types of assessments with mapping to the course outcomes, program outcomes, and domain indicators.

Table 2: Types of course assessment method

No	Course Outcomes	Program Outcomes	Domain indicator Psychomotor	Assessment Methods Practical Test
1	Assemble structural and material laboratory experiments using standard test and measurements.	Conduct investigations of well-defined problems; locate and search relevant codes and catalogues, conduct standard test and measurements.	Psychomotor	Practical Test
2	Laboratory activities related to structural and materials.	Apply appropriate techniques, resources, and modern engineering and IT tools to well-defined engineering problems, with an awareness of the limitations.	Psychomotor	Laboratory Activities
3	Demonstrate leadership skills in task related to structural and materials.	Demonstrate knowledge of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant engineering technician practice and solutions to well defined engineering problems.	Affective	Laboratory Observation

3.4 Laboratory Observation

In general, a comprehensive briefing session is compulsory to be conducted by the instructor during the first meeting on week 1 every semester. This is to ensure that students understand the evaluation criteria and implementation procedures of OEL, including the matters pertaining to safety and health rules and regulations.

Hence, students equipped acquired themselves with the OEL knowledge and will make preparations before attending the laboratory session.

In the this context of the this study, the discussion focuses is focusing on the laboratory observation assessment which measured the affective domain. Each student will be evaluated individually based on their involvement and performance during the lab session for the whole semester from week 1 until week 14. Table 3 shows the six elements to be assessed which cover the intrapersonal and interpersonal aspects.

Table 3 Suggested elements for observation assessment

No	Elements to be Assessed	Remarks
1	Punctuality	√
2	Discipline (Dress Code, Safety Shoes, Safety Regulations)	√
3	Knowledge on Open Ended Laboratory	√
4	Communication	√
5	Leadership and Performing	√
6	Effectiveness of The Team	√

A set of the rubric was developed as a tool for assessing the students' involvement and performance during the laboratory session. The rubric is designed using a 10-point Likert Scale namely 1-10. Each scale is labeled with the criteria needed in measuring students' performance. The six criteria designed to be evaluated in this course includes punctuality, discipline (dress code, safety shoes, and safety regulations), knowledge on open-ended laboratory, communication, leadership and performing, and effectiveness of the team. Table 4 shows the rubric used for assessing a student's affective domain.

Table 4 Assessment rubrics for observation (individual assessment)

Category										
	E		D		C		B		A	
Punctuality	1	2	3	4	5	6	7	8	9	10
	Able to arrive laboratory on time.									
	More than 10 min. late		Between 5 to 10 min. late		Up to 5 min. late		Arrive on time but not fully utilizing lab hours		Arrive on time and fully utilizing lab hours	
	1	2	3	4	5	6	7	8	9	10

Discipline (Dress code, Safety Shoes and Safety Regulation)	Able to follow the laboratory dress code and follow all regulation and safety.									
	Does not wear dress code, shoe and did not follow lab procedures		Does not fully conform to lab's dress code and major flaws in safety		Conform to lab's dress code, and nearly follow all lab regulation but with minor flaws in safety		Conform to lab's dress code and nearly follow all lab regulation and safety		Conform to lab's dress code and follow all regulation and safety	
	1	2	3	4	5	6	7	8	9	10
Knowledge on open ended laboratory	Having basic knowledge on open ended laboratory.									
	Not able to explain, design and conduct the experiment-al work in the lab		Not able to explain the experiment and the work assigned		Able to design, conduct and explain the data obtained but not the work assigned		Able to design, conduct, testing and explain the data obtained and the work assigned		Able to design, conduct, testing, interpret and explain the data and the work assigned	
	1	2	3	4	5	6	7	8	9	10
Communication	The ability to exhibit interpersonal communication skills.									
	Unable to exhibit interperso-nal communication skills.		Able to utilize non-verbal skills minimally but with constant prompting		Able to utilize non-verbal skills limitedly.		Able to utilize non-verbal skills effectively and appropriately most of the time.		Able to utilize non-verbal skills effectively and appropriately at all times.	
	Delegation of tasks, good communication skills, capable of motivating, fair, inspire and confidence, and good cohesion									
Leadership and Performing	1	2	3	4	5	6	7	8	9	10
	Tasks are not delegated and members are not motivated all the time.		Tasks are not delegated and members are not motivated most of the time.		Some tasks are delegated with some motivation.		Tasks are delegated and members most of the times motivated.		Tasks are well delegated and members are highly inspired and motivated all the times.	
	Contributing ideas, completion of the task, shared mission/goals, communicate effectively									
Effectivenes of the team	1	2	3	4	5	6	7	8	9	10
	Members did not contribute ideas and not communicate. Tasks are not completed all the times.		Most members did not contributing ideas to accomplish common goals/ tasks and tasks are not completed within the stipulated given most of the times.		Some members contributing ideas to accomplish common goals/tasks and some tasks are completed within the stipulated given		Members contributing ideas to accomplish common goals/ tasks and tasks are completed within the stipulated given most of the times.		Members actively contributing ideas to accomplish common goals/tasks and tasks are completed within the stipulated given at all times.	

4. Results and Discussion

Figure 1 shows the final results obtained from by the students according to the grade. 88.4% (206 students) managed to secure For Grade A which consists of A+, A, and A-. This shows a normal distribution shape with the mean grade is A and A-. The marks for grade A is 80 - 89 marks and the interval marks for grade A- is 75 - 79. The lowest grade obtained by the student is B- which the interval mark is 60 - 64.

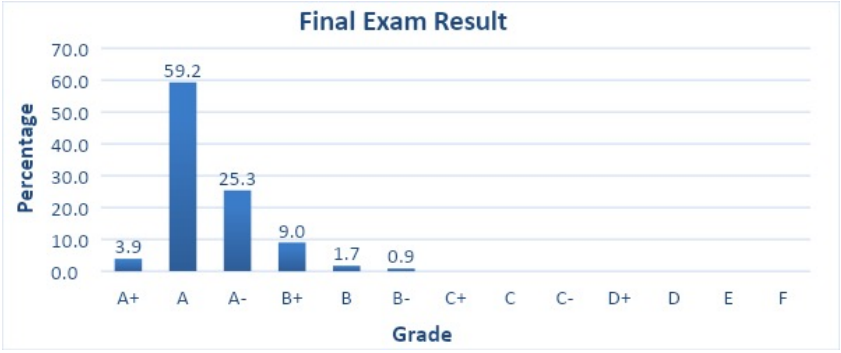

Figure 1: The final grade of students

The total mark for all course assessment is 100%. The percentage of assessment allocated for the affective domain is 10% which is evaluated from the laboratory observation. This assessment is mapped with Course Outcome 3 (CO3) which demonstrates leadership skills in task-related structural and materials. From the results as shown in Figure 1, all 233 students acquired the generic skills due to 100% marks attainment. Students were able to demonstrate leadership skills during the OEL session, as they were involved and participated in each laboratory and experiment exercise; thus, they managed to practise the leadership skill.

According to Sutkin et al., (2008) the acquisition of non-cognitive, relationship-based, and personal attributes is more difficult to develop and teach. Thus, to help in cultivating the non-cognitive attributes which is the affective domain, OEL can be adopted as an alternative of effective teaching. By practicing OEL, it develops many soft-skills and empowers the affective domain in student self-development. This is crucial for the students to improve their personal skills and attributes. This can be an additional value for them during the industrial training session.

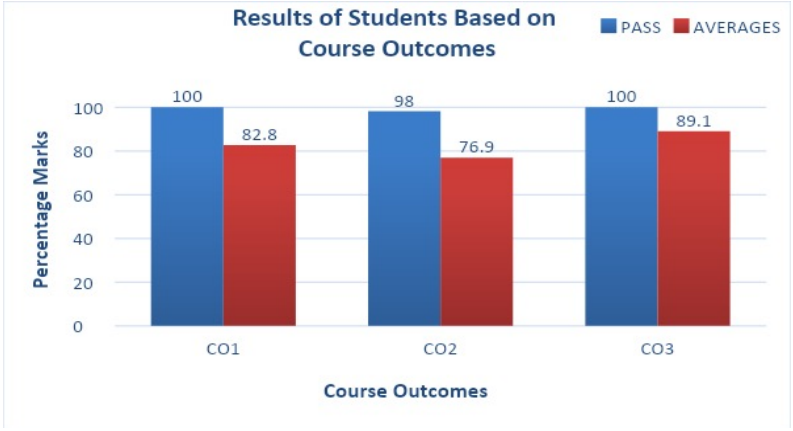

Figure 2: Results of students based on course outcomes

In comparison, the average scoring marks for each course outcomes are shown in Figure 2. The average attainment marks for CO3 is 89.1 %. This is the highest average mark if compared to CO1 and CO2. The difference between passing marks and average scores by the students is 10.9 %.

There are six elements of affective domains; namely, punctuality, disciplines, knowledge on OEL, leadership and performing and team effectiveness of the teams were being evaluated. The overall average marks of students for each element of the affective domain are shown in Figure 3. The students gained the highest average marks on disciplines element which is 93.1%. Besides, the lowest average mark is knowledge on OEL which is 84.6%. Overall, the score marks of all six affective domains for this course shown is greater than 80%.

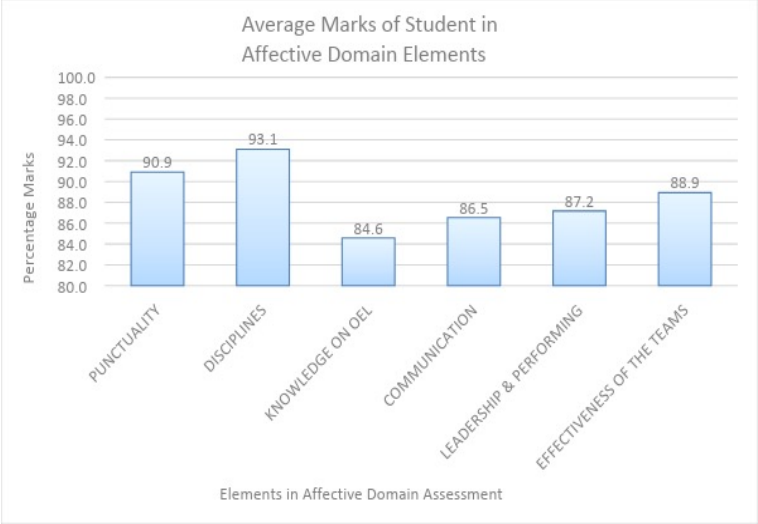

Figure 3: Average marks of students in affective domain elements

To further investigate the achievement of each element in the affective domain, the attainment between the two genders was established using descriptive analysis. The frequency analysis is adopted to indicate the different attainment of average marks between female and male students as shown in Figure 4.

The different average mark of punctuality element between female and male students is 8.8 %. Thus, It shows that female students are is more punctual compared to the male students. Besides, female students also show a better quality of discipline as compared to male students. This is indicated by the average score marks of 95.6% for female students and 89.6% for male students. For the element of knowledge of OEL, communication, and effectiveness of the teams, the female students show better understanding and performance compared to male students. This indicates the difference of 1% - 3% of the average score marks between both genders. On the other hand, both groups show almost similar performance in leadership and performing elements with the average marks of 87%. This shows positive implication as reported by Isacke (2013) and Remedios (2012), leadership is a valuable skill that industry looks into employees (students). Overall, even though this course is tough due to its nature, the results show that female students attained higher marks compared to the male students.

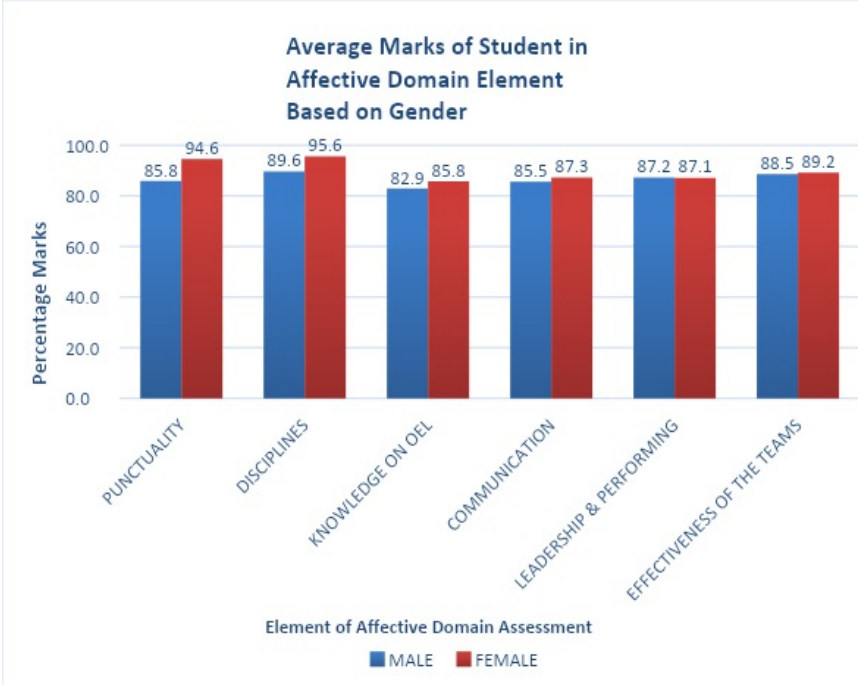

Figure 4: Average marks of student in affective domain element based on gender

5. Conclusion

The implementation of the affective domain in the laboratory course is not something new. In this study, the affective domain has been assessed through the observation approach which involves the evaluation of students' generic skills in the areas namely; punctuality, disciplines, knowledge on OEL, leadership and performing and effectiveness of the teams in the open-ended laboratory. All the students were graded by adopting evaluation rubrics. The descriptive statistics analysis was carried out and four categories have been classified; final grade of students, results of students based on course outcomes, average marks of students in affective domain elements, and average marks of students in affective domain element based on gender. The obtained results showed that the percentage of students obtained grade A (which consist of A+, A, and A-) is 88.4%, which almost 206 students. It shows that all 233 students acquired generic skills due to 100% marks attainment. Besides that, the average attainment marks for CO3 is 89.1 %. This is the highest average mark if compared to CO1 and CO2. By implementing an affective domain in OEL, it assists students to develop many soft-skills; as is crucial

for the students to improve their personal skills. It also serves as great attributes for them in their incoming in dustrial training session. Moreover, the students gained the highest average marks on disciplines element which is 93.1% compared to the other five elements in the affective domain. The lowest average marks among the six are knowledge of OEL which is 84.6%. Overall, the score marks of all six affective domain elements for this course shown is greater than 80%. On top of that, the achievement of each affective domain element, the attainment between the gender of the student is discovered. The average score mark between both genders is 1% - 3 %. On the other hand, both groups of the student show almost similar performance in leadership and performing elements with the average marks of 87%. This shows a positive implication where leadership is a valuable skill that the industry will look for in their future employees (students). Overall, even though this course is tough due to its nature, the results show that female students attained higher marks compared to male students. There are no many differences in affective domain attainment between gender. Female students shows better performance in punctuality and discipline attributes compared to the male students. Hence, few improvements are necessary to increase students' awareness about the importance of the affective domain elements. The new knowledge of this study is to observe that the OEL approach creates positive impacts in developing students' generic skills such as leadership, communication, and teamwork. This attribute is not only expected by the industry, but also it is believed that it will contribute to the overall students' learning experience.

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