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January 15, 2020

Assessing Teamwork Value in Project-based Learning of Capstone Project Course

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Abstract

Teamwork is a crucial soft skill that need to be instilled to the undergraduates from Petroleum Engineering course in order to address the 10th and 12th Program Outcome outlined by the Engineering Accreditation Council for Malaysia higher education institution. Teamwork is beneficial to the students in order to build their self-confidence, exchange their opinions, develop critical and creative thinking to improve their learning process and serves as a life-long learning skill that could be utilized in the oil and gas industry and other engineering sectors. The key objective of this study is to investigate the teamwork in capstone project which is a summative assessment to address the affective domains to produce well rounded graduate. This study aims to examine the impact of teamwork in the process of project-based learning in the compulsory capstone course for final year students to their individual performance. Its assessment was claimed to be designed based on capstone project requirements by the Engineering Accreditation Council. The capstone course design is a project-based learning (PBL) approach as it is designed for group activity that will go on for two semesters. The research measured for the teamwork performance in four dimensions which is Working with Others, Planning and Organising, Effectiveness under Stress and Commitment to job. Additionally, this study deployed a quantitative method through a set of questionnaires. The design capstone course is unable to accommodate or evaluate excel teams of Teamwork performance and it addresses heavily on the cognitive domain through their Coursework performance. These findings could be an eye-opener to lecturers in designing appropriate student-centred learning approaches.

Keywords: project-based learning; teamwork performance; final year students; capstone project

1.0 INTRODUCTION

Capstone projects is the one of criteria need in engineering academic to integrate multi-disciplinary subjects and teach students regarding professional skills that are difficult to deliver in the normal lectured course (Shekar, 2017). Capstone design projects may be completed individually or in a team of group depending on the course program relevant. Since teamwork is considered a critical and creative skill to teach the young engineer to be and treat how professional it can be in such a real world industry. Most capstone design planning course require students to attain a design project in a team.

The Field Development Plan (FDP) course is the capstone project for the final year students in Petroleum Engineering Department. It is designed based on the requirements set forth for capstone project by the Engineering Accreditation Council (Engineering Accreditation Council, 2017). The capstone project should be a complex

engineering problem that requires an integration of core knowledge of the discipline as well as skills of the students that had been developed throughout their learning.

The FDP project aims to produce a feasible solution taking into consideration the technical, the economics and the sustainability aspects. For each FDP course, the student presentation and report are assessed on Week 7 and Week 14. Individual assessments are conducted throughout the course and at the end of the course.

The FDP course design fits well with the project-based learning approach as it is designed for group activity that will go on for two semesters. The final product will be a report and a presentation at the end of the term period. It has specific timeline and milestones, where the students are going to be assessed while the project proceeds (Donnelly and Fitzmaurice, 2017). The students are given an open ended project with more than one possible solutions, this was intended to simulate a real world production of a field development plan.

The implementation of the FDP courses in the Petroleum Engineering Department had faced some challenges. The students' performance was less than satisfactory as indicated by the fairly "low" assessment marks given by both internal and external examiners for the project final products, i.e. the presentation and the report. Some of comments given by the examiners were poor integration among group members, low quality report and lack of interests. The students' performances were inconsistent between the FDP1 and the FDP2, and their performances also varied from batch to batch.

This research will assess the application of the project-based learning approach on the FDP course delivery to identify any gaps, and to propose suitable interventions in order to improve the students learning and hence the course learning outcome. The study will look, in particular, at how by providing conducive environment for students to develop their teamwork skill would contribute towards students' learning experience and the course learning outcomes. This study deployed a quantitative method through a set of questionnaires and is required to evaluate their team member according to the question given.

2.0 LITERATURE REVIEW

2.1 Problem based learning

The project-based learning originated from pedagogy theory that postulated the students learnt best through their experiences and solving the real-world problems. It involved students working in small groups and taking control of their own learning with the lecturer as a facilitator (Thomas, 2000). Many researchers have reported the positive effects of well implemented PBL in higher institutions such as improving the student collaborative skills, engagement, critical thinking and problem solving skills (Krajcik *et al.*, 1998; Brush and Saye, 2008; and Moalosi *et al.*, 2012).

The project-based learning is a learning model that structures complex tasks based on the real world problems that requires student to design, solve problem, makes decision, and investigate problems (Thomas, 2000). Project-based learning has several advantageous such as affecting positively student knowledge contents, developing soft skills (e.g. collaboration, critical thinking and problem solving), as well as increasing student motivation and engagement (Krajcik *et al.*, 1998). These benefits conclude the requirement of support for the lecturer on planning the project-

based learning structure and the students on setting up and directing the problem's goal and time management.

Perrenet *et al.*, (2000) explained that project-based learning is usually accompanied by subject courses (e.g. mathematics, physics, etc. in engineering) and it requires the student to manage the time, the resources, the task, and the role differentiation. There are variations in the project-based learning models proposed by various researchers. Morgan (1983) mentioned there were three general project-based learning models which are project exercise, project component, and project orientation. Heitmann (1996) put project-based learning into two categories: project oriented studies which was applied in individual courses and project organized curriculum which was applied throughout curriculum.

Heitmann (1996) explained that project oriented study involved small projects within individual courses progressing to a final year project. The small projects usually were combined with traditional teaching methods within the same course. These projects focused on the application and integration of previous knowledge. The small projects may be carried out as individuals or small groups. Project organized curriculum uses projects as the structuring principle of the entire curriculum with the elimination or reduction of subject oriented courses. The students were divided into small groups and they would have project teachers that acted as advisors and consultants. The projects were undertaken throughout the length of the course that could last of few weeks or to a whole year.

Heitmann (1996) also mentioned that in Engineering Department of Aalborg University in Denmark, the completely project organized curriculum did not exist yet and the closest programs made up to 75% of the project organized curriculum.

Harbor (2000) mentioned that he captured the PBL students satisfactory from questionnaire with results of student considered it as a challenging course but respond well as a transition to post-university employment. Harbor (2000) showed the importance of capstone project in Geology Departments of Purdue University. The capstone project focused on past course knowledge usage, written and oral presentation skills, real world problem identification, team work skills, and working under tight deadlines. Redirecting the students in preferred direction without neglecting student autonomy is another important aspect of project-based learning.

2.2 Teamwork

Teamwork is small group working together in a cooperative environment to achieve similar team goals through sharing their ideas and opinion (S. Sanyal & M. W. Hisam, 2018). Team members must be flexible to adapt to cooperative in a team through discussion rather than individualised activities.

In order to successfully prepare engineering student in real working environment, the undergraduate student must be able to develop their soft skills. An engineer is must be possess on scientific skill and non-scientific skills such as know the limitation, gain new knowledge, great teamwork and communication skills with others to be able solved problem regarding engineering issues. This valuable attitude can be gain from teamwork activities (A. Imazawa *et al.*, 2014). In short, teamwork has a positive influence on team performance and team satisfaction if team members knows how to interact with each other.

To overcome any difficulties regarding teamwork are confidence, well communication and productive leadership. The following points are crucial benefit

regarding the competence and efficiency of teamwork to build up an efficient teamwork without any others negative factors.

1. Trust among all team members.
2. Learning how to give commitment to make decisions and plans of action.
3. Effective leadership with well-defined roles among team member.
4. Focusing on achieving collective data.
5. Well prepared to engage in team to contribute an ideas.
6. Professional performance evaluation of team members and recognition for outstanding work.

3.0 METHODOLOGY

This study examined the relationship of teamwork through peer review evaluation and the coursework performance of the final year students in an engineering capstone project. The questionnaire consists of respondent profile, based on their group number and the names of their members and to rate their members based on four criteria which are Working with Others, Planning and Organising, Effectiveness under Stress and Commitment to job. Their coursework marks are obtained to compare with the peer review evaluation. The marks for coursework and peer review of each team members are averaged in to team marks, to correlate the performance in team basis.

The creation of team is self-choice which the students gathered their members to create a group of 5 to 6 members for 28 weeks commitment on the capstone project. The capstone project require fundamentals from several core subjects in the Petroleum Engineering course. The outcome of the course is to produce and present a technical plan of the complex case study in the oil and gas field given to them. The course addresses the Engineering Accreditation Council (EAC) for cognitive and affective domains through several Program Outcomes. Individual and team formative assessments are conducted throughout the course and at the end of the course.

The statements are being arranged in the orders of all four criteria, by keying in their team member name and to rate them accordingly. The respondents are required to rate 4 statements, by providing their opinion on the statement through a Likert composite reflected in statements. Each statement for each criterion, is orderly arranged and have difference in intensity of the response towards the criteria. The statements are ranked from high marks of 5 for Option number I until 1 mark for Option number V.

The survey is to measure the teamwork performance of the final year student towards Project-based learning, which on the other hand, assist educators to improvise the capstone lesson plan.

The participants are final year undergraduate students from Petroleum Engineering, of different batches, one in September 2018 and the other is January 2019. The participants for the survey are 75 students in January 2019 and 100 students in September 2018. The group of students are required to participate in the evaluation, in order to evaluate their team members interest and involvement, on the other hand, self-assess their own interest and involvement to the capstone project.

The set of questions is as displayed in Appendix.

4.0 RESULT AND DISCUSSION

A total of 175 respondents from final year undergraduate engineering course have answered the Teamwork assessment through peer review evaluation. The peer review was deployed during week 28 which is end of the semester. The individual Teamwork marks and the individual Coursework marks were averaged based on the two components in order to obtain the average marks of the team. Plot and analysis were done based on team marks rather than individual to evaluate the project-based learning on team basis. The discussion will deliberate on the result of two batch which are September 2018 and January 2019. The following are the analysis:

- i. Mean Comparison between Coursework and Teamwork
- ii. Grade Difference between Coursework and Teamwork
- iii. Teamwork Competencies Rating

4.1 Mean Comparison between Coursework and Teamwork

There are 20 groups in September 2018 and 14 groups in January 2019 batch. The mean, variance and standard deviation were calculated to gain an insight on the data points distribution. The measurement of data points between Coursework and Teamwork based on team performance is shown in Table 1.

Table 1 : Team Average Marks in coursework and teamwork for September 2018 and January 2019.

Group Count (N)	Assessment	Mean	Minimum	Maximum	Variance	Standard deviation
20 (September 2018)	Coursework	78.52	70.90	87.56	22.15	4.71
	Teamwork	82.87	70.5	100	72.95	8.54

Group Count (N)	Assessment	Mean	Minimum	Maximum	Variance	Standard deviation
14 (January 2019)	Coursework	74.23	60.85	85.17	45.72	6.76
	Teamwork	83.82	64.79	96.5	88.69	9.42

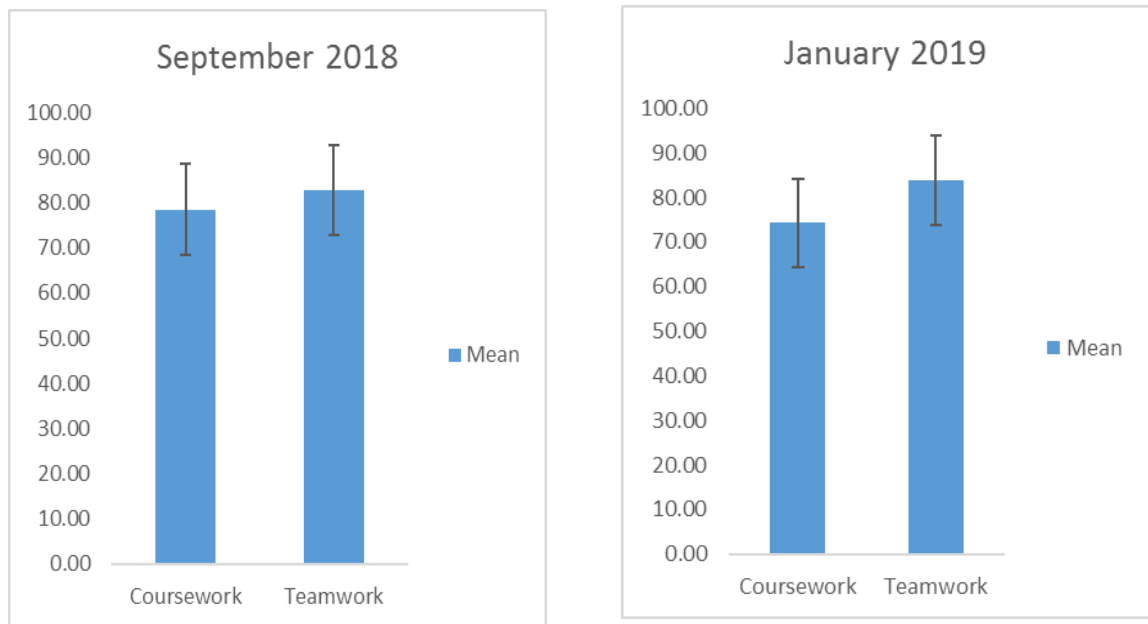


Figure 1: Team Average Marks in coursework and teamwork for September 2018 and January 2019.

The standard deviation value showed less than 10 for both semester data points. The spread of data point for Teamwork is higher compared to Coursework, which indicate that the Teamwork result is showing wider spread of group marks from the mean marks for both semesters. This indicate that the students evaluated their team members for each criterion in the peer review rubric with precaution. The minimum and maximum Coursework and Teamwork marks for each respective semester showed similarity and consistent trend. A clear trend discrepancy is observed in Teamwork assessment for January 2019 between the minimum mark and the mean mark. The student individual performance influences the large difference from highest mark to lowest mark. This may indicate the presence of less performed individual which can be reflected from the mean marks which is very far from the minimum marks. There are three groups which their average coursework is less than 70. It is clearly shown the same team scored lowest marks for Coursework and Teamwork. Therefore, the performance of the team in terms of teamwork is crucial in order to gain a better performance in their coursework.

The T-test value were calculated for both semesters. The significant difference between Coursework and Teamwork marks for September 2018 is 0.06, whereas T-test value for January 2019 is 0.01. If the T-test equals to 0 of both Teamwork and Coursework it will lead to a null hypothesis, however an absolute value was shown, which indicate that there is a significant difference between the marks and slightly increase in level of null hypothesis. However, the overall observed difference is less than 0.1 of the size of the variability between the marks.

4.2 Grade Difference between Coursework and Teamwork

The team marks for both Coursework and Teamwork were converted into percentage and being labelled based on grading system of A (85-100), A- (80-84), B+ (75-79), B (65-74) and C+ (60-64). The Teamwork and Coursework were compared to check the grade difference in order to observe the relationship of both performances.

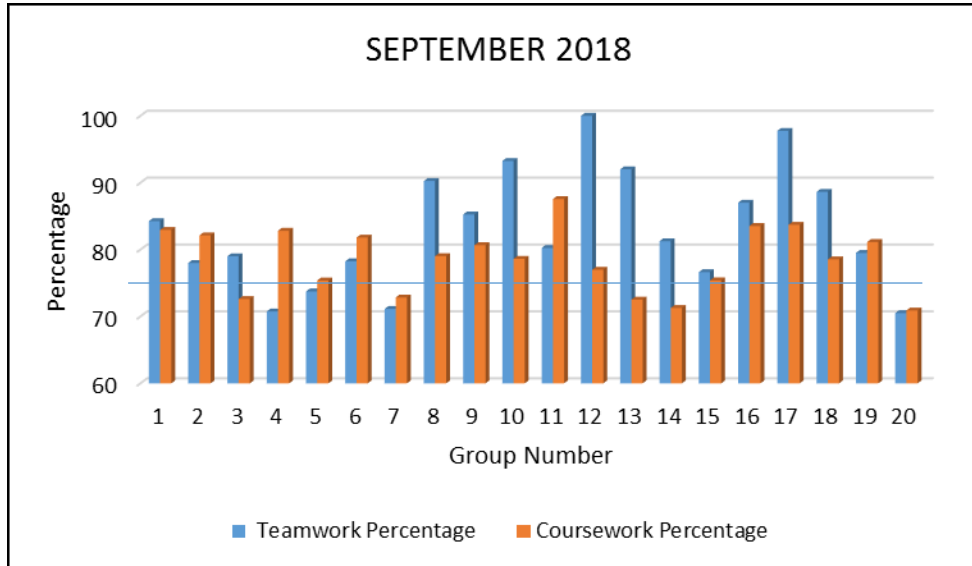


Figure 2: Performance based on group for September 2018.

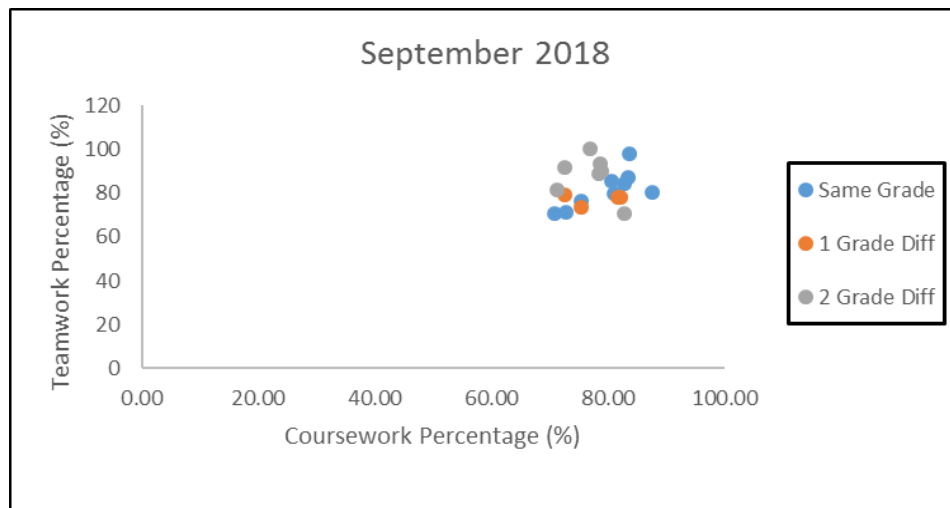


Figure 3: Plots on grade difference between Teamwork and Coursework for September 2018.

For September 2018, there are 45 % obtained same grade for both performance of Teamwork and Coursework. A portion of 20 % of the teams gained one grade difference and the remaining 35 % obtained two grade difference. This is equivalent to 7 teams having two grade difference which is alarming and reflecting

that the assessment of the capstone course is not addressing the measurement of affective domain which is 75% mapped to the course learning outcome.

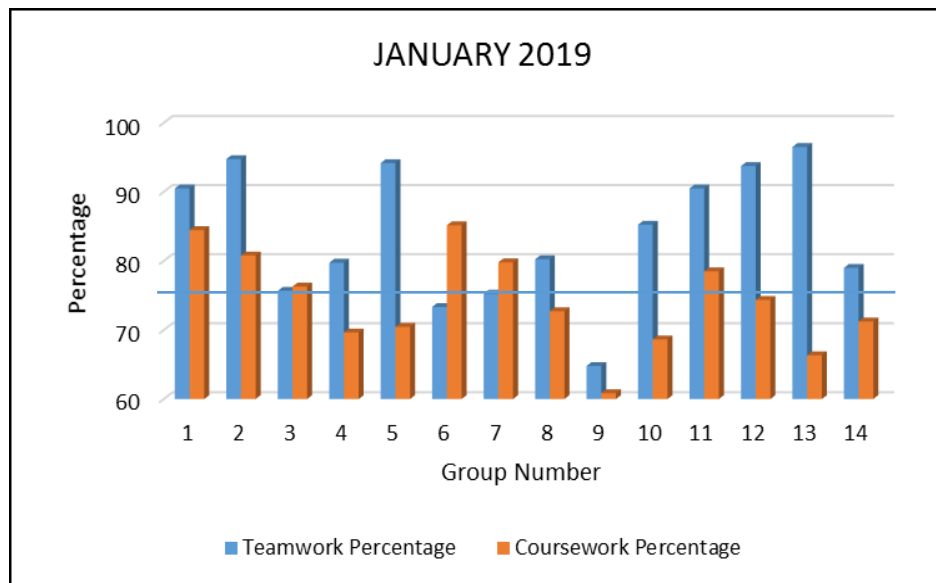


Figure 4: Performance based on group for January 2019.

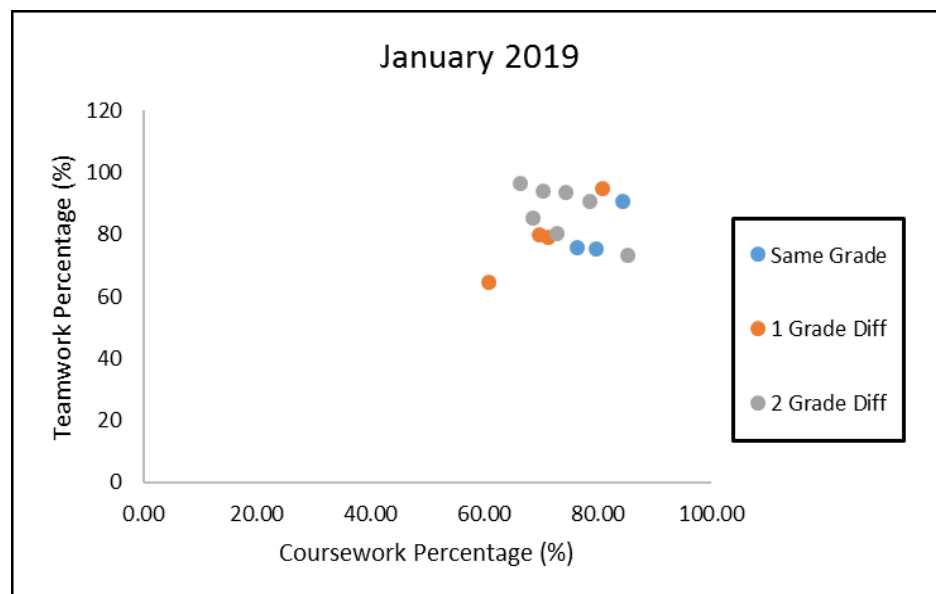


Figure 5: Plots on grade difference between Teamwork and Coursework for January 2019.

For January 2019, the smallest percentage which is 21 % of the teams having the same grade for both performances and 29 % of the teams obtained one grade difference between the two results. However, a majority of 50 % showed two grade difference between coursework and teamwork results. Most of the teams evaluated high marks for teamwork, but unable to perform in their coursework which the weightage of the assessment is towards the cognitive domain. The groups did not manage to gain similar grades for their Coursework, probably due to the course lesson plan and course delivery of the capstone which is highly influenced on the cognitive domains or another possible factor would be lack of supervision by the team's

supervisor on their capstone project work. This draws an assumption to the January 2019 batch, which majority of the team consist of cohesive members with strong team motivation, which brings to another analysis in 4.3 on the specific competencies that lead to high Teamwork marks. On another hand, only one team showed 2 grade difference of opposite items which is an average B grade for Teamwork, but average A grade for their coursework.

4.3 Evaluation based on Teamwork Components

The Teamwork components are discussed based on four criteria, which are the Working with Others, Planning and Organising, Effectiveness under Stress and Commitment to Job.

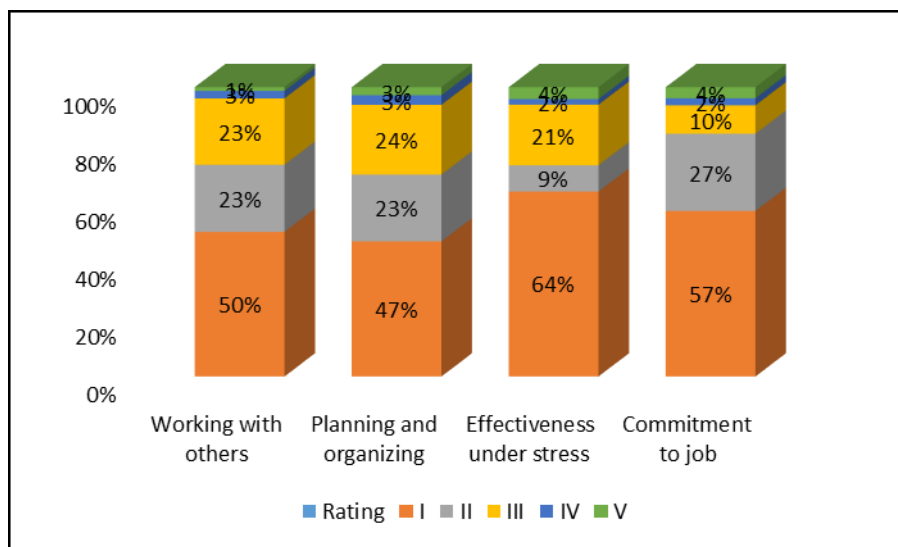


Figure 6: Distribution of Teamwork Competency based on Frequency of Evaluation for September 2018.

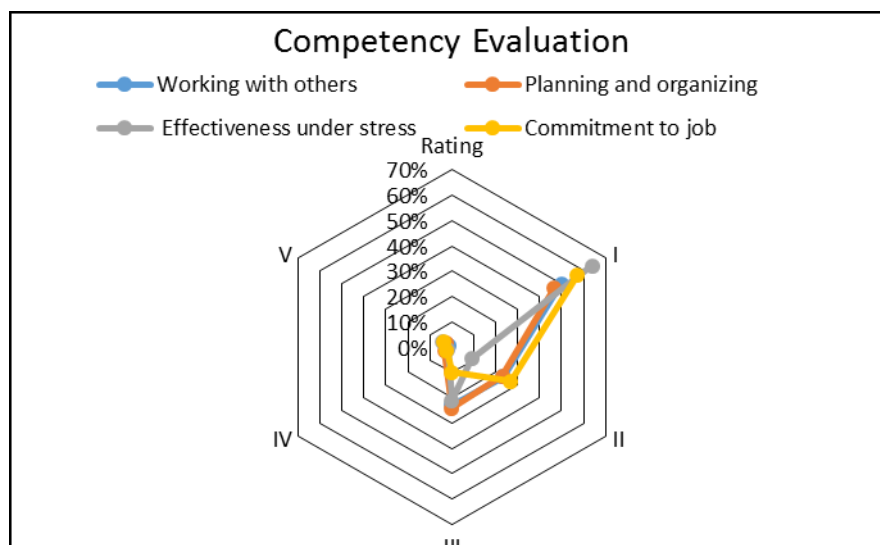


Figure 7: Radar Chart on the Comparison of Teamwork Competency Frequency for September 2018.

Rating I showed a record of 46-65 % response for the overall Teamwork competencies by the students of September 2018 batch. The result displayed half of the class could not acquire excellent teamwork competencies for their groups. There is a significant number of ratings for II and III in each competency, which indicate the members of the team rated satisfactory and good evaluation among them. The poor ratings of Rating IV and V is less than 6% of the whole class which leads to a frequency of 24 ratings that received negative statements for their Teamwork competencies. The number of low ratings was further investigated, and a portion of it was voted for three members in Group 2, 4 and 7. This led to poor team dynamics, as only two members in the team received good ratings.

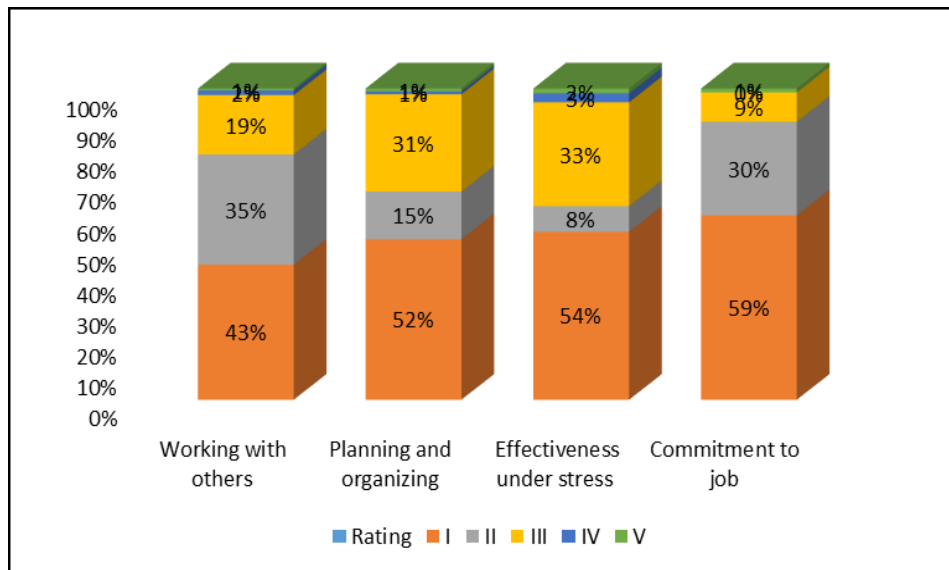


Figure 8: Distribution of Teamwork Rating based on Frequency of Evaluation for January 2019.

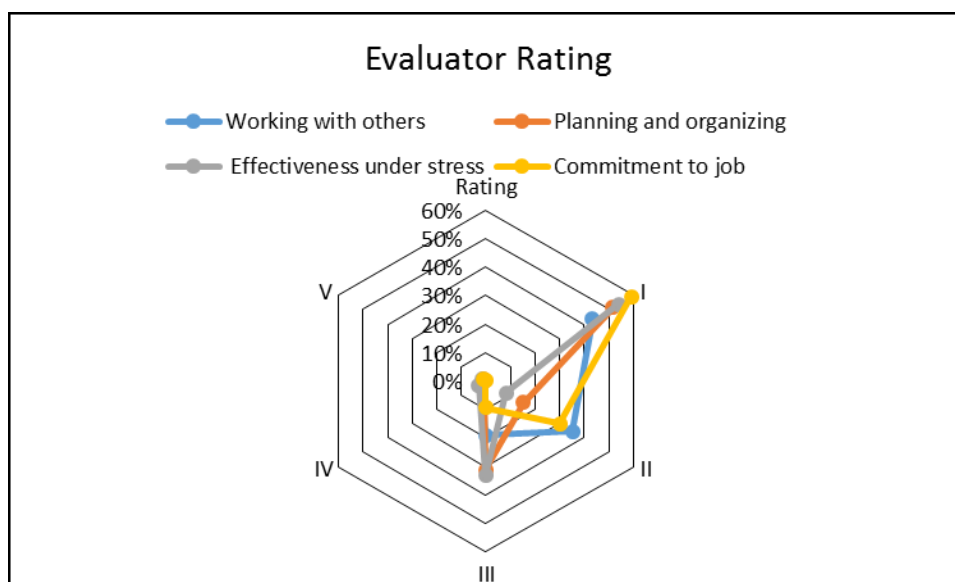


Figure 9: Distribution of Teamwork Competency based on Frequency of Evaluation for January 2019.

On another hand, the overall result for January 2019 showed a good track of teamwork performance which the negative statements are rated for less than 5% for overall rating IV and V. This reflects 14 frequency ratings for 14 members who received the negative rating that belongs to different group. Majority of the members are good in Working with others, Planning tasks, Handling Stress and Commit to the Task. The overall record showed positive team dynamics and enhances the learning experience for the course.

4.0 CONCLUSION

Addressing the cognitive and affective domains in capstone course are crucial in developing a well-rounded graduate. The ability of the students to evaluate their peers showed their maturity and awareness on the importance of teamwork in order to successfully deliver the project. The variation of team marks for teamwork showed that there is a need in intervention during the 28 weeks for teamwork module in order to develop responsibility of the student as a member working in the team, to deliver the project outcomes. The consistent trend of large difference between maximum and minimum marks for Teamwork in the course indicate that there is a large gap of teamwork performance between teams which is highly unlikely to reflect a well-rounded graduate attribute.

The cohesiveness shown by the January 2019 batch have displayed good to excellent marks for their Teamwork performance, however, they did not manage to gain good grades for their Coursework. The design capstone course is unable to accommodate or evaluate excel teams of Teamwork performance and it addresses heavily on the cognitive domain through their Coursework performance. This require a quality improvement to the capstone course as the number of course learning outcome mapped to cognitive domain is only one, whereas the course learning outcomes mapped to affective domains are three items. This led to the need of intervention by placing a scaffolding for team development or a team supervision that is able to monitor and improvise the Teamwork competencies and to be reflected in their Coursework marks.

Therefore, in order to produce a graduate with a good teamwork attribute, these findings could be an eye-opener to lecturers in designing appropriate student-centered learning approaches. Design of the capstone formative assessment should be tailored to include a portion of affective-domain in order to perform better in the coursework that will enhance the students' learning experience in project-based, while catering an integrated technical knowledge.

ACKNOWLEDGMENT

The paper is supported by the Center of Teaching and Learning CeTAL, under Scholarship of Teaching and Learning (SoTL) grant number: 0152AA-A88. Authors would like to express their appreciation to the final year respondents in Universiti Teknologi PETRONAS for their participation and time in doing the Peer Evaluation.

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Teamwork Competencies

Competency 1 : Working with others

No.	Options
I	Initiates and cultivates key contacts. Uses tact and diplomacy. Gets unpopular things done
II	Receptive to other ideas. Always makes a contribution and cooperates
III	Makes and maintains workable relationships with others
IV	Sometimes fails to share ideas to gain support
V	Impatient listener. Does not consider people's opinions. Loses their interest and support

Competency 2 : Planning and organizing

No.	Options
I	Always on top of things and in control. "Panics" handled smoothly
II	Carefully plans so that support is available when needed
III	Organises work to keep productively occupied
IV	Does not prioritise. Spends too much time on nonessential items
V	Does not plan ahead. Always waits to the last minute. Frequently misses deadlines

Competency 3 : Effectiveness under stress

No.	Options
I	Raises Game. Smoothly produces high quality work to meet each new and existing deadline
II	When a crises occurs, drops everything and produces high quality work
III	Stays calm during hectic periods and maintains steady output
IV	Keeps work flowing smoothly in normal situations but loses it when pressure mounts
V	Easily flustered when given more than one assignment to do

Competency 4 : Commitment to job

No.	Options
I	Eagerly seeks new assignments and challenges. Pursues development activities in own time.
II	Very attentive to responsibilities. Discourages casual conversation when there's work to be done
III	Works dependably on regular assignments but does not take on extra work
IV	Does not devote time to develop new job skills.
V	Frequently tardy or absent for reasons others consider frivolous. Outside interests more important.