INVESTIGATING RELATIONSHIP BETWEEN LEARNING PROCESS AND PERFORMANCE OF TEAM PROJECT IN ENGINEERING EDUCATION

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Abstract

Introduction:

Project-based learning is one of the important pedagogies in an area of engineering education. It helps students understand fundamental engineering concepts and build professional skills such as communication and teamwork. A goal of this study was to investigate relationship between a learning process, including planning, implementing and dealing with a problem, and performance of a team project. Each team had to answer three questions regarding the process daily during the project assignment. We hypothesized that when students encountered a problem, a group that tried to solve the problem early (planning and implementing) would achieve better performances in the project than other groups that did so later. Additionally, a group that spent more days in planning their work would complete the project with better results than others who spent fewer days in planning it.

Methods:

Data collection was conducted with students in an undergraduate course of Statics and Dynamics for two sessions. During Fall 2015, a motion machine project was assigned to students (10 teams). They had to build a machine that could move continually after an energy was given only once and the last one stopping would win the tournament. They were also asked to answer 3 questions daily for 4 weeks as a project progress log. During Fall 2016, the lecturer assigned a waterwheel project to another group of students (9 teams). They had to build a machine that could pump water continually after an energy was given only once and the last one stopping would win the tournament. They had to record their answers of the same questions for 7 weeks. Moreover, the 12-Item grit scale was collected before and after the project assignment in order to evaluate student's grit. The data were computed and categorized into 3 different factors, including a number of days before planning, a number of days before implementing, and a number of planning days before implementing. We used R, a statistical software, to analyze the correlations of these factors with the success of the project.

Results:

Results from the class of 2015 showed that there were no significant correlations between a number of days before planning and a duration that a machine could move, and a number of days before implementing and the duration. There was a positive correlation between a number of planning days before implementing and the tournament time, but it was not significant ($r = 0.63$, $p = 0.1$). Results from the class of 2016 also indicated that there was no significant correlation between a number of days before implementing, and pumped volumes of water. However, a number of days before planning and volumes of pumped water was significantly negatively correlated ($r = -0.68$, $p < 0.05$). There was also a substantial positive correlation between a number of planning days before implementing and the volumes of water ($r = 0.72$, $p < 0.05$). Additionally, there was no strong evidence supporting an effect of grit on the project achievement.

Conclusion:

The aim of this study was to investigate how the learning process influenced performance of a team project. The findings suggested that when the students had a problem in the project, when they started solving it did not affect their project's outcomes. However, focusing more on planning before implementing or constructing a prototype has a positive influence on the final results.

Keywords: project-based learning, grit, assessment.

1 INTRODUCTION

Project-based learning (PBL) is one of the important pedagogies in an area of engineering education. It helps students to understand fundamental engineering concepts and build professional skills such as communication and teamwork. This teaching method is usually combined with traditional teaching such as lectures, and it can be used in individual courses or integrated with other courses in a curriculum [1]. In Thailand, Engineering Science Classroom (ESC) at King Mongkut's University of Technology Thonburi (KMUTT), a high-school program, has designed an engineering and science curriculum that involves projects in every semester [2], or an undergraduate program of Robotics and Automation Engineering at KMUTT also integrates projects in many courses. However, there is no standard method for assessing student's cognitive abilities during project assignments besides examinations, which evaluates only subject matters of courses after the projects have been done. Thus, we developed a simple cognitive assessment that was able to measure student's learning and problem solving processes as a team project. The assessment is similar to a self-report in which each team had to record answers of 3 questions regarding planning, implementing and dealing with a problem daily, and then the data were analysed along with project outcomes, which represent a level of each team performance in order to indicate how the best team performed.

A goal of this study was to investigate how a learning process, which includes planning, implementing and dealing with a problem might be related to performances of a team project. We hypothesized that when students encountered a problem, a group that tried to solve the problem early (planning and implementing) would achieve better performances in a project than other groups that do so later. Additionally, a group that spent more days planning their work would complete a project with better results than others who spent fewer days planning. The 12-item grit scale was also incorporated in the study in order to explain whether besides the cognitive abilities, the character trait such as grit of each student could help a team achieved a goal of a project or not.

1.1 Project-Based Learning and Assessment

Project-based learning (PBL) is a pedagogy that combines projects in learning and teaching methods. It has been widely used in K-12 education [2, 3] and undergraduate level in engineering program such as [4]. However, a definition of this learning model is varied by researchers, so it is hard to indicate what is PBL and what is not, and it is difficult to find standard assessments in order to validate an effectiveness of PBL [5]. The project evaluating methods that have been frequently used are interviewing students and teachers, conducting surveys, observations in classroom and analysing students' reports such as in [6] and [7], which are mainly qualitative data. Therefore, we developed a new evaluating model that would obtain quantitative results, so that we were able to see relationship between the data and project outcomes, which would represent the effectiveness of PBL.

1.2 Grit

Grit is defined as passion and perseverance for long term goals. It is the important personality trait that helps individuals continually perform their work and maintain an effort toward their goals and challenges [8]. There have been many studies investigating relationships between success in academic areas and a result of 12-item grit scale. For example, Duckworth [8] explained the correlation between the character trait and academic achievement. They revealed that post-college graduates and more educated adults had higher grit than less educated adults. They also found a significant correlation between grit and Grade-Point Average (GPA) of Ivy League students in the United States. However, Jaeger [9] argued that grit was not able to predict academic performance or student success. They also found that engineering students' grit scores were varied by their majors in which Chemical and Mechanical engineering students were grittier than Computer engineering students. Moreover, findings from Bazelais [10] indicated that grit was not significantly correlated with student cumulative GPA or a final exam score.

Previous research has not been investigated grit on performance of project-based learning. Basically, in order to complete a project assignment, students need to maintain their effort, self-control and hard working. Therefore, determining grit score of a team may be another approach to establish the effect of grit on a success of student learning.

1.3 Hypothesis

In this study, we hypothesized that:

- When students encountered a problem, a group that tried to solve the problem early (planning and implementing) would achieve better performances in the project than other groups that did so later.
- A group that spent more days on planning their work would complete the project with better results than others who spent fewer days on planning it.
- A grittier group (a group with a higher average grit score) would yield a better project outcome than a group with a lower average grit score.

2 METHODS

Data collection had been conducted twice in a course of Statics and Dynamics during Fall semesters of 2015-2016 and 2016-2017. Subjects were second-year undergraduates in the program of Robotics and Automation Engineering at KMUTT. For the first sessions, 74 students (17 females and 57 males) were divided into 10 teams. A motion machine project was assigned to students (10 teams). They had to build a machine that could move continually after an energy was given only once and the last one stopping would win the tournament. They had 4 weeks to finish the task. Sixty-eight students (10 females and 58 males) from the second session were separated into 9 groups. During the class, the instructor assigned a waterwheel project to students (9 teams). They had to build a machine that could pump water continually after an energy was given only once and the last one stopping would win the tournament in 7 weeks. Both sessions had to record a project daily log manually as a team progress, and they had to submit it to the instructor or a teaching assistant every week. Moreover, the 12-Item grit scale [8] was collected before and after the project assignment of the session 2 in order to evaluate whether the character trait impact project achievement.

2.1 Project Daily Log

Each team had to record the daily log as a project progress and submit it to the instructor or a teaching assistant every week. To check whether students made any progress on each day, they had to answer these 3 questions:

- Did you plan for your project today?
- Did you build or construct a prototype for your project today?
- Did you have any problem when you did your project today?

After the projects had completed, we analyzed student's working process by computing a number of days before planning, a number of days before implementing and a number of planning days before implementing. A number of days that we computed was relative to the day that they faced problems. For example, if a group of students got a project problem on Friday, they might start planning and discussing the problem in a group on Monday. Thus, the number of days before planning would be 3. An example of a daily log worksheet is shown in Fig. 1.

Team	Process	Week 1							Week 2						
		Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.
	Planning														
	Implementing														
	Problem														

Figure 1: example of project daily log

2.2 12-item Grit Scale

The 12-item grit scale [8] was translated to Thai by lecturers in Thai universities, and then it was validated by 3 experts in languages including 2 Thai-English translators and a Thai language teacher using the Item-Objective Congruence (IOC) [11]. The evaluation process was that the experts had to rate how accurate each question was translated from degrees of -1 (clearly incorrect), 1 (clearly correct) and 0 (unclearly translation). Results of the translated questionnaire were 0.67 for the question 1-4 and 7-12, and 1 for the question 5-6 and 12. Since the IOC indexes were greater than 50 %, it indicated that the questionnaire was able to be used in the study. It was given to the students of the session 2 before and after the project assignment.

3 RESULTS

In order to analyze success factors of the projects, we used tournament time and volume of water as success outcomes of session 1: class of 2015-2016 and session 2: class of 2016-2017, respectively.

3.1 Session 1: Class of 2015-2016

All teams in session 1 had to build motion machines that could move continually after giving energy only once in 4 weeks. The tournament time of each time ranged from 50 to 2640 seconds (Mean (M) = 843.1, Standard deviation (SD) = 813.0). Results from the project daily log of the class of 2015-2016 are shown in Fig. 2-4. There were no significant correlations between a number of days before planning and a duration that a machine could move, and a number of days before implementing and the duration (see Fig. 2 and 3). However, there was a positive correlation between a number of planning days before implementing and the tournament time, but it was not significant (see Fig.4). This indicated that the groups that spent much time on planning the project when they faced problems were likely to achieve greater outputs than that others that spent less time on planning it.

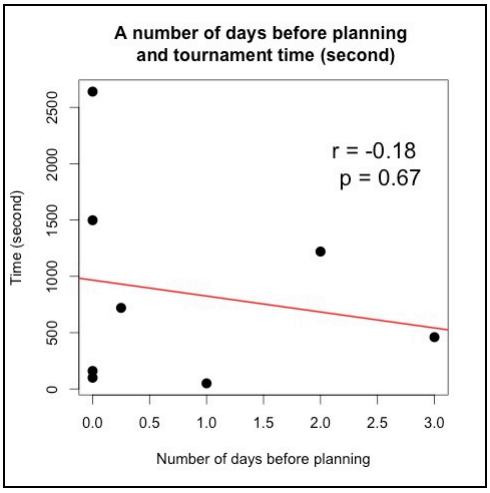

Figure 2: Correlation between a number of days before planning and tournament time

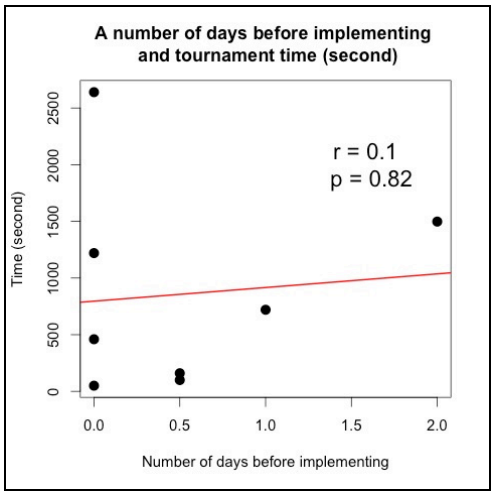

Figure 3: Correlation between a number of days before implementing and tournament time

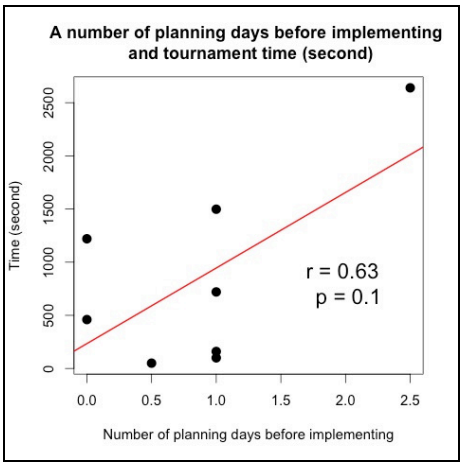

Figure 4: Correlation between a number of planning days before implementing and tournament time

3.2 Session 2: Class of 2016-2017

Fig. 5 shows an example of a water wheel prototype and results from the class of 2016-2017 are shown in Fig. 6-8. The volume of pumped water of each team ranged from 0 to 5700 cubic centimeters (cm^3) (M = 1594.44, SD = 1771.55). A negative correlation between a number of days before planning and pumped volumes of water was significant (see Fig. 6). There was also a substantial positive correlation between a number of planning days before implementing and the volumes of water (see Fig. 7). However, a correlation between a number of days before implementing and pumped volumes of water was not significant (Fig. 8).

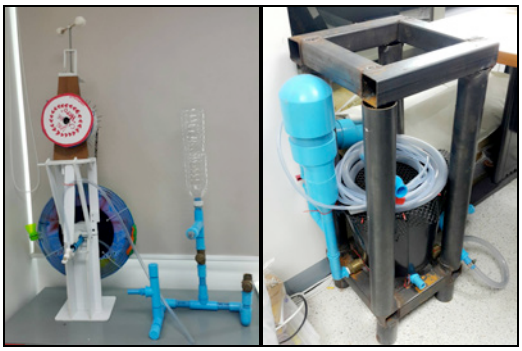

Figure 5: example of a water wheel prototype

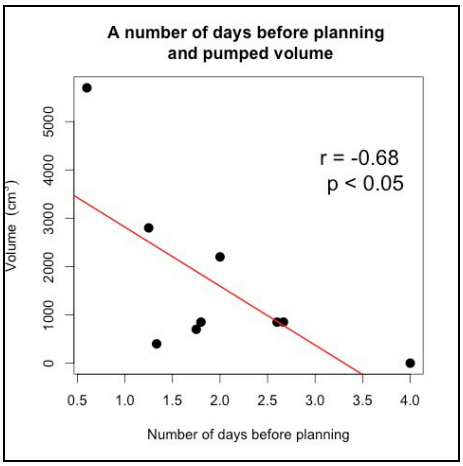

Figure 6: Correlation between a number of days before planning and volume of water

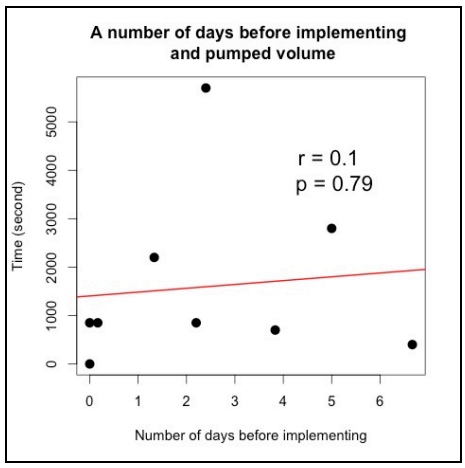

Figure 7: Correlation between a number of days before implementing and volume of water

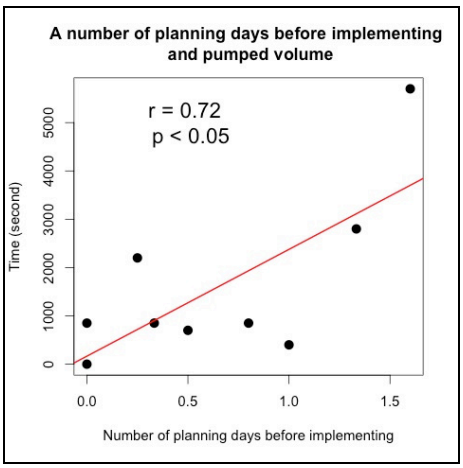

Figure 8: Correlation between a number of planning days before implementing and volume of water

The 12-item grit scale was given to the students before and after the project. There were only 55 students who completed both pre- and post-grit tests and means of pre-score and post-score are 3.16 ± 0.38 and 3.29 ± 0.37, respectively. An average score of each team was computed as well as a correlation between the score and pumped volume. Nevertheless, it was not significant (see Fig. 9).

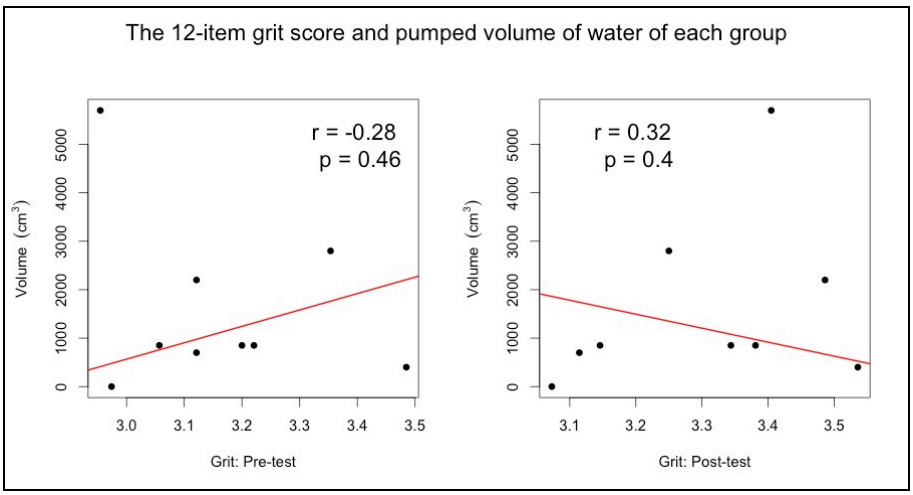

Figure 9: pre- and post-grit score and water volume

4 DISCUSSION AND CONCLUSION

The goal of this study was to investigate how processes of planning, implementing and dealing with a problem influenced performance of a team project. The results showed that the negative correlation between a number of days before planning and the project outputs was significant only in session 2: the water wheel project. Similarly, a number of planning days before implementing and volume of pumped water were significantly correlated. These findings suggested that for session 2, a success factor of the project was a number of days before planning. It could be explained that if students in a team start solving problems earlier, they will get better results than the others who did it later. Another success factor was a number of days that they spend on planning before implementing. It could be concluded that if members in a team spend more days on planning, they will yield better results than the others who spend fewer days on planning it.

However, none of results from session 1 were statistically correlated. That might be because the total amount of time that students in session 1 had to complete the project was shorter than the amount of time the other session got (4-week task versus 7-week task). The project duration could affect the amount of data that we got from the project daily log. In addition, results between a number of days before implementing and the project outcomes on both sessions were not substantial correlated. We hypothesized that sometimes, when students had project problems, although they tried to come up with some solutions as in a planning process, they had not implemented it until a couple weeks before a deadline of the assignment.

Another factor that we tried to investigate in the study was grit. Results of team grit scores were not significantly correlated with volumes of water, the session 2 project outcomes. It indicates that even though members in a team get higher grit scores, it does not affect the project achievement. Nevertheless, it could be argued that since the definition of grit is individuals' passion and perseverance for long term goals, the team grit score which was computed from the individual grit might not be properly represented the team effort.

For future work, we should increase a number of teams in order to achieve concreted results. We also would like to develop an automatic data collecting robot or a chatbot that can track student's teamwork. Previous research has been tried to apply a chatbot to a field of Education. For example, Freudbot [12] was used for online learning and distance education or MOOCBuddy [13], a recommender system in Facebook Messenger, has been used to find best learning resources on Massive Open Online Courses (MOOCs) for users based on their information on Facebook . Our chatbot may be similar ELIZA [14], the first chatbot, or ALICE, the most successful chatbot. It can communicate with students directly and remind them to record the project daily log.

Altogether, the findings suggested that when the students had a problem with the project, when they started implementing it did not affect their project outcomes. However, focusing more on planning before implementing a prototype has a positive influence on the final results.

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