A Very Short Capstone Project Design Management and Design Tactics

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***Abstract*—Multi-disciplinary design projects in the graduating year of undergraduate study are one of the most challenging tasks for both students and faculties. The faculties need to define and organize projects that are suitable for all students from all different disciplinary. In our context, the students come from different disciplines, namely Product Design (PD), System Design (SD), Information Science Design (ISD), and Architectural Design (AD), which are the most diversify group of students. The students from different discipline must have a mutual understanding of the project execution, set the right expectation and exercise proper project management skill. This work summarized the guidelines for the multi-disciplinary design project management bases on the instructor's and student's perspectives.**

***Keywords*— ethics, design project, design tactics, multi-disciplinary, project management.**

I. Introduction

In the academic institution, the design project also serves as a tool for teaching and learning to achieve the Student Learning Outcomes (SLO) in a broader and deeper manner, [1-2]. The final year project in the institution is a multi-disciplinary design project. Together with industries, the design projects are proposed and planned. The project scope must be suitable for a group of students that come from different pillars, e.g. EPD, ESD, ISTD, and ASD. In another word, no project can have a group of students from one discipline only. EPD students mainly focus on engineering solution from hardware design perspectives, such as electrical engineering, mechanical engineering, materials engineering, etc. On the other side, ISTD students focus on engineering solution from software design perspectives, such as programming, software engineering, etc. Students from ESD focus on system-level modeling, optimization, etc. Lastly, ASD students focus on architectural design.

This kind of final year project is called capstone project in most of the institution. As illustrated in **Figure 1**, the pillars represent the four disciplines in supporting the capstone project, [3]. Due to the diversity of the students' background, and the multi-disciplinary nature of the project, the management of the project is extremely challenging for both instructors, as well as the students, although the students have explored to the multi-disciplinary design projects in their study, [4].

This paper is organized as follow. Section-II describes the basic working principles of the capstone projects management. A few important design tactics and guidelines for the capstone project is described in Section-III. The students' experience and advice are also shared in Section-IV. Section-V concludes the paper.

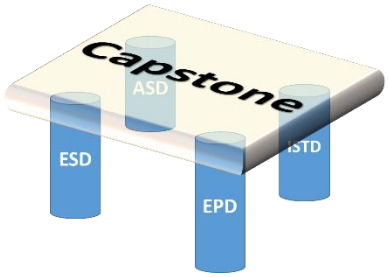

Figure 1. Capstone project organization bases on four major disciplines

II. Working Principles in Project Management

Regardless nature of the project, one can treat a project difficulty level either a 'complicate task' or an 'uncertain task.' The basic guideline will be nailed down to make 'uncertain task' to 'complicate task' which is manageable. A complicated task can be managed technically, but the uncertain task may require consultation with product owner (role of the industry sponsor), carrying out a survey to know the market, consultation with product supervisor (role of the university instructor), etc.

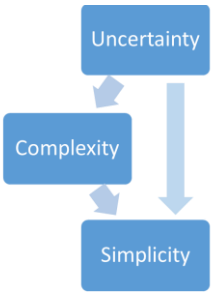

Figure 2. Uncertainty concept

Uncertain does not mean complicated or more difficult, but it is a barrier for the project to progress. One should also realize

that perception about task difficulty level is different for different personal. A task maybe 'uncertain' for one student, but only a 'complicated' for another student. In this case, once the students could define the difficulty level by identifying the supporting factor. They could bring their thought to the group discussion for a solution. It is to resolve the uncertainty to the complexity and followed by the simplification. The guideline is summarized as:

i. Is this a complicated task or an uncertain task?
ii. Why?
iii. List down the reasons by an individual team member.
iv. Bring for group discussion, and generate the solution.

Capstone project execution involves various parties from different entities. The parties are students forming the capstone team, university instructor as product supervisor, and lastly industry sponsor as product owner. The roles and responsibilities must be defined and make know to the three parties.

i. Capstone Team: Students form the team members are responsible for any part of the design and development process of the product.
ii. Product Supervisor: Institute faculties who advocates for improving the capstone team performance.
iii. Product Owner: Industry sponsor who represents the customer or stakeholders that prioritize the work of the Capstone Team. Product Owner also responsibility in given the specification of the product.

Figure 3. Engineering ethics

There are too many aspects of engineering ethics in the practical engineering industry, [5]. The morals are part of the ethics in a group project, as illustrated in Figure 3. As can be interpreted from the figure, the morals are much more constrained to an individual. However, the ethics set the boundary for a team member in the design project management specifically. In our context, the most important code of ethics that one must stick to is

"***A practitioner must co-operate in working with other professionals engaged in a project***", [6].

A team member must have the following attributes:

i. Carry out his/her task in the team, and always considering the integration.
ii. Resolve conflict among team members as soon as it was found.
iii. Be positive always in the team.
iv. Be part of the team, and everyone must contribute to the project.
v. Project member cannot only focus on the project management, as everyone must contribute to the technical solution.

The project schedule is constrained by academic calendar, the Product Supervisor must setup a predictive project management framework to schedule the project. At the project team level, however, adaptive project management must be adopted to address the multi-disciplinary aspect of the project. We cannot expert all disciplines can achieve to a similar level of accomplishment at the same period. The team members must learn the new skill along the way, where Just-in-Time Learning (JiTL) must be carried with them, [7].

It is a big mistake if the project's documentation such as report is only prepared at the end of the design phase. A lot of detail will be missed if the report is prepared in a rush, especially it is a report for capstone which requires a lot of information from system level to every single component design and integration. One must start the documentation on the day one of the project execution, and a few good habits:

i. Getting the proper technical document template ready for every team member.
ii. Updating the report for every review.
iii. Keeping the technical sketch, image, photo, video, simulated results, Computer-Aided Design (CAD) drawings etc. in the appendix.
iv. Converting the report content to presentation slides for review to save time in documentation.

III. Design Tactics

The goal of the capstone project is to provide a complete solution to the industry that sponsors and supports the project. In this case, the project is not merely an academic exercise, but a project that solves the real-world problem. Naturally, the final work should not only functional but also presentable and attractive as the following quote:

"*When I am working on a problem, I never think about beauty. I only think of how to solve the problem. But when I have finished,* ***if the solution is not beautiful****, I know it's wrong.*" - Buckminster Fuller.

The design tactic here is one must always consider how to present the product in the design phase besides technical consideration.

The three parties in the capstone project shall not be trapped by the ***Not Invented Here*** syndrome in the capstone project execution. A useful solution does not need to be novel always. Instead, it is about the innovation which focuses on the modification or improvement of the existing solution. One should always value the originality of the solution which is brand new, but does not mean rejecting any possible solution.

Of course, one shall not fall into the extreme of ***Never Invented Here*** syndrome, by simply copying existing work without improvement. The design tactic here is about the innovativeness rather than an expectation.

This is always a bad habit of spending too much time in planning and brainstorming without any execution or implementation of the design. The design cycle can be shortened if one can identify a similar design to study, duplicate and finally turn into a design solution. It is nothing wrong "***Standing on the shoulders of giants***". Isaac Newton has used this phrase a few hundred years ago, [8].

IV. Student Perspectives

The above guidelines, and tactics are provided by the experience instructors. However, the students who are the real stakeholder has also shared the following experiences which are helpful for the most challenging project in the undergraduate study.

It is very common to have an in-experience and an irresponsible instructor who sets an impractical goal. In such case, the project team members should continue work hard and independent. In short, bear with something that you cannot change, and continue work with a positive attitude.

The project team has been formed with the computer program that considers only numerical value such as academic results. It is inevitable a team member is inactive, who would not spend time for the project. This situation must be reported if project progress is affected. If you are lucky to have active instructors, you must report and seek help. Otherwise, work hard with other members and distribute the work excluding the in-active member to prevent undeliverable of the project. In this case, seek for approval to outsource the non-critical task.

All members must meet and brief each other the progress before the weekly review meeting with the instructors. This process is to improve the effectiveness of the review, and reduce the possibility of conflicting each other. There must be a note-taker during the weekly review meeting.

V. Conclusion

This work provides a very short guideline for the capstone project which is full with uncertainties. Student's perspectives are also taken into the text for sharing. The guidelines serve the institution's capstone project which involves the most diverse group of students, in the knowledge of the author. Similar approach can easily be adopted by another institution.

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References

[1] J. W. Best and J. V. Kahn, Research in Education 8th Edition, Needham Heights, MA: Allyn and Bacon, 1998.

[2] T. H. Teo, "Student learning outcomes accomplishment through design project," *GSTF Journal on Education (JEd)*, vol. 3, no. 2, p. 19, 2016.

[3] "Capstone Project," Great Schools Partnership, 23 March 2016. [Online]. Available: http://edglossary.org/capstone-project/.

[4] T. H. Teo, "An effective interdisciplinary teaching and learning methodology through crossed-subjects design project," *GSTF Journal on Education (JEd)*, vol. 3, no. 2, pp. 18-22, 2016.

[5] C. E. Harris, M. S. Pritchard, M. J. Rabins, R. James and E. Englehardt, Engineering Ethics: Concepts and Cases, 5th Edition, Cengage Higher Education, 2014.

[6] "Professional Engineers, Ontario, Canada," Professional Engineers Ontario, 2013. [Online]. Available: http://www.peo.on.ca/. [Accessed 13 October 2016]

[7] T. H. Teo, "Just-in-Time teaching visual instruction for cohort base interactive learning for engineering course," *GSTF Journal on Education (JEd)*, vol. 3, no. 1, pp. pp. 1-4, 2015.

[8] G. Martin, "The meaning and origin of the expression: standing on the shoulders of giants," 1996-2016. [Online]. Available: http://www.phrases.org.uk/meanings/268025.html.

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