Project Design (PD) Education System - A Model to Equip Industry-Ready Engineers A Case Study of Project Design I

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Project Design (PD) Education System – A Model to Equip Industry-Ready Engineers

A Case Study of Project Design I

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Abstract— **This paper describes the Project Design (PD) Education at Kanazawa Institute of Technology (KIT) and an effective module to equip students with the relevant skillsets of an engineer to be ready for the industry. A case study of the Project Design I (PD I) is used to demonstrate the workflow involved. The process in each Project Design (PD) courses will ensure students acquire soft skills, e.g. communication, collaboration/teamwork, presentation, etc., from early years and continue to apply the skills in their problem-solving process at the final year. This paper also illustrates several steps involved in the process such as identifying, investigating and analyzing problems before creating ideas or providing selected solutions to the problems. Teamwork skills are specifically instilled in the course in order to ensure participation of each student. The communication and thinking skills that were claimed lacking before, are improved with the continuity of the courses in any educational program.**

Keywords—Project Design Education System, Industry-Ready Engineeers, Teamwork, Communication and thinking skills

I. INTRODUCTION

Problem or Project-Based Learning (PBL) is a well-known teaching model implemented by many higher learning institutes to produce students with high thinking skills. This approach requires students to analyze problem, investigate problem, create, justify or evaluate their solutions and it is normally embedded into higher level of engineering courses such as in [1-7]. However, the PBL courses are introduced quite late and they are inadequate for students to become skill-full graduates. Payscale, Inc. reveals in the 2016 Workforce-Skills Preparedness Report [8] that 60 percent of managers feel critical thinking/problem solving is the soft skill lacking the most among recent college graduates while 39 percent of managers feel public speaking skill in recent graduate is frequently lacking or absent. These soft skills cannot be learned by just studying about them but they have to be learned through a process of change [9]. They require prolonged and systematic efforts in order to convert weaknesses into strengths and to be successful.

KIT observed this issue when they implemented Engineering Design (ED) classes with PBL in 1995 and a subsequent review in 1999. [10-12]. They found that the students did not fully acquire the soft skills because of the restricted time and probably only focused on developing prototype or verifying function of their design in their ED classes [13]. Another factor that causes the development of critical thinking and problem solving skill being less efficient is technology advancement. Students can get access to all information through internet without analyzing, interpreting and thinking critically and this hinders their ability to solve the problems because internet offers most of the solutions [14]

For the above-mentioned reasons, KIT updated ED to Project Design Education System (PDES) in 2012 which offers continual process in soft skills, especially in innovation skills. With this program, they also identified techniques in developing the skills through some PD courses.

This paper focuses on the methodology of teaching PD courses and illustrates a case study of PD I. Section II of the paper describes the structure of PDES and Section III illustrates the techniques with examples. The last section concludes the findings.

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II. Project Design Education System

Project Design Education System (PDES) was fully developed in 2012 [15] and it becomes the backbone of KIT curricula similar to ED in the past, which all other fundamental and specialized courses anchored on, as shown in Figure 1. The PDES has the following objectives:

(a) To train students to be independent thinking engineers through collaboration with others, learning the process and methods of problems identification and solving; solutions testing, verification and evaluation;

(b) To allow students to think and act independently;

(c) To allow students to implement active thinking;

(d) To allow students to present their results in a detailed and clear manner.

PDES consists of five courses including Introduction to Project Design, Project Design I, Project Design II, Project Design Hands-on, and Project Design III. The PD III is the final year project which students can integrate knowledge from all PD courses and other courses to develop the ability of engineering research and solving problem similar manner to a real-world engineer. Figure 2 shows the details of the PD courses and the workflow. There are two main outcomes from these courses which are to **acquire problem-solving skills** and to **acquire verification process skills**. The objective of Introduction to PD is to get students interested in their major study by exploring things and carrying out experiments safely using appropriate tools by themselves. Therefore, they acquire skills in using specific tools with little theoretical knowledge about it. PD I and PD II, on the other hand, focus on acquiring problem-solving skills. The characteristics of PD I are as follows: -

(1) Integrate knowledge acquired from primary to secondary school into solving a real-world problem.

(2) Discover a problem → Grasp current condition → Analyze the cause → Set the conditions and achievement standards for the solution → Propose a solution for the problem.

(3) Instructors set, in writing, scope of the problem as main theme.

(4) Scope and level of tasks is within the bounds of what students have previously learned.

(5) Activities should mimic OJT (On the-Job Training). Instructors are facilitators, supporting and encouraging students to be active participants.

(6) Problems are from students' own lives (or someone close to them).

(7) Promote awareness of the problems around them.

(8) Understand there are many possible solutions to real-world problems and that it is necessary for those from different fields to work together.

(9) Classes are made up of a mix of students from all departments (in 2018, it is done for partial departments and from 2019, it will be for all departments).

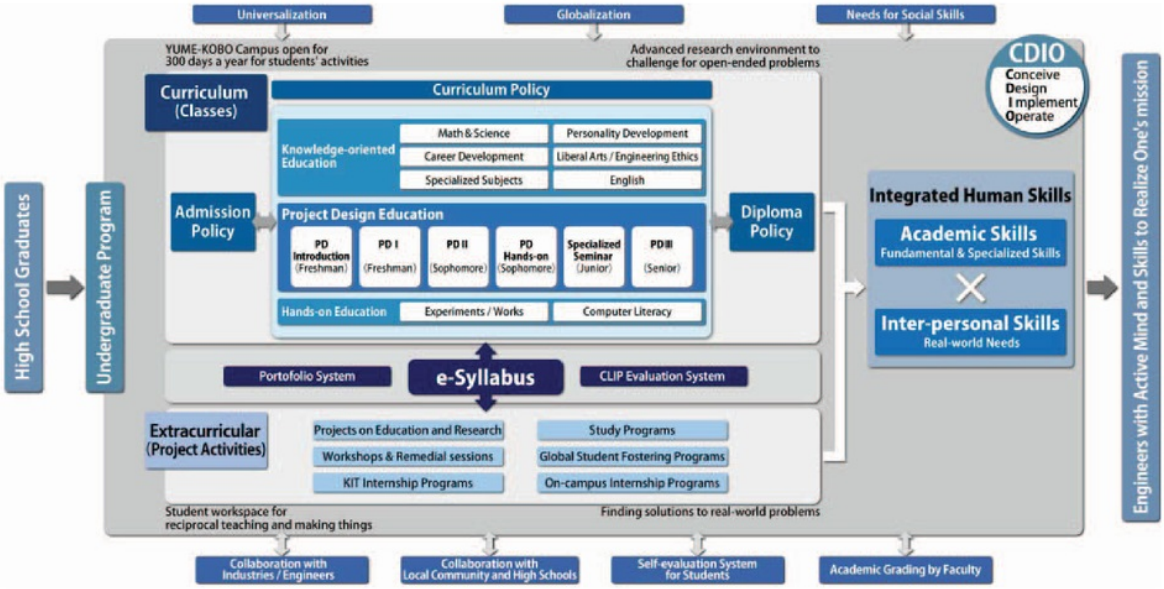


Fig. 1. The framework of KIT curriculum

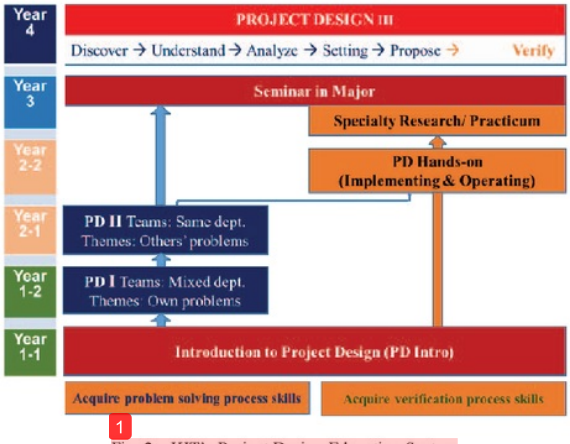


Fig. 2. KIT's Project Design Education System

On the other hand, PD II has similar characteristics as that of PD I, with exception of the last four, i.e. bullet points (6) to (9).

(6) Real-world problems are used (including those from local organizations).

(7) Classes consist of students from the same college or same department.

(8) Connection to PD Hands-on: Practical skills department and each department will work together to determine themes, problem solutions, and team make-up in PD II.

PD I only emphasizes learning the process of acquiring problem solving skills by finding out a problem, collecting information required for problem solving and reporting ideas. The course does not require the students to necessarily make any prototype. PD II also emphasizes the same process of acquiring problem solving skills but with different level of problems. It also requires them to plan for realization of the idea.

The objective of PD Hands-on is to realize and verify some of the functions of students' ideas created in PD II. They polish up the experimental technique and improve their design based on the evaluation results. Through these courses, students appear to be continually repeating particular things, such as literature research, idea creation, investigation and presentations. This will become a habit to them and it will lead them to be actively engaged engineers.

III. Workflow of Project Design I

There are seven steps in the workflow of PD I that guide students in the process of acquiring problem solving skills, from identifying the problem to proposing the solution concept as shown in Figure 3. The Main Theme (MT) of the project is given and students have to identify their Project Theme (PJ Theme), which is related to the MT.

Students work in a group which has five to six members in each group, and there are five to six groups for each class. There is also a structural organization in each group that consists of a leader, a secretary, a recorder, and presenters. These roles are rotated on weekly basis to ensure everyone can serve different roles during the course. This will also help give them a better understanding by experiencing work as a team. Furthermore, students are given individual and teamwork assignments during the course.

In this case study, the MT of the course was "Comfortable Campus Life." The following are the steps that students worked on before proposing a solution to the problem. The results shown in this paper are from one team in the PD I class.

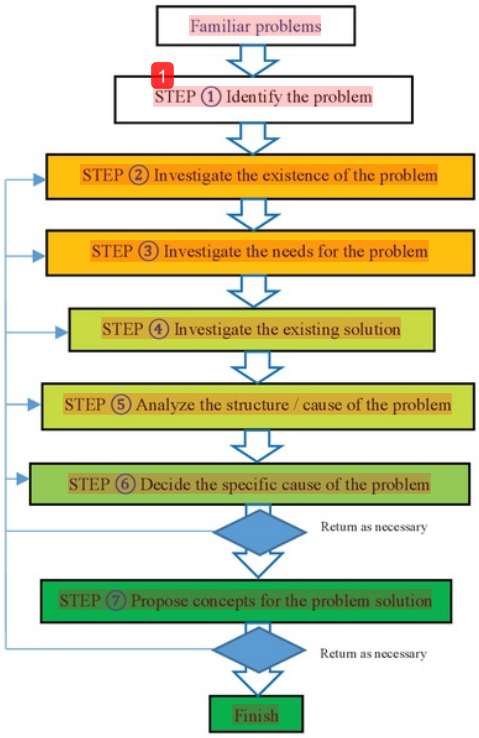


Fig. 3. Workflow of PD1

A. Step 1 – Identify the Problem

After being introduced about the MT, students were asked to look around the campus to find out areas of improvement. Each student gave his or her own proposed opinions before selecting the best idea.

Each student investigated the situation to gather information of the idea selected. Subsequently, he or she proposed the PJ Theme based on his or her observation or investigation result by clarifying the target and its problem.

Students then decided one best PJ theme in the team using matrix evaluation as shown in Figure 4. The PJ Theme chosen in this case is "Cafeteria is crowded during lunch time." The target of this PJ Theme is the KIT's Cafeteria inside the campus and its problem is the crowdedness.

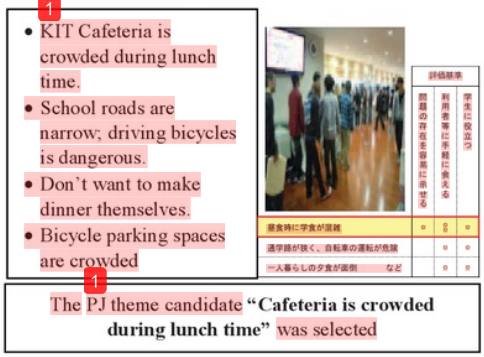
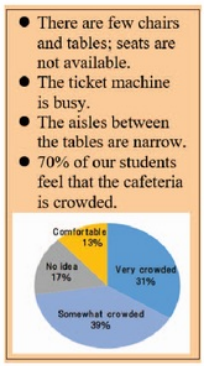


Fig. 4. One example of identifying the problem

B. *Step 2 – Investigate the Existence of the Problem*

Next, the students investigated the existence of the selected PJ Theme problem by conducting surveys and doing comparison with other universities on the similar problem. The questionnaires for the survey were related to the current conditions of KIT cafeteria and the reasons of the crowdedness of the cafeteria. Students worked in a team to define different area of investigation and each member was in charge of investigating one area. Figure 5 shows the findings of the survey.



Current Conditions	
Length of stay	About 20 to 30 mins
Waiting to buy lunch tickets	About 30 to 90 seconds
Number of seats	About 650 seats
Width of aisle	With chair 85cm No chair 120cm

Fig. 5. Investigation results of existence of the problem

C. *Step 3 – Investigate the Needs for the Solution*

More investigations were conducted by the students in order to know the importance of solving the problem of KIT's Cafeteria. Based on the data collection (e.g. interviews, surveys, and any other forms) from users and other related parties at KIT's cafeteria, they found out that many people wanted to solve the crowdedness at low cost. The results were described in form of pie chart in Figure 6.

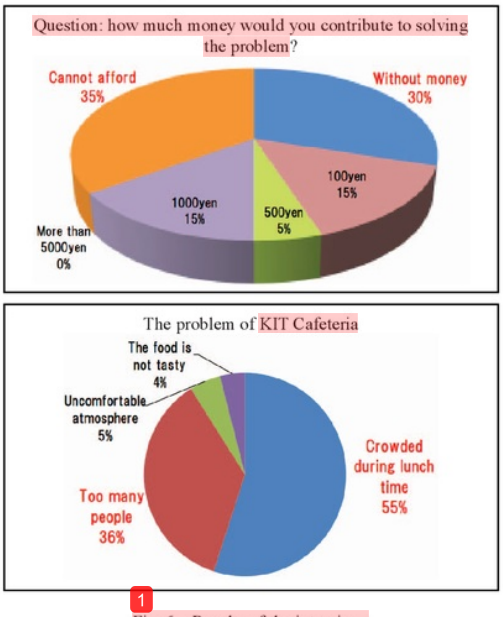


Fig. 6. Results of the interviews

D. *Step 4 – Investigate the Existing Solutions*

In this step, students investigated many existing solutions that were applied to solve crowdedness of KIT's cafeteria, especially the solutions, and explained why the crowdedness was not fully-solved yet.

This investigation was conducted by observing the existing solutions and they were analyzed for each of its ineffectiveness. Examples of solutions available at the cafeteria are shown in Figure 7 below.

Fig. 7. Result of investigation of the existing solution

E. *Step 5 – Analyze the Structure or Cause of the Problem*

In the beginning step of this stage, they did brainstorming to generate all ideas (possible causes of the problem), then by using KJ-method, they grouped all causes in different categories. Next, they transferred those ideas to the fish-bone

diagram to better see the cause-effect of the temporary PJ Theme problem.

The Fish Bone or Cause Effect Method as shown in Figure 8 was used in analyzing the root cause of the problem. Students observed various situations in the Cafeteria and came up with different possible causes of the problem. By placing the causes in a form a Fish Bone, they could see the relationship between each cause and chose one specific cause which could be solved by them.

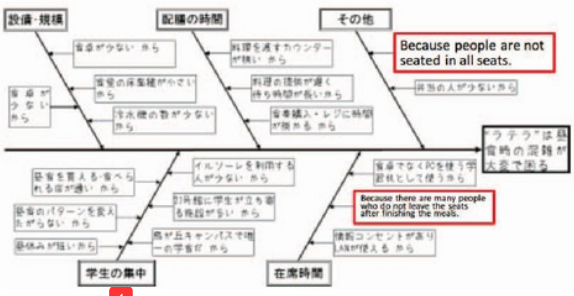


Fig. 8. Fish Bone Method for cause and effect

F. Step 6 – Decide the Specific Cause of the Problem and Setting the Preconditions

Since students cannot propose solutions to all causes of the problem, only one cause was selected to be solved. This selection would depend on the student's evaluation by considering all aspects, including time, ability, and feasibility. The teacher's role is very important here to give advice and suggestions for their decision.

After all the team members agreed on the specific cause of the problem, they had to set the preconditions or limitations for their solutions. The preconditions were based on various investigations they had done on early steps. In this case, they came up with the following preconditions (Table 1).

TABLE I. PRECONDITIONS SET FOR IMPROVING THE EFFICIENCY OF THE SEATS

Preconditions
We cannot make a new cafeteria
We cannot change the size of cafeteria
We cannot change the number of seats
The number of students does not change

G. Step 7 – Propose the Concepts for the Problem Solution

The last step of the process is proposing the concept of the solution. Each member proposed one concept with its description. After deliberating with team members and receiving consultation from their instructors, they chose one best concept in the team and students need to present their ideas using drawings or model and describe it during final presentation. For the Cafeteria problem, one proposed solution is shown in Figure 9 below.

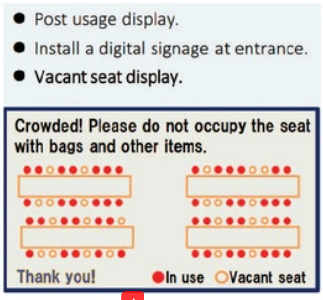


Fig. 9. Concept of Solution for crowded cafeteria

IV. RESULT AND ANALYSIS

For this case study, we only focus on the performance of students' presentation skills. There were three presentations held in this course. The first two were mini presentations whereby the students had to present what they had learnt or found for their PJ Theme thus far. The third was the final presentation which they would highlight their results and findings. The measurement of presentation skills were based on the students' voice projection, body language, eye contact and tools used in the presentation. Figure 10 shows the presentation results and they clearly show that Group 2 to Group 5 had shown a remarkable improvement in their presentation skills at the final presentation.

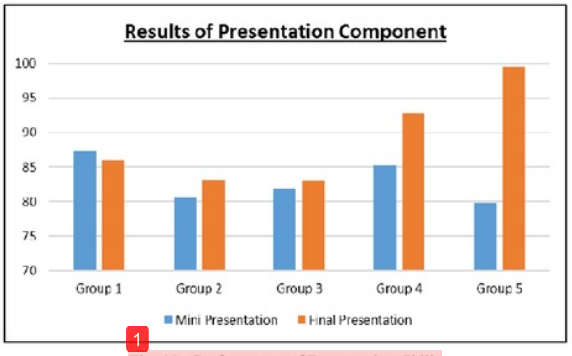


Fig. 10. Performance of Presentation Skills

V. CONCLUSION

The Project Design Education System is well established in Kanazawa Institute of Technology (KIT) and had trained many engineers working in the industry. The high percentage of 99.9% of students from the academic year 2016 (students who graduated in March 2017) who secured a job proved that KIT graduates are highly sought after by the industry. The relevant skillsets acquired while studying in KIT enabled the graduates to be more effective at their workplace.

The PD I case study illustrated the systematic approach of problem solving. The students went through each step with

clear learning objectives. Apart from sharpening their analytical skills, other complementary soft skills, such as communication, collaboration/teamwork and presentation, have seen marked improvement throughout the course of their study in KIT.

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