Solution-Based Learning Implementation in Design Course

Risdiyono

Mechanical Engineering Department, Islamic University of Indonesia, Yogyakarta, Indonesia

Corresponding author: risdiyono@uii.ac.id, https://orcid.org/0000-0002-1395-6023

Abstract. Student participation is a key success in almost every learning process. It is believed that concept-level of understanding could be achieved only if students are actively involved in the learning activities. The concept of student centered and active learning is usually adopted in order to improve student participation. Problem Based Learning is one of popular methods used in this paradigm, in which students learn both thinking strategies and domain knowledge of a subject through the experience of problem solving. In addition to this current well-known learning method, this paper introduces a new approach so called Solution Based Learning in which students learn about a subject by analyzing solutions that has been given by some experts. Basically, the concept urges students to analyze the way of thinking of the experts on why they could give the solution like this and that. Students then may adopt the thought or criticize it in a positive manner. In order to see its viability and applicability, this new concept has been implemented in Product Design and Development Course as a case study. Based on the process performance analysis, it is shown that the proposed approach is able to improve student participation, to make class more active and to improve the overall student understanding of the subject of study.

1. Introduction

Product Design and Development (PDD) Course plays a very important role in enhancing student competency in design and manufacturing. The basic competencies every student should fulfill after completing the course include a comprehensive understanding of industrial product design and a wide-range ability to bring the design theory into real implementation. Hence, the success in delivering the course will give a significant contribution to the student’s standard competences.

Good understanding of PDD concept is a foundation for students to do a final project, as it is a combination of many important preceding subjects (figure 1). Therefore, the ability to identify market opportunity and customer need, to define product specification, to generate product concept, to evaluate and select optimum concept, to create prototype and to do final product evaluation are some skills students should have in doing a project, especially that relates to PDD topics.

One of important indicators in evaluating learning process is the level of students’ active participation in the class and their average final grade. From previous experience, it is observed that Teacher-Centered Learning (TCL) could not give optimum result. Student participation is very less due to monotonous environment as teaching method is relied only upon the slides in a lecture-based environment.

Fundamental principles that significant to teaching and learning include: (1) knowledge is constructed from the experience of the learner; (2) knowledge resides in the mind rather than...
externally; (3) learning is a personal interpretation of the world in that the learner's beliefs and values are used in interpreting objects and events; (4) learning is an active process of making meaning from experience; (5) learning takes place in contexts relevant to the learner; (6) reflection is an essential part of learning; and (7) learning is a collaborative process in which multiple perspectives are considered[1].

Figure 1. Relationship between Product Design Course and other subjects

It is reasonable to say that there is no best method that suitable for all learning situations. A proven good teaching method for a subject is not always good when applied for another subject. Hence, teaching method should be build based on the characteristics of the course, students’ motivation and facilities availability. The introduction of new approach of Student Centered Learning (SCL) gives different paradigm and diverse point of view in order to optimize its goal achievement. Combination of many methods in teaching should be a good alternative to a single method.

2. Student Centered Learning

The term Student Centered Learning (SCL) is widely used in literature. Many terms have been linked with SCL and therefore the term can mean different things to different people. The notion that unifies them together is that the student is the central entity who must be actively engaged in learning things. Rogers [2] describes SCL as the shift in power from the expert teacher to the student learner, driven by a need for a change in the traditional environment. The power shift paradigm from teacher to the students has emphasized focus on learning rather than on teaching [3,4].

The use of Student Centered Learning concept appears to be thoughtful of today’s society. Lea et al. [5] reviewed several studies and found that overall it was an effective approach. In this approach, students felt that there was more respect for the students, it was more interesting and it boosted their confidence. Correspondingly, Hall and Saunders [6] found that students had increased participation, motivation and grades in an Information Technology course where 94% of the students would recommend it to others over the more conventional approach.

The implementation SCL is believed to provide numerous benefits in the classroom including a greater depth of understanding of concepts, broader knowledge base, improved communication and interpersonal/social skills, enhanced leadership skills, increased creativity, and improved writing skills. There are many types of SCL, including project-based learning and problem-based learning.

Project Based Learning is a comprehensive viewpoint focused on teaching by involving students in investigation. Students pursue solutions to nontrivial problems by asking and refining questions, debating ideas, making predictions, designing plans and/or experiments, collecting and analyzing data, drawing conclusions, communicating their ideas and findings to others, asking new questions, and creating artifacts [7]. Teacher as facilitator gives a "driving question" to students working as a team to respond to, and then direct them to create an artifact (or artifacts) to present their gained knowledge.
Artifacts may include a variety of media such as writings, art, drawings, three-dimensional representations, videos, photography, or technology-based presentations.

Problem-based learning assigns students learn about a subject through the experience of problem solving. Students learn both domain knowledge and thinking strategies that can help the students develop flexible knowledge, effective problem solving skills, self-directed learning, effective collaboration skills and intrinsic motivation [8].

Students, working in groups, identify what they already know, what they need to know, and how and where to access new information that may lead to resolution of the problem. Teacher, known as the instructor or tutor plays a significant role to facilitate learning by supporting, guiding, and monitoring the learning process [9]. The tutor needs to build students' confidence, encourage them, while also stretch their understanding.

3. Solution Based Learning: A New Approach

Problem-based learning has been implemented widely in many disciplines, mainly in medicine, pharmacy, biology, social, economy, law, as well as engineering. In engineering, however, project-based learning is more popular due to its unique characteristic (i.e. the creation of artifacts at the final phase).

Based on the characteristic of PDD course, project-based learning is considered as a good candidate to be adopted in learning process. However, in order to improve its effectiveness, some modifications might be needed. Presented in this paper is a research on project-based learning modification so-called “solution-based learning” as a contrary to “problem based learning”. While problem-based learning aims on student activeness through dealing with a “problem” to be solved, solution-based learning provides students a “solution” to be analyzed.

Solution-based learning (SBL) is a new term coined for learning method that encourage students to learn from proven solutions given by the experts (learning from experts). SBL has inherent capacity towards increased emphasis on preset values and measures, clear outcome indicators, and ability to generate meaningful feedback [10]. Therefore, when the outcome of problem-based learning is a proposed solution from student discussion to a problem defined by facilitator, the outcome of solution-based learning is students’ comprehensive understanding about “how and why the solution is like this”. Students have also opportunity to examine pros and cons of the solution (that might be outdated already) that can be starting point to make improvements. This method enables students to know and see how the experts found solution of the problems under investigation, and then adopt them to solve similar cases. The example of implementation of the proposed method is shown in figure 2.

![Figure 2. Example of solution-based learning study path](image-url)
In order to implement SBL, supporting media should be provided while combination of lecture, group discussion, question-answer, and student presentation as well as information technology practice should be used. The media used in this research includes mechanical products, industrial products and art-jewelry products. The examples of real products as learning media can be found in figure 3. A total of 12 products are available to be chosen by students that have been randomly grouped.

![Figure 3. Example of a real product as learning media](image)

4. Implementation and Discussion
The new approach of solution-based learning has been implemented in Product Design and Development course with 60 students registered. The students were grouped into 10 groups with 6 students in each group. Every group took one product as object of investigation. Presentations of all groups were made in order for students share their thought and improve their presentation skill. In addition, discussion and question-answer session were employed so that multi-direction interaction could be made. Learning atmosphere was very joyful and student participation was very high. The classroom scenery can be depicted in figure 4.

![Figure 4. The classroom scenery](image)

In order to evaluate students competency achievement and learning indicator accomplishment, many aspects have been considered including quiz, question-answer, students presentation, mid exam, final exam and group project presentation. Performance indicators of PDD course by using solution-based learning can be found in table 1, while examples of student’s work is shown in figure 5.
Student perception on SBL method has been evaluated by using a questionnaire. Two other courses delivered in conventional method were used as comparators in order to see the objectivity. Twenty-two items were questioned by using rating scale (1-4). In general, it is shown that SBL method perceived better than traditional method. This result is in line with the finding of Chandra [11] and Rowe [12]. Outstanding improvements include (figure 6):
- Learning environment is more joyful
- The assignment is very helpful
- New knowledge is engaged more
- Feedback for assignment is managed better
- Classroom become more alive

Table 1. Performance Indicators of PDD Course

| No | Indicator          | Base Line | Target | Achievement |
|----|--------------------|-----------|--------|-------------|
| 1  | Attendance         | 79%       | 85%    | 95%         |
| 2  | Grade > C          | 46%       | 75%    | 88.3%       |
| 3  | Satisfaction level | -         | 3.5/4.0| 3.65/4.0    |

In addition to questionnaire-based analysis, Focus Group Discussion (FGD) was also conducted, incorporating 10 representative students from all groups. Some advantages of SBL identified by students include improvements in:
- Computer skills related to CAD system and software
- Teamwork skills
- Time management
- Self-evaluation and objectivity

It is important to note that many students were identified uploading their project to social media like Facebook and Instagram, and used the media to show their project to public. This indicates that they were happy with the project.
5. Conclusion
Solution-based learning, a new approach of Student Centered Learning has been introduced. The concept places students in the center of activity in analyzing a proven solution provided by experts. The outcome of solution-based learning is students’ comprehensive understanding about how and why the experts gave that solution of the problem. Opportunity to examine pros and cons of the solutions can be used as starting point to adopt them to solve similar cases or to make new improvements. The concept of solution-based learning has been implemented in Product Design and Development course and it is found that in general, the proposed approach is able to improve student participation, to make class more active and to improve the overall student understanding of the subject.

References
[1] Semple A 2000 Learning Theories and Their Influence on The Development and Use of Educational Technologies Australian Science Teachers Journal 46 3.
[2] Lea S J, Stephenson D, and Troy J 2003 Higher Education Students’ Attitudes to Student Centred Learning: Beyond ‘educational bulimia’ Studies in Higher Education 28 3
[3] Hall J and Saunders P 1997 Adopting a student-centred approach to management of learning in Bell C, Bowden M, and Trott A (Eds.) Implementing Flexible Learning (London: Kogan Page)
[4] Barr R B and Tagg J 1995 From Teaching to learning - A New Paradigm for Undergraduate Education *Change* **13** 25.

[5] Rogers C R 1983 *As a teacher, can I be myself?* in *Freedom to Learn for the 80’s* (Ohio: Charles E. Merrill Publishing Company)

[6] Blumenfeld et al 1991 Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning *Educational Psychologist* **26** 3

[7] Silver H and Cindy E 2004 Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review* **16** 3

[8] Schmidt, Henk G, Rotgans, Jerome I, Yew, Elaine H J 2011 The process of problem-based learning: What works and why *Medical Education* **45** 8

[9] Edwards R 2001 *Meeting individual learner needs: power, subject, subjection* in Paechter C, Preedy M, Scott D, and Soler J (Eds.) *Knowledge, Power and Learning* (London: SAGE)

[10] Khattak A 2018 Solution-Based Learning: Educating for Solutions *Khyber Medical University Journal* **9** 4

[11] Chandra V J 2016 Solution-based Learning(SBL): Using Systems Engineering Principles to Guide Capstone Projects in Technology *Proceeding of ASEE Annual Conference & Exposition* 2016

[12] Rowe R 2016 *Solutions Based Learning in Education*. Available online at: https://www.ole.org/2016/02/solutions-based-learning/