Evaluating project-based design learning in Manufacturing Engineering University of Surabaya

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ABSTRACT: Project-based learning is defined as a systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks. Manufacturing Engineering, University of Surabaya has implemented project-based learning in some design courses. One of those courses, which named Design Project, is used as a case study in this paper to evaluate the implementation of this learning method. The goal of this course is that students must have certain competencies in product design i.e. ability to design and develop a manufactured product, to analyse a design of product, to determine the optimal process needed to manufacture the product, and to analyse and optimise the cost involved in the design and manufacturing process. The implementation of project-based learning in this design course has some advantages and disadvantages. This paper presents an evaluation of implementation of project based learning in product design that is performed in Manufacturing Engineering, University of Surabaya and gives some suggestions for development of the project based design learning in the future.

1 INTRODUCTION

Manufacturing is the transformation of raw materials into finished goods for sale. Manufacturing encompasses the design of the product, the selection of raw materials, and the sequence of processes through which the product will be manufactured (Kalpakjian, 2001). Instead of that definition, some industries, like semiconductor and steel manufacturer use the term 'fabrication' to define manufacturing. In the process, manufacturing engineers often create simulations of the operation of objects, as well as the manufacturing processes to be used, in order to optimize performance, cost effectiveness, and energy efficiencies, before settling on a particular design.

University of Surabaya is one that offers undergraduate programme in manufacturing engineering. The programme related with product design and development, beginning in idea, design concept, and realized into a product through manufacturing processes. The aim of the programme is to prepare professionals that give their contribution to manufacturing industries sector by providing its students with competencies in product design and development, manufacturing process design and optimization, and manufacturing system design and operation. The graduate students from Manufacturing Engineering at University of Surabaya can involve in product design and development, manufacturing processes design, improvement effort of productivity, quality control, or other related field of work. Some of them have already got a good careers in all walks of

life particularly in manufacturing industry such as chief of work shop at jewelry industry, area manager at accessories of automobile industry, manager at spare part of automobile industry, staff of production department at house ware industry, product designer at paper industry, etc.

There are two specific areas of expertise in Manufacturing Engineering at University of Surabaya, which are Product Design and Manufacturing Technology and Management. Product Design area is focused on how to design a product based on concepts, function, aesthetic, usability and ergonomics. The main courses in Product Design area in curriculum 2000 are Engineering Mechanics, Engineering Drawings, Strength of Materials, Computer Aided Design/Manufacturing, Ergonomics, Machine Elements I, Machine Elements II, and Product Design and Development. Along with those courses, there are two courses in form of project-based course, which are Machine Elements Analysis and Design Project.

For some following reasons, these two project-based courses were designed and implemented as courses in Product Design in curriculum 2000 area. At the end of implementation of the previous curriculum, it was found that skills of students in design did not achieve the expected level. Based on the evaluation results, one of the main causes is that students did not know how to apply the theory of design in practices. The second reason is that the economic situation and condition of Indonesia require professionals, which have knowledge and skills in design, to improve the competitiveness of Indonesia in the global world. To prepare professionals that have such competencies, classical methods of learning is not sufficient. It is expected that project-based learning will improve the knowledge and design skills of students. Furthermore it will prepare students to be success in their professional careers. Afterward, by using their competencies, they can increase the competitiveness of Indonesia.

2 PROJECT-BASED LEARNING

Project-based learning is widely used in engineering education, including in design learning. Project-based learning is defined as a systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks (anonymous, 2002).

Project-based learning has some differences compare to problem-based learning (anonymous, 2003). First, in project-based learning, the end product drives the planning, production, and evaluation process. On the other hand, in problem-based learning, end products are simpler and more summative. Second, in project based-learning, any number of problems arises and students should use problem-solving skills to solve the problem. Conversely, in problem-based learning, problems are clearly stated in the beginning and they require a set of conclusions or a solution in direct response.

Project-based learning has some advantages (anonymous, 2003), which are providing an integrated learning experiences, enhancing student motivation, promoting greater understanding of the value of theoretical knowledge, developing a rang of specific and generic knowledge, skills, and abilities.

In its implementation, several different project types can be given in project-based learning, which are individual or group project, open or closed project, and incremental or innovative project. To achieve the purpose of the project, the type of project must be selected to match the topic area and the intended learning outcomes (anonymous, 2003).

The learning outcomes are important to describe the expected competencies of students and to evaluate the result of learning. Therefore, learning outcomes need to be specified in the beginning of the project-based learning. Learning outcomes cover knowledge acquisition, understanding intellectual skill, generic transferable skills, and practical and subject-specific skills (anonymous, 2003).

3 DESIGN PROJECT

Manufacturing Engineering, University of Surabaya has implemented project-based learning in two design courses. One of those courses, which named design project, is used as a case study in this paper to evaluate the implementation of this learning method. The goal of this course is that students must have certain competencies in product design i.e. have ability to design and develop a manufactured product, have ability to analyse a design of product, have ability to determined the optimal process needed to manufacture the product, have ability to analyse and optimise the cost involved in the design and manufacturing process.

In this course, first, students identify a need of customer that can be fulfilled by designing and developing a manufactured product. Then, they determine a product specification of the manufactured-product, which are fitted to the customer need. Based on the determined specification of manufactured-product, students must generate some concepts and select the best concept that can realize the product specification as required. Before the concept is embodied, it must be analysed according to some aspects, which are manufacturing, assembly, safety, economics, ergonomics, aesthetics, energy efficiency, and environment. Finally, the detail drawing of the design is made as a documentation and presentation of the design result. For evaluation need, the student must submit a report consist of all processes that they did. Along the project, which has six months duration, lecturer is functioned as a guide to help students on the right track and as a facilitator to develop their creativity.

As described above, Design Project is an open project. In this project, students find their own problem and convert it into a project. Then students must find their own strategy to solve the problem and finish the project. The basic theory needed has already given in previous course and if there is still other information needed; students must find it through independent research.

In its implementation, Design Project course is an individual project. It means that the project is carried out by one student. The communication among students is allowed as far as students only share information, ideas and problems. It is not acceptable that students work together in designing the same products. In the learning process, the student is supervised by one lecturer. The lecturer as project supervisor has responsibility only to guide students in designing the product and there is no obligation to give a lecture. For that reason, the regular meeting between lecturer and student is necessary and is documented by using a certain form. By attending the regular meeting, the supervisor can monitor the progress and help students in case there are some difficulties in the design process.

Learning outcomes of this project cover the understanding of design concepts, principles, and techniques, the skills in using design tools, equipment, and relevant software, the abilities in data collecting, analysis, interpretation, and problem solving, and the skills in communication and presentation. To be able to evaluate the achievement of students related to the goal of this course, at the end of this course, students must present their works and two examiners will examine their works.

4 EVALUATION OF DESIGN PROJECT

The implementation project based learning in this design course has some advantages and disadvantages. The advantages of implementing project-based learning in design are the learning process can cover wide but integrated information, students are grounded in real-life engineering problem, learning achievement can be assessed immediately by the project supervisor, students receive immediately feedback on their understanding or progress, the participation of student is more obvious.

However, in its implementation, there are a lot of problems appear in design project course. The first problem is the difficulties in finding problems as a starting point of the project. Students are accustomed to given problem and then they try to solve the given problem. It is difficult for student to find an appropriate problem and then create a project based on the problem. Furthermore, the equity of problems in determination of project topics also results in problem. One problem may be considered more difficult than another problem. Therefore students must be supervised by their supervisor in determining project topics and the supervisor must be met to discuss about the project topics.

Second problem is a certain level of design skill, especially in analysis, is needed to finish project-based learning. To increase the skill, students require to be introduced to a various kind of design problems and explain some solutions how to solve it.

Third problem is that students have resistance to discuss with other students because they consider that this project is individual project. As a result, students do not have a peer-learning partner. Every time they face a difficulty, they try to solve it by themselves. And if they cannot solve it by themselves, then they stop working the project.

The problems above caused the difficulties for students in finishing the project on schedule. The percentage of the students, which pass and fail the project in one year, is shown in Table 1 below.

Table 1. The percentage of pass and failure

Years	% pass	% failure
2001 – 2002	48	52
2002 – 2003	51	49
2003 – 2004	39	61

To solve that problem, there are many solutions, which can be applied. For example, performing a group project, adding some lecture, multiplying number of presentation. However, for some reason, manufacturing engineering will implement new specific technique to conduct product design course. As recommended course design, design project course will be a combination of lecturing, demonstration, discussion, presentation, and the project itself.

In the lecturing, there is a review of the main-content or topics related with product design. The teacher in this step is very important because he/she must deliver some relevant topics coverage, and also increase the motivation of students. The teacher must be sure that all delivered main ideas relating to a course or topics are useful for the project students.

As proven in many cases, demonstration will make learning process easier and increase the motivation of students. Furthermore, the visual learning helps students to

remember most of delivered topics. By using a demonstration, lecturer can focus attention and can dramatize important points. Demonstrating to a group helps the lecturer to share the learning experience, through ideas, observations, questions and comments on what they have watched.

In small group discussion, students discuss their problem or a chosen case study. All member of group must be active on group discussion. In this discussion, they must discuss and find a solution of the problem in-group. After discussing the problem, they must make conclusion of the discussion.

The conclusion of discussion, which covers the problem solving process and the solution, is important not only for the group itself but also for other groups. Therefore it must be presented to other groups. In this presentation, other groups could ask and argue.

5 CONCLUDING REMARKS

Project-based learning in design gives some advantages. However, to accomplish the project, students require a certain level of design skill. For students with various levels of skill, a careful and proper approach is required in directing and guiding students. Meanwhile, for students with lack of skill, another approach is required to guide students in working the project. If each student has to be guide one by one and step by step, it will take a lot of time and it is not an effective method. Based on the evaluation, a peer learning is suggested to solve the problem. By performing peer learning in form of small group discussion, it is expected that students can work together in group to solve every individual problem.

REFERENCES

Anonymous. (2002). *Introduction to project based learning*. Retrieved from http://www.bie.org/pbl/pblhandbook/intro.php

Anonymous. (2003). *A guide to learning engineering through projects*. Retreived from www.pble.ac.uk

Barber, P. (2004). Developing and assesing group design work: A case study. Paper presented in International Engineering and Product Design Education Conference, Delft, 2 – 3 September 2004.

Kalpakjian, S., & Schmid, S.R. (2001). *Manufacturing engineering and technology*. Prentice Hall International.

Morris, R., & Katz, T. (2002). Evaluating problem based learning in the teaching of design in post modular education. Paper presented in International Engineering and Product Design Education Conference, Delft, 2 – 3 September 2004.

Thomas, J.W. (2000). *A review of research on project–based learning*. The Autodesk Foundation. Retrieved from http:/www.autodesk.com/foundation

Kresna (ꦏꦿꦺꦱꦤ)
Known as a wise and visionary leader in the world of Javanese wayang (shadow puppets)

PROCEEDINGS

6th AUAP General Conference

Higher Education Leadership:

Strategic Relevance for Asia-Pacific Communities

Surabaya, Indonesia: 4-8 September 2005

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PREFACE

On 4-8 September 2005, the University of Surabaya together with the Indonesian Rectors Forum hosted the 6th Association of Universities of Asia and the Pacific (AUAP) General Conference. The event took place in Surabaya and was organized in conjunction with the 10th AUAP Anniversary. The General Conference was held at the Sheraton Surabaya Hotel and Towers and the 10th AUAP Anniversary was celebrated at the Mandarin Hotel.

The AUAP General Conference is held bi-annually. The continuation of this AUAP tradition took the theme "Higher Education Leadership: Strategic Relevance for Asia-Pacific Communities." The rationale behind the theme selection is that diversity and uniqueness of the nature, value, and other characteristics of Asia-Pacific countries and communities should be explored and taken into account in creating strategies for higher education systems. Higher education institutions require a resilient leadership to define appropriate and tough strategies. Leadership becomes increasingly important as the competitiveness of the organization is mainly built on the competence of the leaders in properly creating and implementing the strategies. Building an excellent strategy requires mastermind so that larger groups of people with various inspiring ideas could be involved.

Growth of demand for higher education to provide high quality education should be proactively responded. In the midst of massiye change due to globalization, Asia-Pacific universities should deliberately think about repositioning their existence. In many countries, the credibility and standing of universities are increasingly subject to question since all too often, the process and product of higher education lack of relevance to encounter the need of communities, particularly the diverse and unique Asia-Pacific.

In response to these challenges, AUAP and the University of Surabaya worked together to hold a program addressing the issues related to the strategic relevance for Asia-Pacific communities. This program was aimed at gaining various ideas and perspectives to better solve problems and improve the quality of the higher education systems. Furthermore, a medium for alliances and networking of institutions was established in this forum, so that institutions could hand-in-hand achieve the end-goal, the increase of prosperity of Asia-Pacific nations.

The forum presented three sub-themes: *developing regional needs-based curriculum*, *supporting communities through innovative learning processes*, and *enhancing the effectiveness of Asia-*

Pacific higher institutions networking. Each sub-theme produced numerous interesting discussions during the event, of which the full papers can be read in this proceedings. We wish for the proceedings to be fruitful and able to provide insights for the readers, particularly those interested in the central theme on leadership and strategic relevance for higher education institutions in Asia-Pacific.

Surabaya, September 2005

Eric Wibisono
Chair, Steering Committee
6th AUAP General Conference

Acknowledgments

We are truly indebted to our invited plenary speakers for their willingness to share their expertise and experience before the conference audience. It is partly from their contribution that this conference turns to big success. We would like in this opportunity to thank those people:

Di Yerbury

Macquarie University, Australia

Pornchai Mongkhonvanit

Siam University, Thailand

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University of Guizhou, China

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University of Surabaya, Indonesia

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Asian Institute of Management, Philippines

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Ronny Adhikarya

R-Adhikarya International, United States of America

Pambudi Sunarsihanto

Learning Center Manager, Nokia Asia Pacific

Ng Wun Jern

National University of Singapore, Singapore

Porntip Kanjananiyot

Fulbright Thailand, Thailand

Mohd. Salleh Mohd. Yasin

Universiti Kebangsaan Malaysia, Malaysia

Opening Speech

Wibisono Hardjopranoto

Rector, University of Surabaya

President, Indonesian Rectors Forum

President, Association of Universities of Asia and the Pacific (AUAP)

6th AUAP General Conference

Higher Education Leadership:

Strategic Relevance for Asia Pacific Communities

Distinguished Guests, Ladies and Gentlemen:

It is my great pleasure to welcome all of you to Surabaya and to the opening session of the 6th Association of Universities of Asia and the Pacific (AUAP) General Conference on the theme "Higher Education Leadership: Strategic Relevance for Asia Pacific Communities." It is also a great honour for the University of Surabaya to host this event in collaboration with the Indonesian Rectors Forum.

The purpose of the 6th AUAP General Conference is to gather various ideas and perspectives to respond the challenges and opportunities in order to build higher education leadership and its strategic relevance for Asia-Pacific communities.

Higher Education in Asia Pacific should reposition their existence as they have different characteristics and uniqueness as well as different needs and opportunities. To face this challenge, it is important to conduct a sharing forum in order to learn each other's capacity related to this issue. Therefore we are here now to fulfill this need and work hand-in-hand to be more creative in finding solution that is more relevant to us as Asia Pacific nations.

The important issues that need to be addressed in this forum are: *Developing Regional Needs-Based Curriculum*, *Supporting Communities through Innovative Learning Processes*, and *Enhancing the Effectiveness of Asia-Pacific Higher Institutions Networking*.

In similar vein, the Indonesian Rectors Forum also portrays the theme as an essential issue, where Higher Education in Indonesia must also be involved and give their thoughts and perspectives as part of the Asia-Pacific communities, to improve the quality of Higher Education system. Indonesian Rectors Forum as a forum of university's leaders believes by working together, the goal of taking higher education to have more competitive advantage in the global village could be achieved. Education is what will determine the future well-being of individuals and of nations. Therefore the advancement of a nation strongly relies on how well higher education performs and contributes to the benefits of the society.

Many scholars and practitioners from Asia-Pacific region today come to this conference. Moreover, experts outside Asia-Pacific region such as Europe, America and many others also come to this conference to share their ideas and perspectives. I deeply appreciate all thoughts and efforts contributed to the success of this conference.

International discussion allows us to make our contribution to the major world-wide issues related to the higher education as well as to establish our place among the nations of the world. The substance of the various session of this conference and the expertise of the presenters and other participants will provide us with excellent opportunities both to give and receive from the international dialogue. I believe by the end of our conference we will be able to identify benefits of our work together that will apply individually and collectively to educational systems of all countries participated in this conference. I wish for you to continue your endeavour during the conference.

Once again, let me welcome you to the 6th AUAP General Conference. I look forward to learning your discussion and deliberations. And I wish for you an enjoyable and productive stay in our beautiful capital city, Surabaya.

Thank you and best wishes.

Wibisono Hardjopranoto
Surabaya, 06 September 2005