Journal of Engineering Education Research
Vol. 19, No. 2, pp. 8~13, March 2016

Case Analysis of Program Outcomes Depending on Teaching Methods in Engineering Design Course

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공학설계 교과목에서 교수-학습 방법에 따른 학습성과 분석 사례

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ABSTRACT

This paper is concerned with the development case of CEA(Course-Embedded Assessment) design tool for engineering education accreditation operations department for CEA system implemented. Each university or programs are already devoting efforts to build research and CEA system for CEA applied to. In order to effectively apply the CEA studies for each program it is required and particularly, the preferred way to build an operating system is considered a difficult situation of the course unit. Therefore, this case study and to propose a method and procedures required to assessment the design basis for curriculum and program assessment unit in terms of the applicability of CEA, proposes a virtual application results. The information proposed in this case study is determined that could be used in the design for the outcomes and assessment of a variety of programs as one of the steps to build the CEA systems.

Keywords: Teaching Methods, Engineering Design, Technical Writing, Program Outcomes, Problem-based Learning

I. Introduction

These days there is increasing interest in the writing of science and engineering college students(Kwon, 2010; Oh, 2014). Reports from both industry and government repeatedly highlight the importance of strong communication skills for engineers entering the workplace(Paretti, 2008; Robinson et al., 2005). Along with stand-alone technical communication courses and laboratory courses, design courses have long been a key site for helping students develop these skills(Dannels, 2003; Helbling et al., 2005). Therefore it is very important to integrate the engineering design and technical writing.

Engineering design is an application of the various techniques and principles in order to correctly identify appropriate equipment, processes and systems(ABET, 2015). By doing so, students can improve their skills through participation in various levels of design courses, which will enable them to be more effective in the field. Furthermore as creativity increases in importance in the field of engineering design, it also increases in importance in the classroom(Karsnitz et al., 2012). In particular, students need to integrate their knowledge and experience they have learned in component design courses. Also through these courses, students can enhance their design and communication skills.

The importance of effective communication is also evident in a 2006 report on the impact of EC 2000. In a survey of over 1,600 employers representing diverse geographic locations, industry types, company sizes, educational attainment levels, and experience evaluating engineers, employers rated the importance of the ability of new engineering hires to communicate effectively at the top of all student outcome Criterion 3 competencies, even above primarily technical ones(Lattuca et al., 2006; Leydens &

Received September 30, 2015; Revised February 3, 2016
Accepted March 28, 2016
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Schneider, 2009). To date, engineering education scholarship surrounding communication in design courses has focused on describing course assignments and strategies for integrating communication into curricula(Boiarsky, 2004; Thompson et al., 2005). However, there are few integrated engineering design and technical writing program in the view of the teaching and learning.

In order to implement effective component design courses, teachers have to develop optimal teaching methods to support their students. This study analyzes the effectiveness of current component design teaching methods and makes suggestions based on its findings.

II. Engineering Design and Teaching Methods

1. Engineering Design

Design is the process of planned change. Design demands that we plan change so that we end up with the results we want. Engineering design refers to the process used to create something new to solve a problem.

The engineering design process can be complicated. Design process is nothing more than a logical problem-solving technique. It is a systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to solve a problem or satisfy human needs and wants and to narrow down the possible solutions(Karsnitz et al., 2012). A good understanding of problem-solving techniques is useful in all aspects of life, not just designing products. In a design process the goal is to minimize undesired effects and control risk.

Problem solving is the process of understanding a problem, devising a plan, carrying out the plan, and evaluating the effectiveness of the plan in order to solve the problem or meet a need or want(Ford & Coulston, 2007). Experienced engineering designers take the time to form a plan that lists, orders, and prioritizes items. However, as design problems get more complicated, you need to increase your planning to solve the problem efficiently. The step of the engineering design process is to Improve. Obtaining additional knowledge through iteration often results in better ideas. Iteration in a design process is analogous to a closed-loop system, allows feedback within the process.

Engineering is certainly one field where proficiency in written communication is valued(Shuman et al., 2005). Especially the senior design courses are the culmination of the previous years of the undergraduate curriculum. ABET EC2000 mandates that mastery of skills such as written communication, teamwork, and design be acquired progressively throughout the undergraduate curriculum(ABET, 2006). The goal of engineering design courses are to develop students' communication(oral and written), interpersonal, teamwork, analytical, design, and project management skills through a team-based design experience(Goldberg, 2009).

The Writing Across the Curriculum(WAC) movement has promoted the idea that writing should be taught as a mode of learning and not merely a means to remediate deficiencies in writing skill(Shuman et al., 2009). In recent years, written communication has also been included vertically in Northwestern's design curriculum in the Institute in Design and Engineering Applications(IDEA, 2016). Much of the research in engineering writing has focused on the pedagogical approach taken.

2. Teaching Methods

The theoretical framework of teaching methods is currently characterised by a variety of perspectives and viewpoints on the issues of learning, activity, and knowledge appropriation, as researchers and scientists interested in the complexities of learning in a wide range of research fields. Project-based learning is a form of contextual instruction that places great emphasis on student problem-finding and framing, and which is often carried out over extended periods of time(Laffey et al., 1998). Project-based learning places demands on learners and instructors that challenge the traditional practices and support structures of schools. Thus instructors need help to be coaches and facilitators. Instructors have to act as role models, manage multiple projects, consult in areas of limited expertise, guide with feedback, promote teamwork, recognize and intervene when problems arise(Kim, 2009). Learners need support for taking on the whole project, not just carrying out tasks assigned by the instructor. They also need to make sense of their results and transform project efforts into valued products and results.

Within student-centered teaching, recent research highlights problem-based learning(PBL) as a particularly productive model for engineering education(McIntyre, 2002; Perrenet et al., 2000; Omar, 2014). Problem-based learning environment, students have opportunities to practice applying their content knowledge and workplace skills while working authentic, contextualized problems and projects(Dunlap, 2005). Student-centered pedagogies such as problem-based learning provide ideal vehicles for such a redesign because they transform the instructor from all-knowing lecturer and evaluator to engaged participant and mentor(Paretti, 2006). Within these learning experiences, students can address open-ended problems in their disciplines.

III. Methods

1. Participants & Group profiles

This study looked at 72 third-year students in program B at a Seoul-based university. Each instructor taught 2 courses each; one course(N=38) used project-based learning method, and the other(N=34) used problem-based learning method. All students were surveyed at the end of the semester.

We used random assignment in order to ensure the homogeneity of the two groups. We have tried comparing the previous year prerequisite average scores(Case1=67, Case2=69), there was no statistically significant difference (t=0.999, p=0.392). In addition, the overall academic level was similar. Random assignment means that each participant has an equal chance of effect of participant relevant confounding variables.

2. Data Gathering and Analysis

In this study, an university program was chosen, and based on course evaluations, an adequate representative case subject was selected. The sample was analyzed based on the course syllabi, topics of study and course contents, teaching methods, course evaluations and learning outcomes.

This study used SPSS version 20.0 to conduct its analysis. two sample independent t-test were used to compare the average program outcomes.

3. Cases Comparison

A. Class Structures

a) Project Based Learning : Case 1

We designed a teaching & learning model for project based learning focused on technical writing for Component Design course. This class consists of four processes; students ask questions, make predictions, design, investigations, collect and analyze data, use technology, make products, and share ideas.

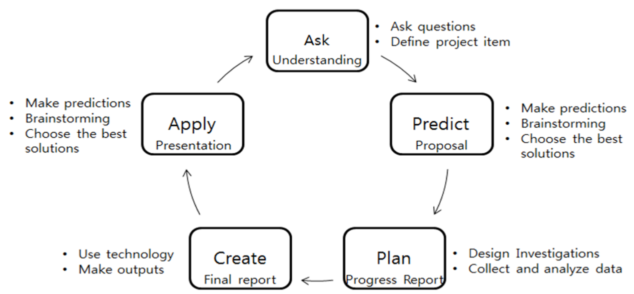


Fig. 1 PBL focused on Project process

b) Problem Based Learning : Case 2

We designed a teaching & learning model for problem based learning focused on technical writing for Component Design course. This class consists of four processes; reading for data collection & understanding, planning for writing proposal, writing for final report, revising for final revision. In this class, students will participate in multiple feedback sessions; instructor feedback, peer feedback, self feedback. They are not distinct. Because this is a fluid process.

During regular class time, students must present their output based on their design report individually, and after receiving feedback, they must revise and update their final design.

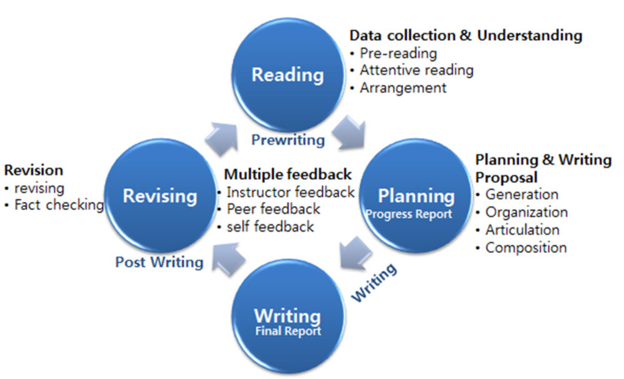
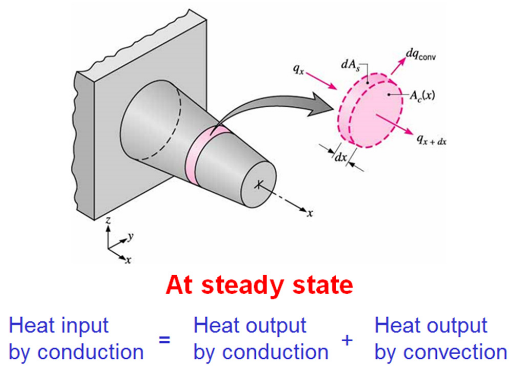


Fig. 2 PBL focused on Technical Writing process

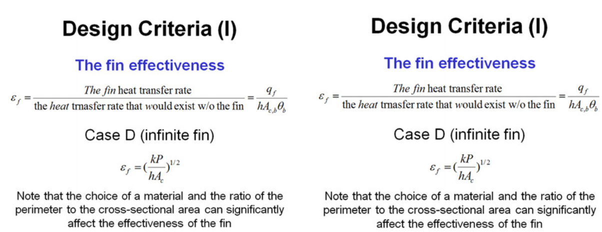
B. Problem & Design Criteria

In both cases the problem and design criteria were the same. The proposed problem was "how to enhance heat transfer?".



$$q_x = q_{x+dx} + dq_{conv}$$

Design criteria that students should meet in solving a program below.



C. Evaluation Guidelines

Evaluation of case1 class was based on two exams(mid-term and final, 50%), design assignments(30%), homework, and class participation(20%). Evaluation of case2 class consists of 3 processes; academic and writing self evaluation, peer evaluation, instructor evaluation. Evaluation Guideline strategies can be seen in Table 1 below.

Ⅳ. Results

This course has five program outcomes out of a total of 12 program outcomes. According to Figure 3, on average, students in Case 2 reported having accomplished more of the desired course outcomes than those in Case 1. Compared to Case 1, Case 2 also demonstrates an upward trend in accomplishing desired course outcomes, as compared to Case 1. In particular,PO (1), (2), (4), (6) and (7) show a significant upward trend in reported results. Furthermore, PO (6) and PO (7) demonstrate a significant statistical difference in comparison with the other cases.

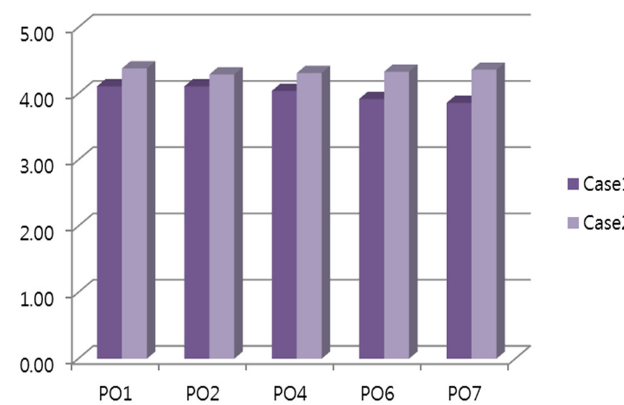


Fig. 3 Analysis of Achievement of Program Outcomes

Table 1 Evaluation Guideline (Case 2)

Academic Criteria(60%)	Writing Criteria(40%)
Relevance of the design objectives(20%) - Have the design objectives occurred in the heat transfer? - Have the design objectives improved the heat transfer? - Have you found any heat transfer structures in your practical surroundings that are not electronic devices?	Writing(50%) - Were the right words chosen? - Is the grammar correct? - Is the spelling and spacing suitable? - Is the flow of your sentences natural?
Creativity of design structures(30%) - Have your created a design besides the fin structure? - Have you integrated course knowledge in this design? - Have you applied course knowledge creatively?	Revision1(30%) - Does the writing represent your intention? - Is there anything this writing lacks? - Does the writing thoroughly communicate your message?
Interpretation of design structures(50%) - Was the designs structure analyzed with the comparison group? - Is the design economic and material access for the project feasible? - Was the feedback applied to the work?	Revision2(20%) - Is the message clear? - Is the topic relevant? - The evidence, tone, presentation of the writing associated with the topic?

Table 2 Analysis of Achievement of Program Outcomes

Program Outcomes	Case	N	M	SD	t
PO1	1	38	4.11	0.90	-1.723
	2	34	4.38	0.58	
PO2	1	38	4.11	0.92	-1.077
	2	34	4.29	0.64	
PO4	1	38	4.04	0.96	-1.599
	2	34	4.31	0.64	
PO6	1	38	3.92	1.01	-2.373*
	2	34	4.33	0.69	
PO7	1	38	3.86	0.96	-2.972**
	2	34	4.36	0.66	

*P < .05, **P < .01, ***P < .005

Table 3 Program Outcomes

PO	Explanation
PO1	an ability to apply knowledge of mathematics, science, and engineering
PO2	an ability to design and conduct experiments, as well as to analyze and interpret data
PO4	an ability to identify, formulate, and solve engineering problems
PO6	an ability to function on multidisciplinary teams
PO7	an ability to communicate effectively

V. Conclusions

In our case study we looked into project based learning and problem based learning. With regards to our findings, we put forward the practical instruction methods for the component design class. We concluded the following:

First, we raised achievement of the program learning outcomes through systematic feedback on design challenges.

Second, we identified that effective communication skills increased by implementing problem-based learning method focused on the technical writing model to improve communication skills. This can be seen as an effect of the feedback design challenges.

Third, students were given evaluation guidelines at the start of the course, which allowed students more direction through their design class and project. In addition we confirmed that the multiple feedback.

I suggest we put forward the following as methods to improve the Component Design class.

First, instructors are encouraged to proceed with the pre-assessment to identify the learner's prior knowledge before the start of class.

Second, instructors need to motivate students for performing design tasks. Students tend to lack a self-directed learning approach and rely only on class contents. Instructors should motivate students to extend their ideas beyond the regular class setting.

Third, instructors should prepare detailed guidelines for the design task performance to solve practical problems when performing a design challenges.

Fourth, instructors are required to prepare a systematic feedback to help learners to improve higher-order thinking and communication skills through the design task performance focused on process based technical writing.

There are many challenges that we have experienced while trying to implement engineering design course with PBL focused on technical writing. Assessment is difficult particularly at the quantitative and qualitative measurements to this integrated learning process. The PBL process needs students to be very self-directed in their learning and to get ownership. Also instructors should guide such as coaches and facilitators with feedback.

Hopefully, some of the experiences shared in this paper will support others to facilitate the integration of these activities throughout their engineering design courses.

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