A Study on Student Cognition for Multi-dimensional Appraisal of Introductory Engineering Design Course

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Abstract

This article describes student opinions of an evaluation method for introductory engineering design-course by multi-dimensional views including student's scorings. That introductory engineering design-course mainly proceeded with student participation and performance for design practices during semester. This project based on course has to employ a different evaluation than typical engineering course because various presented works and creative ideas would be evaluated different grades by viewpoint of appraiser. By means of multi-dimensional evaluation for introductory engineering design-course, it is reflected by student's scoring for designed works of other team. In addition, contribution ratio for team works of members were also evaluated by belonged to the same team members. As an effectiveness evaluation, the multi-dimensional evaluation system was intended to avoid singular evaluations by viewpoint of supervisor and organized an evaluation system with student opinions and participations. Furthermore, it is enhanced that the positive participation for team operations, collaborations among members for performance of team project and opinions exchanges in each members for team activities.

Introduction

Engineering education is the term of activity of teaching engineering and technology, at college and university levels. The purpose of engineering education is not only to prepare for student to practice engineering as a profession but also to spread technological literacy, increase student interest in technical careers through science, math and computer education(so called as called MSC) and hands-on learning. Engineering education often begins with technology education from high schools and continues on college and university.1)

Besides common MSC course, a good many different and similar courses focuses on engineering education including chemical engineering, mechanical engineering, construction science, computer science and engineering, electrical engineering, and other forms of related education courses.

Among those disciplinary courses, engineering design is the process of devising a system, component or process to meet desired needs and generally applied to design that is concerned with the technical workings of mechanized products and machines rather than their aesthetic characteristics. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective. The fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation.2)

An engineering design course is a process used by engineers to help developing products in industry and researches. This process can be divided into multi-step, which includes identifying a need, defining the problem, conducting research, narrowing the research, analyzing set criteria, finding alternative solutions, analyzing possible solutions, making a decision, presenting the product, and communicating and selling the product. This process is not universal for all engineers or all processes. Individuals utilize their personal knowledge and experiences to follow the path for design success.3)

In order to satisfy the demand of industry and research fields, it is necessary to produce creativity and team activities of the engineering education system for engineer course students. With beginning of ABEEK(Accreditation Board for Engineering Education of Korea) program at each university, capstone design course was implemented as a final engineering design course.

Capstone design, organized senior subject, applies the engineering sciences to the design of a system, component or process. Students choose the particular design project with approval of appropriate faculty. Design teams are organized. Each project includes the use of open-ended problems, development and use of design methodology, formulation of design problem statements and specification, consideration of alternative solutions, feasibility consideration and detailed system descriptions. It also includes realistic constraints (such as economic factors and social impact).

The mission of the capstone design course is as follows:
- To involve students in collaborative design project that require them to frame a design problem, explore solutions, develop a single solution.
- To communicate the obtained results by teamwork in oral presentations and written reports.
- To provide with the experience of engineering a prototype or implementing a solution.
- To broaden, deepen and integrate the background of the students.
- To prepare students for the expectations and standards of the professional workplace.

Before capstone design course, lower grade students have to pass an introductory engineering design-course as a prerequired course which is telling the basic concept and team activities of engineering design. In that course, all of the students have to be associated with a team and they have to make a sample product through team project by themselves. Therefore, this type course is called as a project-based engineering design(in general it is called project- based learning) that is the use of classroom projects, intended to bring about deep learning, where students use technology and inquiry to engage with issues and questions that are relevant to their lives. These classroom projects are used to assess student's subject matter competence compared to traditional testing. An appraisal of team products and activities is very difficult to evaluate each member precisely because all of the members in the team have their own roles for the team activities and make different contributions to gaining a result. In order to gain objective assessment for team activities, multi-dimensional appraisal was applied to an introductory engineering design-course.
In this study, we investigated affirmative results of multi-dimensional appraisal than supervisor base general evaluation. In addition, we suggest questions of distrust among members in the team and discreditable evaluations by other teams which should be solved to succeed in multi-dimensional appraisal and engineering design course.

The project-based engineering design

Project-based learning is a so different teaching method that promotes and practices new learning habits to students than typical education courses. The purpose of project-based engineering design is making students who create their own investigation of their own team which allows students to develop valuable research and development skills. The members engage in engineering design, problem solving, decision making, and investigative activities by themselves. It allows students to work and to cooperate in their teams and members or by themselves and allows them to come up with ideas and practical solutions or presentations. Students take a project and apply it to a real industrial situation with assigned projects. Project-based engineering design provides complex tasks based on challenging questions or problems that involve the students' problem solving, decision making, investigative skills, and reflection that include teacher facilitation, but not direction. Project-based engineering design is focused on realistic questions that drive students to encounter the central concepts and to find principles of a subject hands-on. After project-based engineering design creative ideas and skills would be actualized by showing that there are many ways to complete a project.
Project-based engineering design is an approach for team activity and evaluation of accomplished results that emphasizes learning activities that are long-term, interdisciplinary and team-based cooperation. In general, this approach is shown less structured than traditional lectures by teacher leading; in a project-based class, students often must organize their own work and manage their own time. Within the project based learning framework students collaborate, working together to make sense of what is going on. Project-based instruction differs from inquiry-based activity by its emphasis on collaborative learning. Additionally, project-based instruction differs from traditional inquiry by its emphasis on students' own artifact construction to represent what is being learned.
Project-based engineering design mainly relies on participating teams. Student teams determine their goal and titles

by assigned topic from teacher, in so doing, they engage student voice by encouraging students to take full responsibility for their learning through team project. This is what makes project-based process constructivist and then students work together to accomplish specific goals.

When students use technology as a tool to communicate with others, they take on an active role vs. a passive role of transmitting the information by a teacher, a book, or broadcast. The student is constantly making choices on how to obtain, display, or manipulate information. Technology makes it possible for students to think actively about the choices they make and execute. Every student has the opportunity to get involved either individually or as a group.

Instructor role in project-based engineering design is that of a facilitator. They do not relinquish control of the classroom or student learning but rather develop an atmosphere of shared responsibility. The Instructor must structure the proposed question/issue so as to direct the student's learning toward content-based materials. The instructor must regulate student success with intermittent, transitional goals to ensure student projects remain focused and students have a deep understanding of the concepts being investigated. It is important for teachers not to provide the students any answers because it defeats the learning and investigating process. Once the project is finished, the instructor provides the students with feedback that will help them strengthen their skills for their next project

Student role is to ask questions, build knowledge, and determine a real-world solution to the issue/question presented. Students must collaborate expanding their active listening skills and requiring them to engage in intelligent focused communication. Therefore, allowing them to think rationally on how to solve problems. Project-based engineering design forces students to take ownership of their success.

Multi-dimensional evaluation for project-based engineering design

More important than learning science, students need to learn to work in a community, thereby taking on social responsibilities. The most significant contributions of project-based engineering design have been in schools languishing in poverty stricken areas; when students take responsibility, or ownership, for their learning, their self-esteem soars. It also helps to create better work habits and attitudes toward learning. In standardized tests, languishing schools have been able to raise their testing grades a full level by implementing project-based engineering design. Although students do work in groups, they also become more independent because they are receiving little instruction from the teacher. With project-based engineering design students also learn skills that are essential in higher education. The students learn more than just finding answers, project-based engineering design allows them to expand their minds and think beyond what they normally would. Students have to find answers to questions and combine that using critically thinking skills to come up with answers.

Project-based engineering design is significant to the study of (mis-)conceptions; local concepts and childhood intuitions that are hard to replace with conventional classroom lessons. In project-based engineering design, project science is the community culture; the student groups themselves resolve their understandings of phenomena with their own knowledge building. Technology allows them to search in more useful ways, along with getting more rapid results.

Opponents of project-based engineering design warn against negative outcomes primarily in projects that become unfocused and tangential arguing that underdeveloped lessons can result in the wasting of precious class time. No one teaching method has been proven more effective than another. Opponents suggest that narratives and presentation of anecdotal evidence included in lecture-style instruction can convey the same knowledge in less class time. Given that disadvantaged students generally have fewer opportunities to learn academic content outside of school, wasted class time due to an unfocused lesson presents a particular problem. Instructors can be deluded into thinking that as long as a student is engaged and doing, they are learning. Ultimately it is cognitive activity that determines the success of a lesson. If the project does not remain on task and content driven the student will not be successful in learning the material. The lesson will be ineffective. Like any approach, project-based engineering design is only beneficial when applied successfully.

Project-based engineering design is a similar pedagogic approach, however, problem-based approaches structure students' activities more by asking them to solve specific (open-ended) problems rather than relying on students to come up with their own problems in the course of completing a project.

Method

The outcomes are based on a questionnaire survey with students who attended to introductory engineering design course. The survey was performed after last class of introductory engineering design that was right after of student participation for multi-dimensional evaluation. The survey represented 10 questions of multi-dimensional evaluation for project-based lecture: multi-dimensional evaluation(n=3, _type), team contribution evaluation for team activities(n=2, _ type), fairness and objectivity for team contribution evaluation(n=4, _ type) and fairness and objectivity of evaluation by another team (n=1,_ type). The questionnaire surveys were analyzed by the author in the following way: to diminish counting error the marking were counted in an iterative manner.

The purpose of this survey was to capture all student opinions for multi-dimensional evaluation of project-based lecture. Basic introduction for survey was written briefly in head of questionnaire. Before the survey, supplementary and additional explanation for purpose and literal meaning etc. of survey questions were not performed for reflection of student own intention. Moreover, to classify opinions of each department, participated students marked only their associations without other affiliations of university ID number, name and grade etc.

By means of questionnaire survey, students' opinion for multi-dimensional evaluation could be gathered and the results could be summarized. To present as-resulted opinions without specific analogical and broad interpretation, literal interpretation was occurred from summarized results.

Result

In this study we try to find out student's opinions about multi-dimensional evaluation including student scoring of project-based engineering design. It focuses on three directions. First, How do students think about multi-dimensional evaluation? Second, How do they think about other members scoring? And third, How do they think about their team's evaluation done by another teams?

In order to find answers to the above questions, questionnaire survey for students who have a project-based engineering design course was carried out after final class. After analysing students' answers for the questions all the answers were classified five categories: strongly agree, agree, neither agree or disagree, disagree and strongly disagree. And, if it possible, it could be simplified by three category as positive, neutral and negative. The followings are intends of subjected question to survey:

Q1. Objectivity of multi-dimensional evaluation for project-based engineering design(_)
Q2. Need for contribution evaluation of team member(_)
Q3. Need for contribution evaluation of team member in project-based course(_)
Q4. Fairness and objectivity for member evaluation of one's own team by oneself(_)
Q5. Fairness and objectivity of evaluation by other members(_)
Q6. Opinion about motive for student participation by team contribution evaluation(_)
Q7. Objectivity of evaluation for presentation and team works by student participation(_)
Q8. Opinion of one's own team for evaluation of other team presentation and works(_)
Q9. Opinion of one's own team evaluated by other teams(_)
Q10. Reflection of general team opinion(_)

All answers of the survey were counted and summarized in Table 1. The generalized results were individually presented as a percentage value at each question and categories of answer.

It could be understood that how some of student tell their definite opinions through survey. As shown in Table 1, the most of students agreed positively to multi-dimensional evaluation of introductory engineering design course and it is agreed that the evaluation includes enough reflection and opinion changes between members. A half of students agreed to objective evaluation for team works and presentation performed by another teams but 32% of student could not convince their opinions. And, 12% of disagreed opinions revealed.

Scoring of team contribution by own team member was needed for harmonious team activity and was served to proper tool for this course. Also in those questions, a quarter of answer didn't reveal their definite intention.

The most of answer tell their own team and themselves conducted objectively a scoring to other team member for

team contribution and an evaluation to presentation and team work of other teams. And their negative view was about 4 ~ 6 % revealed. As definite opinions were under 20 % in this questions.

In a question of project-based course, a greater part of answer agreed it need an evaluation of contribution among team members for team activity.

Table 1 The obtained result from questionnaire survey for multi-dimensional evaluation

	Strongly Agree	**Agree**	**Neither Agree nor Disagree**	**Disgree**	**Strongly Disgree**
	(Positive)		**(Neutral)**	**(Negative)**	
1	9 %	69 %	18 %	5 %	0 %
2	10 %	54 %	23 %	9 %	3 %
3	19 %	54 %	18 %	8 %	2 %
4	13 %	65 %	18 %	3 %	1 %
5	6 %	42 %	47 %	4 %	1 %
6	6 %	48 %	26 %	14 %	5 %
7	8 %	48 %	32 %	11 %	1 %
8	12 %	66 %	15 %	5 %	1 %
9	4 %	42 %	50 %	4 %	0 %
10	15 %	68 %	13 %	4 %	0 %

Conclusion

In this article the generalized results of multi-dimensional evaluation for project-based course by student could be summarized followings:

1. Project-based course like as introductory engineering design progressed by student performance and their outcomes need a different evaluation method than typical educations with test and reports etc. In addition, if that evaluation could include a multilayer view point, the reliability and validity would be increased and students prefer to changed evaluation than conventional way.
2. In case of student participated evaluation, reliability of one's own evaluation shows not high result and the same result was obtained from evaluation between teams. However, an evaluation to other members or another team conducted by one's own team or by oneself shows most high objectivity among this survey.
3. It is conclude that to enhance a student creativity and spontaneity for project-based course, an evaluation method of student satisfied improve from conventional supervisor-based evaluation.

References

01. A. Eide, R. Jenison, L. Mashaw and L.Northup. (2002). Engineering: Fundamentals and Problem Solving. New York City: McGraw-Hill Companies Inc.,
02. Anna Parpala and Sari Lindblom-Ylanne. (2007). University teachers' conceptions of good teaching in the units of high-quality education. Studies in educational evaluation, 33, pp 353-370.
03. Barron, B. (1998). "Doing with understanding: Lessons from research on problem- and project-based learning." Journal of the Learning Sciences. 7(3&4), 271-311.
04. Caroline Ballie and Ivan Moore. (2004). Effective learning and teaching in engineering. Routledge.
05. Douglas, J., Iverson, E. & Kalyandurg, C. (2004). Engineering in the K-12 classroom: An analysis of current practices & guidelines for the future, American Society for Engineering Education: Washington, DC
06. E. Spurlin, Sarch A. Rajala and Jerome P. Lavelle. (2008). Designing better engineering education through assessment. Stylus.
07. Foulger, T.S. & Jimenez-Silva, M. (2007). Enhancing the writing development of English learners: Teacher perceptions of common technology in project-based learning. Journal of Research on Childhood Education, 22(2),

109-124.
08. John Kalafat, Robert J. Illback and Daniel Sandres Jr. (2007). The relationship between implementation fidelity and educational outcomes in a school-based family support program: Development of a model for evaluating multidimensional full-service programs, Evaluating program planning. 30, pp 136-148.
09. Sherly A. Sorby and William M. Bulleit. (2006). An engineer's guide to technical communication. Person Prentice Hall.
10. Tanner leBaronWallace. (2008). Intergrating participatory elements into an effectiveness evaluation. Studies in educational evaluation, 34, pp 201-207.
11. Ullman, David G. (2009) The Mechanical Design Process, Mc Graw Hill, 4th edition
12. Wynne Harlen. (2007). Criteria for evaluating systems for student assessment. Studies in educational evaluation, 33, pp 15-28 .
13. John Heywood. (2005). Engineering education research and development in curriculum and instruction. Wiley interscience

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