ACTION LEARNING TEACHING-LEARNING STRATEGY IN ARCHITECTURAL ENGINEERING DESIGN CLASSES

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ABSTRACT: The importance of engineering design increases due to the expansion of engineering education certification. But there are not much teaching methods and examples of engineering design to be referred to the college classes. This paper introduces a new teaching and learning method of Action Learning adopted to a engineering design class in the Department of Architectural Engineering, J University in Korea. The class included a team project to find problems of facilities or safety management factors in a building construction site, and to provide the alternatives to solve the problems. The Action Learning helped to improve the learning effect of students and to increase the quality of the project deliverables.

Keywords: Engineering education, Architectural engineering design; Action learning; Building Construction Management

1. INTRODUCTION

To improve the quality of engineering education, number of universities and number of programs to apply for Accreditation of Engineering Education are increasing in Korea[1]. The Accreditation of Engineering Education is an effort to establish educational goals that consumers demand and to achieve the goals. And it has strengthened engineering design education to cultivate creativity and problem solving skills needed in the industry.

Engineering design has three categories of basic design, capstone design, and component design. The basic design introduces basic concept of engineering design and cultivates basic creativity. The capstone design of higher grade covers design experience based on knowledge and techniques learned in lower grades. Component design teaches detail parts of engineering education through small design project with limited resources[2].

There are many examples of engineering design class in the department of electronic engineering and mechanical engineering where experimentation and development of products or system are active. Engineering design is increasing the importance in architectural engineering where cases and experiences of engineering design are not enough. This paper introduces a case of engineering design required by Accreditation of Architectural Engineering Education. The case is a component design class in the Department of Architectural Engineering of J University in Korea, The paper shows the result from new teaching-learning strategy of Action Learning adopted to the class and proposes the improved teaching method.

2. ENGINEERING DESIGN AND ACTION LEARNING

2.1 Engineering Design

ABEEK (Accreditation Board for Engineering Education of Korea)[1,2] requires the systematic curriculum of engineering education related subjects to improve a university graduate's adaptability to business, and divides engineering design classes into basic design, capstone design, and component design. Basic design and capstone design should treat all design elements and realistic design constraints. Especially, capstone design should treat design elements including design objective setup, synthesis, analysis, manufacture, test, and evaluation and also treat most of realistic constraints such as economy, environment, society, ethics, aesthetics, health and safety, productivity and durability, and the industry standard based on knowledge and techniques learned in lower grades. Basic design and component design should be located in the curriculum for a student to experience in advance design elements and realistic constraints treated in capstone design. Component design needs to be allocated to an area of study and detail sub-areas in order to educate engineering design about the theme of detail sub-areas. Students should complete various element design classes evenly in the detail sub-areas.

Engineering design started to emerge to engineering colleges in the mid 2000's and it continuously extends along with the accreditation of engineering education. Cases introducing engineering design classes in various departments of engineering are increasing. Faculty of Mechanical Engineering in KR University[3] created an overall capstone design courses in 2005 with the

introduction of Accreditation of Engineering Education through full-scale restructuring of its curriculum. Conceptual design, modeling and preliminary evaluation, detailed design, prototyping, performance and economic evaluation, and so on were the components to perform capstone design projects. School of Mechanical & Automation Engineering in ST University[4] managed a capstone design for 16 years and evaluated that the capstone design had the foundation for the strengthening of engineering process, industry participation, student-centered management, leadership, and so on. School of Electrical Engineering in SK University[5] has opened a creative engineering design class for the freshmen since 2005. They studied the concept of engineering design, product development process, design creativity, and design methodology. And they performed their team projects to understand the concept and knowledge of engineering design. School of Chemical Engineering in YS University[6] has had basic design(1 subject 2 credits), element design(16 subjects 19 credits), and capstone design(2 subjects 4 credits). It adopted the curriculum structure with many prerequisite in consideration of the ABET(Accreditation Board for Engineering and Technology) of United States. It concluded that finishing engineering design courses and following the curriculum structure led the students to improve their presentation skill and team work more than 10～30% in the past.

According to a survey[7] on the current state of capstone design-related subjects of architectural engineering program in accreditation of engineering education, engineering design classes were increasing in the departments of architectural engineering. The survey analyzed the overview of design, design management, and design evaluation of capstone design subjects managed in 18 programs accredited in Dec 2010. The overview of design showed the contents and themes were alternative designs and virtual designs. Design management showed that the engineering design classes had pursued the integration of structural engineering, building environment, and construction management. The results of projects performed by students were evaluated twice a semester.

2.2 Action Learning

Action Learning is defined as 'a process which involves working on real challenges, using the knowledge and skills of a small group of people combined with skilled questioning, to re-interpret old and familiar concepts and produce fresh ideas.'[8] Figure 1 shows the general process of Action Learning.[8] First of all, a learning team is built with 4～8 members and is given an important and difficult problem. The team finds solutions with several meetings within the restricted duration, where a learning coach attends the meeting for more effective problem-solving. Using a variety of powerful techniques such as problem-solving skills, communication skills, project management skills, and meeting operation skills, the team discusses about the problem with the learning coach and with reflections which give rise to alternative development and learning

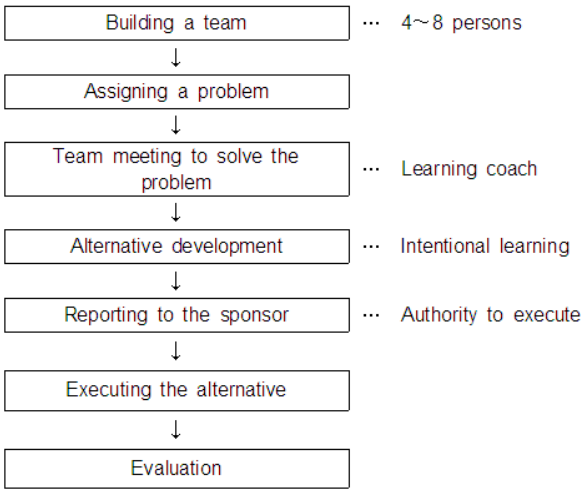

Figure 1. Process of Action Learning

simultaneously. The alternative is evaluated by the sponsor who has a right to execute the alternative.

The components of Action Learning are a team, a problem, strong will to execute, acquisition knowledge from the problem and problem-solving, questions, reflections and feedback, and learning coach. The problem is important and difficult, and it is a real problem which is directly related to the profit or survival of a team/organization, not virtual one. Appropriate team size is usually 4-8 people. Less than four members of a team decrease the diversity of the group and it is difficult for the team to be creative and challenging. If the team has more than nine people, while the interaction between the team members are too complex and insufficient time is allocated to comments and reflections to each member, it is also too difficult to expect effective actions. Because Action Learning is a problem solving strategy to resolve practical problems in the risk of failure, the problem solving requires practice and the strong will to execute the alternative derived from the problem solving is very important. In addition, problem-solving process gives knowledge such as team leadership, communication skills, presentation skills, project management skills, conflict management, meeting management skills, and so on.

The problem, a series of actions for problem solving, and careful reflection about team meetings themselves grant the participants insight that enables them to ask fresh questions in a situation when nobody knows what to do. Team members are able to reach common view on things and learn from each other's experience. They will also establish a close relationship.

A learning coach participates in team meetings as a team member to increase the effectiveness of learning team. He stands on the center in discussing and has no formal authorization to determine. And he intervenes to help the team to improve how to recognize problems, how to solve the problem, and how to make decisions.

One of the characteristics of Action Learning different from other education programs is that learning takes place not when a learning coach leads the team, but when the team finds and analyzes natures of the problem, methods

to solve the problem, questions to answer, and reflections. That is, wise questions promote creative thinking by shaking basic assumptions that the team members know, by forming the new relation among objects or phenomena, and by helping to develop a new thinking model about the existence of objects and desirable forms of the objects. Table 1 shows the comparison of Action Learning and other problem-solving strategies[8].

3. DESIGN OF A SCHEDULE MANAGEMENT TOOL FOR SMART DEVICES

3.1 The objective of the classes

This paper's case is Construction Safety & Environment Design of Department of Architectural Engineering in J University in Korea that has two credits and four hours a week. The department has all of engineering design, that is, a basic design is in the first grade, element designs are in the second and the third grades, and a capstone design is in the first semester of fourth grade. The element designs have the contents required separately by the detail parts of architectural engineering such as construction management, construction structure, construction environment, and construction material.

The Construction Safety & Environment Design class is a element design where students propose alternatives to improve safety and environment of a construction site and get chances to experience a role as a safety manager in advance. To make the alternatives, the students study various types of safety accidents, safety facilities, safety tools, and equipments. They also review environmental factors such as weather, traffic, social and economical situation, circumstances of a field. The objective of the class is as follows. (1) A student finds problems in safety facilities or factors of safety and environment, proposes an alternative to remove or relieve the problem, and verify the alternative. (2) The student is able to experience and learn the importance of safety by these actions.

3.2 Class design

The Construction Safety & Environment Design class focuses the importance of management of construction safety and environment from suggestions to improve the factors of safety and environment. The class introduces current statistic, causes and effect of safety accidents in early weeks.

The class is designed for 4~5 students to perform a project because the project requires many ideas and various roles to investigate factors of safety and environment and to propose alternatives. The results of the performance are evaluated by efforts and outputs done to clearly state the problems of the project, and improve them. Role playing, team coordination, and communication skills in the process of the team project are also evaluated.

A lot of teaching-learning strategies such as Problem-Based Learning and Team-based Learning are able to be adapted to the problem-solving process in the team project. Action Learning teaching-learning strategy was applied to the construction safety and environmental design class to make more active and various alternatives because a construction field has many stakeholders and lots of management methods of safety and environment.

3.3 Class operation

The Construction Safety & Environment Design class is a lesson to learn the management of construction safety and environment. Internship at a construction site is a good way to learn and practice construction management. Since the opportunities of internship are scarce and the internship doesn't focus on the safety and environment management, this class enables students to obtain opportunities to investigate problems threatening construction safety, to propose an alternative and to learn safety facilities, factors, gears and equipments.

The class had 2 credits and 4 hours a week in the 2nd semesters of 2010 and 2011. The contents and projects in both semesters were similar as shown in Table 2. Teams

Table 1. Comparison of Action Learning and other problem-solving strategies

Strategy	Leaning Objective	Learning Method	Properties
Action Learning	To find & solve real business issues focusing environmental & systematic factors	Student-leading learning, Intentional learning	- Learning from checking execution and reflection of the alternative - Focusing the development of individuals and organization
Task Force	To focus on a specific task/problem on real situation	Learning by chance	- Management having right to execute the alternative
QC (Quality Circle)	To focus on quality improvement on real situation	Learning by chance	- Management having right to execute the alternative
Simulation	To solve imaginary problems	Intentional learning	- No responsibility to the results given by the alternative - No opportunity to verify the practicality of the alternative
Problem-based Learning	To solve real and imaginary problems	Intentional learning	- No responsibility to the results given by the alternative - No opportunity to verify the practicality of the alternative

Table 2. Syllabus for 2011

Week	Contents
1-3	Introduction to Construction Safety Introduction to Action Learning Team project orientation & Team building Selecting team subjects
4-6	On-site survey on the team subject Presentation (1st) - Objective, Method, & Cases of the team subject Reflections (1st) – Individuals & Team
7-9	Alternatives proposal - Building a model and Implementing a system with ideas, knowledge, methods, & tools - Recording the process of model building & system implementation - Presentation, evaluation, & reflection Presentation of what to be progressed in every week
10-12	Presentation (2nd) - Team's alternative - Evaluation of other teams Reflections (2nd) – Individuals & Team
13-15	Presentation of Alternatives - Sponsor's comments (Construction manager, CEO of construction company, etc) - Reflections (Individuals & Team)

were built and the teams' themes were chosen to propose alternatives to safety management as a final objective. The teams investigated safety accidents and safety management cases on construction sites, and made their presentations two times to the final results. The 15 weeks of a semester were too short to investigate cases, visit construction sites and analyze data in a classroom. The teams repeated to perform most of reports and surveys out of the classroom and discuss their results to find alternatives in the classroom.

Class size was 15 people in 2010 including four seniors and one sophomore. The sophomore had not experienced a engineering design, and some of the seniors had participated in engineering designs. In 2011, number of enrollment was 14, but a student didn't attend the class. The 13 students took the construction management class including construction safety in previous semesters. The 10 out of 13 students responded they found the content of the class in advance. Most students (12 out of 14) experienced engineering design classes.

The class in 2010 used the Action Learning method to foster team learning and problem solving skills, and same method was used in 2011 to complement the shortcomings of the previous year class. Team organization, project selection, implementation and evaluation were followed the procedure of the Action Learning. It was difficult to select team projects in 2011 that were different from ones in 2011 because the classes in 2011 and 2011 were conducted in a similar way. Site manager interviews, field trips, and investigation of safety management data and patent-related materials were conducted to find more creative themes and projects.

The result of class in 2010 adapting the Action Learning for the first time showed that a member absence from the class caused the team damage after the team was built. When teams were built in 2011, students who couldn't attend to perform the team project were required to drop the class. The students taking the class in 2011 had known about the Action Leaning method because some of them took a basic engineering design class in 2010, and others heard of the method indirectly. The Action Learning method raised level of participation and level of satisfaction. It needed most of class hours to perform the project in discussing collected data and many ideas.

Every team presented the results that the team had performed in every week. Each member randomly changed his/her role as a speaker, a clerk, and a panel in every week or twice a week. At the end of the class, every team and each member reflected on what the team and the member had done and what should be done for the team, the members, and the project. The members' reflections were described in emotional words such as 'fun,' 'pleasant,' and so on in early weeks and gradually objective words such as 'useful,' 'helpful,' and so on were used much. The team reflected their deficiencies, and needs to be improved, so they became guidelines for the team to improve the team activities.

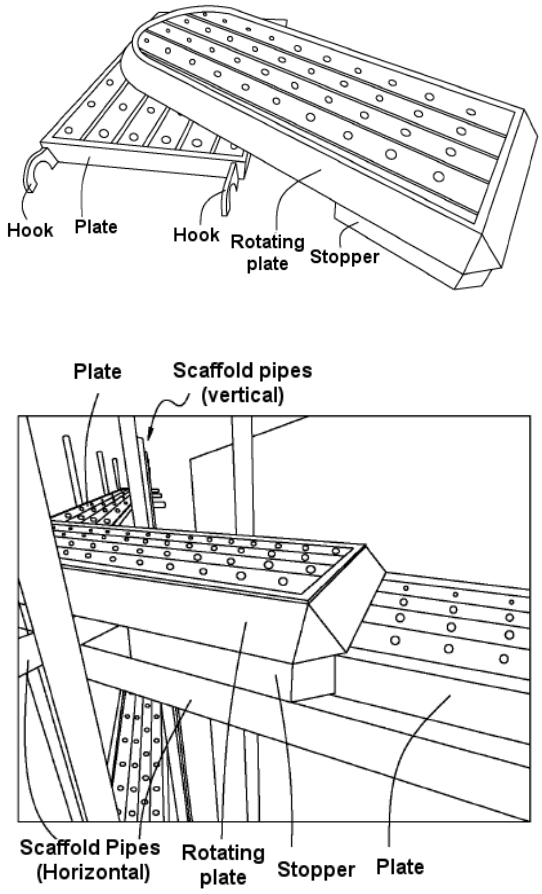

Figure 2. A result from the class - Plate for control of angel with scaffold (Patent pending)

Active participation in the team project of the project had resulted in 4 objective alternatives in 2010 and 3 alternatives in 2011. One out of four and two out of three results have been applied for patents are pending [9,10,11]. Figure 2 is an example of the results.

3.4 Results of the classes

The teacher and the students had difficulty in adjusting the Action Learning to the engineering design class because it was a new teaching-learning strategy. In spite of the difficulty, team activities made improvements to level of participation and level of satisfaction though class hours for theory lectures were insufficient. Every member elevated his/her presentation skills and communication skills due to experiencing all roles in a team.

Surveys were conducted at the end of each class in 2010 and 2011 to investigate level of participation, level of satisfaction, and role allocations as shown in Figure 3. 15 students took the class in 2010 and 14 in 2011. Respondents to the each survey were 8(53.5%) and 12(85.7%) respectively. The level of participation is a question about 'How the level of a student's participation in the class is.' The answers of 'very high' were 50.0% in 2010 and 83.3% in 2011. Most students participated actively in the class because the responses became 100% and 91.7% including the answer of 'high.' Each level of satisfaction was 100% including the answers of 'very high' and 'high.' It seemed that the students were more satisfied with the class in 2011 considering the respondent ratio was 75.0%. Answers to 'How the level of role sharing and team communication was in the team' showed the role sharing and communications were good in the team because the responses were 100% in 2010 and 83.4% in 2011 including the responses of 'very high' and 'high.'

A systematic teaching-learning process of Action Learning introduced to an architectural engineering design class could raise level of participation and level of satisfaction. Role-sharing within a team and exchange of ideas were considered to be actively performed. But first adaptation of the Action Learning in 2010 made the teacher and the students confused to manage the class and perform the projects.

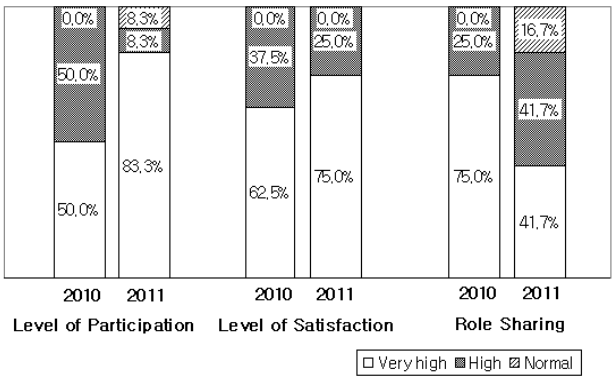

Figure 3. Annual comparison of students' responses

3.5 Discussions

Hours to lecture theories about engineering design, construction safety, and environment management decreased as the Action Leaning needed much time for students to survey, discuss, and make alternatives. Theories and materials for lectures need to be given to the students out of the class and questions and discussion should be focused on in the class.

5 project teams in 2010 and 4 in 2011 were suitable for the teacher to coach. But the teacher had some difficulties through lack of experience using the Action Learning. Afterwards, more active team activities can be possible if an engineering design class is supported by a student who has taken an Action Learning class.

The students and their team reflected on learning and feeling from the class and the team activity, and how to use them at the end of the class or team activity. They were not familiar to express their feeling in early hours of the class, and gradually they became more active. The reflection is very important to the Action Learning, but it is difficult to use in a class because the student is unaccustomed to express their feeling and to criticize others. Therefore various methods, tools and techniques are needed to make use of reflection in a class.

4. CONCLUSIONS

The class is one of element designs required by ABEEK that students should take. Generally they take a basic engineering design in 1st or 2nd grade to understand the concept, necessity, and process of engineering design. But, most students of J University have never taken a basic engineering design or an element design because J University started to prosecute the accreditation of engineering in 2009. Thus the students had difficulties to perform their element design projects. The classes used the Action Learning teaching-learning strategy for two semesters in 2010 and 2011 to overcome the difficulties. The results are as follows.

(1) The classes had the systematic engineering design process using the Action Learning in 2010 and 2011. Its processes and guidelines such as team building, team rules, discussion method and order, and reflections technique produced good results of patent applications.

(2) Surveys at the end of the classes showed that the new teaching-learning strategy enabled the students to participate more actively in team activities, to become more satisfied, and to share well member roles and communicate more clearly each other.

(3) The teacher and the students had difficulties in using the Action Learning because they had known it a little. An orientation is required to give them information about the concept and process of the Action Learning in early week of a class to overcome fear of the new method and motivate the students to perform their project more efficiently.

Though the Action Learning provides a systematic process, the role of a teacher is important to use it properly. And, the students will produce much better results of a project if a student who has experienced the

Action Leaning in an engineering design class or an Action Learning expert helps them to perform the project.

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