

## **Analysis of Learning Experience on Team-based Technology Design Project of Non-Engineering Students\***

Insu KIM

Korea National Sport University, Korea  
Korea

The design project of a technology product provides an opportunity for students to experience the inter-connectedness of academic information and ill-defined real-world problems. This study focuses on non-engineering students' activity and perception through the assistive technology design project. For this purpose, participants engaged in a team-based technology design project. Then, a qualitative research approach was adopted, which included reflective journals with 24 undergraduate students majored in Adaptive Physical Education. The analysis identified six factors (knowledge value, social value, reality value, accomplishment value, perspective value, benefit value) of perception and five stages (topic selection, function suggestion, visualization, presentation preparation, and presentation) of activity.

*Keywords : team-based project learning, technology design, assistive technology, higher education*

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## Introduction

Assistive technology (AT) design class lets students create real-life products that will allow people with disabilities to live more independently (Goldberg & Pearlman, 2013). Integrating team-based technology design throughout the undergraduate engineering and technology curriculum has become commonplace. This is because students are challenged to learn how to work in teams, develop hardware or software, and practice systems-level thinking when integrating technologies. Moreover, students learn technical skills and intangible skills, such as teamwork (Jang, Kim, & Kim, 2013; Savage, Chen, & Vanasupa, 2007), responsibility (Jang et al., 2013; Savage et al., 2007), and enhanced interpersonal communication through team-based project (Jang et al., 2013; Kim, 2006). However, non-engineering undergraduate students rarely have the opportunity to design or develop technology as part of their curriculum. Therefore, this study explored the non-engineering students' experience in team-based design projects. The following questions were asked:

1. What steps do non-engineering students follow in order to design an assistive technology?
2. What perceptions of the values of team-based technology design do non-engineering students have?

## Review of the Literature

### Technology Design Team Project

Visualization has proven to be effective in making knowledge explicit (Keller, Tergan, 2004) and in representing both abstract and concrete ideas (Rha, Park, & Choi, 2009). AT design uses visualization to create products that support people

with disabilities. Recently, the importance of technology design education has been gaining recognition in the field of engineering (Kim & Kim, 2013). Moreover, team-based project has become widespread as the new curriculum at the department of mechanical and engineering with the aim of enhancing creativity (Kim, Kim & Kim, 2007), team working (Jang, Kim, & Kim, 2013; Savage, Chen, & Vanasupa, 2007) and communication capability (Jang et al., 2013; Kim, 2006) which modern engineering education emphasizes. Throughout a team-based project, the students are challenged to work in teams and practice thinking of inter-relationships of design solution when integrating technologies. Students have the opportunity to realize how their designs could solve technical problems and contribute to society (Savage et al., 2007). Jang et al. (2013) presented a case study on a creative engineering design course of environmental engineering through problem-based learning. The results of the study showed that this course had positive effects on the perceptions of learning about the importance of team work and responsibility as a team member. Additionally, Kim (2006) also presented a case study on a creative engineering design course. Participants of the course were first-year engineering students, and the object was to provide them with learning opportunities that pursued design solutions through team-based activities. Kim, et al. (2014) further conducted research on the learning experiences of the engineering department in a course-based AT development program. The results showed that learning experiences were classified into four sequential themes: “expectation”, “frustration and failure”, “challenge and compromises”, and “rewards and increased awareness”.

Despite educational effectiveness of team-based project, phases and activities of project on learning are various (Kim, 2011). Kim (2011) proposed ‘theme-making’, ‘planning’, ‘inquired information’, ‘task-solution’, ‘reporting’ and ‘presentation’ as procedures of project. Lee (2005) suggested that ‘preparing the project’, ‘selecting the project’, ‘exploring the information’, ‘designing’, ‘making’, and ‘evaluating’.

While there were researches on team-based technology design on the side of

engineering, non-engineering undergraduate students rarely had the opportunity to design or develop technology in their curriculum.

## Methods

### Participants

The participants of this study were 24 undergraduate students who majored in Adapted Physical Education. They were grouped into eight teams for a “Special Education Technology” course. The participants were selected because design principles to develop technology and appropriate use of AT were placed on curriculum even though they were not engineering students.

### Team-based technology design

Team-based technology design for the study was conducted in four steps. The specific project processes are presented in Figure 1.

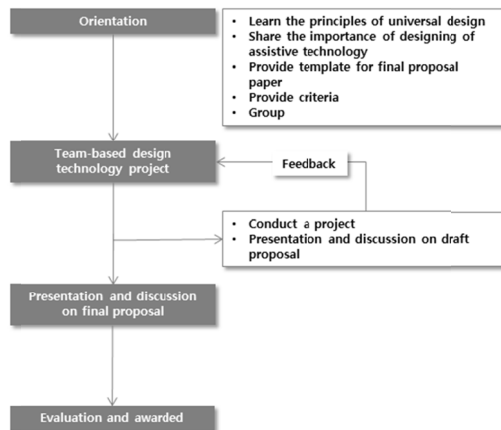


Figure 1. Team project-based AT project process

The aim of the project was to design an AT. The Principles of Universal Design were studied and applied for designing. Universal design (UD) is a term used in architectural and product development (McDonald-Peltier, 2014). The aim of UD is to “design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design” (Story, Muller, & Mace, 1998: p2). The Center for Universal Design proposed seven principles of UD: 1) equitable use, 2) flexibility in use, 3) simple and intuitive use, 4) perceptible information, 5) tolerance for error, 6) low physical effort, and 7) size and space for approach (The Center for Universal Design, 1997). The theme of the project was the contest of “Designing an AT for people with disabilities”. Judges of the contest were two professors and all participants. All participants rated products except for their own product. The scores were totaled up and the winner was announced. Evaluation criteria included creativity, practicality, effectiveness, logicity, aesthetics, and application of the principles of UD. The final product form was based on a contest by the Quality of Life Technology (QoLT) Research Center, including: a) overview of product, b) technological and social needs, c) beneficiary, d) final goal, e) core idea, f) detailed explanation and concept drawing, e) cost of the trial-manufactured product, and f) applied principles of universal design. The project differed from the contest in that one of its important objectives was to understand the principles of UD and apply them to design of an AT.

## Analysis

The final products of the eight teams included eight development proposals, a 171-minute video presentation, and 72 reflection journals on project activities and perceptions. For this study, the 72 reflection journals were analyzed in open coding.

To analyze perceptions and activities of the participants, data were analyzed in open coding. Open coding were divided into ‘segmenting’, ‘issuing of initial code’ and ‘in-depth coding’ (Kim, 2006). For ‘segmenting’ and ‘issuing of initial

code', phrases and sentences that would be significant to the study were compartmentalized and underlined to mark them from start to end. Phrases that described specific meaning were written down next to the sections as shown in the following example. In this process, phrases and sentences about perceptions and activities were divided and analyzed separately and named.

*I feel great about having completed this project (Sense of accomplishment) without anyone giving up.*

For 'in-depth coding', named phrases were grouped. For perceptions, 'deepening the understanding of principles', 'deepening the understanding of disabilities', 'active communication', 'cooperation', 'fellowship', 'getting to know current state of AT', 'sense of accomplishment', 'changing thought about AT', 'changing thought about disability issues', 'beneficial mind' and themes were categorized as cognitive values(deepening the understanding of principles, deepening the understanding of disabilities), internal values(active communication, cooperation, fellowship, sense of accomplishment, changing thought about AT, changing thought about disability issues, beneficial mind), realistic value(getting to know current state of AT). Named phrases were reviewed and categorized repeatedly until newly coded names were not emerged or were not changed into other names. Then values were categorized as six values based on discussion with one PhD in Educational Technology.

To explore the stages of activities, phrases and sentences about detailed activities were positioned to each cell. Cells were grouped and separated according to activities. Activities were defined by the grouping of cells.

For confirming the validity, a PhD in Educational Technology as an external expert reviewed adequacy of naming with example sentences and adequacy of categorization with description for verification.

## Results

### Six Factors of Perception

The participants perceived six values in the team-based technology design.

- a) Knowledge value: deepening the understanding of the subject materials
- b) Social value: involving active communication and cooperation
- c) Reality value: wakening to the realities of the subject
- d) Accomplishment value: completing the project
- e) Perspective value: changing the perspective of AT and disability issues
- f) Benefit value: students' belief that if their AT designs would make life more convenient for people with disabilities, it was worth the effort

Values were divided between the team-based project and about technology design: knowledge value, social value, reality value, accomplishment value were themes about the team-based project, while perspective value and benefit value were themes about technology design.

Knowledge value is the participants' opinions about focusing on a deeper understanding through team project-based AT design. Students commented that they understood deeply because they tried to apply the principles to the device:

*I have acquainted myself with the principles of universal design and gained a deeper understanding of them, which I applied in inventing the device. (Student 21)*

*I learned that the principles of universal design apply to both able-bodied and disabled people. I can put this knowledge to good use when I invent something. (Student 17)*

Social value is about the students' focus on involving active communication, such as hearing, explaining, criticizing and accepting the comments of other team

members. They exchanged opinions, shared responsibility, and cooperated through team-based technology design. Groupwork enhanced communication skills and students' ability to manage group dynamics (Stanford University Newsletter on Teaching, 2001). The participants exchanged their opinions, shared their own responsibilities, and cooperated with each other through team-based technology design:

*We set the store by the others' ideas. At the same time, we demanded an explanation from our team members when their ideas seemed unrealistic and we didn't understand them. If we accepted those ideas without demanding an explanation, our results would only be a packet of information. (Student 11)*

*While doing this project, we put our heads together and generated ideas. We cooperated by continuously coming up with ideas and discussing whether our design could become a reality. (Student 17)*

Reality value concerns the students' views about focusing on learning reality. Through this project, they found out which AT was developed, which regulation or system was supported, and what major improvements had been made in technology, regulation, systems, and so on:

*I found out how advanced AT is. This project provided an opportunity for considering issues of imbalance between development of new AT and support for legalization or institutionalization. (Student 18)*

Accomplishment value is what students attach to completing the project. They revealed that this was their first experience in design technology, including visualizing the mechanical process and sketching the device or screen shot. They joined this class because it was a part of the curriculum, although they did not consider the project as being beyond their capacity. Therefore, they felt a sense of achievement when they completed it.



*I feel great about having completed this project without anyone giving up. We felt terrible after proposal presentation. Some gave up, but our team members didn't. After that, we had a meeting and undertook research with a passion.* (Student 10)

*Designing the face washing device was difficult. The operating principles were difficult because we lacked technological knowledge. Nevertheless, designing that new product gave us a big sense of achievement.* (Student 5)

Perspective value refers to changing people's perspective of AT and disability issues. To design, students have to consider which AT is needed to people with disabilities on the basis of their disabilities. During searching developed assistive technologies and appliance, they expand thought people with disabilities to people with abilities through AT:

*I used to think that "people with disabilities" were in need of help and friends. After this project, I realized how they could overcome disability with AT. I think the value of this project is providing me with the opportunity to change my point of view.* (Student 9)

*I don't have any disabilities. During this project, I realized that I didn't think about the inconvenience that people with disabilities felt. As an adaptive physical education major, I'm now trying to look at people with disability from their angle.* (Student 10)

Benefit value is how students' look at benefits to people with disabilities. Students report that reward of team-based technology design project is awareness that their design can contribute people with disabilities' convenience:

*If persons with disability will receive service more easily, I find our project very rewarding. I believe that if our ideas are put into practice, assistance voucher system (personal assistance support system for disabled persons) for them will flourish.* (Student 8)

## Stages of Activities

Activities were categorized into five stages: topic selection, function suggestion, visualization, presentation preparation, and presentation. An information search was conducted in all stages.

At the topic selection stage, team members collected information and determined topic by discussing the necessity, usefulness, existence, possibility of development.

The topic selection stage had four aspects:

- a) The team, through the criticism and discussion of ideas, determined which device or service they would design. This included listening to explanations as well as specific ways of realizing the ideas.
- b) The team members had similar experiences and opinions; thus, they were able to choose the AT without resorting to intense arguments.
- c) One team member had strong opinions and relatively plenty of experience.
- d) During brainstorming, an idea would pop up and be developed.

At the function stage, the team members did research on or surveyed the needs of their end-users, considered the mechanical principles and materials, and selected the function according to practicality, development feasibility, and so on. At this stage, the participants shared what they studied and the information they were able to acquire.

During the visualization stage, the mechanical principles and completed image or screen shot were sketched. This and the previous stage (suggesting function) sometimes occurred simultaneously because sketching was needed when discussing and explaining operating methods.

At the presentation preparation stage, team members made a presentation file and divided among themselves the parts that they would present.

During the last stage, the entire team presented their device/service by explaining it in detail, and the other teams asked questions or suggested

improvements.

## **Conclusion and Discussion**

In conclusion, the participants experienced six values (knowledge value, social value, reality value, accomplishment value, perspective value, and benefit value) and proceeded with the project in five stages (topic selection, function suggestion, visualization, presentation preparation, and presentation).

According to factors of perception, social value (Jang et al., 2013; Kim, 2006; Savage, Chen, & Vanasupa, 2007), reality value (Kim et al, 2014), accomplishment value (Kim et al, 2014) and perspective value (Kim et al, 2014) were reported in advanced researches. However, with respect to benefit value, Savage et al. (2007) commented that students have the opportunity to realize that their designs would contribute to society through team-based project. However in their research benefit value was not reported empirically.

According to activities, five stages are topic selection, function suggestion, visualization, presentation preparation, and presentation. There was similar stage. 'Topic selection' corresponded with 'theme-making' (Kim, 2011) and 'selecting the project' (Lee, 2005). But information searching activity like 'inquired information' (Kim, 2011) and 'exploring the information' (Lee, 2005) were separated stage in advanced researches. In this study information searching activity was executed at all stages.

There are two limitations of this study: generalizability and relying on reflection journals. The generalizability of this research is limited because curriculums of all non-engineering departments would not include contents that could be integrated with technology design. Another limitation is that analyzed data were relying on reflection journals. However, perceptions are necessarily self-reported. Therefore, this is an avoidable limitation of this study.

For further study, crossing disciplines would create a synergy effect. Technology design requires the expertise of multiple disciplines. In this research, knowledge in various disciplines was required. For technology design, participants appreciated a wide range of technology, made design drawing, and calculated production costs. Team-based technology design would be a convergent project of involving different disciplines. And non-engineering students could have opportunities to design technology in their curriculum.

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**Insu Kim**

Korea National Sport University

E-mail: [insu@knsu.ac.kr](mailto:insu@knsu.ac.kr)

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