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Project collaboration between art and science students as a venue for engineering design education

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Abstract. It is expected that increasingly active new technologies will be developed due to the rapid advancement accompanying technological innovation of artificial intelligence and machining technology typified by 3D printers. On the other hand, rapid social change, such as replacement of simple labor with machinery, is also expected. For future manufacturing and university design education, there is an urgent need for research into contemporary education methods. Particularly, engineers who constantly create new concepts are required, who have the creativity to make products based on user needs, cooperative skills, and the executive ability to form and realize projects and shape ideas. To foster innovation talent, it is necessary to conduct learning and project implementation by interdisciplinary teams. However, in engineering education in Japan to date, education within individual departments has been the main focus. In this research, we propose a mechanism, for fostering technicians who can create and implement new concepts, that entails fusing students of undergraduate departments with students of other undergraduate projects. Our research goal is to evaluate the idea of design in the investigation of the literary fusion project and its activities. In order to verify the influence of divergence and convergence of ideas on the project, we quantitatively evaluate the change in ability of divergence and convergence of learner's ideas through design thinking education. In addition, in order to verify the pedagogical value of design-based education of teams with diverse specializations, we investigate the educational effects and communication problems through a project-execution student project. Based on the results of the experiments, Discover problems occurring in the team with diverse specializations, we conclude by proposing a method for improvement.

1. Introduction

In order to avoid technical stagnation, industry is seeking engineers who constantly create new concepts, and educators face the challenge of implementing design education to nurture such technicians. At the same time, university educators have been actively engaged in learning activities through problem based learning (PBL) and university societies, but a certain degree of autonomy and expertise is required for these learning methods be effective.[1] There is a problem with guaranteeing uniform learning effect for learners with low experience and expertise and being properly managed by a learning team with different expertise.

In order to achieve this proposition, we focused on technological innovation caused by digital production technology and implementation of interdisciplinary education based on design thinking. These are expected to be effective for further developing the creativity of technicians and developing the ability to create new concepts required of engineers.

Chris Anderson, in his book “MAKERS,” [2] writes that manufacturing using digital production technology is the industrial revolution of the 21st century. In the industrial revolution in the latter half of the 18th century, when industrial society was born, industrial products were designed and produced for the purpose of mass production and mass consumption. In our century’s industrial revolution, on the other hand, product manufacturing is expected to become possible in small industries and niche varieties. This presents an opportunity to bolster the influence of manufacturing education and design education in universities, and Cathy N. D. [3] said that the majority of elementary school students are entering unprecedented occupations.

Masaki [4] has analyzed engineering education at the Design Engineering Society and has discussed changes to technician education at the Department of Mechanical Engineering from Handwritten Drafting to 3DCAD as well as the response to these changes. Considering the influence of the technological innovation mentioned above, he showed the necessity to investigate and consider engineer education at science and engineering universities in response to major changes in industry and education, themselves resulting from evolutions in computer technology that occurred in the 1990s.

However, surveys and research on engineering education at the Department of Mechanical Engineering have not been conducted sufficiently Yoshioka [5] surveyed the current state of design education at Japanese universities and compared engineering students to economics students and found that the engineering students belonging to the laboratory had more opportunities related to manufacturing than the economics students. However, before belonging to the laboratory, engineering students got the same degree of opportunity as economics students, and there were actually few opportunities connected to manufacturing. In the survey on the penetration of the manufacturing industry at home, engineering students belonging to the laboratory have a high proportion of engineering students in their homes, and relatively few engineering students and economic students who are not belonged. From this, it is clear that there is a difference in experience and expertise in manufacturing between university engineering students who do full-scale research and those who do not.

Abundant research has been conducted on design education using design thinking from the viewpoint of cognitive psychology. It is said that configuration self-efficacy [6], goal setting[7], elimination of cognitive bias[8], etc. are effective for improving design performance, and it is known that these can be improved by the mindset cultivated by design thinking. Design thinking seeks T-shaped teams [9] with different skill dimensions, which logically suggests the need for interdisciplinary project. As an example of design education based on design thinking, Jeanne Liedtka [8] analyzed how design thinking works and how to overcome cognitive bias to make non-designers acquire design thinking to create innovative results.

Since the effects of such psychological effects were studied almost in the field of cognitive psychology, research is not active from the viewpoint of education. For example, the development of the ability to overcome the cognitive bias is detailed in Literature on Cognitive Flexibility [10] and literature on resistance to change [11], but studies related to the design education field have been little attention until now. In other words, although it is theoretically understood that elements of design education are effective for design education, designers who are learners do not necessarily behave uniformly in cases, so a more fundamental analysis is necessary.

Based on the above matters, we aim to research and propose design education for engineers who increase learners' creativity, create new concepts. Specifically, we conduct the following research.

(1) Implement not only the technology of manufacturing and the science and engineering expertise education, but also design thinking education with interdisciplinary project, and analyze the learning effect.

(2) We propose a design education program to train engineers with the ability to discover technical skills and needs.

(3) Study a program to learn a method to create a new concept by combining multiple expert knowledge.

2. Design thinking

Micah J. L [12] proposed that an innovation can be defined as a new concept that satisfies technological possibilities (technology), can generate profits (business), and is needed by customers (human values). The task of this research is to cultivate engineers who possess both the creativity to create innovation and the cooperativeness and execution ability to formulate and bring to fruition a project to shape the idea created.

In order to achieve this task, we focus on design thinking and interdisciplinary projects.

Design thinking is a characteristic way of thinking used by designers that seeks to discover essential solutions to a given problem through “divergence,” the process of devising many ideas, and “convergence,” the process of choosing the best answer from among them. Design thinking refines the chosen idea by repeating divergence and convergence of the idea at each stage, leading to a final conclusion. Here we introduce the five-step process [13]:

(1) Empathize: Observe the user deeply and clarify needs
(2) Define: Come up with an actionable problem based on needs
(3) Ideate: Generate ideas and mentally “go wide”
(4) Prototype: Refine ideas by building and testing iteratively
(5) Test: Have users use prototypes and get iterations

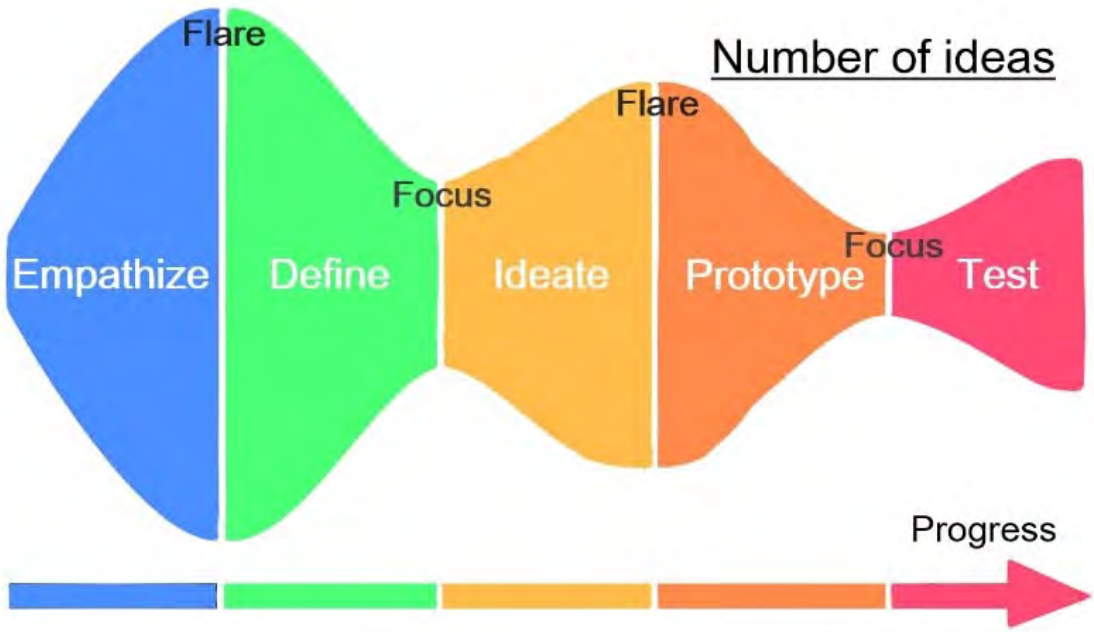

Figure 1. Design thinking.

An interdisciplinary project is one in which experts from various fields collaborate. This paper refers specifically to a project in which technicians and non-technical persons collaborate. The foundation of ideas is the mindset and knowledge of the people who create them. For this reason, it is advantageous for people with different perspectives and knowledge to gather and exchange ideas to create new ideas.

On the other hand, differences in specialized fields are not limited to expertise; they are also great in terms of mindset. It is difficult for people with different expertise to communicate smoothly, especially in the Japanese community. As an example, there are few opportunities for university students in science and literature to interact, and there are conflicts between technical and sales departments in companies. For this reason, it is necessary to observe communication among different professionals and discover ways to promote more vigorous exchange.

3. Research method

In this paper, we investigate the interdisciplinary project and evaluate the idea of design in it.

One of the merits of interdisciplinary projects is that teams with diverse membership can expect to discover unique ideas. For this reason, it is expected that the implementation of a team in a way that creates more ideas will have a positive impact on the project. In order to verify the influence of divergence and convergence of ideas on the project, we quantitatively evaluate the change in ability to practice divergence and convergence attained through design thinking education.

Moreover, one of the challenges of technical education in Japan is the difficulty collaborating among people with different fields of specialization. Although it is expected that exchanging different perspectives and knowledge will lead to the creation of ideas, differences in sharing and thinking among fields may hinder active exchange of opinions.

In order to verify the pedagogical value of education based on integrating cooperative persons with different fields of specialization, we investigate the educational outcomes and problems with communication of students participating in the interdisciplinary project.

4. Interview

We analyze design education for college students in Japan as an example of an interdisciplinary project. In this project, engineering students and design students worked as teams, proposing workshops for design education. Team members learned about the fundamental elements of design education in advance, and teams conducted activities using design thinking methods.

Analyzing the interviews with the team members of the project, we examine the effect of divergence and convergence of ideas on the project and the influence of differences in specialized fields on team communication.

Participants worked on projects to propose design education workshops for beginners using 3DCAD and 3D printers. We shared the progress of the projects online, holding meetings mainly at night.

There were differences in the designs of products created in the project. Engineering students' designs tended to emphasize the functions of products. They excelled at grasping the problems that arise when actually creating the designed products, realizing the projects proposed by the team in a realistic manner. It is interesting to predict the time required to process ideas proposed by design students, compare them with the time available for workshops, and adjust the ideas.

On the other hand, design students focused on design. They sought attractive ideas to make products more interesting to customers. While engineering students try to make the product have a certain level of functionality, it is interesting to propose flexible ideas without sticking to functions in order to prioritize design education proposal by 3DCAD.

As for the question of whether they are dissatisfied with each other, engineering students tended to emphasize the originality and attractiveness of ideas rather than feasibility for design students, and evaluated that it was difficult to make discussions that used engineering knowledge with high expertise. In order to make full use of the flexibility of the ideas of design students, they showed the need for engineering students to lodge coordination on specialized fields.

On the other hand, design students stated that the designs of engineering students, who prioritized function, were very simple and perceived them as having a passive attitude toward communication within the team. In order to ask for more opinions from engineering students, they showed the need for the design students to lead the communication within the team.

In connection with this, through an additional interview, we learned that engineering students are not good at positively communicating with group with shallow association. Design students commented that even engineering students who were active as leaders in university society gave the impression of being inactive compared to themselves.

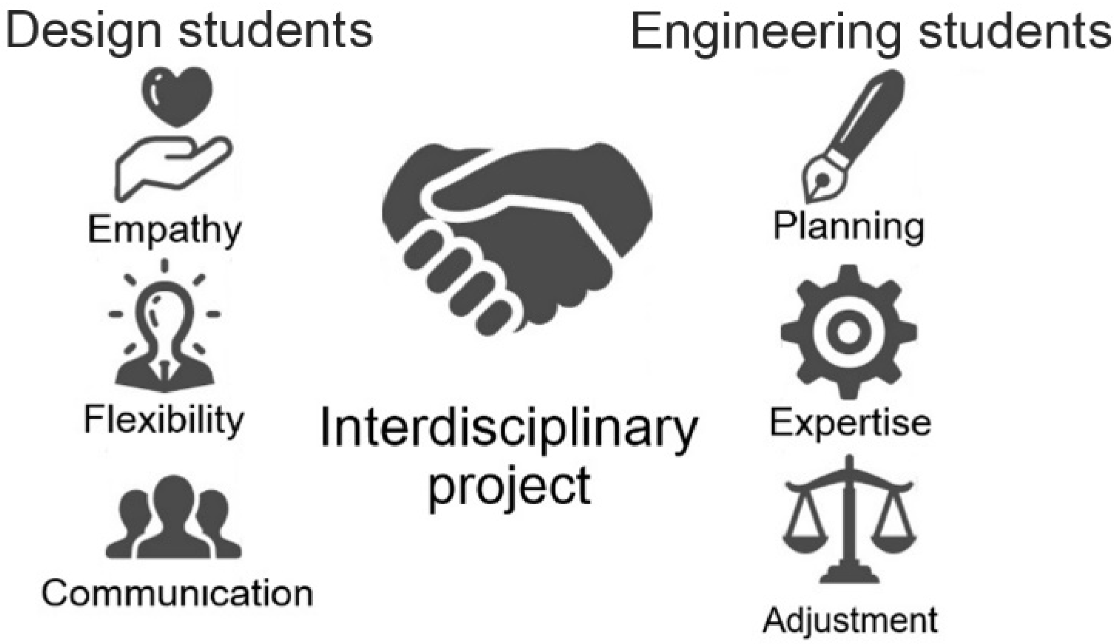

Figure 2. Interdisciplinary project.

5. Suggestions

What is important is the difference in approaches to projects due to differences in expertise and communication problems. It was commonly recognized among engineering and design students that combining different approaches had a positive impact on their projects. We deem our radical collaboration between engineering students and design students to have succeeded because we were able to deal with not only the planning stage, but also the actual implementation problems.

Regarding communication problems, engineering students tended to observe a deep relationship with people with the same expertise while recognizing the importance of communication with group with shallow association. On the other hand, design students tended to positively communicate with others, asking about their opinions and skills, and there were opinions that they consciously strove to widely interact.

In our interview, we were able to improve these problems through active mutual cooperation. We believe it is important to adjust to differences in expertise and communication ability to make a project function effectively. In other words, it is necessary to encourage mutual compromise by members or facilitators who understand correctly that these problems may occur in project practice.

6. Conclusion

In this research, we analyzed issues of engineering students' and design students' projects, a previous unexplored topic, through interviews and made proposals on how to implement more effective interdisciplinary projects in the future.

For further research, in addition to analyzing the interviews, we would like to conduct quantitative assessment of project activities and outcomes.

Acknowledgments

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