A Case Study of the Engineering Ethics Education and Developing Teaching Materials

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Abstract

Preceding studies on engineering ethics education in Japan have mainly focused on the educators' perspective. The authors are currently engaged in the "Improvement of Education and Development of Effective Learning Materials through Practical Education Research of Ethics Education for Engineers".
Our study focuses on the interaction and learning process between teachers and students in an engineering ethics class, using discourse analysis and video review. In our research, we conducted a trial engineering ethics class, recorded group work, and made transcripts.
After analyzing the transcripts and video review, we found that students not only completed the assigned tasks but also constructed better arguments, dynamically adjusting, and integrating their knowledge through discussions. In addition to that, we pointed out that the discourse analysis and video review will also work for teachers to improve their classes effectively.
Furthermore, based on the results of these analyses, our research project will also work on developing new engineering ethics education materials. Last year, we tried to create learning materials with our Environmental studies class students.
In this endeavor, we have incorporated the Serious Board Game Jam (SBGJ). SBGJ is a combination of three words such as "Serious game" which means to think about social issues, "Board game" and "Game Jam" which means to create a game together.
Creating games in groups has advantages over lecture-type classes so that they can learn independently even while having fun. It also requires a sense of fun and design. It is not only "fun". The theme of the ethical problem must be appropriately set, and the conditions, definitions, and rules of the game cannot be created without understanding the structure of the problem that has been set. Furthermore, to create a good game, it is important to consider the users' point of view to devise and implement tricks so that users can enjoy the game and not get bored. In conclusion, the creation of game-type learning materials requires abstraction and communication skills. In other words, it is not only fun but also a learning process with high educational effects.
Based on the results obtained from this report and the issues it addresses, we would like to work on the creation of learning materials on engineering ethics next year.

Keywords: *engineering ethics, discourse analysis, learning process, learning materials, serious game*

Introduction

Preceding studies on engineering ethics education in Japan have mainly focused on the educator's perspective. However, teaching is a "complex activity involving diverse values and factors" (Akita & Sakamoto, 2015, p. 228) and "an interaction that students develop with others over the content of the subject matter" (Akita & Fujie, 2019, p. 3).

In this sense, educational research in engineering ethics requires not only curriculum development using pre- and post-questionnaires to students, but also observation and description of how teachers and students act and discuss during class, how teachers teach, and how students acquire knowledge.

The authors are currently engaged in the "Improvement of Education and Development of Effective Learning Materials through Practical Education Research of Ethics Education for Engineers". Our study focuses on the interaction and learning process between teachers and students in engineering ethics class, using discourse analysis and video review. In our research, we conducted a trial engineering ethics class, recorded group work, and made transcripts (Takehara, 2021) (Takehara & Fujiki, 2021).

As a result, we found that students not only completed the assigned tasks but also constructed better arguments, dynamically adjusting, and integrating their knowledge through discussions. In addition to that, we pointed out that the discourse analysis and video review will also work for teachers to improve their classes effectively (Takehara & Fujiki, 2022).

In this paper, firstly, we summarize the educational research using discourse analysis and video reflection on our research project. And secondly, we will also report on our efforts to develop learning materials that include game elements on the theme of environmental issues through a trial class in 2022.

Discourse Analysis of Student Discussion in "Engineering Ethics"

One of the characteristics of ethics education for engineers is that there are no predetermined correct answers. Therefore, it is important to learn how to reach conclusions. Video materials have been produced to present issues and perspectives without explicitly stating conclusions.

So there, in 2021-2022, we conducted a trial engineering ethics class at the National Institute of Technology (KOSEN), Nara College, recorded group work, and made transcripts. The class progressed as follows: First, students studied the "Seven-step Guide to ethical decision-making" (Davis, 1999) by watching the video learning material (Muroran IT, 2008). Next, they watched the "Solar Blind" video (Kanazawa IT, 2009). Finally, the class was divided into groups, and group work was conducted based on the "Seven-step Guide to ethical decision-making".

Figure 1 Video recording of group work (the July 2021 class data)

From the transcripts and video recordings, we analyzed and considered "the process of discussion = the learning process of ethics for engineers," "how group work works," and "how teachers interact and work with the students".

As a result, we obtained the following three findings. First, each group proceeded with discussions based on different procedures, different conclusions, processes, and durations. Given the diversity of the discussion process, teachers need to evaluate not only the results of group work but also the process to develop problem-solving skills in group work.

Second, we focused on the inherent nature of group work itself. We found that students discussed the contents of engineering ethics, and "how to work in groups" at the same time. We found that during the discussion, they often showed their understanding by nodding, agreeing, and repeating others' opinions, and such attitudes activated the discussion and also showed their implicit acceptance of others. Therefore, teachers should be aware of the process that students accept others in group work, in other words, it is important to recognize the discussing issues in a democratic and open relationship and to advise them so that they can create such an environment.

Third, we focused on the teachers' behavior and analyzed how they interact and cooperate with students. We found that teachers were involved with students while engaging in various behavioral patterns such as providing guidance, questioning/utterance, patrolling, and advising in the classroom. However, not all of these actions were successful (of course, appropriate guidance may be given). This indicates that it is effective for teachers to review the video to get their class improved. Teachers can improve their lessons appropriately by analyzing the factors of "success or failure of behavior in the lesson" while recognizing "teacher involvement" and "student reaction".

As described above, the analysis of the learning process through discourse analysis in group and video review revealed several important perspectives and issues. These were shown to have the potential to improve classroom teaching.

Development of learning materials

Based on the results of analyses of the learning process in Engineering Ethics, our research project will work on the development of new materials.

In preparation for full-scale implementation, last year, we were challenged to create game-type learning materials over the theme of environmental problems in a general education elective Human Environmental studies class for fifth-year students at National Institute of Technology(KOSEN), Nara College.

While conducting the class, we have incorporated the Serious Board Game Jam (SBGJ) taking into account the characteristics of students in KOSEN who prefer experiments, practical training, and hands-on work. The name "Serious Board Game Jam (SBGJ) " is a combination of three words such as "Serious game" which means to think about social issues, "Board game" and "Game Jam" which means to create a game together (Figure 2). The term was named by Kazuhiko Ota, an associate professor at Nanzan University, Japan

(SBGJ2022, 2022).

Figure 2 Illusts of SBGJ (SBGJ2022, 2022)

In the class, students learned basic knowledge such as the current state of environmental problems, legal system, environmental conservation technologies for air, water, and soil, environmental indicators and monitoring, environmental ethics, and living environment in a lecture format.

After that, students were divided into groups and worked to create experiential learning materials that would enable participants to think seriously about the environment while having fun and playing games based on what they had learned in class.

In the group work, the students were first asked to experience some serious board games. Then, the students worked on game ideas and actual production activities. Finally, students gave final presentations about their games to real-life policymakers, who worked for the Environmental Policy Division of Nara Prefecture.

Students created a very wide variety of games: a speed game to sort trash, a card game to balance industrial development and environmental sustainability, a game to experience the benefits and challenges of building and operating a power plant, a card game to guess the habitat of endangered species, a poker game to learn how to dispose of trash, a game to experience the pleasantness of environmental conservation and the discomfort of pollution, a card game to learn about environmental issues, and a game of cards to learn about environmental problems, a karuta game to learn environmental issues, and a board game in which villagers cooperate to overcome natural disasters. Some of the groups used 3D printers and laser cutters to create prototypes (Figure 3). Another group created a card game linked to the Web by

programming by themselves (Figure 4).

Figure 3 Prototype for a game made with a 3D printer

Figure 4 Creating a card game linked to the web

Creating games in groups has advantages over lecture-type classes so that they can learn independently even while having fun. It also requires a sense of fun and design. It is not only "fun". The theme of the ethical problem must be appropriately set, and the conditions, definitions, and rules of the game cannot be created without an understanding of the structure of the problem that has been set. Furthermore, to create a good game, it is important to consider the users' point of view to devise and implement tricks so that users can enjoy the game and not get bored.

In conclusion, the creation of game-type learning materials requires abstraction and communication skills. In other words, it is not only fun but also a learning process with high educational effects.

Conclusions

In this paper, we summarized the educational research using discourse analysis and video reflection on our research project and described our efforts to develop learning materials that include a game element on the theme of environmental issues through a trial class in 2022.

The analysis of discourse analysis and video reflection revealed the following.

First, the generation, confrontation, transformation, and integration of arguments that occur in group work and discussion, in other words, the process of debate, are important. In addition, there is an inherent nature of group work, and classes should be conducted on this basis. Finally, the effectiveness of teachers' video reflections in improving their classes was pointed out.

And the creation of game-type learning materials requires abstraction and communication skills. In other words, it is not only fun but also a learning process with high educational effects.

Based on the results obtained from this paper and the issues it addresses, we would like to work on the creation of learning materials on engineering ethics next year.

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