What and How are Students Learning in an Engineering Ethics Class?
- An Attempt at Discourse Analysis and Video Review Using Multiple Recordings -

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Abstract

Since the mid-1990s, engineering ethics, which originated in the U.S., has been recognized as an essential element in engineering education. As a result, engineering ethics has been rapidly integrated into the curriculum of engineering faculties in Japan.
In accordance with these processes, perceptions have changed from a teacher-based to student/learner-based learning process. In other words, there was a change from the "what is taught" to "what is learned." Preceding studies on engineering ethics education have mainly focused on the educator's viewpoint. However, determining how students learn has mostly been based on the analysis of students' pre- and post-questionnaires, and not on the student learning process itself, or the actions of teachers.
Teaching is "a complex activity involving diverse values and factors" (Akita & Sakamoto, 2015, p. 228) and is "an interaction that students develop with others over the content of the subject matters" (Akita & Fujie, 2019, p. 3). In this sense, it is necessary to observe and describe how teachers and students act and discuss in class, and how teachers teach and students acquire knowledge, in addition to curriculum development using the pre- and post-questionnaires of students in educational research on engineering ethics. Therefore, this study examines discourse analysis and video review in a class on engineering ethics, focusing on the interaction between teachers and students and the learning process.
In our research, we conducted a trial class, recorded the group work on video, described the teacher's and student's discourse, behavior, and actions, and reviewed the class.
From the transcripts and video recordings, we analyzed and discussed that "the learning process of ethics for engineers," "how group work actually works," and "how teachers interact and work with the students," and then categorized them by the student learning process from these three viewpoints. We found that students did not only complete the assigned tasks, but they also constructed better arguments on their own initiative, dynamically adjusting and integrating their knowledge through discussion. We conclude that discourse analysis and video review are effective measures for confirming these learning processes.

Keywords: *engineering ethics, video review, discourse analysis, learning process, interaction between teachers and students*

Introduction

Since the mid-1990s, engineering ethics, which originated in the U.S., has been recognized as an essential element in engineering education. As a result, engineering ethics has been rapidly integrated into the curriculum of engineering faculties in Japan (Fujiki, 2011) (Sugihara et al., 2017).

To determine the best method of teaching engineering ethics in Japan, the research committee of the Japanese Society for Engineering Education (JSEE) conducted various research and analysis and developed educational methods such as learning /educational goals, teaching materials, and evaluation methods (Fudano, 2011) (Kobayashi et al., 2014). The research committee of JSEE established the Learning and Educational Objectives (JLEO, 2016) and Model Syllabus of engineering ethics education with reference to Bloom's taxonomy, and published them in 2016 (Table 1) (Kobayashi & Fudano, 2016).

Table 1 JSEE's Learning and Educational Objectives 2016 (JLEO, 2016)

Cognitive domain	Category 1 : Understanding the relationship between science and technology and society/environment
	Category 2 : Understanding the roles, obligations, and responsibilities of engineers
	Category 3 : Ethical decision-making and problem-solving skills
Effective domain	Category 4 : Attitude and value as an engineer to be shared

However, as we have indicated, research studies on engineering ethics education so far have mainly focused on the educator's viewpoint. There have been many studies and reports on "teaching content" and "teaching methods." However, studies on the student learning process were often based on an analysis of the scores of students' pre- and post- questionnaires, rather than teacher behavior in class or the student learning process itself (Takehara, 2021) (Takehara & Fujiki, 2021).

Teaching is "a complex activity involving diverse values and factors," (Akita & Sakamoto, 2015, p. 228) and is "an interaction that learners develop with others over the content of the subject matters" (Akita & Fujie, 2019, p. 3).

In this sense, it is necessary to observe and describe how teachers and students act and discuss in class, and how teachers teach and students acquire knowledge, in addition to curriculum development and student pre- and post-questionnaires in educational research on engineering ethics.

Therefore, we introduce a method of discourse analysis and video review in a class on engineering ethics, focusing on the interaction between teachers and students and the learning process.

In our research, we conducted a trial class, recorded the group work on video, described the teacher and student discourse, behavior, and actions, and reviewed the class. From the transcripts and video recordings, we analyzed and how students learn.

Methods and Analyses

Although our research activities were restricted by COVID-19, we conducted the educational practice research in 2020–2021.

The curriculum for the regular courses of National Institute of Technologies is generally consisted of 5-years learning process. In February 2021, we held a class on engineering ethics as a part of human environmental studies for 5th grade students, corresponds to the sophomore of undergraduates. In July 2021, we conducted similar classes entitled "Public" for the 3rd grade students equivalent to the 3rd year high school student.

As the recording method, the entire classroom and the group work of the students were filmed and recorded using a WEB camera and PC (Figure 1–2). In the group work, a few groups were randomly selected from all the participants and recorded, respectively.

The class progressed as follows: First, students studied the "Seven-step guide to ethical decision-making" (Davis, M. (1999) by watching the video learning material (Muroran IT, 2008). Next, they watched "Solar blind" (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."

For the analysis, the video recordings were transcribed. From the transcripts and video recordings, we analyzed and discussed that "the process of discussion = the learning process of ethics for engineers," "how group work actually works," and "how teachers interact and work with the students," and then categorized them by the student learning process.

Figure 1 Video recording of the entire classroom (the July 2021 class data)

Figure 2 Video recording of group work (the July 2021 class data)

Results and Discussion

The Process of Discussion

Table 2 shows how much time each group spent on the Seven-step guide to ethical decision-making in the July 2021 class data. Table 3 outlines the conclusions of each group in the July 2021 class data. As shown in Tables 2 and 3, it is obvious that each group proceeded with discussions based on different procedures, with different conclusions, processes, and durations.

In addition, we found that after opinions had been stated, there were conflicts and agreements, changes in opinions, divergence, convergence, and integration in the process of discussion in group work.

Moreover, we found that students did not only complete the assigned tasks, but they also constructed better arguments on their own initiative, dynamically adjusting and integrating their knowledge through discussion.

As the process of discussion varies, it is difficult to predict the course of a discussion.

Of course, the difference itself is one of the reasons for engineering ethics education because there is no predetermined correct answer to engineering ethics questions, and answers depend on the situation and context in which engineers are immersed. Therefore, not

only knowledge of engineering ethics, but also the ability to solve problems in cooperation with others are required.

That is why debates and discussion in engineering ethics education is recommended. In the JSEE's Learning and Educational Objectives, "ethical decision-making and problem-solving skills" are established as one of the educational goals (Table 1: Category 3 of JLEO 2016). And PBL or discussion using case studies are prepared in the model syllabus to enable acquisition of those abilities.

Therefore, teachers should recognize that it is important to develop problem-solving skills while collaborating with others by focusing on the group work process, rather than just evaluating the group work output, e.g., conclusions and submitted worksheets.

Table 2 Time each group spent on the Seven-step guide to ethical decision-making (the July 2021 class data)

		Group A	Group B	Group C	Group D
step0	Empathic understanding	3:56	1:39	3:46	1:38
step1	State the problem	3:44	3:15	3:25	1:35
step2	Check the facts	3:32	2:10	4:51	3:00
step3	Identify relevant factors	9:32	3:44	4:23	4:10
step4	Develop a list of options	4:57	8:51	8:41	6:32
step5	Test the options	16:29	9:05	16:27	15:57
step6	Make a choice	1:32	18:52	2:00	3:43
step7	Review	6:55	NR	9:31	10:57
	Total	50:37	47:36	53:04	47:32

Table 3 Conclusions (the July 2021 class data)

	Step7:Review step 0-6
Group A	Early detection of problems Communication with employees and colleagues
Group B	Communication with employees and colleagues
Group C	Share safety throughout the company
Group D	Establishment of a neutral third party Early discovery of problems

How Group Work Actually Works

The goal of this group work is to "complete the worksheet by introducing the Seven-step guide to ethical decision-making," so students work together to achieve it. How do students acquire "better" practices in these situations when "the answer is uncertain?" From the transcripts and video recordings, we found that the students discussed not only the contents of engineering ethics, but also how to proceed with the discussion.

For example, the moderator in each group discussed the definition of words, the meaning of the questions, how to proceed with group work, etc. while sharing opinions with other members.

Group work cannot be achieved simply by gathering people together. It is premised upon a mutual relationship of "accepting others," so that actions such as nodding and agreeing can work properly. In addition, actions such as nodding or agreeing can act as an "opportunity" and "connection" which are triggers for subsequent discussions, and this activates case study discussions.

Here we found that the group work in engineering ethics education is strongly linked to the "Attitude to accept a diversity of values" and "Attitude to share values" in the JSEE's Learning and Educational Objectives (Table 1: Category 4 of JLEO 2016).

Therefore, teachers should be aware of the importance of accepting the presence of others in group work and advising students to develop such attitudes. In addition, they should also recognize the importance of the role of the moderators who are elected from each group.

How Teachers Interact and Work with The Students

So, how do teachers interact and work with the students? Video review by the teacher provides an opportunity to observe class improvement. Teachers engaged in various behaviors; sometimes they spoke to all the students; sometimes they silently patrolled the classroom; and sometimes they interacted with specific groups during the class. However, not all such behaviors had successful outcomes.

For example, one teacher continued patrolling the room without stopping to mediate one group's discussions or to offer advice or a trigger to change the discussion when the discussion had stalled. There was also a scene where the teacher gave misplaced advice due to a misunderstanding of the situation. Furthermore, from the transcripts and video recordings, we found that students sometimes complained about the meaning of the words and the perplexing nature of the questions on the worksheets made by the teacher. Of course, there were cases where appropriate advice was given.

In this way, video review makes it possible to recognize outcomes of teacher behavior such as failures and successes. It also enables analysis of these factors. Teachers can determine how to improve the lesson preparation by, for example, revising and recreating the worksheet and explaining, advising, and presenting how to ask questions in class.

Conclusions

In this paper, we conducted a trial engineering ethics class, recorded group work and made transcripts. From the transcripts and video recordings, we analyzed and considered thet "the process of discussion = the learning process of ethics for engineers," "how group work actually works," and "how teachers interact and work with the students," and then categorized them by the students' learning process. As a result, we obtained the following three findings.

First, there is no predetermined correct answer to engineering ethics problems, and therefore each group proceeded with discussions based on different procedures, different conclusions, processes, and durations. Given the diversity of the discussion process, it is important for teachers to not only evaluate the results of group work, such as conclusions and submitted worksheets, but also to focus on the group work process to develop problem-solving skills while collaborating with others.

Second, we focused on the function of group work itself in our analysis. As a result, we confirmed 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' opinion, and such attitudes activate the discussion and also show their implicit acceptance of others. Therefore, teachers should be aware of the importance of accepting the presence of others in group work and advising students to develop such attitudes.

Third, we focused on the learning process, including the behavior of teachers, and analyzed how teachers interact and cooperate with students. From the transcripts and video recordings, we found that teachers are involved with students while engaging in various behavioral patterns such as providing guidance, questioning / utterance, patrolling, and giving advice in the classroom. However, not all of these actions are successful (of course, appropriate guidance may be given). This indicates the effectiveness of teachers reviewing their own video for class improvement. 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."

Previous practical research on engineering ethics education focused on the educator's perspective. To analyze the student's learning process, the scores of the pre-class and post-class questionnaire surveys were frequently used, and the behavior of teachers in the class was not included in the analysis.

This study analyzed the actual behaviors and conversations of students and teachers through discourse analysis of group work and video review. As a result, several important perspectives and issues were revealed from the findings in this study. We showed that these perspectives and issues could lead to improvement of the class. Therefore, it is important to focus on the learning process in engineering ethics education.

Acknowledgements

We would like to thank Yoshio Katakura, Yukito Kobayashi, Kinya Matsumoto, Sayaka Moriyama, and Shingo Teraoka for their advice and suggestions in our research project.

This work was supported by JSPS KAKENHI Grant Numbers 20K03286 and JSEE (Japanese Society for Engineering Education) Kansai branch.

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