An Application Study of the Discussion Class in a Flipped Classroom Model for Engineering Courses

Xiaolei Qu¹,a, Rui Wang¹,b, Guo Yan¹,c, Shi Yao¹,d and Shangchun Fan¹,e,*

¹School of Instrumentation and Optoelectronic Engineering, Beihang University, Beijing 100083, China

a qxiaolei@buaa.edu.cn, b wr@buaa.edu.cn, c yanguobh@buaa.edu.cn, d zy1817312@buaa.edu.cn, e fsc@buaa.edu.cn

*Corresponding author: Shangchun Fan

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Abstract. There are usually many abstract and difficult concepts in Engineering courses which are difficult for students to learn. In this regard, a discussion-based class would enable students to increase their interest, deepen their understanding of the curriculum, and broaden their horizons. However, the traditional classroom discussion usually cannot fully reach the expected outcomes as a result of an insufficient time to discuss a single topic. In order to make the Discussion Class more effective for the engineering course, we used the “Signal Analysis and Processing” course to explore the specific format and content of the discussion class in an engineering course. Students were divided into groups and given time to prepare a classroom presentation, during which time they were given classroom dominance in a model we have termed the Flipped Classroom. The content of the discussion combines multi-angle topics such as principle of theory, problem solving methods, and practical applications. Student feedback has indicated that the Discussion Class in a Flipped Classroom model can deepen the students' understanding of the curriculum and improve their comprehensive ability.

Introduction

University-level engineering courses are often difficult for students to understand because of the abstract concepts and principles [1]. In the traditional model, teaching is dominated by teachers, and each student receives the same course content and rhythm. This method will lead to several problems.

The first problem is that the teacher must have the ability to grasp the rhythm of the course. Because the learning ability and speed of knowledge reception differs for each student, a limited classroom time makes it very difficult for every student to thoroughly understand the knowledge. A poor teaching rhythm will make many students unable to keep up with the classroom discussion.

Another problem is that the ability of the students to explore and self-learn will not be improved. In the traditional teaching model, students rely on their teachers not only for knowledge acquisition but also in psychology, leading them to be unwilling to explore and learn independently. For an engineering student, strong self-exploration and learning ability are necessary for future research in the field.

A third problem is the decline in students' interest in learning. In the traditional teaching model, students often receive knowledge passively for a long time, causing the students to perceive the engineering course as rather boring. As a result, students are prone to lose interest in the subject.

In order to prevent these problems, it is especially important to add a discussion class to the teaching curriculum. It can allow the students to fully communicate in the classroom, while providing them with repetitive and early access to the information. At the same time, by monitoring the student discussion, teachers can also check student learning and adjust the rhythm of the curriculum accordingly. However, class time is very limited, and students are often unable to gain a deep understanding of the material.
In recent years, the teaching model of the Flipped Classroom has begun to appear with a good response [2]. This teaching model gives the students the dominance of learning, allowing them to research material on their own and discuss their newly acquired knowledge with their classmates before class. In this way, teachers can make more use of the class time and lead students to understand the course at a deeper level. Therefore, the Discussion Class in a Flipped Classroom model can deepen the students’ understanding of the course while improving their interest in the material as well as their research and presentation abilities [3].

Since university engineering courses often have a specific professionalism, it is very important to decide the most appropriate type of Discussion Class in a Flipped Classroom model that would work best for engineering courses [4]. The merits and values of the discussion class can only be reflected when an appropriate discussion is occurring within the classroom. This study will use the “Signal Analysis and Processing” course as an example to explore the application of the Discussion Class in a Flipped Classroom model in engineering courses [5, 6].

The Discussion Class in a Flipped Classroom Model

The Process of the Discussion Class

In this course, we have adopted the following process to carry out the Discussion Class:

(1) Students are given several open discussion topics with different angles and types. Students are also given the ability to raise topics by on their own.

(2) Students for their own groups and choose topics themselves. The number of groups depends on the number of class sessions available for presentations. Students can choose presenters who are able to communicate to effectively to improve efficiency.

(3) Students are given two weeks to complete their discussions and programming. Giving students enough discussion time will allow them to have a more thorough understanding of the principles of knowledge and take full advantage of the initiative in this process.

(4) The presentations are carried out group by group. After each presentation, the teacher and students in other groups can ask questions and a discussion can commence. In the process, students can learn about the research results of other groups and their experience in the research process.

The Content of the Discussion Class

(1) Principle of theory discussion

There are two types of this kind of discussion: the relatively difficult knowledge points that teachers have chosen through years of experience and the topics within the course that students feel difficult to understand. The former is often the reference of the latter, providing students a lot of discussion options. Additionally, the difficulty points that one student group discusses may very likely be a concept that other students had also found difficult to understand. This kind of discussion model provides the students with early access to the information as well as repetition of the material, solving many difficult problems that students have previously had. This type of topic is a common form of Discussion Class.

(2) Problem solving method discussion

The exercises in this class are selected by the teacher based on the teaching experience of previous years and can also be derived from previous exam questions. These exercises cover a wide range of knowledge and are difficult to master, thus creating high requirements for the mastery of students’ knowledge and flexible usability. However, this type of discussion topic is often rare in traditional discussion classes except in the form of homework. We decided to include it into this type of discussion for several reasons. First, the nature of a multi-person discussion often can provide a variety of solutions and broaden the perspectives of the students. Through the comparison of various solutions, students can determine which method is more convenient, enhancing their ability to use each theorem and property. Second, through the classroom explanation, the students who give the presentation can develop a deeper level of knowledge of the relevant chapters. Third, this method can improve the efficiency of the student. Such exercises are often difficult for one
person to accomplish. Distributing the discussion among several people can not only improve the interest in solving problems, but also help the students understand the knowledge points more quickly.

(3) Practical application discussion

This type of discussion encourages students to share either the project in which they are involved or the actual application of signal analysis they have learned, introducing the method of signal processing they use. After entering the university, some students have the opportunity to participate in laboratory engineering projects. Introducing these projects can expand the horizons of the students and make them understand the practical application of the course knowledge in the engineering project. There are also some students who have taken other related courses with engineering content and they can share the knowledge from those courses in this discussion model, enhancing their ability to use interdisciplinary approaches. Students can also share practical projects in this course, such as easy-to-follow problems encountered in programming and the corresponding solutions. Because the combination of practice and engineering curriculum is very important, many students understand the principles, but are unable to apply it in the project successfully.

Specific Application in the “Signal Analysis and Processing” Course

This study used the “Signal Analysis and Processing” course as an example to introduce the application of Discussion Class in a Flipped Classroom model for an engineering course. We divided the class into ten groups with seven students in each group. After selecting the discussion topic, each group had two weeks of discussion time before giving a ten-minute in-class presentation. The following table shows the topics selected by the students in this course. For the sake of brevity, we only selected some of the topics for display.

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<th>Principle of Theory</th>
<th>The Physical Meaning and Application of Convolution</th>
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Topic 1, The Physical Meaning and Application of Convolution, is a difficult course concept selected by the teacher and which many students find abstract. Topic 2, Parity and Parity Analysis of the Fourier Transform, was a difficult concept that the students chose to understand in more depth. Topic 3, An Exercise about the Laplace and Fourier Transforms, and Topic 4, Exercises about Spectrum Analysis, are comprehensive topics carefully selected by the teacher, covering a wide range of knowledge and requiring students to use the theorems flexibly. Topic 5, Application of the Fourier Transform in Audio Processing, is a practical project requiring students to use the knowledge of the course. Topic 6, Application of Power Spectral Density Analysis in Material Hydration Analysis, consisted of projects that students conducted in the laboratory.
Figure 1. Excerpts from student PowerPoint presentations. (a) A pendulum trajectory representing the superposition of two sine waves with different frequencies; (b) A solution to the problem of Laplace transformation; (c) The application of the Fourier Transform in audio; (d) Two discrete results of a signal system.

After two weeks of preparation, the students achieved good performance in the discussion of the class. Figure 1 shows slides from some of the PowerPoint presentations used by the students in the discussion class.

The students who chose Topic 1 used the degree of decay of the steamed buns to express the physical meaning of the convolution, creating an example which was vivid and easy to understand. The students who chose Topic 2 visually reflected the process of Fourier transform with a periodic pendulum, allowing other groups of students to have a more intuitive understanding of the Fourier transform. Figure 1(a) shows the superposition of two sine waves of different frequencies using a pendulum trajectory.

Students who choose topics 3 and 4 first explained and analyzed the knowledge points and principals involved in the topic, then presented a variety of problem-solving methods to provide new solutions for the other students. Figure 1(b) shows a solution to the problem of Laplace transformation. Additionally, the students in both groups utilized the popular online language to explain the topic in a lively and interesting way resulting in a great show of interest from the rest of the class.

Figure 1(c) shows the application of Fourier transform in audio. The students who selected Topic 5 showed on-site the process of filtering news broadcasts from a mixture of music and news broadcast (noise) using the Fourier transform and filtering, intuitively demonstrating the power of signal processing.
The students who chose Topic 6 gave us a detailed introduction to the process of their project, as well as the role of signal analysis and processing, as seen in Figure 1(d), which demonstrates discrete results of a signal system.

Throughout the process, the students actively asked questions and engaged in discussion with the teacher. After the class, the students expressed that they had gained a lot of knowledge and experience that they did not have in the traditional classroom.

Conclusions
Through the practical application of the Discussion Class in a Flipped Classroom model in the “Signal Analysis and Processing” course, this study was able to explore its application in engineering courses. The results show that by providing the students with sufficient discussion time before class as well as group presentations within the class, students can have a deeper understanding of the course, a stronger ability to consult literature, and an increased ability to cooperate. At the same time, combining the knowledge principle, problem solving method and practical application of discussion can consolidate student knowledge, improve the student’s ability to use the theorem naturally, enhance the student’s ability in engineering, and expand the student’s horizons. It has a better effect than the traditional classroom discussion. This entire practice process validates the importance and advantages of the Discussion Class in a Flipped Classroom model for Engineering Courses.

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