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Using a four-step learning activity in a programming course: classroom participation, learning performance, and attitude

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Abstract: In a programming course, a teacher has to teach not only programming concepts and syntax but also how to implement programs. However, teachers do not have enough time to complete the tasks. To address the problem, this study developed a four-step learning activity in a flipped classroom, which consists of testing, task assigning, collaborative problem-solving, and presentation. This study also conducted an instructional experiment for examining the effects of the four-step learning activity on students' classroom participation, learning performance, and course satisfaction. The results showed that the students with the four-step learning activity and the students with the traditional instruction demonstrated the same level of classroom participation. While the students with the four-step learning activity had higher learning performance than the students with the traditional instruction. The students perceived that the four-step learning activity can facilitate learning motivation, classroom interaction, learning performance, and help-seeking. They hoped that the four-step learning activity can be used in other programming courses in the future.

Keywords: flipped classroom, collaborative problem-solving, programming

1. Introduction

Computational thinking (CT) refers to a set of problem-solving skills, such as solving problems, designing systems, and understanding human behavior, by drawing on concepts fundamental in computer science (Wing, 2006). It can be applied to solve everyday problems and has been advocated as a fundamental twenty-first century skill that students need to develop. Therefore, researchers, educators, and policy makers have concentrated on CT in the recent few years. In addition, the development of artificial intelligence (AI) technology has increased the accuracy of prediction and recognition. Some AI libraries have made programmers develop AI applications easier. More and more people and companies have begun to invest in research and industrial applications related to artificial intelligence. Therefore, AI-related applications are gradually appearing, such as image recognition, voice assistants, autonomous driving, and data science. Programming is considered to be a key tool for acquiring CT experience and developing CT skills and is the foundation of artificial intelligence. Therefore, in order to enable students to develop CT skills and apply artificial intelligence to solve domain problems and design innovative applications, it is most important to cultivate students' programming concepts and abilities.

In programming courses, students need to understand the programming concepts (such as function, passing by value, and addressing) and syntax of programming languages (such as

the syntax of control structures, function declaration and call, and object-oriented), Students also need to acquire the abilities to use the learned programming concepts and syntax to solve computational problems. Therefore, programming is not only a course for conceptual understanding but also a subject that needs to be practiced. In general, programming courses may be two credits or three credits a semester. In a traditional lecture-based classroom, teachers may not have enough time to teach programming concepts and syntax and guide students to implement programming codes. To solve the problem, the flipped classroom may be a good approach. In a flipped classroom, teachers can record a video that introduces the programming concepts and syntax taught this week; and students can watch the video to learn these concepts and syntax before the class. In the classroom, teachers can assign several computational problems for the students to practice the programming concepts and syntax. When students implement their codes, teachers can provide appropriate guidance and suggestions for students and can also have more interactions with the students in the classroom.

However, it may not be enough to just upload the videos on the Web for students to watch before class, and to assign several programming problems for students to solve in the classroom. Students may not actively watch the pre-class videos, and may not have the ability and motivation to solve the computational problems in the classroom. Ultimately, let the flipped classroom approach failed. In order to enhance the flipped classroom approach, teachers should design suitable instructional activities for facilitating pre-class video viewing and in-class activities. This study designed a four-step activity, including quizzes, task assignments, cooperative problem-solving, and code explanation to enhance the flipped classroom approach. In addition, this study also conducted a four-week experiment for understanding the impact of the four-step activity on classroom participation, learning performance, and course satisfaction.

2. Flipped classroom instruction

The traditional lecture-based approach uses a teacher-centered method. Students passively accept the knowledge taught by teachers and have fewer opportunities to interact with teachers and classmates. This approach cannot effectively cultivate students' self-discipline and high-level thinking skills (Lai & Hwang, 2016). The flipped classroom instruction responds to this issue by transforming teaching into a student-centered approach. It is divided into two activities: pre-class activities and in-class activities (Long, Cummins, & Waugh, 2017). In the pre-class activities, students build up their basic knowledge through different online learning activities, such as video viewing activities. In the in-class activities, the teacher conducts different learning activities, such as group cooperative learning, problem-based learning, and project-oriented learning. Students apply the knowledge they have acquired before class to develop cooperation and higher-level thinking skills.

Although flipped classroom instruction offers these benefits, previous studies have shown mixed results. Karabulut-Ilgu et al. (2018) analyzed 30 papers that compared the traditional lecture-based approach with flipped classroom instruction and found that 15 papers reported that the students in flipped classroom instruction demonstrated better learning outcomes than the students in the traditional approach, 5 papers reported mixed results, 8 papers reported no difference, and 2 papers reported that flipped classroom instruction had worse learning outcomes than the traditional approach. The mixed results may be due to the pre-class learning activities and in-class learning activities. Therefore, more studies are needed to help us understand how to conduct pre-class and in-class activities in flipped classroom instruction for maximizing students' learning outcomes.

In-class activities are very important for flipped classroom instruction because they help students apply, integrate and evaluate the knowledge learned in the pre-class activities. In the classroom, teachers generally conducted cooperation, problem-solving, or project-based

learning activities. For example, Chen , Chen, & Chen (2015) used the flipped classroom approach in a statistics course. They used a cooperative learning activity in the classroom. The students were divided into groups. Group members discussed the pre-class videos. After the discussion, the teacher gave feedback for the students' discussion. Finally, each group completed a group report. Sun, Xie, & Anderman (2018) used the flipped classroom approach in a calculus course. In the in-class activity, the teacher first explained the content of the pre-class videos with some examples and then divided the students into groups. Group members have to collaboratively solve several problems. Finally, the teacher selected several groups to report their answers.

The flipped classroom approach has also been applied to programming courses. In programming courses, the in-class activities were similar to those used in other courses, including cooperation, problem-solving, and testing. For example, Chiang (2017) used the flipped classroom approach in an object-oriented analysis and design course, the students went to edX to watch instructional videos before class. They needed to solve problems encountered in edX during class. Durak (2018) used the flipped classroom approach in a programming course. In the classroom, the students solved several computational problems and then collaboratively complete a group project. Chis, Moldovan, Murphy, Pathak, & Muntean (2018) used the flipped classroom approach in a programming course. In the classroom, the students first solved several computational problems and then completed a test. Cakiroglu & Ozturk (2017) used the flipped classroom approach in a programming course. In the classroom, the teacher divided the students into groups and then gave the students several computational problems. The students then collaboratively solved them. Finally, They reported their answers. These studies used different in-class activities for the flipped classroom approach. Therefore, this study refers to the activities used in the previous studies to develop a four-step in-class activity.

3. Four steps in-class activity

This study used the flipped classroom approach in a programming course. The flow of the weekly flipped classroom activity is as follows:

1. The teacher published a video lecture on a learning management system before one week of the class.
2. Students watch videos within a week.
3. In the classroom, the teacher uses the four-step in-class activity. The four steps are testing, task assignment, collaborative problem solving, and code explanation.

Step 1 is testing. In this step, students conducted an online test at the beginning of the class. A testing system was developed. Teachers can build up a test sheet by the testing system. The testing system allowed teachers to design three types of questions: multiple choice, filling, and open-ended questions. When students conduct a test, the test sheet was displayed. The students then answered the questions in order. The order of the questions is random, so the students answered the same questions, but the order of the questions was different, which can reduce the chance of students' cheating.

After the testing step, the students then worked in a group of two to solve several computational problems (step 2 task assignment). The grouping of the students considered the students' preferences and their academic performance. The problems assigned by the teacher considered the students' academic performance and testing outcomes. After the grouping and problems assigned, the students collaboratively solved the problems in groups (step 3 collaborative problem solving). If they cannot solve the problems, they can ask the teacher for assistance. Finally, the teacher selected a group for each problem. The selected groups explained their code about the computational problems (step 4 code explanation).

4. Method

This study conducted an experiment. The students in the control group were 37 undergraduate students. They took part a programming course for 16 weeks to learn python programming language. The course teacher used a traditional lecture-based approach in the course. The teacher first introduced the programming concepts in the classroom. He then assigned several computational problems related to the introduced programming concepts and syntax, and the students solved the problems in the classroom. Therefore, for a 3-hour in-class activity, the teacher taught programming concepts and syntax for about 1.5 hours, and the students wrote the code for the problems for 1.5 hours. The teacher also assigned 1-3 computational problems as weekly homework assignments. The students must complete the assignments and upload their assignments to the learning management system after class.

The students in this experimental group were 33 undergraduate students. They took part a programming course to learn python programming language. The course teacher and learned content were the same as the control group. However, because of the course schedule, the teacher used the traditional lecture-based approach before mid-term exam and used flipped classroom approach with the four-step in-class activity after the mid-term exam. Therefore, our analysis focuses on the learning performance after the mid-term exam.

5. Results

5.1 Classroom participation

In this study, the number of roll calls after the midterm exam was used as the degree of classroom participation. There were 5 roll calls after the midterm exam of the control group, and 8 roll calls after the midterm exam of the experiment group. We first calculated the percentage of roll calls, and then used the independent sample t-test to compare the difference in the percentage of roll rolls between the two groups. The results showed that the percentage of roll calls of the students in the control group (N=37, mean=88.65, SD=21.36) was not significantly different (t=-1.315, p=0.193) from the students in the experiment group (N=33, mean=94.32, SD=14.35). The result meant that the four-step activity has no significant impact on students' course participation.

5.2 Learning performance

This study compared the students' final exam scores. An independent sample test was conducted to compare the final exam scores of the two groups. The results showed that the students in the control group had significantly lower (t=-6.010, p<0.000) final exam scores (N=37, mean=24.54, SD=19.42) than the students in the experiment group (N=33, mean=53.45, SD=20.83), which indicates that the four-step in-class activity can significantly improve the learning outcomes of the students.

5.3 Students' attitude to the four-step activity

At the end of the course, the students in the experiment group must answer an attitude questionnaire. The questionnaire contains 8 questions, using a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree), filled in anonymously. The results are shown in Table 1, which shows that students believe that the flipped classroom approach with the four-step activity had better effectiveness on learning motivation, learning performance, classroom interaction, and help-seeking than the traditional lecture-based approach. They hoped that the flipped classroom approach can be used in future programming courses.

Table1: Students' attitude to the four step approach

question	Mean	SD

Compared with the traditional lecture-based approach, I think the flipped classroom approach with the four-step in-class activity can improve my learning motivation	3.83	0.91
Compared with the traditional lecture-based approach, I think the flipped classroom approach with the four-step in-class activity can improve my learning performance	3.90	0.84
Compared with the traditional lecture-based approach, I think the flipped classroom approach with the four-step in-class activity increase my interaction with the teacher.	3.41	1.00
Compared with the traditional lecture-based approach, I think the flipped classroom approach with the four-step in-class activity can increase my interaction with my classmates.	4.03	0.96
Compared with the traditional lecture-based approach, I think the flipped classroom approach with the four-step in-class activity is more interesting	3.86	0.83
When I have problems in class, I can get help more easily in the flipped classroom approach with the four-step in-class activity than in the traditional lecture-based classroom.	3.79	0.92
Compared with the traditional lecture-based approach, I prefer the flipped classroom approach with the four-step in-class activity.	3.66	0.80
Compared with the traditional teaching method, I hope that the future programming courses can use the flipped classroom approach with the four-step in-class activity	3.62	0.72

6. Conclusion

This study designed a four-step in-class activity for the flipped classroom approach. An experiment showed that the students in the flipped classroom approach with the four-step activity and the students in the traditional lecture-based approach had the same classroom participation. However, the students in the flipped classroom approach with the four-step activity had better learning performance than the students in the traditional lecture-based approach. The students also believed that the flipped classroom approach with the four-step activity can promote learning motivation, classroom interaction, learning performance, and help-seeking. They also hoped that the flipped classroom approach with the four-step activity can be used in the future programming courses. These results showed that the flipped classroom approach with the four-step activity is indeed helpful for programming courses.

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