Flipped Classroom Trial for Python Programming with Raspberry Pi Using Moodle

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Abstract: A flipped classroom is a pedagogical method that flips traditional lectures and homework. In the case of a flipped classroom, the traditional lecture is viewed at home before class and homework activities are completed in the classroom with the tutor present to guide students in their work. At present, the above-mentioned flipped classroom has become increasingly popular, and sometimes controversial, within higher education. In this paper, we describe the flipped classroom example for Python programming to control I/O devices with Raspberry Pi. First, the tutor uploads the lecture notes onto Moodle. Secondly, students read the lecture notes prior to the class. Students can then ask questions on the Moodle Forum if there are any questions about the class notes. Thirdly, the students attend the class. As part of the class activities, students form into 10 groups. Each group creates a Python programme based on topics related to the class note, one hour is permitted for this activity. This is an example of a group activity. Next, each group will demonstrate the Python programme they have created to the tutor and other students in a 5-minute presentation. Following this, the tutor and other students will provide comments on the demonstration. Students will then complete a self-reflection journal about the flipped classroom on Moodle after the class. The tutor evaluates each journal written by the students. In this paper, a description of the Python programmes aims to control 8 LEDs is given as an example of a flipped classroom. Finally, the tutor added a questionnaire about the flipped classroom onto Moodle at the end of the semester. Collated questionnaire responses show that students felt the flipped classroom was appealing and helped improve programming skill. Thus, the author concludes that the flipped classroom is engaging and an effective way of teaching.

Keywords: Flipped classroom, Moodle, group work, Python programming, Raspberry Pi

1. Introduction

What is a flipped classroom? A flipped classroom is a pedagogical method that flips traditional lectures and homework. In the case of the flipped classroom, the traditional lecture is viewed at home before class and homework activities are done in the classroom with the tutor present to guide the students work. (Bishop & Verleger, 2013, June).

The flipped classroom started as active learning in the 1990s. Mazur (1997) encouraged students to engage with each other to understand contents during class time rather than passively listening to lectures. This is known as peer instruction (Crouch & Mazur, 2001). Baker (2000) used the phrase "classroom flip" at an education conference for the first time. He proposed a model where students accessed instructional content outside of the classroom. As a technological integration, In 2004, Khan, a founder of Khan Academy, used videos for instructions outside of traditional class time. This contributed significantly to the flipped classroom movement (Thompson, 2011). Bergmann and Sams (2023) began recording lectures in Chemistry class for students to watch at home in 2013. This allowed class time to be used for hands-on activities and individualized instruction, formalizing the flipped classroom model in a secondary education setting.

At CST (College of Science and Technology), RUB (Royal University of Bhutan), the flipped classroom was introduced to all subjects in 2023. This was guided by Alvin Lee, a member of CST-GCBS (Gedu College of Business Studies) transformation team. The author explored how the effective flipped classroom is introduced in a programming language course. In this paper, an example of a flipped classroom using Python programming to control 8 LEDs with Raspberry Pi, is described. This was given to a third-year class of Electronics and Communication Engineering Course students at CST in the spring semester of 2023.

Section 2 is a literature review of the flipped classroom in the engineering field. The process of implementing the flipped classroom is described in section 3. In section 4, an example of our flipped classroom is given. Advantages and disadvantages of the flipped classroom are discussed in section 6. The conclusion is given in section 7.

2. Literature Review of the Flipped Classroom in the Engineering Field

Mason, Shuman and Cook (2013) compared the effectiveness of the flipped classroom to the traditional classroom in an upper-division engineering course. They considered the following three areas: 1) content coverage; 2) student performance; and 3) student observations and perception of the flipped classroom format. The results showed that: 1) the flipped classroom allowed the tutor to cover more material; 2) students

participating in the flipped classroom performed as well or better on comparable quiz and exam questions; and 3) while students initially struggled with the new style, they adapted quickly and found the flipped classroom style to be satisfactory and effective.

Bishop and Verleger (2013, October) implemented the flipped classroom in a numerical methods course for second and third-year engineering students. It combined constructivist and behaviourist learning theories, using asynchronous video lectures and in-class problem-solving. Conducted in 2013 at Utah State University, the study compared experimental and control groups on homework, exams, and conceptual tests.

Kerr (2015) investigated the impact of using a flipped classroom model in undergraduate engineering education. He reviewed a total of 24 studies, and most studies reported high student satisfaction and increased performance in a flipped classroom environment.

Karabulut-Ilgu, Jaramillo Cherrez and Jahren (2018, May) reviewed the use of flipped learning in engineering education, providing practitioner guidance by appraising existing research. A systematic review of 62 articles from 2000 to May 2015, showed that the flipped classroom gained popularity amongst engineering educators after 2012.

Focused on programming education, Çakıroğlu and Öztürk (2017) explored the development of self-regulation in a programming language course. Problem based learning activities were carried out in flipped classrooms to promote self-regulation.

Chis et al. (2018) investigated the effectiveness of combined Flipped Classroom and Problem-based Learning teaching approach in a computer programming module. The combined approach made use of learning technologies and supported authentic learning in terms of authentic context, multiple perspectives through team work and collaboration.

3. The Process of Implementing the Flipped Classroom

The process of a flipped classroom is as follows:

Step 1: The tutor uploads class notes onto Moodle, giving the students the opportunity to understand the class content notes before the class. At this point, students can ask the class tutor questions on the Moodle forum.

Step 2: The class length is 120 minutes. Whilst in class students will form 10 groups, the tutor will explain the task to each group for 10 minutes. Some tasks are the same among all groups, whilst other tasks may not be.

Step 3: Each group will have one hour to develop a Python code according to the instructions given in Step 2. The tutor will oversee the students at work, and give advice as required.

Step 4: Each group will then give a presentation on the Python code developed, to be demonstrated using a Raspberry Pi microcontroller board. A five-minute presentation time is allowed per group, including Q&As.

Step 5: When the class ends, all students fill in a self-reflection journal about the flipped classroom on Moodle. There are three purposes of the self-reflection journal - firstly, to review the experience of a flipped classroom; Secondly, students reflect on the skills they have developed; thirdly, evidence of students contribution is documented.

Step 6: Finally, the tutor evaluates the completed self-reflection journal written by the students.

4. Example of a Flipped Classroom for Python Programming using Raspberry Pi

This section shows an example of the above-mentioned flipped classroom for Python programming, using Raspberry Pi.

4.1 Upload of Class Notes to Moodle

As described in section 3, the tutor uploads the class notes onto Moodle for pre-reading by the students. Below is an example (taken from Osoyoo.com, 2017)

Chapter 12. Blinking Eight LEDs with Raspberry Pi

In this chapter, we connect eight LEDs with raspberry Pi GPIO, the program then outputs a high or low level to the GPIO to control the LEDs blink. Also used is a PWM (Pulse Width Modulation) signal to control and change LED brightness.

12.1 Connection of Eight LEDs with Raspberry Pi GPIO

Connect eights LED (anode) to Resistor (200Ω) to limit the current, cathode to B17, B18, B27, B22, B23, B24, B25, B4 respectively. B means BCM pin number, as shown in Fig. 12-1. Also, Fig.12-2 shows the connection graph of eight LEDs with GPIO extension board.

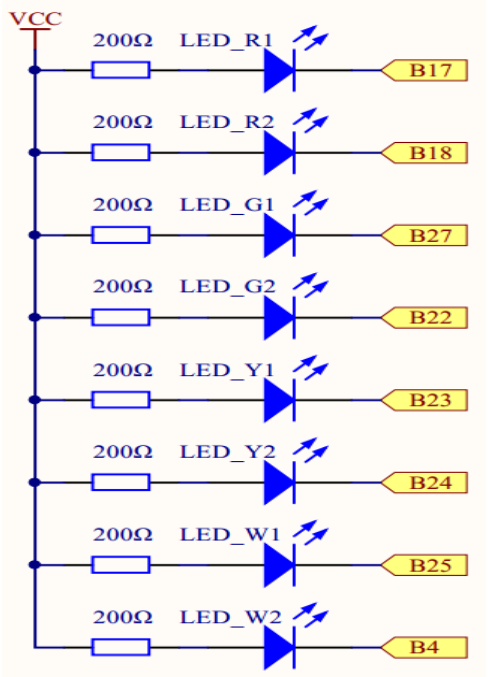

Fig. 12-1 Circuit diagram showing the connection of eight LEDs with Raspberry Pi GPIO

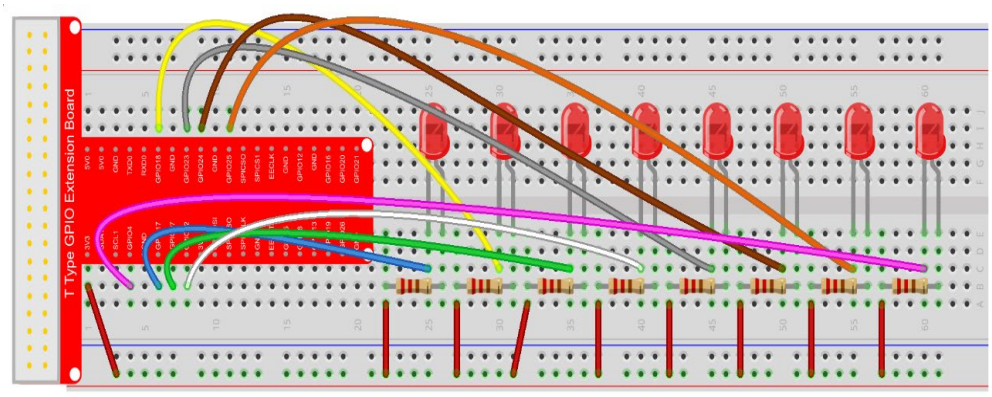

Fig. 12-2 Connection graph of eight LEDs with GPIO extension board

Figure 1: Class note instructions of how to control eight LEDs with Raspberry PiStudents read the class notes show in Figure 1, and understood how to control eight LEDs blinking, before attending the class. In addition, they had the option to ask the tutor and other students questions using the Moodle forum as shown in Figure 2

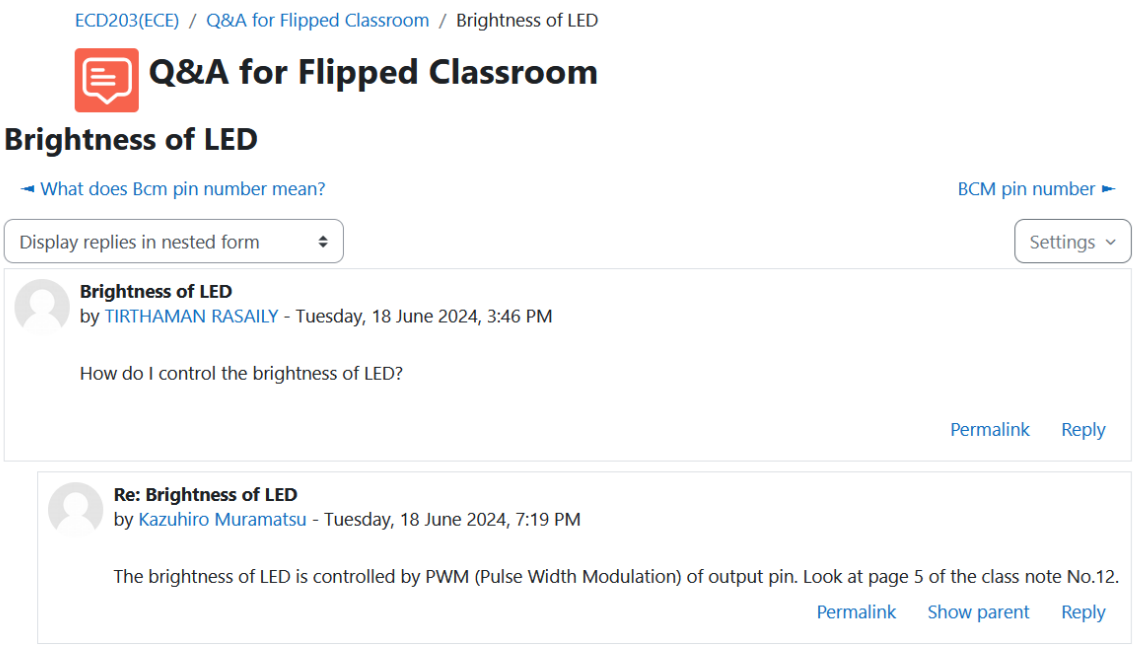

Figure 2: Example Moodle Forum questions regarding the class notes

4.2 Explanation of the task for the flipped classroom

At the beginning of the class, the tutor explains the task for the flipped classroom. In this case, the tutor explains how to control eight LEDs blinking with a projector. The method used for the task are shown in Table 1.

Table 1: Task to control eight LEDs for the flipped classroom

Week 12	
Strategy for FC	Based on Types of Learning Outcomes
Total Time for FC	2 hours. (Not including activities for usual lectures, tutorials and/or practices)
Lesson Plan for FC	2-3 students form a group (total 10 groups), the tutors give Raspberry Pi Trainer kits to each group respectively in FC. Each group develops the Python code to blink 8 LEDs on Raspberry Pi WH. The blinking patterns are originated by each group. Finally, each group explain their Python programme using a projector, and shows a demonstration of blinking 8 LEDs on Raspberry Pi WH. Following the class, each group submits the Python code, and all students complete the worksheet submitted to the tutor via Moodle. 10 mins – Explanation of topics 60 mins – Development of Python programme according to the topic 50 mins – Demonstration of Python programme on Raspberry Pi WH and Q&A (each group has 5 min.)
Expected Outcomes	Students can develop a Python programme related to blinking 8 LEDs. In addition, students will improve teamwork and independent learning.
Resources	Raspberry Pi Trainer kit, Laptop, Textbook and Class notes.

4.3 Development of the Python Code to Control Eight LEDs

As described in the task, the students develop the Python code to control eight LEDs as shown in figure 3. shows a group activity, developing the Python code.

Figure 3: Shows a group python coding development activity

4.4 Presentation and Demonstration of the Developed Python code to Control Eight LEDs

After the 60-minutes group activity developing the Python code, each group gives a 5-minute presentation demonstrating the developed Python code. Figure 4 shows the presentation, and a photo of the demonstration is shown in Figure 5.

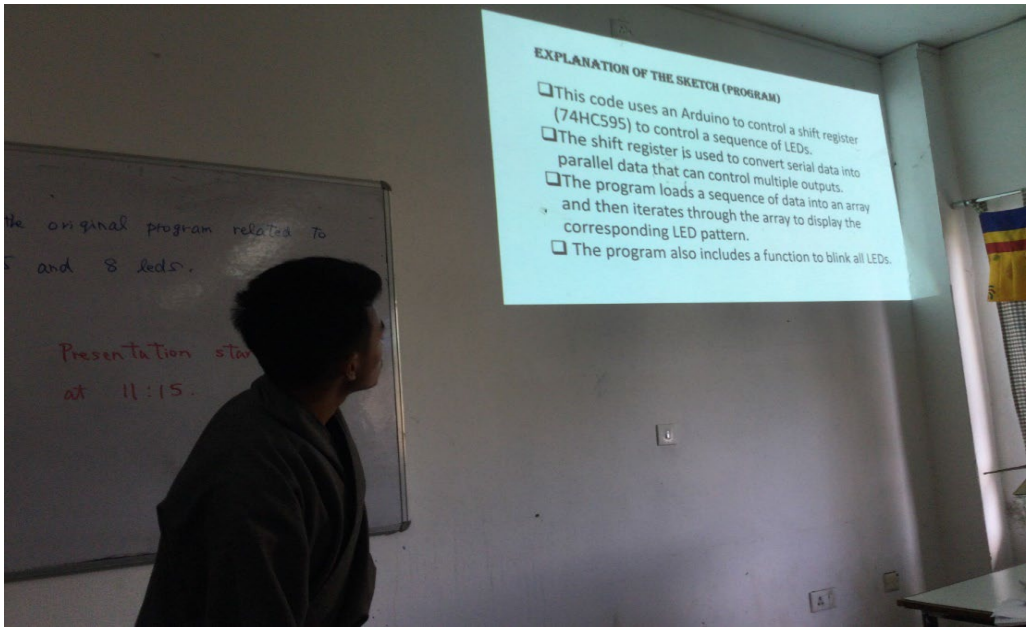

Figure 4: Presentation of the developed Python code

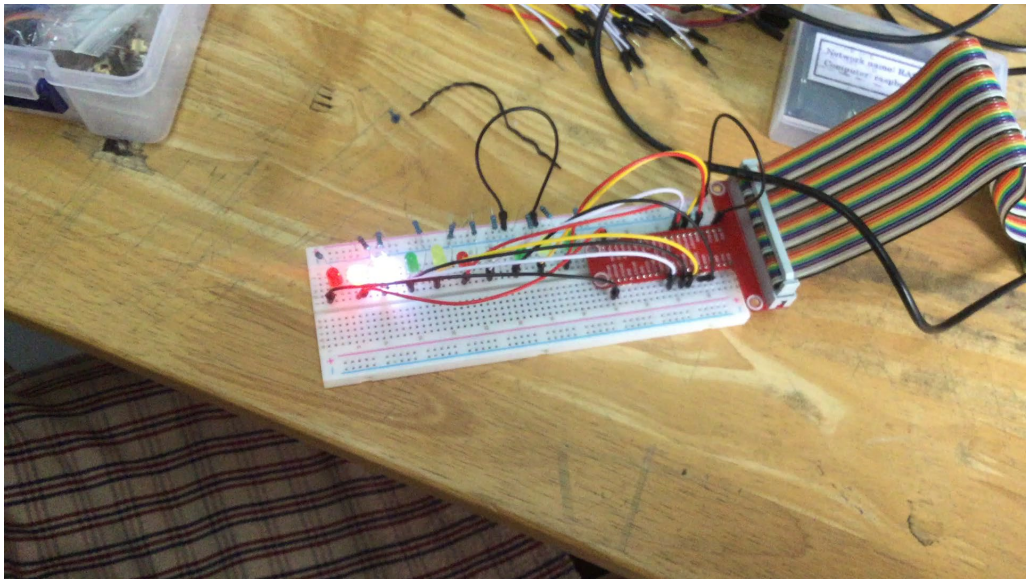

Figure 5: Demonstration of the Python code developed in the flipped classroom

4.5 Self-Reflection Journal About the Flipped Classroom

After the class, students complete the self-reflection journal about the flipped classroom. Figure 6 shows the first page of the self-reflection journal on Moodle.

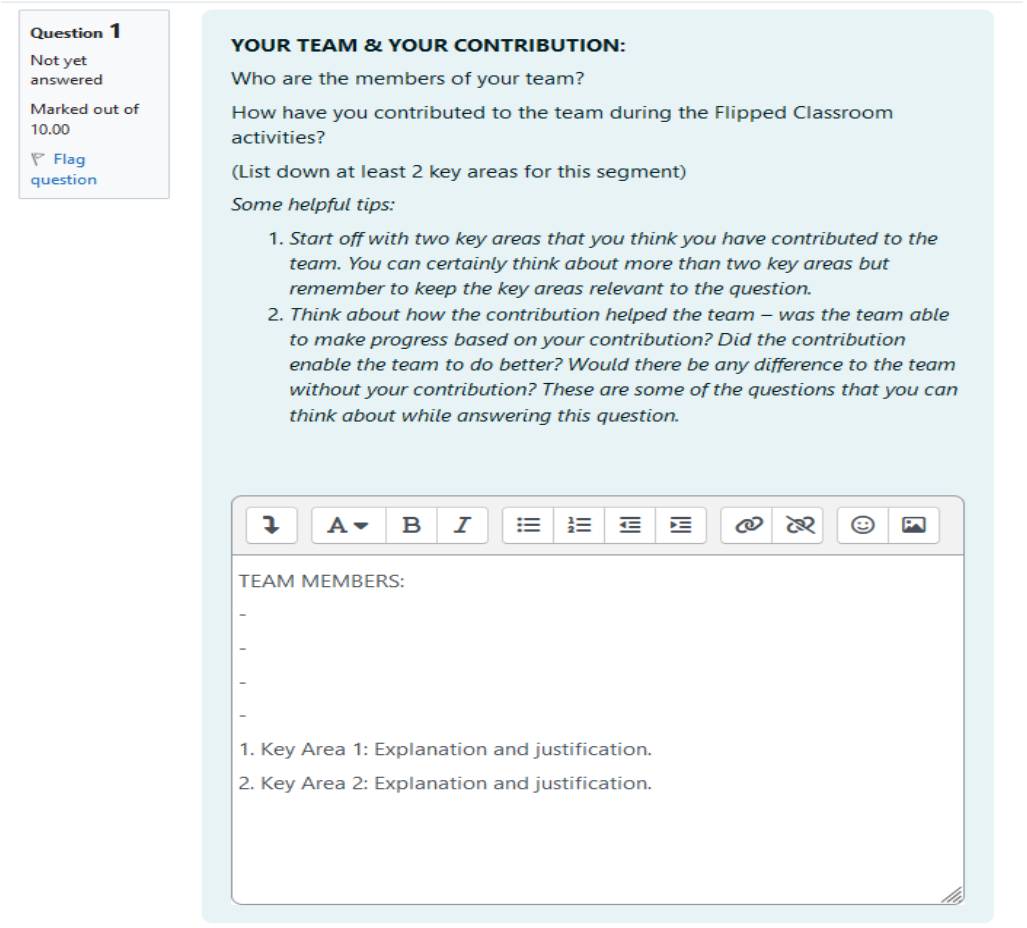

Figure 6: Self-reflection journal

4.6 Evaluation of the Self-Reflection Journal

Based on the marking rubric for the self-reflection journal, the tutor evaluates the filled self-reflection journal written by the students using Moodle. The students can view the marks given on Moodle.

5. Discussion

The author taught 15 2-hour flipped classroom sessions in the spring semester of 2023. Out of 15 flipped classrooms, 9 flipped classrooms follow the Python or Arduino programme as detailed above. The remaining 6 flipped classrooms are investigation activities which use the Internet and e-books. According to the filled self-reflection journal, the students prefer the programming activity over the investigation activity.

The full 60 minutes allocated to the programming activity was used. However, it was felt that 60-minutes was not sufficient time to complete the programming. Therefore, 90 minutes would be required to complete this activity in the flipped classroom.

The third-year class of Electronics and Communication Engineering Course comprised of 21 students. At the beginning of the semester, the class was divided into five groups. Namely, 4 or 5 students formed a group. It was found that 1 or 2 students performed most of the workload, and the other students did not contribute to the task (InnerDrive, 2024). Therefore, the tutor decided to divide the class into ten groups. This led most of the students into contributing to the task.

Finally, the tutor observed that a part of the students did not read the class content notes before the class. Thus, they could not understand the task which was given by the tutor at the beginning of the class. Therefore, the tutor had to explain the class content notes to them in the class. This situation makes the flipped classroom ineffective.

6. Conclusion

In this paper, we focused on the flipped classroom for the Python programming with Raspberry Pi, because the students feel that the flipped classroom activities for the Python and Arduino programming are better than ones for the investigation activities. The author will compare the programming activities and the investigation activities in the flipped classroom in detail.

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