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Enhancing Students' Learning Performance by Combining Flipped Learning and Online Formative Assessment Platform*

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Flipped learning is allowed students to increase opportunities for active learning in the learning process. Although previous studies have shown that there was a positive impact of flipped learning on class, few studies have combined flipped learning with formative assessment to explore students' learning performance in terms of programming. Hence, this study adopted a quasi-experimental design to recruit 121 students for 15 weeks of experimental activities. The experimental group used a combination of flipped learning and formative assessment to explore whether their learning performance was higher than that of the control group using flipped learning. In addition, this study established an online formative assessment platform to provide the experimental group with online formative assessment tests. According to the results, the learning performance of the experimental group in the second test and the third test was significantly higher than that of the control group. On the other hand, the experimental group could still achieve better learning performance in the more difficult units (units 7 to 12). In addition, the researchers showed that when the duration of the experiment was longer and the experimental group of students continued to use the online formative assessment platform to administer the test, their learning performance in terms of programming was also significantly enhanced. Therefore, this study demonstrated the effectiveness and contribution of combining flipped learning with formative assessment in terms of programming.

Keywords: flipped learning; formative assessment; learning performance; visual programming language

1. Introduction

In traditional instructional strategies, most teachers teach students through lectures or classes, but this method may have many limitations and dilemmas [1]. For example, in the traditional classroom, students can only obtain the knowledge and content of the course through the learning materials or books provided by the teacher [2]. With the advancement of information technology, students can acquire a large amount of knowledge and content through E-learning, which has also become a solution to improve students' acquisition of limited knowledge in traditional teaching [3]. Several studies have shown that students can improve their learning outcomes in the classroom through digital materials and multimedia resources [4, 5] and learning motivation [6, 7]. Compared with traditional lectures, students can read a large number of open educational resources anytime, anywhere by combining online learning with digital learning tools to improve students' knowledge in various subjects [8]. In order to enable students to learn more effectively, many researchers have introduced instructional strategies or tools in the classroom to help students acquire useful knowledge and concepts from the learning process. Among them, flipped learning, concept maps, or formative assessment are often used in educational research for related discussions [9–11].

On the other hand, flipped learning is gaining traction in higher education [12], students must preview and read the learning materials provided by teachers before class to actively prepare and learn for the course [13]. Therefore, students can actively acquire the knowledge and content of materials through flipped learning [14]. Many studies have shown that flipped learning can effectively have a positive impact on student learning outcomes [15]. For example, Huang, et al. [16] applied business simulation games in the flipped classroom to explore students' engagement, learning achievement, and higher-order thinking. The results of the study pointed out that students' application of business simulation games can effectively improve students' higher-order thinking skills, and students can effectively prepare instructional materials through the flipped classroom. van Alten, et al. [17] explored students' learning performance in the classroom through flipped learning videos and self-regulated learning. The findings showed that including support for self-regulated learning in the

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film can have a positive impact on students' learning outcomes.

In addition, flipped learning was also discussed in engineering education. For example, Chao, et al. [18] used the flipped learning method to explore the students' learning attitude and achievement in the computer aided design curriculum. The results show that flipped learning can improve students' academic achievement in engineering education, and students' attitude, motivation, and self-evaluation also have a positive improvement (Chao et al., 2015). Özyurt and Özyurt [19] used an adaptive flipped classroom approach to explore the programming success, attitudes, and self-efficacy of software engineering students in learning programming. The results show that using this approach can enhance students' success and self-efficacy in learning programming, and the flipped classroom approach can be effectively used to teach programming courses [19]. Additionally, Bhat, et al. [20] show that the flipped classroom model can provide course materials through technology and tools so that students can learn the content of the course in advance and conduct discussions with other students in the classroom. Therefore, in engineering education, flipped learning can improve student interaction and performance, and its learning effectiveness is better than in traditional classrooms [20].

Although previous studies confirmed that students can improve their learning performance in engineering education through flipped learning, there are still some limitations and dilemmas of flipped learning. One of the issues is that it may be difficult for teachers to know the problems students face in the pre-class learning process [21] so teachers assist students in solving related problems in the materials only through discussions during the course. In addition, Van Alten, et al. [22] showed through a meta-analysis that although flipped classrooms had little effect on learning outcomes, teachers adding tests in flipped classrooms could make students achieve higher learning outcomes. In order to enable teachers to have an in-depth understanding of what students may encounter in the learning process, the formative assessment can effectively help teachers monitor and evaluate students' learning process and performance in the unit or materials [23]. For example, Elmahdi, et al. [24] showed that the use of information technology in the classroom combined with formative assessment can effectively improve student learning outcomes. Moreno-Ruiz, et al. [25] combined flipped learning, project-based learning, and formative assessment strategies to explore the benefits of the system they developed in engineering education. The unified theory of acceptance and use of technology was used to prove the usefulness of the system in the learning process. However, the study did not explore the impact of these strategies and tools on the learning performance of students in engineering education [25].

Formative assessment is considered to improve and enhance teaching aspects of higher engineering education [26]. Therefore, this study considers that formative assessment can effectively allow teachers to understand the situation of students in the learning process and can also improve students' learning performance in the course. In addition, flipped learning can not only be used as an instructional strategy for teaching programming courses in engineering education but also can effectively enhance students' success in learning programming [19]. Although many studies have confirmed the benefits of flipped learning and formative assessment in educational research, this study found that there are few studies exploring the application of combining these two instructional strategies in programming courses, especially the application of visual programming in engineering education. Students may encounter some problems in flipped learning, which make them unable to understand the content of the materials, thereby reducing their learning performance in learning programming. If students encounter difficulties in the process of learning programming, their development of programming logic in the next stage will be directly affected. To the best of our knowledge, previous studies rarely examined students' learning effectiveness after flipped learning through formative assessment, and they did not explore the learning performance of combining these two instructional strategies in units of different difficulty levels for engineering students. On the other hand, Cheng, et al. [11] have not separately explored the impact of implementing formative assessments on students' learning performance in units of different difficulty levels. Although this result suggested that students can improve their learning performance through formative assessment, they still do not explore whether formative assessments are more conducive to helping students improve learning performance in more difficult units or materials. Also, do students in the control group have lower learning performance in more difficult units or materials compared to students in the experimental group using formative assessments? In order to solve the problems that have not been explored in previous studies, this study designed new experimental activities and adopted a quasi-experimental design. The experimental group used flipped learning and formative assessment as learning strategies, while the control group did not use formative assessment. The experimental group implemented several formative assessment tests in the activities to evaluate the learning effectiveness of watching flipped learning materials. The teacher can help students to learn the logic and concepts of programming through the results of formative assessment, so as to master the process of students learning programming. Alternatively, students can reach self-assessment through formative assessment and immediately identify unfamiliar concepts of programming after watching the flipped learning materials. These activities lasted 15 weeks in the App Inventor course. App Inventor was a visual programming language, so it was used by researchers in this experiment to investigate students with an information engineering background. Furthermore, the teacher recorded 84 program videos as learning materials and developed an online formative assessment platform as an online test to explore students' learning performance in programming courses.

2. Literature Review

2.1 The Effect and Application of Flipped Learning in the Educational Field

With the vigorous development of information technology, many teachers are using digital materials to improve the limitations of traditional materials. Flipped learning is attracted much attention in educational research, and it is also attracted relevant research to apply its instructional strategy to explore students' performance in the classroom [27]. Flipped learning is a learner-centered teaching strategy that provides students with pre-recorded videos or instructional materials for students to watch and read before the course so that students can increase opportunities for active learning in the learning process [28]. Therefore, when teachers adopt flipped learning as an instructional strategy in teaching, they can effectively improve students' learning performance or learning engagement in the classroom [15, 29].

On the other hand, many studies have pointed out the effectiveness and benefits of flipped learning applications in the classroom, such as Huang, et al. [30] used gamification-enhanced flipped learning to explore the impact on students' behavioral and cognitive engagement. The results showed that students using gamification-enhanced flipped learning can complete pre- and post-class activities faster, and have higher test scores after class than students who did not use non-gamification flipped learning. Wang and Zhu [31] explored the impact of higher education students' participation, experience, and learning performance through a MOOC-based flipped learning approach. The results showed that most students had a good experience in flipped learning, and the overall average learning performance of students was also better than that of students in traditional classrooms. Awidi and Paynter [32] used flipped learning to explore the impact of students' learning satisfaction in the course and their engagement in activities. The results showed that there is an impact on students' learning experience through flipped learning, and students can get good assistance from the experience of flipped learning. Through flipped learning, teachers can improve students' learning experience in the classroom.

Although some studies have proven that flipped learning can help improve students' learning performance in the classroom [33], it may also cause other problems. One of the problems is that students have to devote a lot of time to flipped learning courses, which can increase their workload [34]. In order to effectively reduce the inherent cognitive load that may be caused by students in the learning process, Huang, et al. [35] showed that teachers must adjust appropriate materials according to the level of students. Therefore, this study attempts to explore the problems encountered by students in flipped learning by means of formative assessment, so that teachers can appropriately adjust the materials of flipped learning.

2.2 The Effect and Application of Formative Assessment in the Educational Field

In traditional assessment methods, teachers can only evaluate students' learning performance and the situation in the classroom through their test scores or homework scores. However, this may lead to students learning wrong knowledge and concepts in the process of learning, and teachers cannot immediately assist students in their process to solve related errors and problems. Therefore, formative assessment can effectively solve its teaching difficulties and limitations. The formative assessment is an assessment method used by teachers to measure students' responses to specific topics and skills [36]. Dunn and Mulvenon [37] indicated that teachers' use of formative assessment in the classroom can help them improve teaching outcomes and practice.

On the other hand, related studies pointed out the effectiveness of formative assessment in the classroom, such as building gamified e-quizzes based on formative assessment and exploring the impact of students' learning and engagement. The results suggested that Zainuddin, et al. [38] used gamified e-quizzes as an effective way to assess learning performance, especially when students complete different topics through formative assessments as a basis for assessing their performance; Dalby and Swan [39] used digital technologies to improve formative assessment in mathematics classrooms and explored the role of its tools in implementing formative assessment. The results showed that digital technology tools can effectively enhance student learning, and that paired with formative assessments can also improve student performance in the classroom.

According to the investigation of this study, many studies on flipped learning and formative assessment confirmed the effectiveness of its application in educational research. However, few studies focus on an in-depth exploration of the combination of flipped learning and formative assessment to improve students' learning performance in programming. Therefore, this study provided programming videos based on flipped learning and developed an online formative assessment platform to explore and test students' learning performance in the App Inventor course.

3. Research Method

Based on the flipped learning and online formative assessment system, this study enabled students to take online quizzes after reading flipped learning materials and explored the differences in their learning performance in the APP Inventor course. Therefore, teachers designed and recorded 84 program videos of APP Inventor courses as materials for flipped learning provided by this study. In addition, teachers have also built an online formative assessment platform as the classroom formative assessment system provided by this study, and the platform included 111 programming test items so that students can take online quizzes.

3.1 Participants

This study used a quasi-experimental design method to investigate 121 students from a science and technology university in Taiwan, 58 students were assigned to the experimental group and 63 students were assigned to the control group. All students come from a background in the field of computer science and information engineering and have basic programming skills. Before the experimental activity, all the students had not participated in the App Inventor course based on flipped learning. In addition, in this experimental activity, the experimental group used flipped learning and formative assessment as instructional strategies, while the control group only used flipped learning as an instructional strategy. All students between the ages of 20 and 21 were recruited by this study, all of whom agreed to conduct this experiment and had a clear understanding of the course of their activities.

3.2 Experimental Procedure

This study investigated 121 students to implement 15 weeks experimental activity, 58 students in the experimental group had to take the flipped learning and formative assessment in the App Inventor course, and 63 students in the control group only took the flipped learning in the App Inventor course. In addition, this study invited two experts with more than 5 years of information and engineering backgrounds to design the experimental activities and evaluate the validity of the test papers. Fig. 1 shows the experimental procedure of this study. Before the start of the experiment, the teacher would introduce the experimental process and method to all students, and the teacher would release a unit of flipped learning materials every week in the learning management system (LMS) provided by the school so that students can watch its videos before class to learn the content of the relevant unit.

After the teacher introduced the experimental activities, both groups of students would take the first test (pre-test) to measure their prior knowledge of programming. After all the students completed the first test (pre-test), the students in the experimental group and the control group would watch the App Inventor programming video before the class and have peer discussions and interactions during the class of the week, while the teacher acted as a tutor to exclude and assist students with related problems encountered in the instructional video. Different from the control group, the students in the experimental group could use the online formative assessment platform developed by this study to take online formative assessment tests to consolidate and assess whether students understand the relevant knowledge and concepts in this unit. A total of five formative assessments were conducted in this study, two times between the first and second tests, and three times between the second and third tests. The students in both groups implemented 12 weeks flipped learning courses, with three lessons per week, a total of 150 minutes. Teachers will release one unit of flipped learning materials on LMS every week, a total of 12 units.

After the students in both groups completed the flipped learning from units 1 to 6, they conducted the second test to measure their learning performance in units 1 to 6. After completing the second test, all students must continue with flipped learning from units 7 to 12. The experimental group also continued to take online tests for formative assessment during this period. After the students in both groups completed the flipped learning from units 7 to 12, they conducted the third test to measure their learning performance in units 7 to 12.

It is worth noting that both groups of students used the same flipped learning materials to watch the programming videos. The difference between

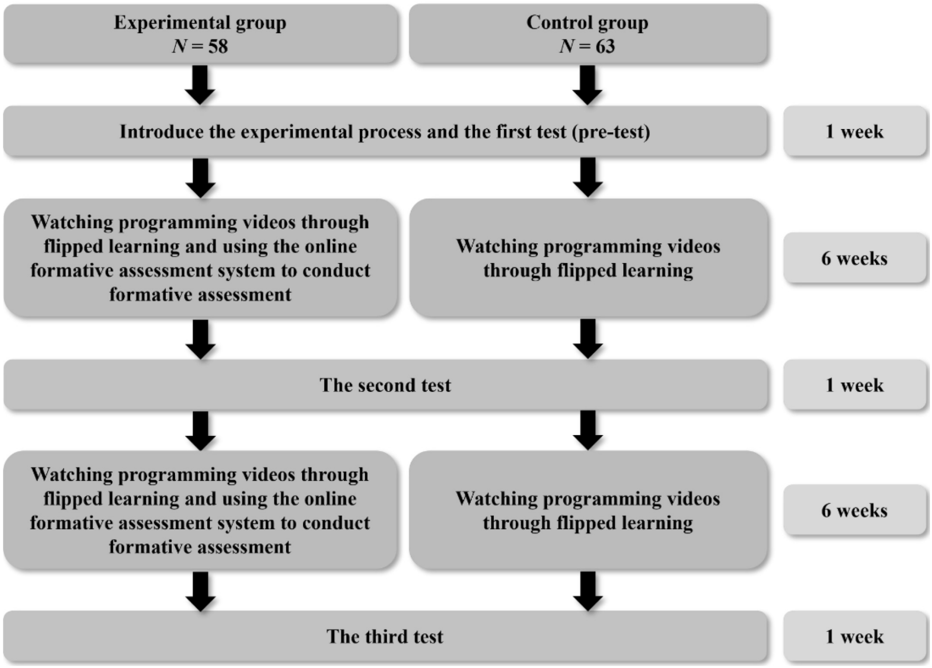

Fig. 1. Experimental procedure.

the two groups was that the experimental group used the online formative assessment system, while the control group did not use it. The teacher published all the materials for units 1 to 12 on the platform. Therefore, the time for the two groups to access flipped learning materials on the platform was the same. In addition, the difficulty and content of the first test (pre-test), the second test, and the third test implemented by the two groups were all the same, and the teacher would not announce the answers to ensure the consistency of each test.

3.3 Flipped Learning Materials

This study was based on flipped learning as an instructional strategy, so the teacher divided the App Inventor course taught into 12 units and recorded 7 different programming videos based on the course content of each unit, including a total of 84 videos for APP Inventor courses. The length of each film varies from 5 to 20 minutes, depending on the unit. On the other hand, teachers used English as the spoken language, and carefully designed and record the videos of each flipped learning material. The flipped learning teaching video of the APP Inventor course contains a total of 12 units, namely (1) user interface; (2) arithmetic & string operators; (3) control blocks; (4) procedures; (5) lists; (6) clock; (7) canvas; (8) web viewer; (9) phone function; (10) the camera and sounds; (11) text to speech; (12) database access. In addition, each unit contains 7 programming videos, namely (1) basic operation; (2) advanced operation; (3) basic operation subtitles; (4) advanced operation subtitles; (5) introduction to basic operation block; (6) introduction to advanced operation block; (7) user interface block.

Fig. 2 shows the flipped learning video of unit 9-1. Students can learn App Inventor related components of knowledge and concepts through video 1 (basic operation video) and video 2 (advanced operation video) of this unit. In these two videos, teachers would operate and introduce the integrated development environment of App Invertor and the learning content of this unit through English explanations. For example, the first unit was to introduce the user interface, and the second unit was to introduce the arithmetic and strings. Since the content of video 1 and video 2 was only introduced by the teacher's dictation in English, students could compare the Chinese and English subtitles of the content of the unit by watching video 3 (basic operation subtitle video) and video 4 (advanced operation subtitle video). In addition, Fig. 3 shows the flipped learning video of unit 9-5. Students could learn the components and code of App Inventor through video 5 (introduction to basic operation block video) and video 6 (introduction to advanced operation block video) of this unit between concepts. Finally, students could review the key content of App Inventor in this unit through video 7 (user interface block video) (as shown in Fig. 4).

3.4 Online Formative Assessment Platform

This study established an online formative assessment platform to provide students with online

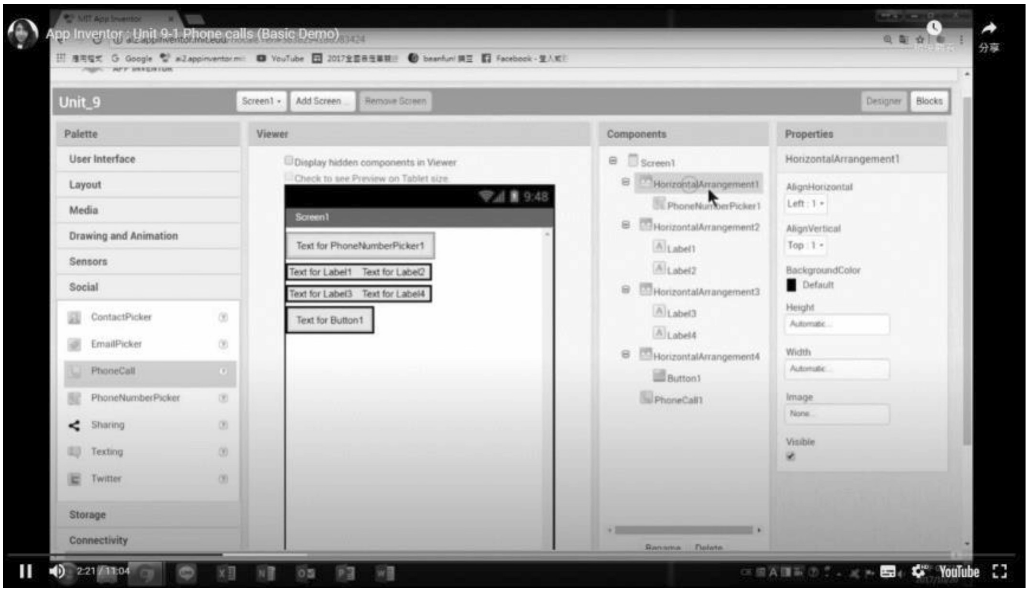

Fig. 2. Flipped learning video for App Inventor.

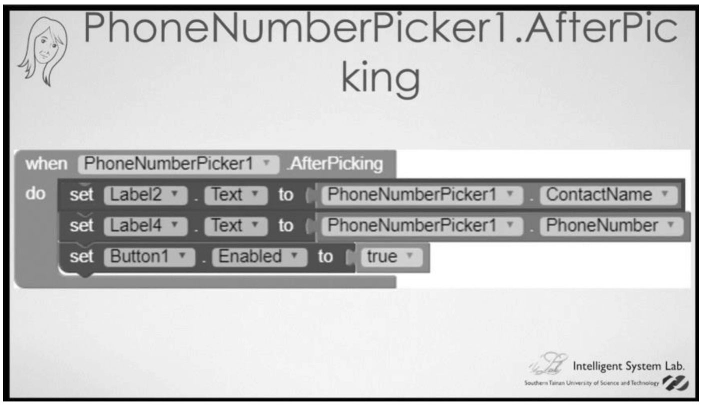

Fig. 3. Introduction to basic operation block video.

Fig. 4. User interface block video.

formative assessment tests after reading flipped learning materials. The system contains a total of 111 items, including 68 items for units 1∼6 and 43 items for units 7∼12. In addition, each test item is related to the components and objects of App Inventor, such as Button, TextBox, Image, List-Picker, WebViewer, CheckBox, etc. Fig. 5 shows the answering situation of the online formative assessment platform. All tests are automatically generated by random numbers. Students need to

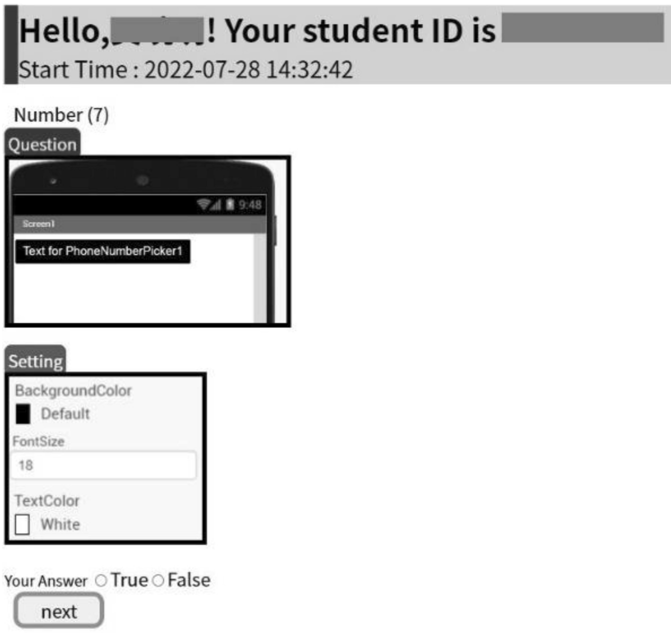

Fig. 5. Test items of objects and components on the online formative assessment platform.

judge whether the setting icon is correct according to the item icon of each test item and click the option at the bottom to submit their answer.

In addition, this platform also included the test items of the building block combination of the visual programming. The answering method for the test items was also the same as the above. Students needed to use the flipped learning videos provided by teachers to learn different objects, knowledge, and concepts of components, and the integrated development environment of APP Inventor can be used to fully understand the program operation process and execution results of the objects and components. Finally, after the students have completed all the formative assessment tests, the students' answer results would be displayed on the screen immediately, and their answer records would be uploaded to the database of the server so that teachers could adjust the contents of the flipped learning materials according to the students' answer records.

4. Experimental Results

This study investigated and collected 121 first tests (pre-test), second tests, and third tests, of which 58 valid tests were from the experimental group and 63 valid tests were from the control group, respectively. It is worth noting that the range of the second test was units 1 to Unit 6, while the range of the third test was units 7 to Unit 12. Due to the scope and difficulty of the first test, the second test, and the third test were different, so the researchers normalized the scores of the three tests respectively to ensure the consistency and standard of the scores. After the normalization of the scores, this study analyzed the learning performance of the two groups on different tests by using IBM SPSS Statistics software. In the analysis of the learning performance, this study used an independent samples *t* test and analysis of covariance (ANCOVA) to explore the differences between the experimental group and the control group in the three tests. In the analysis of ANCOVA, the independent variables were that the experimental group used flipped learning to watch videos and used the online formative assessment platform to conduct experimental activities, while the control group only conducted experimental activities based on flipped learning to watch videos. The covariate variable was the first test (pre-test) scores of the two groups. The dependent variables were the results of the second test and the third test of the two groups.

Table 1 shows the descriptive statistics for the first test of the two groups. The mean of the experimental group was 60.79 and the standard deviation was 16.79; the mean of the control group was 57.47 and the standard deviation was 17.47. The researchers performed an ANCOVA to test the within-group homogeneity regression of the two groups in the first test. According to Table 2, the interaction between independent variables and covariate variables did not reach a significant difference, and its $F = 0.16$ ($p > 0.05$), which was in line with the within-group homogeneity regression test. This means that there was no difference in the prior knowledge and concepts in the App Inventor course between the two groups before

Table 1. The descriptive statistics for the first test of the two groups

Group	N	Mean	Standard Deviation
Experimental group	58	60.79	16.79
Control group	63	57.47	17.47

Table 2. Summary of the within-group homogeneity regression test

Source	Sum of Squares	df	*F*	*p*
Pre-test	289.41	1	0.89	0.35
Groups	417.79	1	1.28	0.26
Groups*Pre-test	51.46	1	0.16	0.69
Error	38087.29	117		
Corrected Total	41048.59	120		

the experimental activity. Therefore, this study could continue to analyze whether there were differences in the learning performance of the two groups in the second test and the third test.

Table 3 shows the ANCOVA results for the second test of the two groups. The mean of the experimental group before adjustment was 74.57, with a standard deviation of 14.83; the mean of the control group before adjustment was 68.37, with a standard deviation of 19.56. After excluding the influence of the first test (pre-test) by ANCOVA in this study, the adjusted mean of the experimental group was 74.38, with a standard error of 2.29; the adjusted mean of the control group was 68.55, with a standard error of 2.2, and its $F = 3.35$ ($p > 0.05$), no significant difference was reached between the two groups. Although ANCOVA did not reach a significant difference, there was still a certain gap between the means of the two groups. Therefore, the independent sample *t* test was used to test the learning performance for the second test of the two groups in this study. Table 4 shows the independent sample *t* test results for the second test. The mean of the experimental group was 74.57, the standard deviation was 14.83; the mean of the control group was 68.37, the standard deviation was 19.56, and the *t* value was 1.97 ($p < 0.05$), A significant difference was reached between the two groups. This means that the experimental group could not only watch the program videos of the App Inventor course through flipped learning but also used the online formative assessment platform provided in this study to significantly improve students' learning performance in units 1 to 6.

Table 5 shows the ANCOVA results for the third test of the two groups. The mean of the experimental group before adjustment was 75.1, and the standard deviation was 13.98; the mean of the control group before adjustment was 65.82, and the standard deviation was 20.99. After excluding the influence of the pre-test through ANCOVA in this study, the adjusted mean of the experimental group was 74.94, with a standard error of 2.37; the adjusted mean of the control group was 65.97, with a standard error of 2.27, and its $F = 7.43$ ($p > 0.01$), there was a significant difference between the two groups. This means that the experimental group could not only watch the program videos of the App

Table 3. The ANCOVA results for the second test of the two groups

		Second test		Second test (Adjusted)			
Group	N	Mean	Standard Deviation	Mean	Standard Error	*F*	*p*
Experimental group	58	74.57	14.83	74.38	2.29	3.35	0.07
Control group	63	68.37	19.56	68.55	2.2		

Table 4. The independent sample *t* test results for the second test of the two groups

Group	N	Mean	Standard Deviation	*t*
Experimental group	58	74.57	14.83	1.97*
Control group	63	68.37	19.56	

Note: *$p < 0.05$.

Table 5. The ANCOVA results for the third test of the two groups

		Third test		Third test (Adjusted)			
Group	N	Mean	Standard Deviation	Mean	Standard Error	*F*	*p*
Experimental group	58	75.1	13.98	74.94	2.37	7.43**	0.007
Control group	63	65.82	20.99	65.97	2.27		

Note: **$p < 0.01$.

Inventor course through flipped learning but also used the online formative assessment platform provided in this study to significantly improve students' learning performance in units 7 to 12.

5. Discussion

Although flipped learning is proven to improve student performance, it still brings a certain workload for students. This study considered that the more difficult materials students learn may have a negative impact on learning performance, so the online formative assessment platform was developed to provide the experimental group with online formative assessment tests. Through this method, students for the experimental group can take a formative assessment test after viewing the flipped learning materials to consolidate and review their knowledge and concepts of the flipped learning materials for each unit.

According to the results of the study, the learning performance of the experimental group in the second test and the third test was significantly higher than that of the control group. This means that in addition to watching videos to enhance the knowledge and concepts of the App Inventor course, they could also use the online formative assessment platform to self-evaluate the knowledge construction of different units. On the other hand, the scope of the second test was units 1 to 6, while the scope of the second test was units 7 to 12. According to the results in Table 3 and Table 4, although the learning performance of the experimental group was higher than that of the control group, the learning performance of the control group was still 68.37 (the adjusted mean was 68.55). Researchers considered that the content of units 1 to 6 contained basic programming concepts and that most students have basic programming skills. Therefore, students might already have basic programming concepts in the course of the pre-weeks, which was one of the reasons why the ANCOVA results in Table 3 were not significant. However, the experimental group could still effectively test the learning content through the online formative assessment platform, which was why the two groups achieved significant differences in the independent sample t test (see Table 4).

According to the results in Table 5, the learning performance of the experimental group was significantly higher than that of the control group. This shows that the experimental group could effectively improve the learning performance of units 7 to 12 through the online formative assessment platform. Especially, the control group had a mean of 65.82 on the third test (adjusted mean of 65.97), which was lower than the learning performance on the second test. However, the mean of the experimental group in the third test was 75.1 (the adjusted mean was 74.94), which was higher than the learning performance of the second test. Regarding this result, the researchers inferred that the frequency the experimental group continued to use the online formative assessment platform, the more effective the learning performance of the course could be improved. On the other hand, compared to the content of units 1 to 6, the materials of units 7 to 12 were more difficult, such as canvas, web viewer, text to speech, and database access. This led to the fact that the control group could not improve its learning performance by watching videos through flipped learning, and the learning performance of the unit with higher difficulty was significantly reduced. This study found that students in the experimental group could enhance learning performance in more difficult materials by combining flipped learning with an online formative assessment platform. In addition to solving the problems that have not been found in previous studies [11], this result also confirms that the combination of flipped learning and online formative assessment platforms can be implemented in engineering education, thereby improving students' learning performance in visual programming. Therefore, the results of this study provide a new method and information system development for engineering education in the application of visual programming courses.

6. Conclusion

This study aimed to investigate whether instructional strategies combining flipped learning and formative assessment could improve students' learning performance in the App Inventor course. Therefore, this study was based on flipped learning as an instructional strategy, and 84 program videos were recorded in the App Inventor course taught by teachers to provide students with pre-viewing materials at home before the course. In addition, this study built an online formative assessment platform based on the instructional strategy of formative assessment to provide students with online formative assessment tests, and the system provided 111 test items related to the APP Inventor course. This study confirmed that the experimental group could effectively enhance the learning performance of the App Inventor course by combining flipped learning and the online formative assessment platform, and students could also review and deepen the knowledge and concepts of the programming through the results of the formative assessment. On the other hand, when the duration of the experimental activity was longer, the learning performance of the experimental group after using the online formative assessment platform also reached a significant positive impact.

On the other hand, this study has several limitations. First, the study was conducted on college students with engineering education (background in information engineering), so the benefit of these experimental activities in K-12 education was uncertain. In addition, the study did not further analyze the time and learning situations of students watching the video. Therefore, this study suggests that K-12 students' engagement or cognitive load in App Inventor courses can be further explored in the future and analyzed learning situations of students watching the flipped learning materials.

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