Reinventing teaching pedagogy: the benefits of quiz-enhanced flipped classroom model on students’ learning outcomes and engagement

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Abstract
Purpose – The flipped classroom model is an emerging teaching pedagogy in universities, colleges and secondary schools. This model will likely be successful if students prepare and acquire basic knowledge before class hours. Pre-class video lectures are common for students to access knowledge before class hours. However, students often do not watch the pre-class videos or do so only immediately before class hours due to poor engagement and supporting strategies, which can have detrimental effects on their learning achievement. To address this issue, embedding quiz questions into pre-class recorded videos may increase the completion of pre-class activities, students’ engagement and learning success. This study examines the effect of a quiz-based flipped classroom (QFC) model to improve students’ learning achievement and engagement in a computer science course.

Design/methodology/approach – The study involved 173 participants divided into experimental and control groups. The experimental group consisted of 78 students who used the QFC model, while the control group consisted of 73 students who used the conventional flipped classroom (CFC) model.

Findings – The 10-week experiment showed that the QFC model effectively improved students’ learning achievement and engagement (both behavioral and agentic) compared to the CFC model.

Practical implications – Embedding quiz strategy into the pre-class video demonstrated the potential support to enhance the efficacy of the CFC model. Based on the results of this research, the authors recommended that flipped educators can use the quiz strategy to minimize pre-class issues (especially students’ disengagement).

Originality/value – This research adds to the existing literature by evaluating the effect of the newly proposed model on students’ learning outcomes and engagement. This study’s results can guide colleges and universities intending to implement a blended learning or flipped learning model. The research also gives design, content and course implementation guidelines, which can help engage students to achieve their learning objectives.

Keywords Universities, Flipped learning, Learning outcome, Engagement, Student

Paper type Research paper

1. Introduction

There has been a paradigm shift from traditional teaching methods to technology-based methods, particularly in universities, colleges and secondary schools. In this century’s teaching and learning environment, information technologies have expanded the boundaries beyond conventional classroom settings. Innovative technology-based pedagogies have improved the quality of teaching and learning, enhancing students’ interest and engagement (Sani et al., 2016). Technology-based methods, particularly the flipped classroom (FC) model, have transformed conventional learning by shifting it from inside to outside the classroom (Han and Klein, 2019). The FC model begins with pre-class preparation by the students,
followed by a readiness assessment based on their preparation in the in-class session. In this model, knowledge acquisition occurs outside the classroom, and learning assessment occurs during classroom time. The students are responsible for their learning through the completion of out-of-class learning activities that cover lower levels of cognition, according to Bloom’s taxonomy (remembrance and understanding) (Sarawagi, 2013). This approach enables the classroom to become an interactive learning environment where students can work through complex cases to achieve high levels of cognition (applying, analyzing, evaluating and creating) (Zainuddin et al., 2018).

The FC model has gained recognition and is used by many educators and researchers due to its simplicity, flexibility and potential for imparting knowledge (Masood et al., 2022; Ristanto et al., 2022). This innovative model’s popularity stems from teachers’ widespread adoption of computer and Internet-based teaching and learning (Jones et al., 2021). It provides a suitable alternative to traditional and unidirectional forms of imparting knowledge, allowing multiple strategies to acquire knowledge anywhere and anytime (Lai and Hwang, 2016). The philosophy of flipping the classroom is to push students beyond observation and begin analyzing and synthesizing (Huang and Hong, 2016). Flipped learning represents a unique combination of learning theories once thought to be incompatible – active, problem-based learning activities founded upon a constructivist ideology and instructional lectures derived from direct instruction methods founded upon behaviorist principles (Bishop and Verleger, 2013). Social constructivist learning theory is embedded in the FC model to make the students critical players in the classroom and active participants in constructing new ideas and knowledge. The theory emphasizes that knowledge is not waiting to be discovered but constructed by human collaboration and interaction with peers and the world around them.

One of the common challenges encountered by scholars when using the FC model is students’ inability to watch pre-class video recordings and lack of preparation before class (Akçayır and Akçayar, 2018). Technological advancement now allows for the incorporation of quiz questions directly into recorded video lectures. Embedding questions into video is an exciting topic around educational interactive videos as questions carry the “testing effect” that deepens interaction and learning. Previous studies indicate that embedding video lectures with quizzes increases video viewing time, active learning and knowledge retention (Jones et al., 2021). However, a knowledge gap exists about whether embedding quiz questions within pre-class video lectures improves students’ performance and engagement in a computer science course. Therefore, this study aimed to conduct experimental research to assess whether embedding quizzes with video lectures can improve students’ learning achievement and engagement in a flipped computer science course. Comparing video lectures using embedded quiz questions with those not using embedded quiz questions will establish the efficacy of this mechanism by determining the impact on learning success.

2. Literature review

2.1 The flipped classroom (FC) model

The role of the FC model in higher education has been extensively discussed in many previous studies (see the work by Stone (2012), Nederveld and Berge (2015) for more details). During pre-class activities, students may fail to plan their time to watch videos or read the e-book and comprehend the learning materials owing to the lack of proper guidance (Ahmed, 2016). In this situation, they are more likely to fail to learn successfully in the following in-class activities (Odo and Eze, 2017). For in-class activities in the FC model to succeed, the students must be deeply engaged and fully prepared before the class. Not watching pre-class instructional videos affects students’ commitment during class
activities (Hsia et al., 2019). When students are not engaged and unable to understand basic knowledge before the class hour, it will harm their academic performance when using the FC model (Ye et al., 2019). Previous studies reported that when students engage and comprehend basic knowledge, they can participate in classroom discussions, and interact with teachers and peers, significantly enhancing their performance and learning achievement (Lin et al., 2019). Therefore, to ensure students watch the instructional videos and acquire basic knowledge before the class hour, it is crucial to embed quiz questions into the videos, which scholars have recognized as a process of engagement and learning acquisition (Kinsella et al., 2017).

2.2 Quiz-based flipped classroom model (QFCM)

Video-recorded lecturers have become more acceptable and important for student learning, particularly in FCs (Han and Klein, 2019). However, getting students to watch these lectures sufficiently to come to class well-informed is a challenge for teachers. Different video recording software such as Covideo, Droplr, Screencast-Q-matic, Loom, OBS Studio, Camtasia, Bandicam, Screencastify, Fluidic, Screencasting, and Movavi was used by the flipped educators to prepare e-video lectures for pre-class learning. For example, Khanova et al. (2015) used screencasting video recording software; specifically, PowerPoint slides with voice-over, to prepare e-video lectures. These e-video lectures allow learners to stop, replay, restart, and skip sections. Most of the instructional videos were less than 60 min. Thus, scholars normally break the video into different segments. Some segments will be as long as 10 min, while others range from 4 to 6 min (Han and Klein, 2019). Students were reported to have a negative perception of too lengthy videos (Boateng et al., 2016). Moreover, teachers found it difficult to understand if the students watch the video lecture or not (Akçayır and Akçayır, 2018).

However, educators believe that embedding quiz questions into the e-video lectures will assist the students to pay more attention while watching the video lectures (Jones et al., 2021). Modern video-recording software has advanced to the point that it allows the incorporation of quizzes directly into recorded lectures. This study used Google Form software to embed quiz questions into recorded video lectures. A quiz-based flipped classroom (QFC) was implemented to support students during pre-class learning activities.

A quiz is one of the effective strategies to help students acquire prior knowledge to facilitate their learning (Kilickaya, 2017). Pre-lecture online quizzes significantly affected students’ achievement and informed teachers about students’ progress (Kinsella et al., 2017). Gholami and Moghaddam (2013) reported that pre-class quizzes could improve the effectiveness of class time by ensuring learners acquire the basic knowledge before the lecture. For FCs, students were encouraged to watch pre-class videos by embedding quiz questions which increased their understanding and academic performance (Warburton and Volet, 2013). Nevertheless, little is known about whether embedding quizzes within pre-class videos increases students’ behavioral and agentic engagement. Therefore, this study investigates whether embedding quizzes into the FC model can enhance students’ learning achievement and engagement in a flipped computer science course.

2.3 Impact of FC on students’ engagement

Students’ engagement is a multi-dimensional aspect of learning related to learner participation in academic and non-academic activities and their desire for these activities (Reeve and Tseng, 2011). Students who exhibit high levels of engagement are more likely to achieve academic success, feel more connected to their school, and have better collaboration and interaction with their peers and teachers (Hava, 2021). Conversely, low student engagement is linked to several unfavorable consequences, including misconduct,
aggression, substance addiction, and school dropout. According to Nagy (2017), low behavioral engagement affects students’ commitment to watch the instructional video and leads to poor academic performance. Literature reports that many students could neither pay attention to their learning nor complete their learning tasks; they participated less, asked few questions, and answered few or no questions during the lecture (Zakana and Esther, 2019). Agentic engagement, which refers to students’ contributions to what to learn and how to learn, has been captured recently (Reeve and Tseng, 2011). Agentic engagement is one of the most important aspects of the teaching and learning process, especially in an FC where students must watch the video lectures and complete the learning exercises before class (Jamaludin and Md Osman, 2014). The issue of student disengagement has yet to be tackled due to the frequent use of traditional teaching methods. Scholars believe the FC model is more effective than conventional teaching methods (Burke and Fedorek, 2017; Elmaadaway, 2018) since it allows learners to access and engage with learning materials before class hours.

Several studies have reported that faculties and lecturers at high institutions of learning are increasingly adopting the FC model to improve their teaching methods and students’ academic performance (Bates and Ludwig, 2020; Ristanto et al., 2022; Samaila et al., 2021a, b). However, many of these studies have highlighted deficiencies in the FC model, particularly in engaging students during the pre-class learning session (Han and Klein, 2019; Lin et al., 2019). As a result, there is a need for better-designed pre-class sessions using the FC model that can attract and engage students to study before coming to class. So far, only a few studies have looked at quiz strategies to improve student engagement in the FC (Asiksoy and Canbolat, 2021). Studies from other fields have shown that embedding quiz strategies into video lectures effectively engages students in e-learning. For example, researchers employed a pre-class online quiz strategy for undergraduates in a pharmacy course. The experimental study showed that students who took the quiz questions prior to class were better engaged, performed better, and completed their learning activities compared to those who did not take the quiz questions (Hasan and Makary, 2021; Jones et al., 2021). This is because the quizzes can supply motivation and attraction for students to watch the instructional videos. Based on these findings, this study embedded quiz questions into the video lectures, and the following hypotheses were tested:

H1. There is no significant difference between QFC and CFC models on students’ behavioral engagement when learning computer science courses.

H2. There is no significant difference between QFC and CFC models on students’ agentic engagement when learning computer science courses.

2.4 Impact of FC on students’ achievement
The traditional teaching method is teacher-centered and the most common teaching approach in developing countries. It dominated classrooms for decades. Learners were reported to have a negative perception and attitude toward the method; they lament having limited time to engage in practical learning activities while using the traditional method, and teachers take most of the class time (Frydenberg, 2013). The traditional methods affect students’ participation in the learning process, which leads to poor academic performance (Mason et al., 2013). On the other hand, students perform better when carried along and allowed to contribute to the learning process (Velazquez, 2020). New teaching methods and strategies such as problem-based learning, constructivist teaching method, problem-solving techniques, blended learning, student-centered learning, and cooperative learning continue to emerge. Learning institutions and lecturers are adopting these methods as a means of teaching. While adopting the specific method, they carefully consider the nature and nomenclatures of the courses.

For instance, some technology and science courses require student-centered learning, more time for practical activities, and problem-solving techniques. In the teaching of
computer science courses, some topics are so abstract that they demand complete student engagement in practice. Researchers and scholars use FCs to engage students with various instructional strategies. It supports podcasting, hybrid course design, active learning, and student participation (Asiksoy and Canbolat, 2021). FC model is a learning strategy that converses conventional teaching methods and allows learners to gain access to learning material outside the classroom, usually through audio or instructional videos. Then class time is used for assimilating knowledge via strategies such as group discussion, debates, and problem-solving (Ode, 2017). Some of the principles of the FC model include active learning, student involvement, blended curriculum design, and course videos. Using this model, a teacher can improve students’ engagement, enhance academic performance, and offer immediate feedback in and outside the classroom (Samaila et al., 2021a, b). It has significant potential to promote students’ ability to collaborate, engage, communicate, think critically, solve problems, be creative, use higher-order thinking skills, and apply knowledge (Hwang et al., 2015). Evidence shows that the FC model can effectively advance learning achievement if well implemented (Hsia et al., 2019). It benefits learners’ academic performance more, especially with effective teaching techniques (Danker, 2015).

Previous studies showed that despite the challenges of the conventional flipped classroom (CFC) model, it enhanced students’ learning achievement compared to the traditional method (Manoj et al., 2018; Odo and Eze, 2017; Pattananaphanchai, 2019). Almodaires et al. (2018) used a quasi-experimental study to examine the FC model’s effects on students’ achievement in an educational technology course. Results showed that the FC model could improve students’ learning outcomes if the pre-class learning activities were supported with extra teaching and learning strategies. Therefore, this study reinvented the FC teaching pedagogy by embedding quiz strategy into the FC model (QFC model) to provide a platform for students to complete their pre-class activities. Consequently, if the innovative QFC model is implemented carefully, the students will be guided to complete learning activities and improve their learning achievement. Therefore, this study was conducted to get the best out of the QFC model, and the following hypothesis is formulated:

H3. There is no significant difference between QFC and CFC models on students’ learning achievement when learning computer science course.

2.5 Application of the social constructivist learning theory in the FC model

Both the QFC and CFC models were supported by the social constructivist learning theory, where learning occurs under the teacher’s supervision. Students were guided to interact with their colleagues and learn from each other. The theory also defines the teacher as the facilitator who encourages the students to work in a group to achieve a common goal. More so, applying the concept of social constructivist teaching in the FC model provided a justification and a base for using a student-centered learning approach instead of a teacher-centered approach. Students were actively involved in the learning process and were the core constructor of the knowledge. Social constructivist teaching encourages students to use experiments to create more knowledge based on their prior experience. In this study, the students learn most of the theoretical aspects of the topics before coming to the class while giving more emphasis on practical aspects during the in-class learning activities. This makes learning more effective in computer science classes where theoretical knowledge mostly complements the practical aspects. For instance, students read and understand the procedure of using the “Track Changes” feature while at home; subsequently, the students were given a Word Document to edit using the “Track Changes” feature during the in-class activities. This is in line with the FC model ideology that students should have exposure (prior knowledge) before class while they should have group-based learning activities in the classroom.
2.6 Uniqueness of the study
The uniqueness of this study comes from embedding quiz questions into a pre-class video of the FC model, which is called the QFC model. This was done to engage students to complete their pre-class learning activities and improve their learning achievement. In addition, the study is unique by comparing the effect of the innovative QFC model and the CFC model on students’ learning achievement and engagement in a computer science class. This study’s experimental design and procedure are rare in the literature, which emphasizes the study’s uniqueness. Most of the previous compared the impact of FCs against the traditional method, while this study compared the impact between two types of FC models (QFC and CFC) model.

3. Methodology
3.1 Experimental design
This study integrated the quiz delivery method into the flipped computer science course. The students were asked to watch the instructional videos and answer the quiz questions simultaneously. The expectation was that this approach would prepare the students better, engage them more effectively, and enhance their academic performance and engagement. To test this hypothesis, a quasi-experimental design was employed. Two intact classes, comprising 173 students, were conveniently selected to avoid disrupting the school’s natural setting.

3.2 Participants
A total of 173 students aged 19 to 35 who were enrolled in a computer course in the science education department were included in this study. The experimental group consisted of 100 students from Class A, while 73 students from Class B were assigned to the control group. However, 22 participants still needed to complete the questionnaire, so data from only 151 students were analyzed. The teacher assigned fixed groups of five to six students during the in-class activities. Different teachers taught the two groups.

3.3 Experimental procedure
Figure 1 illustrates the experimental procedure conducted over ten weeks. The teachers introduced the course outlines and learning objectives in the first week, and students took a pre-test. For the next eight weeks, a single topic was taught each week. During the pre-class activities, the experimental group (QFC model) answered quiz questions while watching instructional videos online. In contrast, the control group (CFC model) only watched the videos online. Both groups participated in the same in-class activities, such as group discussions, problem-solving, and teamwork (using face-face mode). The best students chaired the group discussions in the experimental group, and the teacher intervened to clarify misconceptions. In the control group, the instructor conducted a 15-min mini-lecture, and students interacted and learned from each other.

In the last week of the intervention, the students in both groups took a post-test to assess learning achievement and completed an engagement questionnaire. To reduce the possibility of internal validity caused by exposure and experience throughout the trial, the researchers ensured that all participants had not used the FC model before the intervention. All participants used the same course materials and had comparable backgrounds. However, the layout of the questions in the pre-test and post-test was different, with different question orders. For instance, the first question in the pre-test could be the fifth question in the post-test.
3.4 Instrument
This study utilized two instruments: an achievement test and an engagement questionnaire. Three experienced computer science teachers developed the achievement test and covered topics like Microsoft Office, the Internet, networking, image processing, and database. It consists of 25 multiple-choice questions, with a perfect score of 100. Two experts evaluated the test, and its reliability was assessed using the Kuder-Richardson formula (KR-20), which yielded a value of 0.79. Kuder-Richardson 20 (KR20) is used in this study due to the nature of the instrument. The instrument is a multiple-choice question. Furthermore, it was recommended that the KR20 be used to measure the instrument’s reliability, in which each question has only two answers: right and wrong (Akinoğlu and Tandoğan, 2007). KR20 should only be used if there is a correct answer for each question, as in this study, the multiple-choice questions have the correct answer for each question.

To measure students’ engagement, we adopted a questionnaire developed by Subramaniam and Muniandy (2019). The questionnaire consists of 13 items that measure two types of engagement: behavioral and agentic. Seven items measure behavioral engagement, such as “When I’m in computer science class, I listen very carefully” while six items measure agentic engagement, such as “During this class, I express my preferences and opinions.” Respondents rate their level of agreement on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire has good internal consistency, with a Cronbach’s alpha value of 0.81 (Hair et al., 2018).

4. Results
4.1 Analysis of students’ learning achievement
After the intervention, analysis of Covariance (ANCOVA) was employed to examine the effect of FC models (QFC and CFC) by using pre-test scores as covariants and post-test scores as an independent variable. After confirming that the assumption of homogeneity of regression was not violated ($F = 0.72, p = 0.62 > 0.05$), the ANCOVA was performed (see Table 1). While
controlling the effects of the pre-test scores, the teaching models (QFC and CFC) indicated a significant difference in the students’ learning achievement $F(1, 148) = 18.595, p < 0.05$. The adjusted mean scores and standard error were 66.895 and 1.318 for the experiment group and 58.715 and 1.362 for the control group (see Table 1). This implies that the QFC model significantly improved students’ learning achievement compared to the CFC model.

4.2 Analysis of students’ engagement
The analysis results of homogeneity of variance for behavioral engagement ($p = 0.131$) and agentic engagement ($p = 0.211$) show that the assumptions were not violated, which means that ANOVA can be conducted. The analysis results of ANOVA of behavioral and agentic engagement for the groups are reported in Table 2. There is a significant difference between the two groups, for behavioral engagement, $F(1, 149) = 22.23, p < 0.05$, and for agentic engagement, $F(1, 149) = 11.99, p < 0.05$. For behavioral engagement, the adjusted mean and standard errors were 28.39 and 0.59 for the experimental group and 24.39 and 1.36 for the control group. For agentic engagement, the adjusted mean and standard errors were 23.59 and 0.49 for the experimental group and 21.12 and 0.51 for the control group. This means that quizzes play a significant role in improving students’ behavioral and agentic engagement.

5. Discussion
The FC model has become a more acceptable and important means for student learning. Practical studies have reported some benefits of the FC model and proved that this learning strategy can increase students’ performance. However, getting students to watch pre-class recorded videos to come to class well-informed is challenging for teachers. This indicates that the FC model needs adjustment, improvement, and modification. This led to the birth of reinvented teaching pedagogy called QFC model to assist students in watching pre-class recorded videos and improving the quality of the in-class learning activities. A 10-week

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**Source(s):** Author’s own work

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**Source(s):** Author’s own work

Table 1. ANCOVA, adjusted mean score and standard error analysis results for students’ learning achievement

Table 2. ANOVA results for students’ engagement (behavioral and agentic)
experiment was conducted in a university computer science course to investigate the effect of the proposed learning mode. The experimental group learned with the QFC model, while the control group learned with the CFC model. The students in the experimental group were required to watch videos and answer short quizzes to check their understanding. They were asked to provide the correct answers to proceed. Research (e.g. Jones et al., 2021) suggests that embedding quiz delivery teaching methods into pre-class recorded video lectures improves attentiveness, identifies knowledge gaps, boosts self-confidence, and assists students in retaining information. Students were observed to be engaged substantially and significantly longer with the instructional videos that included quiz questions. The results of this study indicated that embedding quizzes in the pre-class videos produced the effect anticipated. Students were more likely to view pre-class videos and utilize the content, increasing their engagement and learning achievement.

There are several reasons why the QFC model has a more influential impact on students’ learning achievement. One of the reasons behind the QFC model’s success may be short quiz questions; quizzes make students watch videos completely (Narloch et al., 2006). As past studies have reported, there is a positive relationship between students’ completion of pre-class activities and students’ involvement in in-class activities, which positively affects learning achievement (Hasan and Makary, 2021; McDaniel et al., 2012). Another reason is that quiz questions help the students to have deep knowledge of content materials, become more test-wise, and detect the types of questions to be included in the final examination, which positively affect their learning achievement (Narloch et al., 2006). Another reason might be that quizzes create much extrinsic motivation for the students (Gholami and Moghaddam, 2013), which plays a significant role in students’ learning and engagement. This indicates that quizzes motivate students to take responsibility for knowledge acquisition. Moreover, embedding quiz questions assist the students in practicing while they learn; students can reflect on previously acquired knowledge and remember them while quizzing.

Furthermore, the experimental results in this study show that the QFC model increased students’ behavioral and agentic engagement compared to the CFC model. In addition, the significant effect of the QFC model may be attributed to the out-of-class quiz, which allowed the students to have a profound understanding, interaction, and engagement with learning materials before coming to class and have armful time for in-class active learning activities. Having active pre-class and in-class learning activities always resulted in an effective FC approach and improved student engagement. A quiz is a powerful tool used to not only engage the students but provide an opportunity for feedback, reflection, and improving knowledge during pre-class learning activities of the FC model (Jones et al., 2021). It motivates students to learn, engage in classroom discussion, provide teachers feedback, and let them know what is learned or what is not (Hsia et al., 2019).

Integrating quiz questions into pre-recorded videos solves the FC model’s challenges, including learners’ inability to watch pre-class videos, lack of engagement, and inadequate support to complete pre-class learning activities. For students to answer quiz questions correctly, they must pay maximum attention while watching the videos, which increases their behavioral engagement. The results of this study concurred with the previous study that pre-class online quizzes improve students’ behavioral engagement by encouraging them to complete all their activities and exercises during the learning process (Kinsella et al., 2017; Masood et al., 2022). While answering the quiz questions, the students are psychologically testing themselves to determine whether they understand or gain some knowledge from the instructional videos, thereby improving their behavioral engagement.

Likewise, results indicated a significant effect of reinventing teaching pedagogy (QFC model) on students’ agentic engagement in a computer science course. This may be attributed to the fact that the QFC model improved students’ behavioral engagement, which positively impacts students’ agentic engagement. Students who participated in the learning process
behavioral engagement) were always expected to express their opinion (agentic engagement). Similarly, the students who completed their learning activities, exercises, and assignments (behavioral engagement) have more confidence to let the teachers know what they need or are interested in (agentic engagement). This study agrees with the previous studies that students taught using the extended FL model were highly engaged and contributed to the flow of instruction they received more than those treated with the conventional FL model (Huang et al., 2019; Sulong et al., 2021). Answering quizzes while watching the video makes the students identify difficult areas that they need more explanation for; encourages students to ask many questions about the areas they think are important. Moreover, our results showed that when the quiz strategy was carefully embedded in the pre-recorded video lectures, the students’ engagement could be improved, significantly enhancing their learning performance.

Constructivist learning theory plays a significant role in the flipped computer science classroom; it promotes student’s self-directed learning and makes them main body of cognition and active constructors of knowledge. It helps the students to participate in the teaching activities and collaborative learning. The theory places the students at the center of teaching and allows the teachers to play the role as instructors, organizers, and facilitators, only to assist students in the process of learning activities. Teachers cultivate students’ learning independence and regard them as the leader of the learning process. With constructivist teaching and learning, students’ learning motivation in computer science classroom can be fully stirred. In other words, the theory can arouse the students’ learning interest and improve the efficacy of the FC.

6. Limitation and feature studies
One limitation of this study is its reliance solely on quantitative research methods, which suggests additional probability sampling techniques are needed. The results are generalized to a population with similar characteristics to this study’s population. The findings thus help in the development of theories and the establishment of hypotheses. However, the findings may not be generalizable to other languages, art, social science and management courses due to their contents which differed from the science courses. Consequently, the QFC model could be implemented in other fields, such as language, art, social science or management courses, to determine its effectiveness. Another limitation is that using different teachers might affect students’ engagement and achievement. The study was conducted at a single university, making it difficult to generalize the findings to all other institutions. Therefore, future research should include more universities to extend the scope of the proposed model. In addition, this study only investigated two types of engagement: behavioral and agentic engagement. Future research should also consider cognitive and emotional engagement. Finally, this study aimed to address the challenges of the FC model by embedding quiz strategies into pre-class recorded videos. However, future research should also consider developing effective strategies for the FC model, particularly during in-class activities.

7. Conclusion
This study reinvented the teaching pedagogy by proposing QFC model on students’ learning achievement and engagement (behavioral and agentic). The QFC model was found to have significant effect on students’ learning achievement and engagement compared to the CFC model. This is due to the impact of the embedded quiz strategy, which improved students’ acquisition of basic knowledge and participation in whole-class discussions. Embedding quiz questions into pre-class recorded videos in a flipped computer science course increased the likelihood of students viewing the videos and retaining knowledge, resulting in improved
learning achievement and engagement. The success of the FC model relies on the instructor’s ability to adjust the model and make the pre-class session enjoyable and interactive. Students’ engagement and achievement levels may suffer if the FC model is not engaging and interactive. Therefore, instructors implementing the FC model must prioritize helping students engage with and comprehend basic knowledge from assigned pre-class recorded videos or other learning materials. This study can be helpful for educators who wish to implement the FC model to improve class attendance, participation, engagement and grades but have faced obstacles such as disengagement, lack of support during pre-class and inability to watch pre-class videos. As indicated in this study, embedding quiz questions into the FC model can efficiently and effectively solve these problems.

References


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