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Teaching ICT with the Flipped Classroom Approach in Higher Education Settings

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Abstract: In this study, three design cycles have been conducted in three different courses taught by the research team members at the Education University of Hong Kong. The duration of the research spanned two years and all courses were ICT related. In the first case, we focused on how to implement the flipped classroom in the lesson while in the second and third cases, we put more emphasis on the technology issues and assessment strategies in a flipped classroom. The findings show that the flipped classroom approach can be applied to courses in higher education settings. In ICT related courses, the technology issue is not a problem as the technical hurdle is low and the course lecturers should be more ICT educated. Thus, we can implement this approach in courses focused on learning ICT, learning to teach with ICT or learning to teach ICT.

Keywords: *Flipped Classroom; ICT; Pedagogy; Teacher Education.*

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Introduction

The flipped classroom pedagogical approach is becoming increasingly popular in all education sectors due to the advancement of internet technologies and e-learning tools. This approach allows students to explore knowledge and skills themselves through pre-lesson instructional videos. Then, during the face-to-face classroom time they get support from their teachers to solve their problems and difficulties encountered (Ng, 2016). Besides, after the class students can still recap the knowledge and skills they need with the online learning materials prepared by their teachers. This also helps develop students' abilities in independent learning and higher order thinking (Lee & Lai, 2017). However, ways of implementing a

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flipped classroom are diverse. The pre-class instructional materials may be in different formats and levels. Various kinds of learning activities, such as brief review and small group activities, can be incorporated into the class (Lo & Hew, 2017). Meanwhile, only few studies on flipped classroom were conducted in technology classes (Lo & Hew, 2017; Zainuddin & Halili, 2016). Thus, this study aims to investigate the teaching strategies as well as the assessment issues in the flipped classroom approach, especially in teaching ICT in higher education settings.

Literature Review

"Flipped classroom" denotes a new teaching approach. Bergmann and Sams (2012) point out that the flipped classroom approach is student-centered, focusing on students' personalities and learning abilities. When adopting this pedagogical approach, teachers will be enabled to rearrange class time and time for homework. It is also implied that they need to prepare the teaching materials, such as instructional videos, in advance. In addition, their students will be asked to study these instructional materials at home prior to classes. Hamdan, MaKnight, McKnight and Arfstrom (2013) attempt to explain the underlying meaning of the word "flipped". They point out that the first letter F means flexible environment, the second letter L stands for learning culture, the third letter I for intentional content, the fourth letter P for professional educators, the fifth letter P for progressive networking activities, the sixth letter E for engaging and effective learning experience, and the last letter D for diversified and seamless learning platform. In fact, this explanation also helps summarize the main features of the flipped classroom approach. Besides, Talbert (2014) describes four aspects of effective flipped classroom pedagogical methods. Firstly, the pre-class assignments for students should focus on theoretical content. Secondly, suitable linkage should be constructed between pre-class assignments and out-of-class work. Thirdly, some immersive activities should be designed for students. Finally, some channels for inter-communication between students and teachers should be built.

However, some educators disagree that flipped classroom pedagogical models can provide a comprehensive teaching and learning environment (Chen et al., 2014). Moreover, Kim, Kim, Khera and Getman (2014) argue that the design of flipped classrooms in previous studies has often been limited to the concept of replacing in-class instruction with videos and using class time for homework. Therefore, their study deployed a theory-driven analytic framework—Revised Community of Inquiry (RCOI)—to explore the design principles of flipped classrooms in higher education by examining three flipped classrooms in an American university. They have proposed nine design principles under the four elements theorized by the RCOI framework. The four elements relevant to a successful learning environment are Cognitive Presence, Social Presence, Teaching Presence, and Learner Presence. Bishop and Verleger (2013) did a survey on "flipped classroom" studies, finding that most researches about flipped classrooms employed group-based learning activities. They define the flipped classroom in two parts. One part is in-class group learning activities while another part is individual and computer-based out-of-class learning activities. However, they reject the broad definition of flipped classroom, in which the learning activities are simply divided into in-class and out-of-class activities and they claim that there is no underpinning rationale behind the new teaching model.

O'Flaherty and Phillips (2015) review the use of flipped classrooms in higher education settings from 2012 to 2014 around the world. They argue that this model "has the potential to enable teachers to cultivate critical and independent thought in their students, building the capacity for lifelong learning and thus preparing future graduates for their workplace contexts" (p. 94). They also point out that there is no single model for the flipped classroom to date. However, they still identify the core features of the flipped learning approach: content in advance, educator awareness of students understanding and higher order learning during class time. Besides, Goates, Nelson and Frost (2017) conducted a study of undergraduate

students to compare search statement development between traditional lectures and flipped instruction sessions. Their findings show that students have a strong preference for pedagogies that incorporate elements from both lectures and flipped methodologies. Teachers should consider ways to help students make meaningful connections between online tutorials and in-class activities. Davis, Dean and Ball (2013) conducted a study in a college-level information systems spreadsheet course. They point out that a technology-enhanced flipped classroom is both effective and scalable, and it better facilitates learning than simulation-based training. Their results also suggest that the approach is motivating as it allows for greater differentiation of instruction. When considering the assessment issues, O'Flaherty and Philips (2015) suggest that two outcomes can be used to assess the implementation of a successful flipped class approach. They are the effectiveness of student learning that facilitates critical thinking, and improvement of student engagement both within and outside the class.

Methodology

This was a design-based research (DBR) study that adopted a mixed method approach. Both qualitative and quantitative data have been collected, and the qualitative data was triangulated by the quantitative data collected. DBR is characterized as a research paradigm that blends empirical educational research with the theory-driven design of learning environments (The Design-Based Research Collective, 2003; Bell, 2004). It is a collection of approaches that involve a commitment to researching activity in naturalistic settings (Barab & Squire, 2004) and usually involve multiple iterations or progressive refinement. Each design cycle includes design, implementation, analysis, and redesign.

This study was conducted at the Education University of Hong Kong (EdUHK) and the teacher education courses were taught by the members of the research team. In this study, three cases have been done by the research team on teaching ICT in different aspects and each case was a complete design cycle. These cycles were used to refine the teaching and assessment strategies implemented in a flipped

classroom. In each cycle, the implementation process was the same. Before the lesson, the students were asked to learn from different online materials prepared by research assistants or the course lecturer. The online lecture materials consisted of a wide variety of digital formats such as videos, animation and pictures. The students also attempted an online pre-test before studying the pre-lesson learning resources. Then they studied the online materials (e.g. by watching instructional videos) at their own pace and at any convenient time. The students then attempted the online post-test again. The test results were recorded and analyzed by online services. In other words, both students and course lecturer were informed of students' learning outcomes conveniently and quickly. To consolidate learners' knowledge, the students were required to apply their recently acquired knowledge in class activities when they met in class. Meanwhile the teacher could provide more support to those learners who did not do well in the post-test. The activities and assessment strategies adopted in the class should help students become more engaged in the learning process. Additionally, individuals' learning differences could be better taken care of. After completing each cycle, data analysis was carried out. The findings informed the design and implementation of teaching and assessment strategies in the cycle that followed.

The Design Cycles

In this study, three design cycles were conducted in three different courses taught by the research team members at the EdUHK. The study spanned two years. All courses were ICT related, but they focused on various aspects (see Table 1). They were selected in order to cover several aspects: *leaning about ICT* (Case 1), *learning to teach ICT* (Case 2), and *learning about ICT and learning to teach with ICT* (Case 3). In the first case, we focused on how to implement the flipped classroom in the lesson while in the second and third cases, we put more emphasis on the technology issues and assessment strategies in a flipped classroom. We expected that this arrangement allowed us to apply the findings to more ICT courses.

Table 1
The Three Cases Selected for the Study

Case	Program	Study mode	Course Title	Focus	No of Participants
1	Higher Diploma in Early Childhood Education	Pre-service	IT in Education	Learning about ICT	74 *(2 classes - Class 1: 36 and Class 2: 38)*
2	Undergraduate/Post graduate without Teacher training	Pre-service/In-service	Learning and Teaching in IT	Learning to teach ICT	24 (1 Class)
3	Professional Development Programme (PDP)	In-service	Pedagogical Design and Practices in e-Learning Environment	Learning about ICT and learning to teach with ICT	65 *(2 classes - Class 1: 36 and Class 2: 29)*

The teaching and assessment strategies implemented in a flipped classroom were refined through the three cycles. In each cycle, the implementation process was similar, but the intervention for the following cycle was adjusted based on the findings from the previous cycle. Figure 1 shows the research framework for each design cycle.

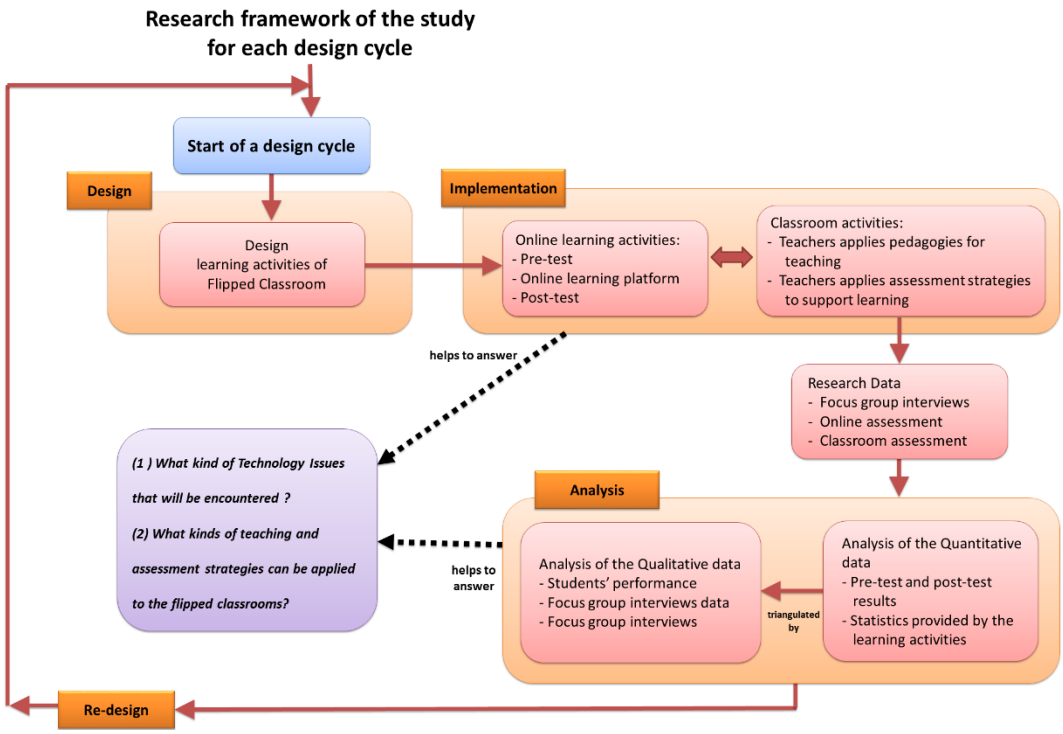

Figure 1. The research framework of the study for each design cycle.

Participants

All participants were enrolled in ICT related courses from different programmes at the Education University of Hong Kong.

The Courses

All courses were 3-credit courses, and therefore there would be thirteen 3-hour sessions in total. Usually, one meeting would be arranged for each week. For each session, the lecturer normally arranged both the lecture and hands-on practical sessions.

Flipped Classroom Implementation

In all three cases, the lecturer introduced the flipped classroom teaching approach to the student teachers at the beginning. They were asked to learn the concepts or skills that would be taught in a selected session at home before attending the face-to-face classes. In all cases, the research team or the course lecturer had prepared a number of instructional video clips. The video clips demonstrated how to use some IT skills or introduced the background knowledge of the selected topic. The student teachers could view the videos based on their needs and at their own pace. Before watching videos, the students were required to complete a pre-test about the knowledge taught in the video, and then to complete a post-test after watching the video. When the students attended classes the following week, they were asked to apply the skills or knowledge learnt at home in class activities.

Views About New Teaching Approach

An online questionnaire with 10 questions was used to collect participants' views at the end of the flipped lesson. The questionnaire adopted a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree) regarding whether their generic skills and content knowledge had been developed by participating in the flipped classroom pedagogy. They were allowed one week to complete the questionnaire, which was done on a voluntary basis.

Case 1 (Design Cycle 1)

This was the first case done by the team in 2015 and it was also treated as a pilot run. At that time, the concept of the "Flipped Classroom" was still new to most colleagues in the University. All of them were female and had recently completed their secondary school education. The course contents covered basic IT knowledge and skills, and the use of IT in early childhood education. In some lessons, the student teachers were taught to use some popular free software and web applications. They learnt how to create and edit Google Sites (a free wiki service provided by Google) for the first two weeks and then used it as a platform for their group project. The group project counted for 50% of the total assessment. Each group was asked to design and create wiki pages for teaching any topic related to early childhood education. This group work was used to consolidate what they had already learnt in the course, including subject knowledge and pedagogical content knowledge. Google Sites was chosen because all the student email accounts were accompanied with Google applications at the University. In this pilot case, the research team had prepared 19 instructional video clips. The video clips demonstrated how to use various editing features of Pixlr. When the students attended classes the following week, they were asked to apply the techniques learnt at home to construct their wiki group project.

Responses to the New Teaching Approach.

Fifty-five students responded to the questionnaire and the return rate was 73.3%. The mean scores for the five questions asked were very high, ranging from 3.85 to 4.04 and the standard deviations for all 5 questions were very similar (0.62-0.68). The question with the highest rating was "I have developed self-study via flipped classroom activities". The remaining four questions, on "development of self-managements skills", "transfer of generic skills learnt to other courses", "development of IT skills", "understanding of the lesson contents", in descending order of mean score, were also highly rated (3.98 to 3.85) by the students. In addition, students were also asked to express their feelings about the flipped

classroom experience. Most students strongly agreed that the new approach allowed them to "learn in my own time" and "learn at my own pace". The results match the findings of most studies on the flipped classroom approach.

Pre-test and Post-test.

The pre-test and post-test were used to examine the learning outcomes of using the pre-lesson instructional materials such as instructional videos. The questions were about the subject contents of the topic taught. It was encouraging to see that a total of 73 students completed both pre-test and post-test, representing a return rate of 97.3% (73/75). The mean of the overall scores for the post-test is higher than that for the pre-test. Since the p-value is 0.00, which is less than 0.05, this difference is significant. Except for Q3 and Q6 (see Table 2), the mean score of the other 12 questions for the post-test is higher than that of the pre-test, and the differences are significant ($p < 0.05$). Besides, the correlation between pre-test and post-test is 0.26 ($p < 0.05$), showing that the post-test is weakly correlated with the pre-test. The findings suggest that the online lectures could help students to improve their learning and help teachers to cater for individual differences.

Table 2
Comparing the percentages of students getting correct answer and the means of pre-test and post-test with exceptional results (Case 1)

Item	% of students getting correct answer		Differences	T-value	P-value
	Pre-test	Post-test			
Q3	96%	99%	3%	1.00	0.32
Q6	33%	40%	7%	1.09	0.28

Pre-test: https://sites.google.com/site/hkiedcomputermultimedia/image/image-pretest
Post-test: https://sites.google.com/site/hkiedcomputermultimedia/image/image-posttest

Table 2 shows that the differences between pre-test and post-test of Q3 and Q6 are not significant ($p > 0.05$). The high rate of pre-test for Q3 (96%) shows that Q3 is so simple for the students that most of them already knew the answer before they studied the online lecture. Table 3 shows the insignificant difference (7%) of the percentages of the answers between pre-test and post-test for Q6, which tests students' ability to merge images, and the large difference (60%) for Q8, which tests students' knowledge

about the concept of contrast ratio. The findings suggest that the online lectures could help students to increase knowledge, but they are less able to help students to improve their application of knowledge and skills.

Table 3
Comparison of the Percentages of the Answers for question on knowledge (Q6) and question on skills (Q8) (Pre-test and Post-test, Case 1)

Item	Options for the question	Pre-test	Post-test	Differences
Q6 Question on knowledge	• Select the backdrop with magic wand tool and clear it (right answer)	33%	40%	7%
	• Select the seagull with marquee tool	58%	40%	-18%
	• Cut the seagull and paste it onto image B	5%	21%	15%
	• I don't know.	4%	0%	-4%
Q8 Question on Skills	• The luminance of the brightest color to that of the darkest color (right answer)	8%	68%	60%
	• the contrast of different colors	75%	27%	-48%
	• the contrast of the clearest part to that of the blurriest part	12%	0%	-12%
	• I don't know.	4%	4%	0%

Case 2 (Design Cycle 2) and Case 3 (Design Cycle 3)

In the next two cycles, we followed similar procedures, but we adjust the flipped classroom strategies based on the findings in the previous cycles and the focus to be explored. As we had confirmed that the flipped classroom approach was welcomed by our students, the questionnaire on attitude toward the new approach was not repeated for the remaining cycles. Additionally, the questions for the pre- and post-tests were designed for each case as they were related to the teaching contents in each case. In Case 2, we conducted a case in a course "Learning and Teaching in IT", which focused on teaching ICT in secondary schools and related to learning to teach ICT. In Case 3, we conducted two flipped classroom lessons for the course "Pedagogical Design and Practices in e-Learning Environment". The first topic was "Student Response Systems" and the second one was "Learning Management Systems". In these two flipped lessons, the students *learnt about ICT*, and also *learnt to teach with ICT*. Figure 3 shows the final design for the second flipped lesson in the last design cycle. In this flipped lesson, all online materials

were prepared by the course lecturer. This indicated that there should be no technical hurdle for implementing the flipped classroom approach in our lessons. Besides, more assessment activities had been added for the pre-lesson online lecture. The students were encouraged to attempt some optional extended activities. Moreover, there was a preview on the in-class learning activities so that they would have more ideas about the intended learning outcomes of the lesson. Furthermore, the students were asked to share their work with their peers after the in-class meeting. Thus, there was a link for sharing their work on the online platform shown in Figure 2.

This is the page that shows the instructions for implementing the final trial of the 3rd case. The topic is about Learning Management System. There are few instructions for the students: Firstly, students need to complete the pre-test. It can help the teacher know the student's understanding of the topic. Secondly, student is required to finish the self-learning part by watching the educational videos and studying other online materials on the platform. Thirdly, the student need to complete the post-test. This will help the teacher know student' learning achievement. Finally, before or after the lectures, students may attempt other extended learning tasks. There are six links on the screen: (1) Pre-test, (2) Self-learning activities, (3) Post-test, (4) Extended learning activities, (5) Class activities (Preview), and (6) Sharing your learning outcomes

Figure 2. The final design of the second lesson in the last design cycle.

As mentioned before, each design cycle had its own purpose and the findings of each cycle were used to inform the design of each subsequent design cycle. Table 4 shows the details of each cycle.

Table 4
Summary of the Three Design Cycles

	Case 1	Case 2	Case 3
Course	IT in Education	Learning and Teaching in IT	Pedagogical Design and Practices in e-Learning Environment
The lesson			
Topic(s)	Photo Editing	Web authoring in secondary ICT curriculum	• Student Response Systems • Learning Management Systems
Focus	Learning about IT	Learning to teach IT	Learning about IT and Learning to teach with IT
Purpose	• Investigate students' responses to the teaching approach • Explore the implementation procedures	• Refine the implementation procedures • Explore the technology issues in the flipped classroom	• Refine the implementation procedures • Explore assessment issues in the flipped classroom
Flipped classroom implementation: Teaching and assessment			
Online Teaching Resources	• 19 videos	• 1 video • 1 online slide • Useful links	• Class 1: 2 videos • Class 2: 1 video, 1 PowerPoint presentation, Useful links
Pre-class Activities	• 1 pre-test 1 post-test	• 1 pre-test 1 post-test • 1 extended class activity	• 1 pre-test 1 post-test • 3 extended class activities • Preview of class activities
In-class activities	• Hands-on Skills	• Discussion • Hands-on workshop	• Discussion • Hands-on workshop • Class Presentation • Sharing outcomes online
Technology for implementation			
IT tools	• PowerPoint • Google Drive • Google Sites • Google Form	• PowerPoint • Google Drive • Google Sites • Google Form	• PowerPoint (Office Mix) • Google Drive • Google Sites • Google Form
Technical support	• Supported by RA	• RA support not required; • All learning resources prepared by the course lecturer	• RA support not required; • All learning resources prepared by the course lecturer
Findings and suggestions			
Pre-/Post tests	• Significant difference found for most items ($p < 0.05$)	• Significant difference found for all items ($p < 0.05$)	• Significant difference found for most items ($p < 0.05$)

	• The online lecture could help students master the subject contents.	• The online lecture absolutely could help students master the subject contents (see Table 5).	• The online lecture could help students master the subject contents (see Table 6).
Implications for next cycle	• The flipped classroom model was positively responded to by the participants. • May explore different issues in next cycles	• The implementation procedure has been validated as a way for implementing teaching and learning. • The technical hurdle can be overcome by the teachers.	• More assessment activities have been added, but the amount still needs to be further investigated.

Table 5

Comparing the percentages of students getting correct answer and the means of pre-test and post-test (Case 2)

Item	% of students getting correct answer		Differences	T-value	P-value
	Pre-test	Post-test			
Q1	31%	69%	38%	2.13	0.05
Q2	31%	77%	46%	3.21	0.01
Q3	8%	85%	77%	6.33	0.00
Q4	46%	85%	38%	2.13	0.05
Q5	46%	62%	15%	1.48	0.17
Q6	62%	92%	31%	1.76	0.10
Q7	69%	92%	23%	1.90	0.08
Q8	77%	85%	8%	1.00	0.34
Q9	8%	54%	46%	3.21	0.01
Q10	15%	69%	54%	3.74	0.00
	Mean (Pre-test)	**Mean (Post-test)**	**Differences**	**T-value**	**P-value**
Total	3.92	7.69	3.77	6.51	0.00

Table 6

Comparing the percentages of students getting correct answer and the means of pre-test and post-test (Case 3- Round 2)

Item	% of students getting correct answer		Differences	T-value	P-value
	Pre-test	Post-test			
Q1	83%	97%	13%	2.11	0.04
Q2	63%	80%	17%	1.72	0.10
Q3	47%	90%	43%	4.71	0.00
Q4	0%	40%	40%	4.40	0.00
Q5	73%	90%	17%	1.98	0.06
Q6	97%	93%	-3%	-1.00	0.33
Q7	63%	93%	30%	3.53	0.00
Q8	97%	97%	0%	0.00	1.00
Q9	70%	93%	23%	2.25	0.03
Q10	17%	83%	67%	7.62	0.00
	Mean (Pre-test)	**Mean (Post-test)**	**Differences**	**T-value**	**P-value**
Total	6.10	8.57	2.47	7.61	0.00

Findings from the Interviews

Based on the analysis of the results of interviews, seven positive features of the flipped classroom could be summarized in Table 7. However, there were still some issues that should be carefully handled. Table 8 lists some negative responses from the students in these three design cycles.

Table 7
Positive features of flipped classroom recognized by the students

Positive features		Responses from students
1.	Overview of the teaching contents	• *I think it's good to know what will be taught in the classroom by having an overview. It helps our study.* • *I think the concept is great. It makes class attractive when we could have some idea of what is going to be taught.*
2.	Supplement for the contents discussed in the class	• *Because the time in the classroom is not enough, these additional teaching materials can make the knowledge more impressive.* • *It can extend to other learning activities such as recommendation of videos on YouTube for those interested in knowing more.* • *Flipped classroom is more diversified than the conventional teaching method.*
3.	Convenience for recapping and learning the course materials	• *It's very convenient that we can watch the videos at any time.* • *We can watch the videos anytime and anywhere.* • *We can watch the videos several times when we do not understand.* • *We can watch the video unlimited times until we fully understand.* • *In lectures, we can only hear what teachers say once. It allows us to re-watch videos. It is the biggest advantage.* • *The arrangement of pre-test, online learning platform and post-test is very good. It's highly holistic.* • *I can learn better when I repeat watching online lectures and find information on the internet.*
4.	Saving time	• *It can save time in class so that teachers can ask students some questions about the video first, and then teach something else.*
5.	Building up students' confidence	• *In the pre-test, I didn't know how to answer some questions or chose the wrong answer. When I watched the videos, I paid attention to what I had done wrong. I felt good when I did it right in the post-test.* • *This experience strengthened my confidence in implementing flipped classroom. I think it does help students.*
6.	Effective learning and self-assessment	• *We learn more easily by watching the online lecture first, finishing the online assessment, and then learning from teachers in the classroom. We can learn more deeply and clearly step by step.* • *It's a good self-assessment when we post what we have done onto Google Drive and share it to our classmates.* • *When I do the pre-test, I will know how much I understand. Watching videos and doing the post-test let me learn what I didn't know. I just learnt what I should learn after I finished the post-test.*
7.	Enhancing interactions between students and teachers	• *I think the teacher will know more about our learning.* • *Teachers can know more about my study by pre-test and post-test.*

Table 8
Negative comments from the students on the flipped classroom approach

Negative Comments	Responses from students
1. Making students become lazy	• *I think it cannot assess the students well because they may not do it by themselves but find the answer on the internet.*
2. Burdens increased for both teachers and students as it is time consuming	• *It takes a lot of time for teachers to prepare videos and many other teaching materials.* • *It may take a lot of time for student to watch videos. Sometimes we cannot find the answers and have to watch the videos many times.* • *It takes a lot of time to do the flipped classroom activities and homework.* • *If not all the students have watched the flipped classroom videos, teachers have to repeat them in class. It does not save but wastes time.* • *There is too much preparatory work before class.* • *Flipped classroom takes some private time of students to watch videos. The homework should be reduced accordingly.*
3. Reducing students' learning motivations in some situations	• *I think flipped classroom is suitable for some students who have high learning motivation.*
4. Difficult to evaluate the students' achievements.	• *It's difficult to manage students' attitude to the online learning activities. We should do something to the students who don't do the online learning activities.*

Conclusion

From the above discussions, we can conclude that flipped classroom approach can be applied to courses in higher education settings. In ICT courses, the technology issue is not a problem as the technical hurdle is low and the course lecturers should be better educated in ICT. Thus, we can implement this approach in courses focused on learning ICT, learning to teach with ICT or learning to teach ICT. The study provides an evidence that the teachers' IT skills may not a problem nowadays when compared with the studies reviewed by Lo and Hew (2017), and Zainuddin and Halili (2016). Besides, we also found the pre-lesson online lesson should not be restricted to instructional videos. It would be better to provide some extended learning activities and online resources for students of higher ability. This also helps students to assess their own learning outcomes before joining the in-class meeting. In addition, we can use online resources in any digital formats such as online presentation, animation, quiz etc. Meanwhile, we should encourage students to make use of the original online platform to share their learning outcomes with their

peers. In any case, there are still a lot of areas to be explored, especially regarding the assessment strategies.

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