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See table of contents

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Article abstract

This study aimed to investigate the effectiveness of two different teaching methods on learning effectiveness. OpenCourseWare was integrated into the flipped classroom model (experimental group) and distance learning (control group). Learning effectiveness encompassed learning achievement, teacher-student interactions, and learning satisfaction. The experimental method was supplemented with qualitative interviews. Overall, 181 freshmen taking a course on physics were allowed to choose their own class based on their preferred teaching method (experimental or control group). The findings indicated that learners in the experimental group scored higher for learning achievement. When selecting a teaching method, if sufficient resources are available, it is suggested that teachers provide learners with the combination of OCW and flipped classroom. Although there was no significant between-group difference in terms of teacher-student interactions and learning satisfaction, the interactions in the flipped classroom had positive effect on students' learning achievement. The use of the flipped classroom model allows for adequate teacher-student interactions, as teachers can provide guidance and assistance to students in person, while there are greater opportunities for collaborative learning among learners. In addition, since the flipped classroom model emphasizes the process of learning rather than its outcomes, information technology tools should be used to keep detailed records and follow the learning process in order to assess various aspects of the learners' growth. The results of this study can serve as a reference for future studies on the flipped classroom model and OpenCourseWare, as well as for teachers and researchers in related fields.

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Analysis of Learning Achievement and Teacher–Student Interactions in Flipped and Conventional Classrooms

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Abstract

This study aimed to investigate the effect of two different teaching methods on learning achievement and teacher–student interaction. OpenCourseWare was integrated into the flipped classroom model (the experimental group) and a conventional classroom (the control group). The experimental method was supplemented with qualitative interviews. Overall, 181 freshmen taking a course on physics were allowed to choose their own class based on their preferred teaching method (experimental or control group). The instruments included a teacher–student interaction questionnaire and physics achievement tests. The findings indicated that learners in the experimental group scored higher for learning achievement. Although there was no significant between-group difference in terms of teacher–student interactions, the small group discussions in the flipped classroom offered students more opportunities to clarify questions in an interactive learning environment than did the self-study in the conventional classroom. Thus, the interactions in the flipped classroom had a positive effect on students' learning achievement. The use of the flipped classroom model allows for adequate teacher–student interactions, as teachers can provide guidance and assistance to students in person, while there are also greater opportunities for collaborative learning. The results of this study can serve as a reference for future studies on the flipped classroom model and OpenCourseWare, as well as for teachers and researchers in related fields.

Keywords: OpenCourseWare; flipped classroom; distance learning; learning achievement; teacher–student interaction

Introduction

Background and aim of the study

The technological advancements in network transmission have reduced the cost of online resources, thus enabling users to gain free access to web-based information (Caswell, Henson, Jensen, & Wiley, 2008). Since 2001, the Massachusetts Institute of Technology (MIT) has continually promoted OpenCourseWare (OCW). However, several current types of OCW require students to take prerequisite courses, but the prerequisite course materials are not uploaded onto the web-based platform; therefore, students without prior knowledge or experience of the course lecture content may encounter difficulties during their self-directed learning (Huijser, Bedford, & Bull, 2008). Compared with conventional courses, OCW can provide multiple resources to assist with learning (Lee, Albright, O'Leary, Terkla, & Wilson, 2008); however, factors that hinder autonomous learning also exist, such as the inability to directly contact the teachers and teaching assistants, the fact that degree and credit certificates are typically not offered, and the fact that not all courses provide audio or video files (Willging & Johnson, 2009). The 2010 Horizon Report indicated that open content has already become an important trend affecting the future development of higher education, although the lack of interaction with peers still poses an enormous challenge for OCW (Johnson, Levine, Smith, & Stone, 2010). This further illustrates the importance of interaction when learning by means of OCW courses.

Distance learning enables students to gain knowledge from the Internet and to have the autonomy to adjust their learning progress without temporal or spatial constraints (Kanuka, 2005; Sun & Rueda, 2012). Swan's (2003) reviews of prior research identified three types of interactivity that affect online learning: interaction with content, interaction with instructors, and interaction among peers. The instructors in the online environment serve the important role of providing timely and supportive feedback as well as clear goals. Previous research focused on comparing the learning effectiveness of online and face-to-face discussions (Swan, 2003); however, online distance learning/OCW cannot completely replace the influences on the cognition, behavior, and psychological states of students that result from actual teacher–student and peer interactions (Vest, 2004). The flipped classroom replaces the conventional classroom lecture format with activities such as peer discussion, interaction, and applied practice and experience; in addition, students read the assigned course material by themselves before class. The existing literature has identified that the learning advantages of the flipped classroom are superior to those of the conventional lecture course format. For example, the flipped classroom can stimulate higher-order thinking, and enhance teacher–student interactions (Bergmann &

Sams, 2012; Gannod, Burge, & Helmick, 2008; Gerstein, 2012; Kellogg, 2009). Education-related studies have explored the application of technology within the conventional lecture format to enhance the learning engagement and interactions of students (Sun, Martinez, & Seli, 2014); however, in the flipped classroom model, studies on the use of technology to create rich activities that enhance interaction and achievement still need to be explored. In short, in conventional, face-to-face classrooms, instructors focus on lecturing and have fewer opportunities to participate in classroom activities, while in distance learning environments, instructors face issues of asynchronous feedback and therefore may not provide immediate feedback to clarify students' questions and allow them to participate in the discussions, which could be available in the conventional classrooms (Swan, 2003). Based on the 2013 Horizon Report, the flipped classroom would become an innovative teaching model emphasized by higher education (Johnson et al., 2013), and rapidly move into the mainstream in the relative research (Tucker, 2012). Recent empirical studies have investigated various integrations of the pre-class self-study learning materials, such as watching teaching videos, listening to podcasts, reading articles, and viewing slide presentations, as well as the in-class activities, such as hands-on activities, student presentations, discussions, and individual quiz (Clark, 2015; Herreid & Schiller, 2013; McLaughlin et al., 2014). These studies focused on the influence of the flipped classroom on learners' engagement, active learning, and learning performance (Clark, 2015; Jamaludin & Osman, 2014; McLaughlin et al., 2014), while there is a lack of research on teacher-student interactions in the flipped classroom environment. Therefore, this study aims to address the aforementioned gap, by integrating the classroom teaching and learning activities with OCW and adapting the flipped classroom model so that the instructors can fully participate in the group collaborative learning activities and have synchronous interactions with the learners.

In summary, Bergmann and Sams (2012) indicated that free open courses can be used as digital learning materials in a flipped classroom, where OCW has the potential to be used as digital teaching materials, and to provide numerous types of preview materials besides the conventional textbook. In the flipped classroom model, OCW can be used for self-study, fundamental, pre-class learning materials, while the interactive classroom activities can offer the instructors more opportunities to collaborate with students and provide them with instant feedback. In addition, this study used OCW integrated with a conventional classroom as the control group. Although the control group also used OCW for the pre-class self-study learning materials, the instructors in this group may have lacked opportunities for interaction and participation in the conventional classroom environment. Thus, this study aimed to use OCW to integrate the flipped classroom and conventional classroom, and to explore the influences of the two teaching models on the students' learning achievement and the teacher–student interaction. Because the flipped classroom incorporates teaching strategies based on peer–peer and teacher–student interactions, the inclusion of course activities can elevate students' metacognition mechanisms. Therefore, we hypothesized that the flipped classroom model would substantially enhance the learning achievement and teacher–student interactions.

Literature review

OpenCourseWare

OCW is a type of Open Educational Resource and is defined as a free, open, and shared web-based platform on which high-quality education materials are available. Through the connectivity, convenience, and improvements of the Internet transmission speed, course materials are offered to students worldwide for noncommercial purposes. OCW typically does not offer degree or credit certificates, and the learning resources offered include course syllabi, audio and video materials, lecture notes and handouts, assignments and examinations, and other supplementary materials (Carson, 2009; OEC, 2014). The concept of OCW originated at MIT in 1999 from the MIT Council on Education Technology, at which a knowledge-sharing plan was announced with the expectation of preserving educational resources through contemporary technology, and transmitting them through the Internet. After MIT began to promote its OCW, numerous other higher education institutions established OCW with their own distinctive features (Caswell et al., 2008).

Lee et al. (2008) suggested that OCW could be applied in the field of health science education to train healthcare workers, to enrich learning resources regarding health science education, and for use as effective materials supplementing learning in other fields. The publicized learning materials on OCW platforms can serve as a type of "free tutor" for students who want to learn at home, and can aid in the creation of abundant and meaningful teaching strategies, such as using them as supplemental learning resources (Lee et al., 2008) and applying them in flipped classroom teaching (Gerstein, 2012). In 2007, a Massive Open Online Course (MOOC) prototype not only ran free and open courses, but also provided a registration and certification system, a platform for teacher–student interactions, an automated system to ensure the integrity of its courses, and a network connection for people to exchange learning resources. However, MOOC is not yet the norm in higher education, and there are still many challenges to be addressed, such as the lack of practical, hands-on experiences and face-to-face interactions, the overdependence on online information, and so on (Johnson et al., 2013).

OCW and MOOC platforms offer students the opportunity for self-directed learning through the Internet; however, compared to MOOCs, OCW lacks multimedia materials that are highly interactive and sensory-stimulating, as well as a set of structurally well-designed learning activities (Margulies, Sinou, & Thille, 2005). When using OCW, students cannot interact directly with teachers and peers to gain guidance and assistance, and thus, students may abandon their learning (Park & Choi, 2009; Willging & Johnson, 2009). Therefore, we attempted to investigate the influences of OCW and various designs of classroom activities on the students' learning achievement and teacher–student interaction; the OCW materials employed for conducting this study included only course audio and video materials, course lecture notes, course syllabi, and course calendars.

Distance learning and the flipped classroom

Distance learning refers to an instructional method of delivering course content through the Internet. One of the most salient features of distance education is that students can perform their class responsibilities at the time and place of their own choosing (Kanuka, 2005; McMahon & Oliver, 2001). The terms synchronous and asynchronous (Guzley, Avanzino, & Bor, 2001), are widely used in distance learning. Synchronous activities require all online participants to work in real-time, while asynchronous activities do not. The scope of this study is limited to asynchronous distance learning. In online learning environments, if students lack prior knowledge, the learning outcome with OCW may be decreased (Huijser et al., 2008). In addition, in asynchronous online discussions, the instructors may not provide instant feedback or interactions (Swan, 2003), which in turn can cause challenges for students to ask the instructors or teaching assistants (TAs) questions (Willging & Johnson, 2009).

The primary feature of the flipped classroom is the exchange of the classroom lecture format with extracurricular activities that inverts the conventional classroom lecture format and out-of-class self-study method (Gannod et al., 2008; Kellogg, 2009; Lage, Platt, & Treglia, 2000). In the conventional teaching model, students complete courses according to schedules planned by teachers; however, because of limited course time, teachers cannot attend to all problems encountered by each student during or after the class. The flipped classroom emphasizes the active participation of students in classroom activities. In the first learning stage, knowledge is transferred to the student through the Internet, without temporal or spatial constraints, to enable self-directed learning outside class. In the second learning stage, through peer and teacher–student collaborations and classroom interactions, students internalize the course material after adequate practice (Johnson et al., 2013). In the flipped classroom model, learners use OCW to self-study fundamental knowledge in the first learning stage at home. They then come to the classroom for the second learning stage to deepen their understanding of the knowledge through classroom activities. With the arrangement of these two stages, students with low prior knowledge can use OCW to increase their learning effectiveness when they come to the classroom. Therefore, this study seeks to integrate OCW and the flipped classroom and investigate its effect on achievement.

Various scholars have offered diverse opinions concerning the usage of class time in flipped classrooms. Bergmann and Sams (2012) suggested that various activities, including question and answer discussion, project-based learning, inquiry-based learning, and group discussion regarding course exercises, need to be included in the flipped classroom; Gerstein (2012) indicated that practical, game-based learning, and oral reports should be required. Kellogg (2009) reported that collaborative learning, problem solving, and performance assessment are necessary. In summary, the activities students conduct outside of class include looking at the course material in a process called passive learning, while the classroom activities include collaborative learning in groups, oral reports, experiments, and problem-based learning. The flipped classroom design used in this study was one in which students were required to look at physics-related materials outside of class that were offered by a specific OCW platform according to the course schedule. In addition, two types of activities were applied interactively for classroom learning: a 1.5 hour collaborative group learning activity on odd numbered weeks, and a one-hour face-to-face review and evaluation of course content instructed by the teacher on even numbered weeks. Because the instructor's role in the flipped classroom model was not only as a lecturer but also as the facilitator to help learners explore and construct their knowledge, the classroom activity chosen for this flipped classroom model was group collaborative activities, focusing on teacher-student interactions. In short, with these classroom activities, the instructors created an environment which facilitated synchronous discussion. In addition, the instructors in the flipped classroom served more roles for increased collaboration and interactions than those in the conventional classroom. Therefore, this study seeks to investigate how OCW integrated with a flipped classroom influenced the teacher-student interactions.

Learning achievement and teacher–student interactions under OCW and the flipped classroom

Distance learning, primarily focusing on online learning activities, is supplemented by several lectured courses, and offers credits to students; in addition, distance learning enables students to gain knowledge from the Internet and to have the autonomy to adjust their learning progress without temporal or spatial constraints (Kanuka, 2005; Sun & Rueda, 2012). The effectiveness of distance learning depends on the autonomy of the students; however, the lack of self-regulation is a crucial problem. Azevedo (2005) pointed out that in online learning environments, the system design should allow self-controlled learning, such as planning the learning session and creating subgoals. Tuckman (2007) indicated that although distance courses are designed according to a specific learning process and set of objectives, students frequently procrastinate because of the lack of supervision by teachers and peers. For students who are inclined to procrastinate, self-learning through distance course materials that do not provide external support (e.g., time management and online group discussion) results in poor learning performance (Tuckman, 2007). Teacher–student interaction is the core activity of education. Aside from students' interaction with their peers and the learning materials, the timely and appropriate interaction between teachers and students is also very important (Swan, 2003). The teacher–student interaction in this study refers to the interactions between the teacher and the students by means of communication and symbols (Tseng, 1999). Winne and Hadwin (2010) reported that when students encounter challenges in their learning, the feedback provided by teachers can correctly and effectively guide students to reexamine their learning processes, overcome their weaknesses, and search for methods to solve their problems. Such interactions allow teachers to better grasp the students' learning process, which can then be used as a basis for adjusting the pace and style of teaching, thereby ensuring teaching excellence and high-quality learning. However, the depth of online interaction provided by distance learning courses is limited because of the restrictions resulting from the time and workforce aspects, and teachers thus cannot offer help to all students who encounter difficulties.

This study therefore aims to increase students' learning achievement through promoting higher level thinking, transforming passive learning into active learning, and clarifying misconceptions in a flipped classroom (Bergmann & Sams, 2012; Gannod et al., 2008; Gerstein, 2012; Kachka, 2012). We also endeavoured to increase the opportunities for teacher–student interactions in order for teachers to clearly grasp the students' learning state and so provide timely and appropriate assistance (Bergmann & Sams, 2012; Gannod et al., 2008; Gerstein, 2012; Kellogg, 2009; Lage et al., 2000). When students participate in discussions and conversations, they promote scaffolding between existing and new knowledge. This teaching model not only improves students' learning achievement, but also improves teacher–student interactions. In brief, we expected to combine OCW with a flipped classroom to elevate learning achievement and teacher–student interactions.

In summary, the use of OCW may encounter the issues of self-regulation, learners' lack of prior knowledge, and asynchronous discussions. To overcome these challenges, some research has tended to advance the teaching methods in online courses (Tuckman, 2007), or has tried to compare distance learning with traditional face–to–face classrooms in order to explore the features and effectiveness of the online learning (Brown & Park, 2015; Swan, 2003). This study seeks to integrate OCW with conventional classrooms for possible benefits to students' learning achievement and teacher–student interactions. In a flipped classroom, more opportunities for teacher–student interactions during group collaborative learning activities are necessary because the number of teacher–student interactions may be low when combining OCW and a conventional classroom. In this study, our aim was to explore the influences of the integration of the two types of teaching models offered by OCW platforms on the learning achievement and teacher–student interaction: the flipped classroom (experimental group) and conventional classroom (control group). Our research questions were: 1) Do the different teaching models affect learning achievement? and 2) Do the different teaching models affect teacher–student interaction? With the interactive nature of the flipped classroom, we wanted to create a learning environment to promote students' learning achievement and enhance teacher–student interactions. In the control group (a conventional classroom), the instructors conducted only reviews and tests, which may lack the interactiveness available in collaborative learning environments and therefore may create challenges regarding deepening the understanding of the pre-class OCW learning materials. Therefore, we hypothesized that students in the experimental group would exhibit more effective learning achievement and teacher–student interactions than the students in the control group.

Methods

The current study utilized a quasi-experimental design. Our research model is shown in Figure 1. In order to diversify the interpretation of the results, we conducted qualitative and semi-structured interviews to supplement the quantitative data. The OCW used in this study was designed for a freshman physics course at a national university in Hsinchu, Taiwan. The students in both the control and experimental groups took the same course, OCW, pre-class course materials, and biweekly one-hour face-to-face reviews and tests. Every week, learners in the experimental group attended a 90-minute flipped classroom with collaborative learning activities, including face-to-face instructor–learner interactions, as well as assistance from the TA, while learners in the control group undertook self-study at home and completed the assignments by themselves. In sum, the teaching model used in the experimental group was the intergration of OCW and a flipped classroom while that in the control group was using OCW intergrated with a conventional classroom (the learning progress was self-paced). At the end of the experiment, we conducted a post-course survey about learning achievement, learning satisfaction, and teacher–student interaction to evaluate the differences between the control and experimental groups.

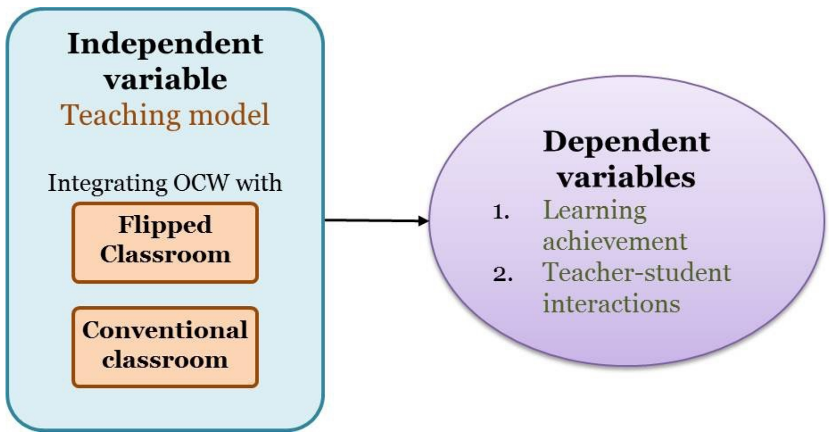

Figure 1. Research model.

Participants

A summary of the participants' demographic variables of group, gender, and institute are listed in Table 1. The study participants were students from a freshman physics course at a national university located in Taiwan. The participants were allowed to choose their preferred teaching method (i.e., the control or experimental group). The number of students who signed up for the experimental group was 142, while only 39 students signed up for the control group. In order to ensure the right to education and equity, we made an announcement that the students in the experimental group would be selected in order of the sign-ups received. As a results, the first 90 students who signed up for the experimental group were selected and the rest of the students were assigned to the control group. Of the 181 students who participated in the survey, 49.7% (n = 90) were in the control group, and 50.3% (n = 91) were in the experimental group. Male students (n = 140) represented 77.3% of the participants in this study. In terms of their study programs, the majority were enrolled in the college of computer science (65.2%), followed by engineering (22.7%).

Table 1

Descriptive Statistics of Demographic Variables

Demographic variables	Frequency	%
Group		
Experimental group	91	50.3
Control group	90	49.7
Gender		
Male	140	77.3
Female	41	22.7
College		
Computer Science	118	65.2
Engineering	41	22.7
Science	22	12.1

Experimental design

The experimental design is shown in Figure 2.

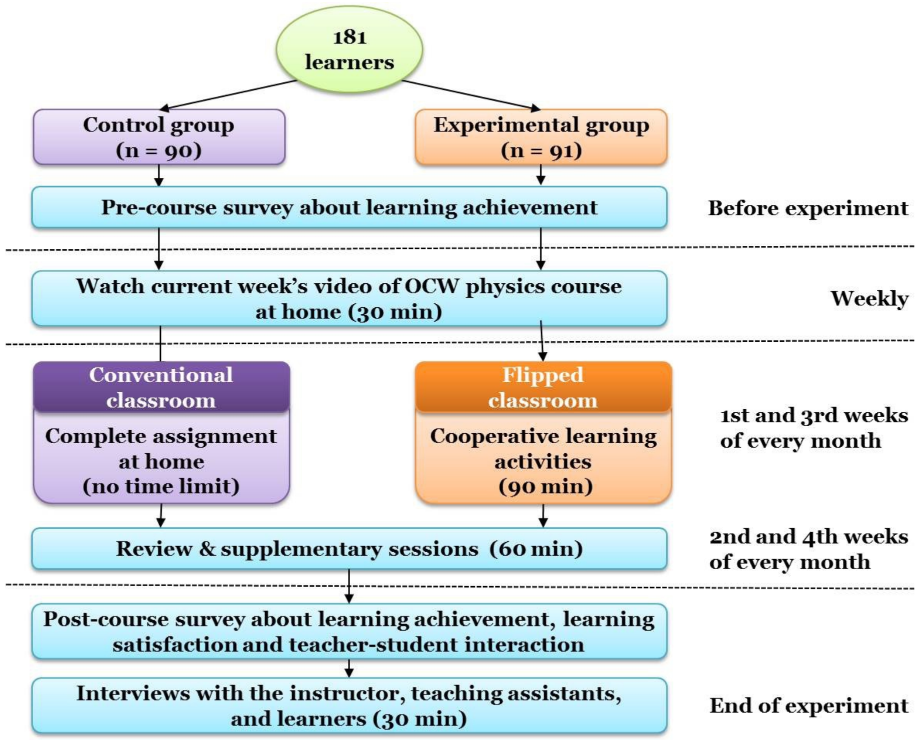

Figure 2. Experimental design.

Every week, the instructor recorded a video of the course curriculum for the OCW physics course. The learners had to watch the video independently and at their convenience (see Figure 3 for examples). The OCW includes the following features: instructional videos, course materials, a syllabus, and a calendar. The duration of each instructional video was approximately 30 minutes. Learners could watch the videos an unlimited number of times before the class.

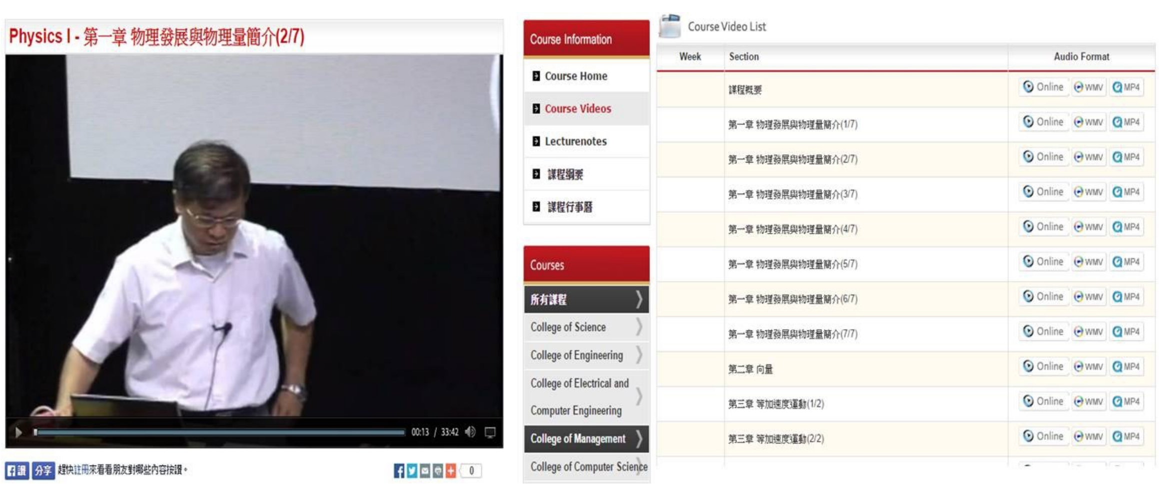

Figure 3. Screenshots of selected OCW physics course materials.

In the first and third weeks of each month, the learners in the experimental group attended a 90-minute session and participated in the flipped classroom with collaborative learning activities, while the learners in the control group completed the assignments at home. To facilitate collaborative learning, the learners in the experimental group were divided into small groups of five individuals based on their prior knowledge (previous results scored in physics) so that each group included low, medium and high level learners. Because the characteristic of the flipped classroom is the increased teacher-student interactions, which may supplement the issues of the lack of interaction in the conventional classroom, this study chose collaborative learning as the classroom activity. In order to diversify the interactions, the teaching team in this study consisted of both the instructor and the TAs. One TA was assigned to every three groups in order to provide sufficient guidance and interactive teaching and learning opportunities as required by the flipped classroom (Gannod et al., 2008). The TAs were postgraduate students studying for their masters or doctorate degrees. Before the students started the learning activities, the instructor delivered a review lecture to help them understand the topics of the corresponding week, followed by small group discussions and a learning sheet assignment on physics (see Figure 4). The TAs would note down any observations on the actual performance of each group and collaboratively select the top two groups and the best two group members for awards. In the second and fourth weeks of each month, students in both the control and experimental groups attended a 60-minute review and supplementary sessions.

Before beginning the experiment, all learners took a pre-course achievement test, a learning satisfaction survey and a teacher–student interaction survey. At the end of the experiment, a post-course achievement test was administered. The questions for the pre- and post-course achievement tests differed: the former was used to gauge learners' level of high school physics, while the latter related to their comprehension of the course curriculum. In addition, surveys on learning satisfaction and teacher–student interaction were conducted after the experiment. At the end of the course, we also conducted interviews with the instructor, TAs, and learners.

Figure 4. Photo of the classroom learning activities in the physics course.

Instruments

The instruments used in this study included a teacher–student interaction questionnaire as well as the pre- and post-course achievement tests in physics.

To measure teacher–student interaction, we referred to the survey instrument devised by Sun, Shih, and Wang (2007) and modified it according to the requirements of our research conditions. A 6-point Likert scale was used. The collaborative learning activity in this study included both the teaching team and the students, so the survey items measured the interactions involved with the teaching team of the instructor and the TAs, e.g., "I think the instructor and the TAs would try to understand my ideas." The higher the score on this survey, the more teacher-student interactions there were. The Kaiser-Meyer-Olkin (KMO) measure of Sampling Adequacy and Bartlett's test of sphericity were employed to find out whether employing factor analysis to extract latent variables was appropriate. Both the KMO (.85) and the Chi-square value of Bartlett's test of sphericity ($df = 28$, $p < .001$) verified the appropriateness of using factor analysis in the current data set (Kaiser, 1974). Two factors (eight questions) were extracted using exploratory factor analysis: influence and proximity. The alpha value of the two factors was .91 and .77, and the factor variance was 55.53% and 16.24%, respectively. The total alpha value was .88 and the total explained variance was 71.77%. In terms of the standard for internal consistency and reliability, the value of the entire survey should have been greater than .70 (Nunnally, 1978). The alpha values for this study were all greater than the standard value.

The pre-course learning achievement test, which covered high school physics, included five questions: one multiple choice item and four calculation questions. The post-course learning achievement test, which covered Newton's Laws of Motion and Thermodynamics, included nine calculation questions. We used Ahmann and Glock's (1981) standard of item difficulty index of P value (0.4~0.7) and the widely accepted educational measurement standard of the item discrimination index of D value (Ebel, 1979) to assure the quality of the achievement tests. D > .4 means the quality of items is very good; .30 < D < .39 is considered reasonably good; .20 < D < . 29 is considered serviceable; and D < 19 is considered questionable (and the items must be modified or discarded). In the current study, the P values of the pre-course test were between .25 and .80 and on average, P = .53; the D value were between .21 and .80 and on average, D = .47. The overall Cronbach's alpha value was .71.

Results

After data collection and collation, we used SPSS 17.0 to conduct a basic analysis of the means and standard deviations of the data. In addition, we also conducted a t-test and one-way analysis of covariance (ANCOVA). For the latter, the covariates were the pre-course achievement tests, the independent variables were the two teaching models, and the dependent variables were the post-course achievement tests and teacher–student interaction. We also compared the average results obtained in the post-course achievement test of the two groups.

Learning achievement

One-way ANCOVA was used to verify whether the between-group differences in the results of the pre- and post-course learning achievement surveys were statistically significant. Regression coefficients indicated that there was no significant interaction between the covariates and independent variables ($F(1,153) = .36$, $p = .55$); hence the regression coefficients within the groups did not violate the assumption of homogeneity. For ANCOVA, the result of the Levene's test was not significant ($F(1,153) = .81$, $p = .37$). This indicated that residual variance homogeneity existed between the groups and that the one-way ANCOVA could be used to verify any significant between-group differences in terms of post-course learning achievement. The results showed that the post-course mean in learning achievement between learners in the flipped classroom ($M = 69.09$, $SD = 13.28$) and distance learning ($M = 62.58$, $SD = 15.31$) was significantly different ($F(1,153) = 9.70$, $p < .01$). The post-course scores for learning achievement by learners in the flipped classroom model were significantly higher compared to those in distance learning (Table 2). The effect size (partial $\eta 2$) was 0.06 and the power was 0.87, both meeting the standards of medium effect size and power > 0.80 (Cohen, 1988, p. 390).

Table 2

Learning achievement with the different teaching models

Source of variance	SS	df	MS	F	p

Covariates	6343.94	1	6343.94	37.69	< .001
Inter-group	1632.58	1	1632.58	9.70	.002**
Intra-group	25754.47	153	168.33		
Total (after correction)	33731	155			

Teacher–student interactions

As seen in Table 3, there was no significant difference between the teaching methods in terms of teacher–student interactions ($t(154) = .44$, $p = .66$). However, the mean for both teaching models was as much as 4.4 points above the average (flipped classroom: $M = 4.46$, $SD = .60$; conventional classroom: $M = 4.41$, $SD = .75$).

Table 3

Teacher–student interaction with the different teaching models

Teaching method	N	M	SD	t	p
Flipped classroom	68	4.46	.60	.44	.66
Conventional classroom	88	4.41	.75		

Discussion

The dependent variables for this study included learning achievement and teacher–student interactions. The results showed that for the learning achievement tests, the scores for the experimental group (the integration of OCW with the flipped classroom) were significantly higher than those of the control group (the integration of OCW with a conventional classroom). However, there was no significant difference between the two groups for the teacher–student interactions. Nevertheless, the learners generally found the teacher–student interactions to be positive and high. This was probably due to the course design, where learners had equal opportunities to reach the instructor and the TAs.

The findings for learning achievement were consistent with those of previous studies. More specifically, the flipped classroom created a richer and more dynamic physical environment for internalizing the knowledge. Consistent with the two stages proposed by Johnson et al. (2013), in the first stage of learning, the use of technological media to transfer knowledge helped to break through the temporal limits. The learners were able to carry out self-study during their own time outside of the classroom for the easier and most basic learning materials. In the second stage of learning, there were adequate numbers of TAs to provide guidance and sufficient resources, and then the learners were able to internalize the knowledge and practice the advanced applications through collaborative learning and discussions with their peers and TAs in the classroom. Overall, this method effectively enhanced the learners' level of focus and commitment, and promoted higher level learning outcomes (Bergmann & Sams, 2012; Gannod et al., 2008; Gerstein, 2012; Kachka, 2012; Kellogg, 2009; Lage et al., 2000; Zappe, Leicht, Messner, Litzinger, & Lee, 2009).

The analysis of the qualitative interview data also corroborated our findings. Learners from the experimental group indicated that the flipped classroom provided them with the additional opportunity to seek help immediately from their peers or TAs whenever they faced any questions. They were also able to revise their work faster after discussions with the TA and their peers. In contrast, OCW integrated with a conventional classroom allowed the learners to ask their peers for help whenever they encountered any questions; however, their time management was poor, and they tended to cram for the biweekly tests. The TAs felt that despite the different characteristics and qualities of the group members, all of them benefitted from this learning approach. The following qualitative data from the interviews corroborate the above results:

"When I had trouble answering the questions, I could ask other group members, listen to other students' ideas, and discuss with others. If the questions were too difficult, I would ask the TA in real time. The explanations from the TA gave me the opportunity to clarify my misconception and get a deeper understanding of the topics." (Experimental group, Learner A)

"(In terms of the time management), I just studied whenever I wanted to, or studied at the last moment right before the test." (Control group, Learner a)

Previous studies have highlighted that in flipped classrooms, teachers can clearly grasp the learning state of the learners and provide timely assistance and feedback (Bergmann & Sams, 2012; Gannod et al., 2008; Gerstein, 2012; Kellogg, 2009; Lage et al., 2000; Zappe et al., 2009). We originally hypothesized that the integration of the OCW with the flipped classroom would enhance the quality of the teacher–student interactions. However, the findings of the study did not correspond to our assumptions. We deduced that the instructor and TAs had treated the learners in both groups in the same manner. In order to further research the possible reasons, we compared the interview data from both groups. The results showed that both groups of learners had positive feelings about their interactions with the instructor and TAs. In addition, because of the socio-cultural and educational influences, the students in both groups interacted mostly with the TAs and peers instead of with their instructor, as evidenced by the following qualitative data from the interviews.

"In addition to better time management, I could adjust my learning pace. When I had any doubts or queries, I could clarify and resolve the problems with the TAs or my peers during the discussion sessions. If I studied on my own, it was easy to get stuck on certain obstacles, causing me to give up. I felt very good during the discussions because of the opportunities to interact with my peers and the TAs. The small group discussions also provided an additional push for me to study.” (Experimental group, Learner B)

“I would just ask my classmates first. If I still had problems, I would then seek help from the TAs.” (Control group, Learner b)

Gannod et al.’s (2008) research pointed out that the key to successful flipped classrooms is the instructor or TAs’ interactive teaching, so it was suggested that the instructions in the larger classroom should be supplemented with sufficient instructors or TAs. However, from the aforementioned interview data, the objects of the learners’ interactions in the collaborative learning are possibly TAs or peers, while the self-study learners also chose to ask TAs or peers when they had problems with the assignments. These aspects thus contribute to the lack of significant difference in the scores for teacher-student interactions.

Conclusions

This study investigated the differences in learners’ learning achievement and teacher–student interaction using two different teaching methods. The results showed that the learners in the experimental group had greater learning achievements. Overall, the quantitative data showed no significant differences in teacher–student interaction between the two groups. However, the qualitative interview data showed that the small group discussions in the flipped classroom provided more opportunities for question clarification and interactions than the self-study in the conventional classroom. Thus, the interactions in the flipped classroom had a positive effect on students’ learning achievement. In short, in the flipped classroom model, learners undertake self-study to obtain the fundamental knowledge, which helps identify the problems when carrying out the classroom learning activities. They collaboratively practice how to apply the knowledge with problem-solving activities, which in turn may increase their learning achievement. The findings in the teacher-student interaction showed that both the experimental and control groups of learners interacted mostly with their peers and with the TAs, but that they lacked interaction with the instructor. It is possible that the learners considered the interaction with the instructor as a different relationship than that with the TAs. The learners positioned the instructor and the TAs in different roles in the classroom. However, we did not evaluate the effect of these two roles, which is one of the limitations of this study. In addition, this study did not utilize a truly random assignment for the participants, and the subject was limited to a compulsory freshman course. Also, the measurement in this study was focused on quantitative analysis. Although supplemented with qualitative interview data, the learning process in the flipped classroom was not recorded for in-depth analyses. Therefore, the generalizations of this study should consider the above limitations.

Since the flipped classroom model emphasizes the learning process rather than the outcome, in future studies, researchers could design multi-dimensional assessment methods to assess the various aspects of the learners’ growth, with a computerized system to track, manage, and identify the assignments, examinations, and learning situations of the students (e.g., emphasis on community interaction and provision of online assessment through MOOCs). We would like to suggest that when teachers select a teaching method, they should consider using the flipped classroom if there are sufficient teaching resources available. In addition, the integration of the distance learning and flipped classroom model helps learners deepen their understanding of the learning materials through in-class interactions, which may in turn increase their learning performance. Therefore, we would suggest the instructors design the distance learning courses progressively and conduct the in-class group activities with clear instruction so that the learners can effectively learn how to apply their knowledge. This model provides learners with sufficient opportunities to interact with the TAs and peers, while the teachers and TAs can also immediately provide learners with guidance and assistance in person. Finally, the instructors may increase the diversity of course activities, incorporating classroom polling activities (Sun, 2014; Sun et al., 2014), mobile or game-based learning activities (Hung, Kuo, Sun, & Yu, 2014; Hung, Sun, & Yu, 2015; Sun & Chang, 2014), multimedia learning management systems (Walsh, Sun, & Riconscente, 2011), or portfolios (Middlebrook & Sun, 2013) with the flipped classroom to enhance the teacher–student interactions. We hope that the findings of this study will serve as a reference for further research on the flipped classroom model and OCW as well as for teachers and professionals in the education field.

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