MODESTUM
OPEN ACCESS
EURASIA Journal of Mathematics, Science and Technology Education, 2018, 14(6), 2453-2466
ISSN:1305-8223 (online) 1305-8215 (print)
Research Paper https://doi.org/10.29333/ejmste/89938

Investigating the Effects of Flipped Learning, Student Question Generation, and Instant Response Technologies on Students' Learning Motivation, Attitudes, and Engagement: A Structural Equation Modeling

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Received 4 December 2017 ▪ Revised 13 February 2018 ▪ Accepted 30 March 2018

ABSTRACT

In recent years, flipped learning has grown in popularity and been more widely adopted as a mechanism of enabling active learning, which is used in different educational scenarios. This paper describes a novel extension of flipped learning by integrating student question-generation and an instant response system into the higher education curriculum and examining the impacts of this extension on students' learning motivation, attitudes, and engagement. Data were obtained from 54 sophomores at Zhejiang University, China, and the data were tested using the partial least squares structural equation modeling approach. The results indicated that this research model predicted 47.3% of the variance of learning motivation, 78.6% of the variance of attitudes toward learning, and 62.4% of the variance of learning engagement. Also, the results showed that the constructs of flipped learning and student question generation have a positive impact on the students' learning motivation, attitudes, and engagement. In contrast, though the instant response system also has a positive impact on students' engagement, it does not influence motivation or attitudes. Instructional implications and research suggestions are provided based on the results of the study.

Keywords: flipped learning, instant response system, structural equation modeling, student question generation

INTRODUCTION

Flipped classroom, an alternative pedagogical approach focusing on student-centered instruction that reverses the traditional classroom environment, has recently gained much attention and has become more widely adopted in higher education. The flipped classroom approach is to "introduce students to course content outside of the classroom so that students can engage that content at a deeper level in the classroom" (Strayer, 2012, p. 171). The flipped classroom is grounded in student-centered learning, which is a set of theories and methods including constructivism, active learning, and peer-assisted learning (Bishop & Verleger, 2013). Hamdan, McKnight, McKnight, and Arfstrom (2013) also considered active learning and peer instruction as foundations of the flipped classroom. Active learning and peer instruction shift the focus and responsibility of learning from educators to students (Sohrabi & Iraj, 2016). Bergmann and Sams (2012) argued that the success of a flipped classroom is closely related to students' attitudes and engagement in learning and, to maintain or nurture their learning, teachers should provide more participation opportunities for students. However, some researchers have made comparisons between active learning in the flipped classroom versus traditional instruction, reporting similar learning gains (Davies, Dean, & Ball, 2013; Jensen, Kummer, & Godoy, 2015; Strayer, 2012). Kim, Kim, Khera, and Getman (2014) pointed out that the flipped classroom might lead to student frustration and low learning motivation if the support of students is not sufficiently structured. Yilmaz (2017) also asserts that it is important to maintain students' motivation and attitudes, describing how to engage the student in in-class activities of the course to ensure the

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Contribution of this paper to the literature

- This study proposes an innovative flipped learning approach that integrates a student question generation strategy and instant response system for a college curriculum.
- The effects of the flipped learning strategy, student question generation, and instant response system on students' learning motivation, attitudes, and engagement were examined using partial least squares structural equation modeling.
- The flipped learning and student question generation strategies can positively affect the learning motivation, attitudes, and engagement of Chinese college students, whereas the instant response system can only positively affect the students' engagement.

efficiency of the flipped classroom. With the flipped classroom, rather than relying on a singular model, the instructor should apply multiple approaches, such as group discussion, mini-lectures for review, or student questioning (Ogden & Shambaugh, 2016).

Many proponents of active, student-centered learning suggest that flipped classroom activities should be designed to maximize the opportunities of learners to construct meaningful personal knowledge and cultivate a higher level of cognitive skills (such as applying, analyzing, and evaluating) (Hwang, Lai, & Wang, 2015) or higher-order thinking abilities (Coley, Hantla & Cobb, 2013; Mok, 2005). As such, students can determine whether they understood the course content and are able to relate it to their prior knowledge, making it their own by being able to question it in their own words (Rifai, 2010). "Students are generating their own questions" has been proven as an effective approach that could stimulate students into higher thinking and engage conceptual understanding in classroom activities (Yu, 2011). When students were involved in making decisions as to what questions were to be generated, it allowed them to better understand the subject matter (Tu & Conover, 2010). Yu (2011) further pointed out that learners need to generate questions based on material they have studied; they need to reflect on whether there are any parts of the material that seem important, but which they do not comprehend, in addition to how the core concepts can be understood. This process triggers many metacognitive processes, thus aiding learning, with learners becoming more intellectually active and engaged in the learning process (Yu, 2005, 2011). Song, Oh, and Glazewski (2017) indicated that student-generated questioning engages students with the learning topic, thereby increasing their understanding and promoting their interactions; the positive effect on student achievement has been investigated in several domains, including reading, science, and mathematics.

Strayer (2012) posits that "the regular and systematic use of interactive technology" could make the flipped classroom model unique. Some instant, interactive technologies, such as instant response systems (IRSs), can be regarded as educational facilitators because they provide not only platforms for collecting students' responses, but also support stronger communication, sharing, and socializing (Bruff, 2009; Caldwell, 2007; El-Rady, 2006; Kay & Lesage, 2009; Simpson & Oliver, 2007). IRSs can instantly tally and graphically display student responses, which can be summarized simultaneously on a classroom projector (Han & Finkelstein, 2013). By this means, every student in the classroom can express his/her thoughts instantly, and the teacher can get a rough picture of student learning progress in real-time (Chien, Lee, Li, & Chang, 2015). In recent years, numerous studies have examined the effects of IRSs in education and have reported positive learning outcomes (Caldwell, 2007; Han & Finkelstein, 2013; Kay & Lesage, 2009; Lantz, 2010; Latessa & Mouw, 2005; Moredich & Moore, 2007).

Tasks and activities incorporated in higher education teaching are based on pedagogies and supported technologies that might increase student motivation and engagement and improve their attitudes toward learning. Based on the above-cited work, this study choose flipped learning, student question generating, and the adaption of IRS as the major pedagogical approaches. This paper proposes that, if college students have more opportunities to become involved in a flipped learning activity and are encouraged to generate their own questions and to engage in deep thinking and discussion supported by using IRSs, curricula might be constructed differently. As Wang (2017) mentioned, there are only a few conceptual frameworks that can elicit 'how-to' list-associated factors with the design of an effective flipped classroom, and exactly how these factors are contributing to learning. Solutions to the issue require an understanding of what design factors entice student motivation, attitudes, and engagement in the flipped classroom environment. Therefore, this study created an innovative flipped instructional design that incorporated a flipped learning approach, student question generation (SQG), and adapted IRS into the college curriculum. The impact of these factors on college students' learning motivation, attitudes, and engagement was examined. A questionnaire was developed to evaluate the effectiveness of the approaches, and a partial least squares structural equation modeling (PLS-SEM) technique was carried out to analyze the data.

LITERATURE REVIEW

Flipped Learning

In recent years, the flipped learning model of instruction has drawn global attention. The flipped learning approach reverses the role of homework and classroom activities, with students engaged in pre-class tasks for the acquisition of knowledge, such as viewing instructional videos or doing related requirements, and furthermore is involved in practicing acquired knowledge or skills in class discussions or project work in the classroom (Chen Hsieh, Huang, & Wu, 2017). Hamdan et al. (2013) explained the key concept of the flipped learning, using the word FLIP, with the four components being a flexible learning environment, where the method is learner-centered with intentional content, and the where the teachers must have a professional knowledge and attitudes. Chi (2009) pointed out that flipped learning is an alternative to conventional pedagogy, requiring students to acquire information by viewing instructional videos ahead of physical class meetings, and allowing students to apply that knowledge in the classroom, thus engaging students in higher order active, constructive, and interactive activities. A substantial body of research has documented a variety of benefits of the flipped classroom model for teaching and learning processes in various disciplines (Abeysekera & Dawson, 2015; Bergmann & Sams, 2014; Bishop & Verleger, 2013; Chao, Chen, & Chuang, 2015; Lee, 2017; Ogden & Shambaugh, 2016; Sohrabi & Iraj, 2016; Yang, 2017). However, few studies have explored the relationships between students' learning motivation, attitudes, and engagement and the flipped learning model applied in some of China's higher education institutions.

Student Question Generation

SQG is an essential cognitive strategy, as the act of composing questions focuses the attention of students on content and main ideas, checking whether the content is adequately comprehended (Rosenshine, Meister, & Chapman, 1996). Pizzini and Shepardson (1991) classified three types according to the cognitive level of student questions: input, processing, and output. The input-level questions demand students to recall information from sense data; the processing-level questions require students to draw relationships among the data; and the output-level questions need students to go beyond the data to hypothesize, create, and evaluate. Student questions indicate that students have thought about the presented ideas and have tried to link them with other things they know. In addition, the questions can reveal much about the quality of students' thinking and understanding (Watts, Gould, & Alsop, 1997), their confusion about various concepts (Maskill & Pedrosa de Jesus, 1997b) and reasoning (Donaldson, 1987), and what students would like to know (Harlen, Elstgeest, & Jelly, 2001). Asking students to generate questions (along with the answers) based on the learning content could help students develop skills by consciously directing their attention to the target knowledge (Yu, Chang, & Wu, 2015). Previous literature has indicated that the SQG strategy has positive effects with regard to student performance (Chin & Brown, 2002; Chin & Osborne, 2008; Ikuta & Maruno, 2005; Song et al., 2017; Yu & Wu, 2012; Yu et al., 2015; Yu, Tsai, & Wu, 2013), such as comprehension (Drake & Barlow, 2007), learning motivation (Chin & Brown, 2002; Yu et al., 2015), positive attitudes toward subject matter (Perez, 1986), more diverse and flexible thinking (Brown & Walter, 2005), problem-solving abilities (Dori & Herscovitz, 1999), and cognitive and metacognitive strategy development (Yu & Liu, 2008). However, despite the growing awareness of the benefits of using SQG in the classroom, there is little empirical research addressing the incorporation of SQG in flipped classroom activities.

Instant Response System

IRSs, also known as clickers, student response systems or classroom response systems, are used to collect student responses in the classroom, which have gradually become an integral part of classroom interactions (Bruff, 2009; Chien et al., 2015; Cubric & Jefferies, 2015; Kay & Lesage, 2009; Penuel, Boscardin, Masyn, & Crawford, 2007). IRSs can not only be used to engage students' participation and concentration in class, but also can enrich their learning experiences, and improve teaching. Multiple studies have demonstrated the various effects of IRSs on student learning experiences in technology-enhanced classrooms across many disciplines in higher education, such as increasing students' attention (Hung, 2015; Latessa & Mouw, 2005), positive emotion and participation (Stowell & Nelson, 2007), attendance (Bullock et al., 2002; Moredich & Moore, 2007), interaction (Hung, 2015), motivation (van Dijk, van der Berg, & van Keulen, 2001), engagement and metacognition (Campbell & Mayer, 2009; Cubric & Jefferies, 2015), and improving learning performance (El-Rady, 2006). Nevertheless, Trees, and Jackson (2007) pointed out that using an IRS requires more of students' cognitive energy and collaboration, and this extended effort might not be readily accepted by students who are accustomed to relatively passive lectures. Further work is required to determine whether college students accept the additional cognitive effort that may be required when using an IRS. However, related studies tend to focus on investigating the effects of adopting an IRS on student learning via traditional lectures or by teacher questioning, while in contrast relatively little research has shown that

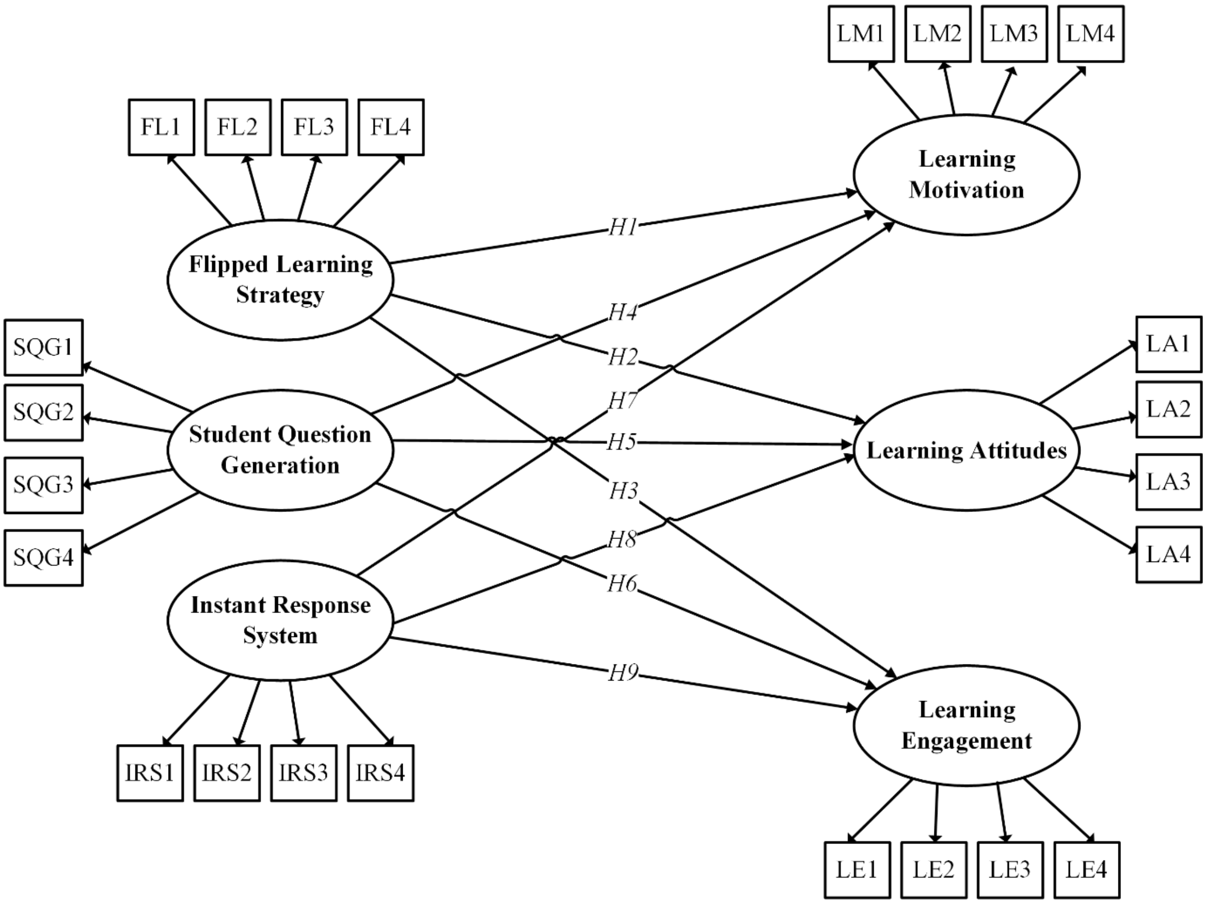

Figure 1. Research hypothesis model

IRSs increase the quantity and quality of student-centered learning (Beatty, 2005; Brewer, 2004; Kay & Lesage, 2009; Penuel et al., 2007), particularly when employed with SQG.

RESEARCH MODEL AND HYPOTHESIS DEVELOPMENT

This study combines flipped learning strategy, SQG, and IRS into a college curriculum to investigate whether these factors have a significant impact on college students' learning motivation, attitudes, and engagement. The proposed theoretical framework and hypotheses are depicted in **Figure 1**, where constructs are represented as ellipses, and observed variables are represented as rectangles. The arrows linking constructs denote the causal relationships (i.e., the hypotheses) among these, while the arrows linking constructs to observed variables symbolize measurement validity.

Flipped Learning Affects Students' Learning Motivation, Attitudes, and Engagement

Compared to traditional teaching methods, positive effects on learning motivation have been reported for the flipped learning strategy (Chao et al., 2015; Chen, Wang, & Chen, 2014; Davies, Dean, & Ball, 2013; Strayer, 2012; Yilmaz, 2017), as well as on learning attitudes (Chao et al., 2015; Lin & Chen, 2016), and student engagement (Bergmann & Sams, 2014; Gilboy, Heinerichs, & Pazzaglia, 2015; Saulnier, 2015). Therefore, in line with previous research, the following hypotheses can be formulated: (*H1*) The flipped learning strategy has a positive impact on students' motivation toward learning; (*H2*) The flipped learning strategy has a positive impact on students' attitudes toward learning; and (*H3*) The flipped learning strategy has a positive impact on students' engagement toward learning.

Student Question Generation Affects Students' Learning Motivation, Attitudes, and Engagement

Some research has indicated that student-generated questions in the learning process have potential to guide student learning and knowledge construction (Chin & Brown, 2000; Chin & Osborne, 2008; Maskill & Pedrosa de Jesus, 1997a; Yu, 2009); facilitate their discussion and debate, thereby improving the quality of classroom discussion (Chen, Chiu, & Wu, 2012; Chin & Brown, 2002); help them to evaluate and monitor their self-understanding (Rosenshine et al., 1996); increase their learning motivation in a topic by inspiring their epistemic curiosity (Chin & Kayalvizhi, 2005; Chin & Osborne, 2008); and enhance their engagement in the course (Bates, Galloway, & McBride, 2012). Also, student-generated questions can "help create a positive attitude to classes" and benefit students "by helping them master the knowledge" (Madsen, 1983; Yu & Hung, 2006). Accordingly, the following hypotheses were proposed: (*H4*) SQG has a positive impact on students' motivation toward learning; (*H5*) SQG has a positive impact on students' attitudes toward learning; and (*H6*) SQG has a positive impact on students' engagement toward learning.

Instant Response System Affects Students' Learning Motivation, Attitudes, and Engagement

A number of studies have offered quantitative and qualitative evidence of the positive effects of IRS-integrated instruction in the classroom (Caldwell, 2007; Kay & Lesage, 2009; Kennedy, Cutts, & Draper, 2006; Lantz, 2010; Simpson & Oliver, 2007). IRSs not only influence students' discussion processes and conceptual learning outcomes (Chien et al., 2015), but also have positive effects on students' emotional, motivational, and cognitive experiences in the classroom (Simpson & Oliver, 2007). In Kay and Lesage's (2009) review regarding attitudes toward IRSs, they reported that students in most previous studies had positive perceptions of the technology. Also, students are more engaged in learning and focused in classroom discussion when using an IRS (Cubric & Jefferies, 2015; Preszler, Dawe, Shuster, & Shuster, 2007; Simpson & Oliver, 2007). Therefore, this study presents the following hypotheses: (*H7*) IRSs have a positive impact on students' motivation toward learning; (*H8*) IRSs have a positive impact on students' attitudes toward learning; and (*H9*) IRSs have a positive impact on students' engagement toward learning.

METHODOLOGY

Instrument

A specific questionnaire was designed to examine students' motivation, attitudes, and engagement toward learning for a college curriculum design by combining the flipped learning strategy, SQG, and IRS. The items for the six constructs in the research model were mainly adapted from relevant items or validated instruments reported in related studies (see **Table 1** for the citations for each construct). The items were modified and reviewed by two university professors in China with rich teaching experience, to ensure their relevance to the flipped learning context of this study. As shown in **Table 1**, the questionnaire consisted of 24 items to evaluate the six constructs, including the flipped learning strategy, SQG, IRS, students' learning motivation, attitudes, and engagement. Each statement was measured on a five-point Likert scale, with 1 point indicating "strongly disagree," to 5 points indicating "strongly agree."

Table 1. Questionnaire items used

Construct	Item	Description	Reference
Flipped learning strategy	FL1	I learned more from flipping, and I prefer the flipped class over conventional teaching.	Pierce and Fox (2012)
	FL2	I learned more by collaborating with others by sharing and commenting.	
	FL3	Flipped learning has reduced my dependency on the lecturer.	
	FL4	Flipped classroom learning has helped my personal development.	
Student question generation	SQG1	I tried to ask in-depth questions in my own words.	Yu and Wu (2012)
	SQG2	By generating questions, it can help me to think in-depth and explore the theme.	
	SQG3	I asked questions to make sure I understood the material.	
	SQG4	During the student question-generation activities, when I need to question, "I read textbooks and assigned readings over and over again."	
Instant response system	IRS1	When there are student discussions before or after answering the questions, IRS can effectively support peer instruction and discussions.	Briggs (2006); Murphy and Smark (2006)
	IRS2	IRS can increase the interactions between an instructor and the students.	
	IRS3	Using IRS can increase my participation.	
	IRS4	Using IRS can increase my class concentration.	
Learning motivation	LM1	I like the way the class is being taught.	Chang, Chung, and Huang (2016); Lin and Chen (2016)
	LM2	The way the class is taught draws my attention.	
	LM3	I have more understanding of the process involved in this curriculum.	
	LM4	I like the strengthening activity that helps me learn about the processes related to educational technology topics.	
Learning attitudes	LA1	I had to work harder in this course.	Lai and Wu (2006); Wei, Lin, and Lin (2016)
	LA2	Overall, I liked learning in this course.	
	LA3	Learning activities in this course are helpful for me.	
	LA4	I had sufficient ability to learn and comprehend the course content.	
Learning engagement	LE1	I am willing to spend more time to learn this course content well.	Hung (2015); Koballa (1988)
	LE2	I will keep my mind on listening to and looking at my teacher's or other students' explanation and demonstration.	
	LE3	I will answer the teacher's or other students' questions on my own initiative when participating in this course.	
	LE4	I can use my own initiative to collect the materials about this course content.	

CloudClassRoom

To support student questioning and facilitate classroom interaction among students and the instructor, CloudClassRoom (CCR) (http://www.ccr.tw) was used in this study. CCR was developed by the Science Education Center at National Taiwan Normal University, Taiwan, and empowers teachers to initiate a series of interactive activities (e.g., exercises or peer discussion), and instantly collect or track students' learning responses in the classroom (Chien & Chang, 2015). CCR works on every Internet-capable device, without further software or plug-in installation. Using CCR, teachers and students can use textual responses to submit their content via their own devices, such as personal computers, laptops, smartphones or tablets (Chang, 2016). In this study, every student can deliver their questions instantly by CCR, and these questions can be automatically aggregated and projected in the classroom.

Participants

The participants in the study were 54 undergraduate students from the College of Education at Zhejiang University in China. There were 16 males (29.6%) and 38 females (70.4%), and the majority (92.3%) of the participants were between 20- and 22-years-old. Convenience sampling was used in this study, and a written consent form was obtained from each of the participants before collecting data.

Course Activity Design

This study was conducted primarily in a required introductory course, "Introduction to Educational Technology." This is a required undergraduate course in the College of Education at Zhejiang University. The activity procedure consisted of a few basic steps, as shown in **Table 2**. First, all students who participated formed different topic teams of five to seven with their classmates. Each team was required to prepare a different course subject report according to the textbook, as well as include an additional one-third of supplementary information to enrich the report content. In pre-class learning, the instructor provided instructional videos covering textbooks

Table 2. Weekly course activities

Activity type	Activity
Pre-class learning	● Students read the theme of the textbook and access Blackboard to view course materials. ● Each team was asked to prepare a different subject report, as well as include one-third additional supplementary information to enrich the report content.
In-classroom learning	● A team member made an oral presentation (about 50 min) related to a course topic. ● Each student needed to generate a question by CCR. ● A discussion focusing on questions that the students generated (about 20 min). ● The team members attempt to answer the others' questions, and other students could express their opinions (about 20 min). ● Teacher feedback, elaborating the different concepts and clarifying misconceptions, and supplementary micro-content (about 15 min).

Table 3. The reliability of measures and convergent validity of the measurement model

Construct	Reliability		Convergent validity
	CR	Cronbach's α	AVE
Flipped learning strategy	.886	.828	.660
Student question generation	.865	.797	.616
Instant response system	.872	.804	.631
Learning motivation	.879	.816	.646
Learning attitudes	.889	.832	.668
Learning engagement	.877	.813	.642

Note. CR = composite reliability; AVE = average variance extracted.

in the chosen units, and all students were required to complete pre-class text-reading and video-viewing. During the in-classroom learning activity, a team of students presented a report every week to offer details about a course subject. Other students generated their questions and sent these to the CCR using their mobile devices before the team report ended. The instructor showed these student-generated questions on the classroom's projector and helped to guide students in the class discussion. Later, the team partners attempted to answer other student-generated questions based on their understanding of the problem, and the instructor explained and elaborated upon the learning contents after the class discussion when necessary.

Data Analysis

Data were collected on students' learning motivation, attitudes, and engagement, all measured by the self-report questionnaire. Students completed the questionnaire individually in pen-and-paper forms. This study performed the partial least squares (PLS) modeling method to analyze the data obtained from the questionnaire. PLS is a multivariate technique that is more powerful than the covariance-based structural equation modeling when dealing with small or abnormally distributed samples (Chin & Newsted, 1999; Hair, Hult, Ringle, & Sarstedt, 2017). The PLS method uses a two-stage approach, in which the first stage is to estimate the measurement model for examining both the reliability and the validity of the measurement, and the second stage is to estimate the structural model for testing the hypotheses and examining the relationships among the factors. In this study, the *p*-value threshold for statistical significance was set at .05. SmartPLS 3 software was used to estimate the measurement and structural models.

RESULTS

Measurement Model

This study assessed the measurement model by evaluating internal consistency reliability of measures, convergent validity, and discriminant validity. The reliability was examined using composite reliability and Cronbach's α, and convergent validity was measured using average variance extracted (AVE). **Table 3** shows that the composite reliability (CR) of each construct exceeded .7; all factor loadings on their relative constructs also exceeded .7 (Hair, Tatham, Anderson, & Black, 1998); all AVE values ranged from .616 to .668, exceeding the recommended value of .5 (Hair et al., 1998). Discriminant validity was assessed by the Fornell-Larcker criterion. **Table 4** presents that all the square roots of the AVE values were greater than their relevant latent variable (i.e., construct) correlations. Therefore, the measurement model displayed an adequate internal consistency, convergent and discriminant validity (Fornell & Larcker, 1981; Hair et al., 2017).

Table 4. The discriminant validity of the measurement model

Construct		Discriminant validity					
		Latent variable correlations					
		1	2	3	4	5	6
Flipped learning strategy	1	**.813**					
Student question generation	2	.778	**.875**				
Instant response system	3	.748	.779	**.795**			
Learning motivation	4	.659	.638	.559	**.804**		
Learning attitudes	5	.792	.817	.619	.756	**.817**	
Learning engagement	6	.726	.736	.522	.625	.709	**.801**

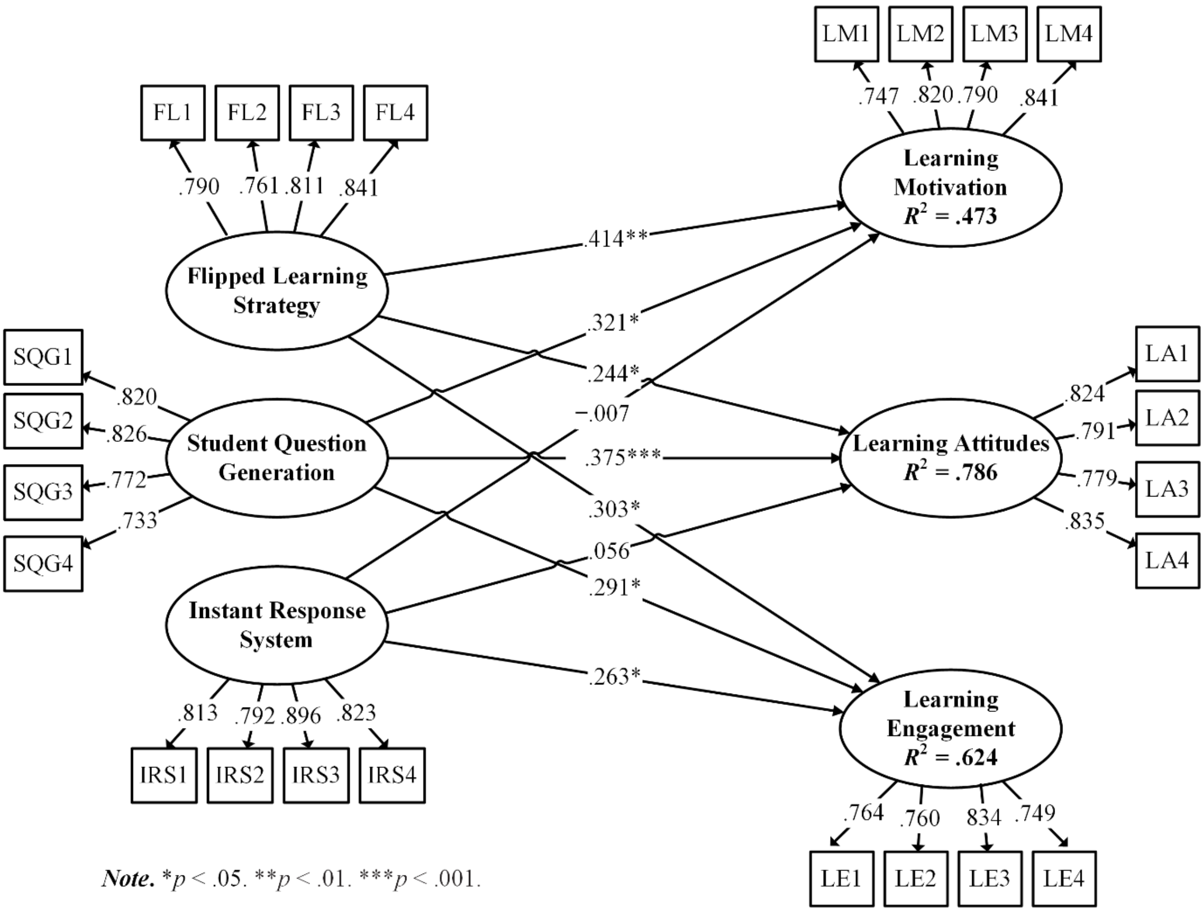

Figure 2. PLS path analysis results

Structural Model

This study calculated the path coefficients, which are the coefficients linking constructs in the structural model, to serve as the indicators for the statistical significance of the hypotheses. Additionally, the R^2 values (i.e., the coefficients of determination) were evaluated to understand the effectiveness of the structure model regarding its ability to explain the variations in the dependent constructs (Chin & Newsted, 1999); the values of .25, .50, and .75 for the constructs could be considered as weak, medium, and substantial, respectively (Hair et al., 2017). A bootstrapping procedure with 5,000 iterations, suggested by Hair et al., was performed to examine the statistical significance of the weights of subconstructs and the path coefficients. The values of R^2 for the dependent constructs of our model showed 47.3%, 78.6%, and 62.4% of variances in learning motivation, attitudes, and engagement, respectively. Figure 2 and Table 5 show the structural relationships among constructs and the resulting values. The results rejected two hypotheses, *H7* and *H8*, while confirming the others, *H1* to *H6*.

Table 5. The hypotheses and results of the structural model

Hypothesis	Path	Path coefficient	*t*-value	Result
H1	Flipping learning strategy → learning motivation	.414**	2.600	support
H2	Flipping learning strategy → learning attitudes	.244*	2.572	support
H3	Flipping learning strategy → learning engagement	.303*	2.380	support
H4	Student question generation → learning motivation	.321*	2.276	support
H5	Student question generation → learning attitudes	.375***	4.204	support
H6	Student question generation → learning engagement	.291*	2.020	support
H7	Instant response system → learning motivation	−.007	0.059	not support
H8	Instant response system → learning attitudes	.056	0.728	not support
H9	Instant response system → learning engagement	.263*	2.307	support

*p < .05. **p < .01. ***p < .001.

DISCUSSION

According to the PLS structural analysis and hypotheses testing, this study yielded three major findings: (1) that the flipped learning strategy plays an essential role in the effect of students' learning motivation, attitudes, and engagement; (2) that SQG also has a positive effect on students' learning motivation, attitudes, and engagement; and (3) that IRS has a positive effect on students' engagement, but no positive effect on students' learning motivation and attitudes.

The first finding in this study was that the flipped learning strategy was significant in affecting the college students' learning motivation, attitudes, and engagement, aligning with prior research findings about how the flipped instruction approach can improve students' learning motivation, such as in Chao et al. (2015), Chen et al. (2014), Davies et al. (2013), Strayer (2012), and Yilmaz (2017); students held positive learning attitudes about the flipped learning strategy, which is in line with previous research (Chao et al., 2015; Lin & Chen, 2016). Also, a positive relationship between the flipped learning strategy and student engagement was detected, in accord with the findings from previous studies (Bergmann & Sams, 2014; Gilboy et al., 2015; Saulnier, 2015). The flipped approach provided the college students in China with ample opportunities to diverge from traditional teacher-directed instruction toward collaborative, student-centered learning, where students can take greater control and engage in active learning contexts. The second finding in this study was that SQG has a positive effect on college students' learning motivation, attitudes, and engagement. This result agrees with previous research, where SQG could positively affect motivation (Chin & Brown, 2002; Simpson & Oliver, 2007; Yu, 2009), attitudes (Perez, 1986; Yu & Hung, 2006; Yu & Wu, 2012), and engagement (De Jesus, Teixeira-Dias, & Watts, 2003; Pedrosa de Jesus, Neri de Souza, Teixeira-Dias, & Watts, 2005). Song et al. (2017) argued that student-generated questioning could foster students' collaborative interactions and engagement. Ikuta and Maruno (2005) also proposed that teachers should provide a classroom with more opportunities for students to comfortably express their feelings of uncertainty when any questions arise. Students could also develop deep explanations and reflections to enhance learning through answering their peers' questions in classroom discussions. Finally, the analyzed results showed that using IRS has a positive influence on students' engagement, but not on motivation or attitudes. This is also in line with findings reported in the literature (Han & Finkelstein, 2013; Song et al., 2017). The adoption of SQG with technology support may increase student engagement, foster classroom interactions and conversation among students and the teacher. However, it does not have a positive effect on students' learning motivation or attitudes. A potential reason for this lack of correlation lies in the fact that the students were already familiar with IRS. When a certain type of technology has frequently been utilized, it does not significantly affect students' learning motivation and attitudes, thus failing to generate a positive use-performance relationship (Chen Hsieh et al., 2017). On the other hand, some cognitive, emotional, and contextual factors (Berg, 2005; Volet, 2001) such as student cognitive levels, a person's belief, classroom atmosphere, teacher-student relationships, and existence within a complex interdependence that might affect students' learning motivation, attitudes or engagement, have not been considered in this study. Moreover, whether students completed reading textbooks or, conversely, viewing instructional videos in pre-class learning also needs to be further explored; a few studies (Bishop & Verleger, 2013; Heiner, Banet, & Wieman, 2014; Sohrabi & Iraj, 2016) indicated that, in general, college students do not complete reading assignments in pre-class learning. Finally, as Sohrabi and Iraj (2016) argued, the challenges of the flipped learning model include: how to successfully apply it in higher education; how to redesign college courses to dedicate in-class time to student-centered activities; and how the designed activities would help students better learn the course content. Instructors in higher education should come up with a variety of activities to incorporate theories, pedagogies, and technologies that are built to enhance student learning (Sabri, Khalid, & Li, 2016).

CONCLUSION

This research describes a curriculum design that incorporates a flipped learning approach, SQG, and IRS into the college course, and examined their impact on students' learning motivation, attitudes, and engagement. This study found that both the flipped learning approach and student-generated questioning positively affected motivation, attitudes, and engagement. This study also found that IRS technology positively affected students' engagement, despite no significant influence on their motivation or attitudes. There are several limitations to this study that should be considered. First, this study included only the targeted students from the College of Education at Zhejiang University, China. Thus, it may be difficult to generalize the results of the study to other university students in other countries. Second, the study was conducted based on the students' general responses from the collected questionnaire. Some qualitative methods, such as unstructured interviewing and direct observation, should be used in future research. Third, this study focuses only on the flipped learning strategy, SQG, and IRS. It should be noted that different results may be obtained when combining additional or different strategies/technologies; future research might consider adding additional variables to run more levels in order to see deeper analysis and relationships related to the measurement model of this study. Strictly speaking, the use of flipped learning in China's higher education context is still in its early stages. Thus, this study provides some valuable insights that can be beneficial in explaining the potential of the flipped classroom and a combination of effective approaches and technologies in the higher education setting. The findings of the current study may assist academics, instructors, and practitioners to reach a deeper understanding from the college students' perspective.

ACKNOWLEDGEMENTS

This research was supported by the Philosophy and Social Sciences Planning Project of Zhejiang Province, China (P.R.C.) under Grant No. 18NDJC026Z; and the teaching and scientific research project for liberal arts teachers in Zhejiang University.

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