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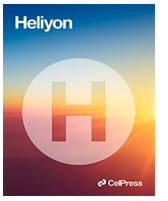

Research article

Pre-class mode "flipped" again: Making videos instead of just watching them

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ABSTRACT

"Flipped classroom" has subverted the traditional classroom teaching model and is believed to have a positive impact on knowledge acquisition and skill training for higher education students. The pre-class learning phase is considered a key factor in the success of flipped classrooms. However, currently, the pre-class learning phase of flipped classrooms mainly relies on video watching, which makes students passive receivers. Teachers need to invest a lot of time and resources in developing online videos, which greatly increases students' learning time and tasks. This also hinders the promotion of this teaching model. This study designs a pre-active learning strategy based on student participation in video production and a flipped classroom teaching model, and uses questionnaire surveys and interviews to observe students' reactions, explore its impact on students' satisfaction, and empirically analyze the path it affects students' satisfaction. We found that in the pre-class phase, the greater the ease of use and usefulness perceived by students in video production, the higher the students' satisfaction. Perceived enjoyment and perceived value are important intermediary paths. In addition, based on the research results, this study proposes suggestions for a flipped classroom teaching model based on video production. The results of this study will provide important references for the pre-class learning phase of flipped classrooms.

1. Introduction

Flipped classroom is a blended learning method that involves students watching videos and completing exercises as pre-class activities, while more class time is devoted to problem-solving, in-depth concept analysis, and peer interaction. The "flipped classroom" reverses or flips the traditional lecture-based teaching mode and has received widespread attention in recent years [1]. Compared to the traditional teaching model where the teacher is the center of instruction and students are passive recipients of

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information, the flipped classroom model places students at the center of learning. Therefore, active learning, cooperative learning, and other learning theories can be fully utilized in the flipped classroom teaching model [2]. This "student-centered" teaching model is considered effective for knowledge acquisition in higher education and essential for skills development [3]. Based on active and independent learning, students participate in various teaching processes, including pre-class, in-class, and after-class evaluation [4]. Students often prepare for class in advance by watching videos so that they can acquire knowledge and skills more effectively by combining classroom learning and discussion.

Student participation in pre-class learning is critical to classroom activities and overall learning and is also a key factor in the success of the flipped classroom [5]. Flipped classroom model can not only effectively improve students' knowledge and skills, but also increase students' active participation in the classroom [3]. According to Self-Determination Theory, supporting basic psychological needs can promote students' intrinsic motivation and extrinsic motivation, thereby enhancing their well-being [6]. Flipped classroom teaching method has special added value for students with unsatisfactory academic performance, which can significantly improve their learning satisfaction and fully meet their three self-determined needs of competence, autonomy, and relatedness [7].

Due to the ease of availability and use of videos, students' primary method of preparation before class is through watching videos [8,9]. In the era of online learning, the flipped classroom teaching model based on online video learning allows students to choose their own learning time and location, which helps to cultivate their active learning habits and personalized learning [10]. Förster et al. [11] found that students who watched videos before class were more effective in short-term and long-term knowledge acquisition, and that the quality of video watching was more important than quantity. However, some scholars have also questioned video watching. The quality of videos is the biggest challenge to the success of the flipped classroom [12]. The existing pre-class learning environment of the flipped classroom relies mainly on digital resources prepared and distributed by teachers, such as online videos and pre-recorded lecture videos. Students are still passive recipients of knowledge. The pre-class preparation phase of the flipped classroom mostly involves moving the teaching phase from offline to online and from inside the classroom to outside the classroom. Whether students have completed the pre-class preparation and whether these preparations are useful have also become issues faced by the flipped classroom [9].

In a flipped classroom, participatory activities are more effective in improving students' attention than traditional passive lectures [13]. Encouraging students to participate in or take on classroom tasks can improve their self-efficacy and satisfaction [14,15]. Students also demonstrate a better understanding of knowledge [16]. Flipped classroom strategies based on active learning [8,17,18], behavioral engagement [19,20], and improved learning attitudes [21,22] are widely believed to enhance academic performance or knowledge retention.

However, this new teaching mode faces many challenges, particularly in pre-class tasks. For example, pre-class tasks are often difficult to complete, student participation is low, and self-regulation is ineffective. The difficulty of pre-class tasks is reflected in the substantial time required for students to engage in independent learning beforehand, while also facing issues of unclear direction and a lack of constructive feedback on their pre-learning efforts [12]. These challenges result in students struggling to adapt effectively to the flipped classroom approach or complete all the pre-class learning content for each session, ultimately leading to subpar performance in classroom activities. Furthermore, compared to traditional teaching methods, teachers invest more time and effort in preparing pre-class materials, such as recording videos [23]. Research by Wanner and Palmer [24] found that the time required for teachers to prepare pre-class materials for the flipped classroom can be much longer than that for traditional teaching methods. Teachers need to prioritize the quality of pre-class videos, as poorly designed video lectures can have negative learning outcomes. Evaluation of performance, competence, and satisfaction are the most used indicators, but there is no standard evaluation system for the flipped classroom, and the research results are contradictory [12]. Current research on flipped classroom student preparation is mostly focused on the use of video recommendations, technical equipment, and network platforms for playback [25], with relatively few studies on the "proactivity" and "participation" of students in the preparation stage [12].

Instead of investing a lot of time and resources in developing online videos and other extracurricular materials, it may be more effective to design better active learning strategies [26]. Could "flipping" the classroom be implemented in the pre-class video-watching stage to stimulate students' active learning and engagement before class? Could there be better ways to assess the effectiveness of students' pre-class learning, rather than just measuring the amount of time or number of videos watched? With the development of information technology education and the widespread availability of video tools, can students participate in video production instead of just watching videos? However, there is limited research on the use of student-created videos or involvement in pre-class teaching resources for pre-class teaching strategies.

Therefore, through this work, we aim to design active learning strategies for the pre-class stage and analyze whether this approach produces better results and how it does so. We attempt to analyze the causal relationship between students' perception of different aspects of the classroom dynamics, their attitudes, and their course satisfaction. Additionally, compared to engineering, education, and medical disciplines, social science teachers have concerns about teaching design time and whether students will participate, which leads to a relatively small number of "flipped classroom" teaching situations in social science [17,27]. Therefore, this article provides valuable insights into the design (structure and learning activities) of a flipped classroom for public management, a social science course, and analyzes the participants' reactions to the course, providing insights into the practice of flipped classrooms in social science.

The study makes the following key contributions. Firstly, this study is grounded in the instructional context of social science classrooms and establishes a connection between social science courses and the flipped classroom teaching model. Secondly, previous research has predominantly focused on the impact of flipped classroom on student satisfaction, without exploring the underlying mechanisms. This study offers a theoretical exploration of the significant role and specific pathways through which video production influences student satisfaction in the flipped classroom, thus expanding the existing literature on teaching strategies in flipped

classrooms. Finally, this study empirically analyzes the correlation between video production in the flipped classroom model and student satisfaction and reveals the mediating role of perceived value and perceived enjoyment in regulating this relationship. It enriches the pedagogical theory and empirical knowledge of the flipped classroom model and boosts awareness of the education field as a whole.

The rest of the article is organized as follows. Section 2 reviews relevant research on the pre-learning phase of flipped classroom and factors that may influence students' satisfaction, and proposes hypotheses. Section 3 describes the research design, including the improvement strategy of video production in flipped classroom, the participants, variables and exhibits the benchmark models. Section 4 analyzes the research results. Section 5 discusses the results of the open-ended questions of the questionnaire and follow-up interviews. Section 6 presents the discussion and implications.

2. Literature review and hypotheses

2.1. Pre-class preparation and flipped classroom

The flipped classroom places a significant emphasis on the pre-class learning phase of students to achieve success in the classroom. After summarizing the definition of flipped classrooms, Cheng et al. [28] pointed out that the practical strategy of learning teaching media before class is an important difference between flipped classrooms and similar teaching strategies. In this model, students are responsible for their own learning processes, and have the flexibility to choose the time, place, and environment before class, and manage their own learning progress [29]. Lesson learning is shifted from the classroom to pre-class, which opens up time for reflection and active learning in the classroom [27]. Akçayır and Akçayır [12] summarized related research on flipped classrooms, and pointed out that videos have become the most important form of pre-class learning, accounting for 79% of all its forms.

With the development of the Internet and information technology, videos are widely used in the pre-class learning stage of flipped classrooms. Scholars have found that this model also faces many challenges. Compared with traditional passive learning in classrooms, the pre-class learning stage of flipped classrooms undoubtedly increases students' learning time and tasks, which can make students resistant and unaccustomed to this new model [30]. Students may weaken the effectiveness of classroom learning due to insufficient pre-class preparation or limited preparation time. Therefore, some students were dissatisfied with this teaching method or considered it useless. Clear learning guidance, such as telling students how to arrange their time and learning materials, can effectively avoid students' self-learning anxiety and confusion [31].

Similarly, teachers must prepare flipped pre-class learning materials, such as pre-recorded videos, which are time and energy consuming. Wanner and Palmer [24] found that the variety of video types and time, such as mini or lecture videos, can provide "flexible" learning modes for different students. However, the preparation time for teachers may increase six times to that of the original traditional course preparation time. Limited time and energy and a lack of technology hinder the implementation of flipped teaching models in the social science curriculum. Jong [27] pointed out that teaching administrators can develop supporting policies, such as recruiting student assistants to undertake technical work and providing technical support for preparing pre-class learning materials, to relieve teachers' pressure on time and technology.

Kay [25] proposed that, when video podcasting was applied to education, attention should be paid to its quality and the design of teaching strategies based on individual differences. According to Kong [32], new technology experiences in flipped classrooms can help students develop digital literacy and improve their learning abilities. Huang et al. [18] proposed the use of artificial intelligence technology to provide personalized video recommendations before class, which can improve students' learning performance and engagement. Thai et al. [33] pointed out that due to the decline in students' attention, the time for pre-class video lectures should be controlled within 20 min. Howell [17] found that testing pre-class learning content could motivate students to attach importance to it, and help them understand and remember the content. Alyoussef [34] discovered that providing pre-class videos together by teachers and students can increase students' overall understanding of class content.

Accordingly, we hypothesize the following:

H1. In the pre-class phase, students' perceived ease of use of video production can positively affect their satisfaction.

H2. In the pre-class phase, students' perceived usefulness of video production can positively affect their satisfaction.

2.2. Flipped classroom and students' satisfaction

The investigation and evaluation of the "flipped classroom" has provided a lot of feedback for the reform and innovative practice of classroom teaching, and a lot of experience and evidence for its implementation in higher education. Scholars have conducted a lot of research on the teaching reform of the flipped classroom in higher education, and questionnaires and interviews are the most commonly used methods for evaluation, which can understand students' views on changes in learning strategies [21]. For example, Wanner and Palmer [24] used two questionnaires and focus group interviews before and at the end of the course to understand students' views on flexible learning, flipped classrooms, and other learning changes. The study investigated how universities can evaluate to increase student experience, flexibility, and learning outcomes. Most studies support the effectiveness of the flipped classroom [21,35,36]. For example, Fadol et al. [37] compared three teaching modes: online, flipped, and traditional, and found that students' performance and perception were best in the flipped teaching mode.

The views and attitudes of students can affect their adaptation and satisfaction with the teaching environment [34]. Murillo-Zamorano et al. [3] constructed a structural equation model to analyze the direct and indirect effects of flipped classrooms on

students' satisfaction, and found that knowledge, skills, and student participation were mediating variables. They further noted that flipped classrooms increase the workload for both students and teachers, and recommended encouraging gamification and digital innovation to make the increased workload more acceptable.

The success of a flipped classroom depends on whether students are motivated to work independently before class and to actively participate in class activities. Self-Determination Theory posits that students' motivation affects their attention and effort in learning activities [38], and that their motivation orientation affects their behavioral performance and psychological satisfaction [39]. Abeysekera and Dawson [8] noted that the effectiveness of the flipped classroom instruction depends on how well it caters to students' learning motivations. The novel and challenging teaching methods used in flipped classroom teaching can help students experience intrinsic motivation and improve their satisfaction.

Accordingly, we hypothesize the following:

H3. In the pre-class phase, students' perceived ease of use of video production can positively affect their perceived enjoyment.

H4. In the pre-class phase, students' perceived usefulness of video production can positively affect their perceived enjoyment.

Additionally, innovative flipped classroom learning environments can meet students' demands for autonomy, competence, and relevance, thereby generating a higher level of extrinsic motivation [8]. There is increasing research on the integration of the full application of technology and innovation in teaching strategies to improve the teaching environment. For example, Cheng et al. [40] believed that experiential learning systems based on mobile technology could stimulate students' active thinking to improve their problem-solving ability, as well as their learning performance, attitude, and collective effectiveness. Viberg et al. [41] proposed that in informal learning outside the classroom teaching environment, instructional design should be based more on learner self-regulation and intentional and interest-based considerations rather than the curriculum. Bond [42] found that teachers' IT skills, the time required to prepare pre-class content, such as videos, and the length and quality of videos were also important factors that affect participation and satisfaction.

Accordingly, we hypothesize the following:

H5. In the pre-class phase, students' perceived ease of use of video production can positively affect their perceived value.

H6. In the pre-class phase, students' perceived usefulness of video production can positively affect their perceived value.

Perceived enjoyment is an example of intrinsic motivation. Perceived ease of use and perceived usefulness are important mediators of the influence of perceived enjoyment on the students' receptivity and behavioral performance. According to Alyoussef [34], using the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Technology Acceptance Model (TAM), students' satisfaction and enjoyment experienced during the acceptance of new technology in online flipped classroom learning can positively promote the perceived usefulness of personal effort and learning outcomes, and improve student acceptance of the flipped classroom teaching strategy. However, the perception of anxiety associated with the adoption of new technology can hinder the acceptance of the course. The author further suggests that teachers can innovate teaching strategies, such as using technology training and explanation to encourage and help students understand the benefits and simplicity of using new technology in flipped classrooms, which can improve the acceptability and effectiveness of the flipped classroom approach.

Accordingly, we hypothesize the following:

H7. Perceived enjoyment can positively affect students' satisfaction.

H8. Perceived value can positively affect students' satisfaction.

Based on hypotheses 1–8, we further propose the following hypotheses:

H9. Perceived enjoyment mediates the relationship between perceived ease of video production and students' satisfaction.

H10. Perceived enjoyment mediates the relationship between perceived usefulness of video production and students' satisfaction.

H11. Perceived value mediates the relationship between perceived ease of video production and students' satisfaction.

H12. Perceived value mediates the relationship between perceived usefulness of video production and students' satisfaction.

3. Research methodology

This study was approved by the Ethics Committee of Zhejiang University of Finance and Economics (20220920-01Y) and conducted following the Declaration of Helsinki. All participants were informed of the study content, and verbal informed consent was obtained from them.

3.1. The study's design

Public administration is a professional elective course that includes both the study of professional theoretical knowledge and the analysis and recognition of social public affairs management. The course meets once a week for 1.5 h of classroom teaching. The theoretical learning of this course is mainly based on traditional teaching methods. Teachers often impart a series of public management theories to equip students with scientific theoretical tools. However, the teaching of theoretical knowledge often takes up a lot of classroom time and can be quite tedious. Many theoretical terms require students to spend a lot of time memorizing and

understanding, which can be easily forgotten.

From the perspective of the teaching objectives of this course, it is not only about imparting some professional theoretical knowledge to students but also about cultivating their cognitive and logical thinking abilities. The characteristics or advantages of flipped classrooms are not just about overturning the traditional teaching order, but also contain more innovative elements. Therefore, I have decided to flip the theoretical learning part of the public administration course, not only allowing students to self-study the theoretical knowledge before class, but also involving them in the production of classroom video materials. However, students have never experienced the flipped classroom mode before and do not have experience in video production. Therefore, this study has established a teaching process based on video production under the flipped classroom model, as shown in Fig. 1, which includes three stages: flip preparation and video production, in-class coaching and video watching, and application of theory learned by video.

3.1.1. Flip preparation and video production

In the first class, I provided a detailed introduction of the pre-class learning tasks on video production to the students, and played two video clips as examples. Additionally, I emphasized the importance of mastering video production techniques, as the video production grades will be an important part of the final grades for this course. I selected 34 key theoretical knowledge points in public administration, and had the students draw lots to match themselves with a theoretical knowledge point to produce a video explaining it. To effectively guide the students' thinking, I provided a brief introduction to these theoretical knowledge points in the first two classes.

3.1.2. In-class coaching and video watching

According to the teaching arrangement of the course, I played videos made by the students individually, in combination with the course progress. I also asked students to share their experiences and feelings about making these videos. In addition, to improve students' attention while watching class videos, two students were randomly selected to comment on and score the videos after they were played. In class, teachers will guide students to use their theoretical knowledge to make in-depth interpretations of public management issues, through case studies and interactions with students.

3.1.3. Application of theory learned by video

The teacher proposed seven cases in class learning that were selected and grouped voluntarily by the students, and seven group leaders were selected. The case analysis was completed using theoretical knowledge points presented in video lectures. The groups also gave a class presentation of their analysis during the final class of the course, followed by an analysis report. The grade for the case study analysis report will also be an important part of the final evaluation for the course.

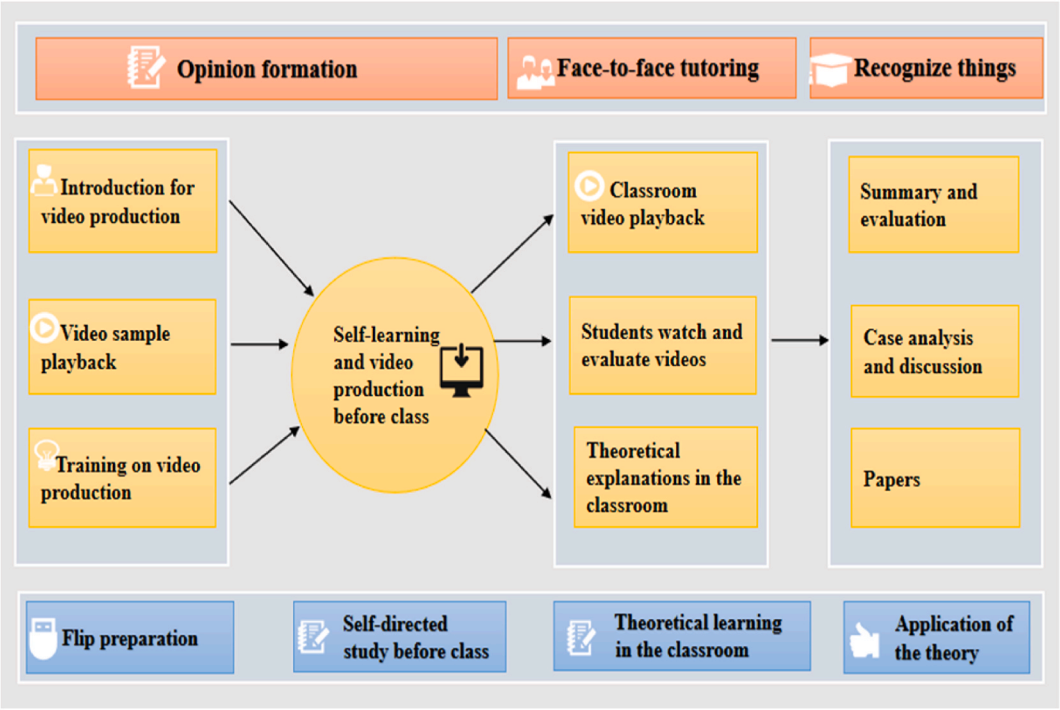

Fig. 1. Teaching flowchart based on video production.

3.2. Data collection

After the course ended, the teacher distributed an online survey questionnaire to anonymously collect students' feedback, which was used to study their satisfaction and acceptance of using video production as a pre-class learning activity. To validate the results, a stepwise regression econometric model was constructed in the empirical study and data analysis was conducted using Stata 14. There were 34 students in the class, and 34 questionnaires were collected with a response rate of 100%. Among the 34 valid questionnaires, 19 were male, accounting for 56% of the total, and 15 were female, which is 12% less than the number of male students. The survey respondents were mainly third-year students, accounting for 91% of the total, with 9% of the survey respondents being second-year students.

At the end of the survey, some students provided open-ended comments. Additionally, in the final three weeks of the semester, the author conducted one-on-one or small group interviews with 12 students. Each interview lasted 20–30 min and was digitally recorded verbatim. The purpose of the interviews was primarily to understand their opinions on the video production component of pre-class learning and the video viewing component of the classroom. Both the comments and interviews provided some additional insights into students' reactions to the flipped classroom.

3.3. Variables

This study designed a questionnaire based on the American Customer Satisfaction Index (ACSI) [43], the theory of technology acceptance and use [44], and the multilevel supply-use model of student learning [11] -all of which adopted a relatively accurate scale for flipped classroom research. Considering the characteristics of the flipped classroom, the descriptions of the items in the questionnaire were modified to make the expressions clearer and more accurate. The questionnaire comprised two main sections. The first part was basic information, including gender, grade, and career intention, and the second part concerned students' satisfaction. The options in the second part were investigated using a five-point Likert scale representing agreement. A higher score indicated a higher degree of agreement with the description of the problem, namely, 1 = Strongly Disagree and 5 = Strongly Agree.

3.3.1. Dependent variable

Students' satisfaction (SS). It is widely believed that students' satisfaction can predict learning effects and behavioral tendencies during continuous learning [45,46]. Based on previous research carried out by Zhai et al. [47], this paper adopted an overall evaluation and loyalty to measure students' satisfaction, with specific questions including "I am satisfied with the teaching method of video production," and "I am willing to continue using this teaching method." The Cronbach's alpha reliability coefficient was 0.871.

3.3.2. Independent variables

Perceived ease of the video production (PEVP). Learning efficiency and preference in flipped classrooms largely depend on learners' mastery of prior techniques [48]. The measurement of PEVP was adapted from the scale of perceived ease of use for platforms by Sun et al. [49] and Thai et al. [33]. Specific questions include "I can easily learn to make video animation" and "I think the software to make video is easy to operate." The Cronbach's alpha reliability coefficient is 0.805.

Perceived usefulness of video production (PUVP). Perceived usefulness is an important factor in the acceptance and sustainable use of technology [50]. Students are more enthusiastic about using technology when they perceive it as useful. The measurement of PUVP was adapted from the scale of Sun et al. [49] and Thai et al. [33]. Specific questions include "Through the way of video production, I have learned a lot of theories of public management before class," "The way of video production is very useful for my long-term study and work" and so on. The Cronbach's alpha reliability coefficient is 0.748.

3.3.3. Mediated variables

Perceived enjoyment (PE). Based on Davis's [44] definition of perceived enjoyment, perceived enjoyment is the term for satisfaction or pleasure experienced when using technology. Users prefer to embrace fun technologies. As an intrinsic motivation, perceived enjoyment is positively correlated with students' satisfaction [51]. The perceived enjoyment measure was adapted from Alyoussef [34]. Typical questions include "Video making increased my interest in the course" and "Video watching increased my interest in the course." The Cronbach's alpha reliability coefficient is 0.826.

Perceived value (PV). According to Chiu et al. [50] perceived value is what students gain in the teaching process, including the improvement of knowledge, skills, and learning efficiency. PV measurements were adapted from Fornell et al. [43]. Typical questions include "the ability to independently think and analyze public management policies is improved" and "the comprehensive quality is improved." The Cronbach's alpha reliability coefficient is 0.860.

3.3.4. Control variables

Prior learning experience not only guides individuals' learning but also influences the formation of their attitudes, expectations, and goals [52]. Therefore, teaching situations must be adjusted according to learners' experiences. Based on previous studies by Förster et al. [11], this study not only considers demographic statistical variables, such as gender and grade, as control variables, but also takes prior learning experience, a factor that presents personal characteristics, as a control variable. The prior learning experience was adapted from Bourgonjon's [53] study, with typical questions including "I can determine the pace of my learning and the strategies I use," "I can actively seek solutions," and "I have participated in blended learning formats." The Cronbach's alpha reliability coefficient is 0.843.

3.4. Reliability and validity

Cronbach's alpha is commonly used as a measure of scale reliability, with values above 0.70 generally considered acceptable in most social science research [54,55]. The Cronbach's alpha coefficients of the above variables are all greater than 0.75, indicating that the reliability of the entire questionnaire is good. Exploratory factor analysis (EFA) was used to verify the validity of the questionnaire [56]. The overall Kaiser-Meyer-Olkin (KMO) of the factors influencing course satisfaction is 0.765, greater than 0.5, and the P value of Bartlett's sphericity test is less than 0.05, indicating that the validity passed the test, and the questionnaire has a reasonable structure that can stably and effectively measure the factors influencing students' satisfaction.

3.5. Model specifications

To investigate the impact of video production on students' satisfaction, this study draws on the mediation effect model proposed by Baron and Kenny [57] and Zhao et al. [58], and uses causal stepwise regression to test the relevant hypotheses. This method has been widely used in recent years [59,60]. The specific model is proposed as follows:

$$\begin{cases} SS_i = \alpha + \beta_1 PEVP_i + \gamma Control_i + \varepsilon_i \\ SS_i = \alpha + \beta_1 PUVP_i + \gamma Control_i + \varepsilon_i \end{cases} \tag{1}$$

$$\begin{cases} SS_i = \alpha + \beta_2 PE_i + \gamma Control_i + \varepsilon_i \\ SS_i = \alpha + \beta_2 PV_i + \gamma Control_i + \varepsilon_i \end{cases} \tag{2}$$

$$\begin{cases} PE_i = \partial + \beta_1 PEVP_i + \gamma Control_i + \varepsilon_i \\ PE_i = \partial + \beta_1 PUVP_i + \gamma Control_i + \varepsilon_i \\ PV_i = \partial + \beta_1 PEVP_i + \gamma Control_i + \varepsilon_i \\ PV_i = \partial + \beta_1 PUVP_i + \gamma Control_i + \varepsilon_i \end{cases} \tag{3}$$

$$\begin{cases} SS_i = \alpha + \beta_1 PEVP_i + \beta_2 PE_i + \gamma Control_i + \varepsilon_i \\ SS_i = \alpha + \beta_1 PEVP_i + \beta_2 PV_i + \gamma Control_i + \varepsilon_i \\ SS_i = \alpha + \beta_1 PUVP_i + \beta_2 PE_i + \gamma Control_i + \varepsilon_i \\ SS_i = \alpha + \beta_1 PUVP_i + \beta_2 PV_i + \gamma Control_i + \varepsilon_i \end{cases} \tag{4}$$

Where i denotes an individual subscript, α is a constant intercept, β_1 in Eq. (1) captures the total direct effect of PEVP or PUVP on SS. To assess the importance of PV or PE, they are introduced into the system through Eq. (2), respectively. The significance of the coefficients of PV or PE (β_2 in Eq. (2)) can directly confirm their effect on SS, which tests H_7 and H_8. The coefficient β_1 in Eq. (4) represents the direct effect of PEVP or PUVP on SS after controlling for the influence of PV or PE, while the coefficient β_2 denotes the effect of PV or PE on SS after controlling for the influence of PEVP or PUVP. The decrease in coefficients of PEVP or PUVP (β_1 in Eqs. (1) and (4)) could provide partial evidence for the important role of PV or PE in linking video production to SS.

To verify the existence of a mediation channel, the following system is proposed. Eq. (3) known as the "mediation equation" [60] is the determinative equation of PV and PE, which is used to test H_3、 H_4、 H_5 and H_6. Eqs. (1), (3) and (4) form a triangular system [57] that can directly test the mediation role of PV or PE between PEVP or PEVP and SS. The indirect channel (β_1 in Eq. (3) multiplied by β_2 in Eq. (4)) measures the extent to which PV or PE mediate the relationship between PEVP or PEVP and SS, determining how much of the increase in SS is due to the enhancement of PV or PE. To test for mediation, it is necessary to focus on the significance of β_1 and β_2 in Eq. (4), β_1 in Eq. (3) and β_1 in Eq. (1) following Zhao et al. [58]. If all of these coefficients are significant simultaneously, the mediating effect of PV or PE through which PEVP or PEVP affects SS is established. Furthermore, the study employs the Sobel approach [61] for robustness testing.

Table 1
Descriptive statistics and correlations.

VARIABLES	SS	PEVP	PUVP	PE	PV
SS	1				
PEVP	0.667***	1			
PUVP	0.683***	0.686***	1		
PE	0.848***	0.649***	0.771***	1	
PV	0.685***	0.568***	0.584***	0.812***	1
Mean	4.157	4.029	4.000	4.147	4.074
S.D.	0.552	0.550	0.522	0.539	0.770

Note: N = 34; *** indicate significance at the1% levels; two-tailed tests; SS = students' satisfaction; PEVP = perceived ease of video production; PUVP = perceived usefulness of video production; PE = perceived enjoyment; PV = perceived value.

4. Results

4.1. Descriptive statistics and correlation analysis

The mean values, standard deviations, and correlation coefficients between the variables were analyzed (shown in Table 1). The average score for the dependent variable, students' satisfaction (SS), is 4.157, which is higher than the average scores of all the influencing factors. This indicates that students, overall, have a high level of satisfaction with the flipped classroom teaching model, and to some extent, it reflects the success of implementing this teaching method. The average levels of all influencing factors have reached the "agree" level. Among them, the perceived usefulness of video production (PUVP) has the lowest mean score, which is 4.000.

The Pearson correlation coefficient was used to measure the correlation between the variables. In Table 1, SS was significantly positively correlated with PEVP ($r = 0.667, p < 0.01$) and PUVP ($r = 0.683, p < 0.01$). PE was positively correlated with PEVP ($r = 0.649, p < 0.01$) and PUVP ($r = 0.771, p < 0.01$). PV was significantly positively correlated with PEVP ($r = 0.568, p < 0.01$) and PUVP ($r = 0.584, p < 0.01$). These findings provided preliminary support for subsequent hypothesis testing.

4.2. Hypotheses testing

4.2.1. The effect of perceived ease of use of video production on students' satisfaction and path analysis

Columns (1) and (2) of Table 2 show the impact of perceived ease of video production on students' satisfaction. The results in column (1) demonstrate that perceived ease of video production significantly increases students' satisfaction. After controlling for personal characteristics such as prior learning experience, gender, and grade level in column (2), the coefficient of PEVP decreases from 0.67 to 0.597, but remains significantly positive at the 1% level. These findings indicate that when students perceive video production to be easier, they tend to have higher levels of satisfaction with it. Perceived ease of video production plays a significant positive role in promoting students' satisfaction. Therefore, H_1 is empirically supported.

Improved perceived ease of video production can enhance perceived enjoyment and perceived value. This viewpoint is supported by evidence in columns (5) and (7), where the coefficients of PEVP are 0.569 and 0.614, respectively, and both are significant at the 1% level. Therefore, H_3 and H_5 are confirmed. The coefficients of perceived enjoyment and perceived value in columns (3) and (4) are 0.845 and 0.489, respectively, and both pass the significance test at the 1% level, indicating that perceived enjoyment and perceived value have a positive promotion effect on students' satisfaction to varying degrees. This provides supportive evidence for H_7 and H_8.

In Table 2, columns (2), (5), and (6) present the estimates of the triangular system discussed in Section 3.5, which includes Eqs. (1), (3) and (4), respectively. The findings in column (6) suggest that when perceived enjoyment is taken into consideration, the direct impact of perceived ease of use on students' satisfaction with video production becomes insignificant. However, the results demonstrate that perceived enjoyment has a significant positive effect on students' satisfaction. Specifically, an increase of one percent in perceived enjoyment results in a 0.735 percent increase in students' satisfaction. The mediation analysis of perceived enjoyment further reveals that perceived ease of use of video production does not directly affect students' satisfaction, but rather improves it by influencing perceived enjoyment. Hence, perceived enjoyment fully mediates the relationship between perceived ease of use of video production and students' satisfaction, thus supporting H_9.

The results of columns (2), (7), and (8) also indicate that perceived value is an important pathway through which the ease of video production impacts students' satisfaction, as shown by the coefficients. After adding the mediating factor of perceived value, the

Table 2
The effect of perceived ease of use of video production on students' satisfaction.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	SS	SS	SS	SS	PE	SS	PV	SS
PEVP	0.67***	0.597***			0.569***	0.179	0.614***	0.392**
	(0.132)	(0.146)			(0.145)	(0.126)	(0.201)	(0.152)
PE			0.845***			0.735***		
			(0.108)			(0.131)		
PV				0.489***				0.333**
				(0.116)				(0.122)
PLE		0.111	0.035	0.036	0.131	0.015	0.332**	0.000
		(0.095)	(0.068)	(0.103)	(0.094)	(0.069)	(0.131)	(0.095)
Gender		−0.032	0.142	0.21	−0.175	0.097	−0.361*	0.088
		(0.153)	(0.106)	(0.15)	(0.152)	(0.109)	(0.21)	(0.145)
Grade		0.408	0.21	0.184	0.222	0.244	0.405	0.273
		(0.259)	(0.184)	(0.259)	(0.256)	(0.183)	(0.356)	(0.239)
Constant	1.459**	0.596	−0.082	1.376**	1.186	−0.276	0.086	0.567
	(0.538)	(0.713)	(0.512)	(0.616)	(0.706)	(0.521)	(0.98)	(0.645)
R^2	0.445	0.514	0.755	0.525	0.501	0.772	0.529	0.616

Note: N = 34; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. SS = students' satisfaction; PEVP = perceived ease of video production; PUVP = perceived usefulness of video production; PE = perceived enjoyment; PV = perceived value; PLE = prior learning experience.

coefficient of PEVP decreased from 0.597 to 0.392. However, the coefficients of PEVP and PV in the triangular system are both significantly positive, providing empirical support for H_{11}. According to the mediation effect test method proposed by Baron and Kenny [57], the total effect of perceived ease of video production on students' satisfaction was 0.597, with a direct effect of 0.392, a mediating effect of 0.205. This indicates that 34.338% of the total impact of PEVP is realized through PV.

4.2.2. The effect of perceived usefulness of video production on students' satisfaction and path analysis

Columns (9)–(10) of Table 3 reveal that there is a significant positive correlation between PUVP and SS. The results in column (10) demonstrate that when the mediator, PE, is not included, PUVP significantly improves SS: every 1% increase in the PUVP can lead the SS to increase by 0.621 units. Therefore, H_2 is empirically supported. According to the results of columns (11) and (13), the coefficients of PUVP are 0.721 and 0.658, respectively, which are both significantly positive at the 1% level. This indicates that as the perceived usefulness of video production increases, students' perceived enjoyment and perceived value also increase. This provides supportive evidence for H_4 and H_6.

The results of column (12) show that after including the mediator, the direct impact of PUVP on SS is no longer statistically significant. However, PE, the mediator, has a significant positive effect on SS. Columns (11)–(12) show the regression results to further verify the existence of a mediating effect. In this case, the impact of PUVP on SS at this time is completely realized through PE, which functions as a mediator. According to Zhao et al. (2010), this phenomenon is called "Indirect-only Mediation". Therefore, H_{10} is empirically supported.

According to the results of columns (10) and (14), the coefficient of PUVP decreases from 0.621 (column (10)) to 0.414 (column (14)). The change in the PUVP coefficient suggests that the inclusion of PV absorbs part of the impact of PUVP, while also reducing the significance of the coefficient (from 1% to 5%). The coefficient of PV is 0.315 (column (14)) significant at the 5% level. This result initially confirms that PV is an important explanatory variable for SS. The results of columns (10), (13), and (14) in Table 3 show the estimate of the triangular system (Eq. (1), (3) and (4) respectively) mentioned in Section 3.5. The coefficients of PUVP and PV in the triangular system are all significantly positive, which offers empirical support for H_{12}. PV acts as a mediator for the relationship between PUVP and SS. According to the results of columns (10), (13) and (14), the total effect of the perceived usefulness of video production on students' satisfaction was 0.621, with a direct effect of 0.414, mediating effect of 0.207. This indicates that 33.333% of the total impact of PUVP is realized through PV.

4.3. Robustness check

We performed the Sobel-Goodman mediation test to robustness checks [62]. The z values of the Sobel test, the Aroian test and the Goodman test, are presented in Table 4 and Table 5. All these three measures, i.e., the Sobel-Goodman test, confirm the mediation effect identified through the stepwise regression analysis.

5. Additional analysis: the open-ended questions and interviews

In response to the open-ended question "What suggestions or feedback do you have regarding the current teaching methods of the course?" at the end of the questionnaire, nine students provided their feedback. It was surprising to note that the majority of the feedback was positive, with comments such as "pretty good" and "rich content." Notably, none of the students provided any feedback or suggestions regarding the pre-class video production, indicating their satisfaction with this learning method. 4 students suggested

Table 3
The effect of perceived usefulness of video production on students' satisfaction.

VARIABLES	(9)	(10)	(11)	(12)	(13)	(14)
	SS	SS	PE	SS	PV	SS
PUVP	0.722***	0.621***	0.721***	0.028	0.658***	0.414**
	(0.136)	(0.144)	(0.12)	(0.159)	(0.197)	(0.155)
PE				0.823***		
				(0.164)		
PV						0.315**
						(0.124)
PLE		0.15	0.14*	0.035	0.368***	0.034
		(0.089)	(0.075)	(0.07)	(0.122)	(0.094)
Gender		0.037	−0.122	0.138	−0.291	0.129
		(0.147)	(0.123)	(0.11)	(0.202)	(0.14)
Grade		0.278	0.083	0.21	0.269	0.193
		(0.254)	(0.212)	(0.188)	(0.348)	(0.235)
Constant	1.268**	0.518	0.752	−0.101	−0.047	0.532
	(0.55)	(0.701)	(0.587)	(0.531)	(0.962)	(0.643)
R^2	0.467	0.535	0.658	0.756	0.55	0.621

Note: N = 34; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. SS = students' satisfaction; PEVP = perceived ease of video production; PUVP = perceived usefulness of video production; PE = perceived enjoyment; PV = perceived value; PLE = prior learning experience.

Table 4
Results of the Sobel-Goodman mediation test of perceived ease of video production on students' satisfaction.

Mediation tests	The Mediation Effect of PE (Model (6) of Table 2)			The Mediation Effect of PV (Model (8) of Table 2)		
	Coeff.	Std. Error	z-value(p-value)	Coeff.	Std. Error	z-value(p-value)
Sobel	0.418***	0.130	3.218(p = 0.001)	0.205**	0.100	2.034(p = 0.042)
Aroian	0.418***	0.131	3.185(p = 0.001)	0.205**	0.104	1.976(p = 0.048)
Goodman	0.418***	0.129	3.253(p = 0.001)	0.205**	0.098	2.098(p = 0.036)

Notes: **, and *** indicate significance at the 5% and 1% levels.

Table 5
Results of the Sobel-Goodman mediation test of perceived usefulness of video production on students' satisfaction.

Mediation tests	The Mediation Effect of PE (Model (12) of Table 3)			The Mediation Effect of PV (Model (14) of Table 3)		
	Coeff.	Std. Error	Z value (p-value)	Coeff.	Std. Error	Z value (p-value)
Sobel	0.593***	0.154	3.852(p = 0.000)	0.207**	0.103	2.016(p = 0.044)
Aroian	0.593***	0.155	3.821(p = 0.000)	0.207**	0.106	1.961(p = 0.0498)
Goodman	0.593***	0.153	3.884(p = 0.000)	0.207**	0.0996	2.076(p = 0.038)

Notes: **, and *** indicate significance at the 5% and 1% levels.

improvements to the pace of classroom teaching, possibly due to some students creating videos that were too long, which impacted the available time for classroom instruction. To address this issue, it is recommended that at the beginning of the lecture, the teacher should set a limit for the video duration based on the number of students and the total lecture time and emphasize it regularly. Furthermore, the teacher should plan the content of the students' videos and the lecture material to complement and coordinate with each other.

During the last three weeks of the semester, the teacher interviewed twelve students. Regarding the workload of video production, students expressed that it was slightly higher than that of traditional courses. Most students felt that they had already gained sufficient PowerPoint skills from previous studies, which made video production relatively easy for them. Some students commented that the course content was rich, and they learned new video editing methods through this project. The method of learning by watching other students' videos in class was also quite interesting. On average, video production took 5–6 h to complete. Some students who worked quickly were able to complete the process in only 3 h, from gathering information to finishing the video production. Most students felt that the task of producing one video per semester was a reasonable course assignment.

Regarding watching videos of other students' work in class, students said that the organization of content and the sound effects in the videos were very important. By watching other students' videos in class, they gained a lot of experience in making their own videos. Therefore, judging by the order of the videos played, the later ones were more polished and exciting than the earlier ones. Some students provided feedback that they were most impressed by video explanations that incorporated case studies, which helped them understand some of the complex management theories, and their memories were more profound than traditional learning methods.

Overall, most students are very satisfied with both the process of creating their own videos and watching those created by their peers. When compared to traditional pre-class learning methods such as watching videos or reading articles, students prefer the fun and usefulness of animation techniques used in video creation. By creating short animated videos, they not only learn theoretical concepts, but also acquire new technical skills. These learned theories can be fully applied in case group discussions and course papers, further enhancing their perception of the value of knowledge acquisition. Some comments on flipped classes based on video production include:

Participant A: I really enjoyed the course. Firstly, I learned a lot of theoretical knowledge and secondly, the video production was very interesting and close to this era.

Participant B: I really enjoyed the learning method of making videos, and watching other students' videos was great too. The class was rich and interesting, and I felt very focused throughout.

Participant C: I loved the idea of making and watching short videos, which made theoretical learning less tedious. The various methods used in class, such as group discussions, case analysis, and summarizing the key points at the end of each lesson, allowed us to fully apply the knowledge we learned in public management. I believe that the knowledge gained from this course will be very helpful and useful in my future life.

Participant D: It was my first time to make videos, and I found it was not difficult at all. I really liked the teacher's teaching style, and the application of theoretical knowledge in case analysis allowed me to use the learned theories to analyze real-world problems. It was great.

The results of the open-ended questions and interviews have strengthened the quantitative findings of this study and provided further insights into the pre-class learning mode and teaching strategies for video production.

6. Discussion and implications

6.1. Discussion

We have designed a flipped classroom teaching model based on student video production rather than just viewing, and explored its impact on students' satisfaction, as well as analyzed the pathways that influence satisfaction. The results showed that the greater the ease and usefulness of video production, the higher the students' satisfaction. Perceived enjoyment and perceived value are important mediating paths in this process.

The findings of this study provide an important reference for the pre-class preparation of future flipped classrooms. The preparation of materials for pre-class learning is a time-consuming and labor-intensive task, which has always been a major obstacle to the implementation of flipped classrooms in social teaching practice. Allowing students to complete video production on their own not only enables them to learn new technologies but also enhances their interest and ability, while also providing rich materials for teachers' preparation of pre-class and in-class materials. It is foreseeable that this will greatly save the energy and practice required for teachers to implement flipped classrooms, and make it more widely accepted and promoted by a large number of teachers.

6.2. Implications

In terms of inspiration for instructional design, there are three points that teachers should pay attention to. Firstly, when assigning the task of video production, teachers should provide excellent examples of video production or training on video production techniques to enable students to master video production tools as soon as possible, without burdening them with excessive extracurricular learning. Secondly, students need to understand the value of this task for their learning and future work. For example, teachers can emphasize the help of video production, animation design, and other technologies for future careers or use case analysis to fully apply theoretical learning to solve real public management problems. The greater the perceived help of this task for their future learning or career, the higher their satisfaction with learning this task will be. Thirdly, when playing videos made by classmates in class, teachers should arrange instructional content reasonably according to the learning process and the time of video playback. Teachers can stipulate the duration of the small videos that students make when assigning the task. 3–5 min is a relatively appropriate length for a theoretical video. Combining case explanations, pleasant voice-overs, or novel animations can improve the viewing experience of the video and help classmates understand and accept theoretical learning.

6.3. Limitations

The sample size in our research is relatively limited. At the same time, this study only takes public administration as an experimental course, and the universality of flipped classroom in other types of courses needs to be further verified. Additionally, future research may also consider different pre-class learning strategies, such as combining video production and viewing, to better improve the satisfaction of flipped classrooms.

Data availability statement

Data will be made available on request.

Ethics statement

This study was reviewed and approved by the Ethics Committee of Zhejiang University of Finance and Economics, with the approval number: 20220920-01Y. All participants provided informed consent to participate in the study.

CRediT authorship contribution statement

Jie Liu: Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Shiyuan Cao:** Writing – review & editing, Writing – original draft, Supervision, Conceptualization. **Xiangfeng Liu:** Writing – original draft, Validation, Methodology, Formal analysis, Data curation, Conceptualization. **Chengjin Ye:** Writing – original draft, Validation, Supervision. **Pierluigi Siano:** Validation, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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References

[1] K. Aghaei, M. Rajabi, K.Y. Lie, F. Ajam, Flipped learning as situated practice: a contrastive narrative inquiry in an EFL classroom, Educ. Inf. Technol. 25 (2) (2020) 1607–1623, https://doi.org/10.1007/s10639-019-10039-9.

[2] Z. Zhu, Z. Xu, J. Liu, Flipped classroom supported by music combined with deep learning applied in physical education, Appl. Soft Comput. 137 (2023) 110039, https://doi.org/10.1016/j.asoc.2023.110039.

[3] L.R. Murillo-Zamorano, J.Á.L. Sánchez, A.L. Godoy-Caballero, How the flipped classroom affects knowledge, skills, and engagement in higher education: effects on students' satisfaction, Comput. Educ. 141 (2019) 103608, https://doi.org/10.1016/j.compedu.2019.103608.

[4] J. Bergmann, A. Sams, Flip Your Classroom: Reach Every Student in Every Class Every Day, International society for technology in education, Arlington, Virginia, 2012.

[5] J.L. Jensen, T.A. Kummer, P.D.D.M. Godoy, Improvements from a flipped classroom may simply be the fruits of active learning, CBE-Life Sci. Educ. 14 (1) (2015), https://doi.org/10.1187/cbe.14-08-0129 ar5.

[6] R.M. Ryan, E.L. Deci, Intrinsic and extrinsic motivation from a self-determination theory perspective: definitions, theory, practices, and future directions, Contemp. Educ. Psychol. 61 (2020) 101860, https://doi.org/10.1016/j.cedpsych.2020.101860.

[7] S. Sergis, D.G. Sampson, L. Pelliccione, Investigating the impact of Flipped Classroom on students' learning experiences: a Self-Determination Theory approach, Comput. Hum. Behav. 78 (2018) 368–378, https://doi.org/10.1016/j.chb.2017.08.011.

[8] L. Abeysekera, P. Dawson, Motivation and cognitive load in the flipped classroom: definition, rationale and a call for research, High Educ. Res. Dev. 34 (1) (2015) 1–14, https://doi.org/10.1080/07294360.2014.934336.

[9] M. Barranquero-Herbosa, R. Abajas-Bustillo, C. Ortego-Maté, Effectiveness of flipped classroom in nursing education. A systematic review of systematic and integrative reviews, Int. J. Nurs. Stud. (2022) 104327, https://doi.org/10.1016/j.ijnurstu.2022.104327.

[10] V.P. Njie-Carr, E. Ludeman, M.C. Lee, D. Dordunoo, N.M. Trocky, L.S. Jenkins, An integrative review of flipped classroom teaching models in nursing education, J. Prof. Nurs. 33 (2) (2017) 133–144, https://doi.org/10.1016/j.profnurs.2016.07.001.

[11] M. Förster, A. Maur, C. Weiser, K. Winkel, Pre-class video watching fosters achievement and knowledge retention in a flipped classroom, Comput. Educ. 179 (2022) 104399, https://doi.org/10.1016/j.compedu.2021.104399.

[12] G. Akçayır, M. Akçayır, The flipped classroom: a review of its advantages and challenges, Comput. Educ. 126 (2018) 334–345, https://doi.org/10.1016/j.compedu.2018.07.021.

[13] J.I. Herrero, J. Quiroga, Flipped classroom improves results in pathophysiology learning: results of a nonrandomized controlled study, Adv. Physiol. Educ. 44 (3) (2020) 370–375, https://doi.org/10.1152/advan.00153.2019.

[14] H.O.K. Ahmed, Flipped learning as a new educational paradigm: an analytical critical study, Eur. Sci. J. 12 (10) (2016), https://doi.org/10.19044/esj.2016.v12n10p417.

[15] R. Martínez-Jiménez, M.C. Ruiz-Jiménez, Improving students' satisfaction and learning performance using flipped classroom, Int. J. Manag. Educ. 18 (3) (2020) 100422, https://doi.org/10.1016/j.ijme.2020.100422.

[16] K. Hava, Exploring the role of digital storytelling in student motivation and satisfaction in EFL education, Comput. Assist. Lang. Learn. 34 (7) (2021) 958–978, https://doi.org/10.1080/09588221.2019.1650071.

[17] R.A. Howell, Engaging students in education for sustainable development: the benefits of active learning, reflective practices and flipped classroom pedagogies, J. Clean. Prod. 325 (2021) 129318, https://doi.org/10.1016/j.jclepro.2021.129318.

[18] A.Y. Huang, O.H. Lu, S.J. Yang, Effects of artificial Intelligence–Enabled personalized recommendations on learners' learning engagement, motivation, and outcomes in a flipped classroom, Comput. Educ. 194 (2023) 104684, https://doi.org/10.1016/j.compedu.2022.104684.

[19] H.M. Lai, P.J. Hsieh, L. Uden, C.H. Yang, A multilevel investigation of factors influencing university students' behavioral engagement in flipped classrooms, Comput. Educ. 175 (2021) 104318, https://doi.org/10.1016/j.compedu.2021.104318.

[20] Y.M. Huang, L.M. Silitonga, T.T. Wu, Applying a business simulation game in a flipped classroom to enhance engagement, learning achievement, and higher-order thinking skills, Comput. Educ. 183 (2022) 104494, https://doi.org/10.1016/j.compedu.2022.104494.

[21] M.C. Ruiz-Jiménez, R. Martinez-Jiménez, A. Liceran-Gutiérrez, E. García-Marti, Students' attitude: key to understanding the improvement of their academic RESULTS in a flipped classroom environment, Int. J. Manag. Educ. 20 (2) (2022) 100635, https://doi.org/10.1016/j.ijme.2022.100635.

[22] C.O. Nja, R.E. Orim, H.A. Neji, J.O. Ukwetang, U.E. Uwe, M.A. Ideba, Students' attitude and academic achievement in a flipped classroom, Heliyon 8 (1) (2022) e08792, https://doi.org/10.1016/j.heliyon.2022.e08792.

[23] P. Strelan, A. Osborn, E. Palmer, The flipped classroom: a meta-analysis of effects on student performance across disciplines and education levels, Educ. Res. Rev. 30 (2020) 100314, https://doi.org/10.1016/j.edurev.2020.100314.

[24] T. Wanner, E. Palmer, Personalising learning: exploring student and teacher perceptions about flexible learning and assessment in a flipped university course, Comput. Educ. 88 (2015) 354–369, https://doi.org/10.1016/j.compedu.2015.07.008.

[25] R.H. Kay, Exploring the use of video podcasts in education: a comprehensive review of the literature, Comput. Hum. Behav. 28 (3) (2012) 820–831, https://doi.org/10.1016/j.chb.2012.01.011.

[26] R. Kay, T. MacDonald, Comparing flipped, active, and lecture-based teaching approaches in higher education, in: EdMedia+Innovate Learning, Association for the Advancement of Computing in Education (AACE), 2016, pp. 1559–1565, https://doi.org/10.13140/RG.2.1.4727.4481.

[27] M.S.Y. Jong, To flip or not to flip: social science faculty members' concerns about flipping the classroom, J. Comput. High Educ. 31 (2) (2019) 391–407, https://doi.org/10.1007/s12528-019-09217-y.

[28] L. Cheng, A.D. Ritzhaupt, P. Antonenko, Effects of the flipped classroom instructional strategy on students' learning outcomes: a meta-analysis, Educ. Technol. Res. Dev. 67 (2019) 793–824, https://doi.org/10.1007/s11423-018-9633-7.

[29] C.L. Lai, G.J. Hwang, A self-regulated flipped classroom approach to improving students' learning performance in a mathematics course, Comput. Educ. 100 (2016) 126–140, https://doi.org/10.1016/j.compedu.2016.05.006.

[30] Y. Chen, Y. Wang, N.S. Chen, Is FLIP enough? Or should we use the FLIPPED model instead? Comput. Educ. 79 (2014) 16–27, https://doi.org/10.1016/j.compedu.2014.07.004.

[31] G.J. Hwang, C.L. Lai, S.Y. Wang, Seamless flipped learning: a mobile technology-enhanced flipped classroom with effective learning strategies, J. Comput. Educ. 2 (2015) 449–473, https://doi.org/10.1007/s40692-015-0043-0.

[32] S.C. Kong, Developing information literacy and critical thinking skills through domain knowledge learning in digital classrooms: an experience of practicing flipped classroom strategy, Comput. Educ. 78 (2014) 160–173, https://doi.org/10.1016/j.compedu.2014.05.009.

[33] N.T.T. Thai, B. De Wever, M. Valcke, The impact of a flipped classroom design on learning performance in higher education: looking for the best "blend" of lectures and guiding questions with feedback, Comput. Educ. 107 (2017) 113–126, https://doi.org/10.1016/j.compedu.2017.01.003.

[34] I.Y. Alyoussef, Acceptance of a flipped classroom to improve university students' learning: an empirical study on the TAM model and the unified theory of acceptance and use of technology (UTAUT), Heliyon 8 (12) (2022) e12529, https://doi.org/10.1016/j.heliyon.2022.e12529.

[35] T. Roach, Student perceptions toward flipped learning: new methods to increase interaction and active learning in economics, Int. Rev. Econ. Educ. 17 (2014) 74–84, https://doi.org/10.1016/j.iree.2014.08.003.
[36] A.S. Burke, B. Fedorek, Does "flipping" promote engagement? A comparison of a traditional, online, and flipped class, Act. Learn. High. Educ. 18 (1) (2017) 11–24, https://doi.org/10.1177/1469787417693487.
[37] Y. Fadol, H. Aldamen, S. Saadullah, A comparative analysis of flipped, online and traditional teaching: a case of female Middle Eastern management students, Int. J. Manag. Educ. 16 (2) (2018) 266–280, https://doi.org/10.1016/j.ijme.2018.04.003.
[38] M.S. Cole, H.S. Feild, S.G. Harris, Student learning motivation and psychological hardiness: interactive effects on students' reactions to a management class, Acad. Manag. Learn. 3 (1) (2004) 64–85, https://doi.org/10.5465/AMLE.2004.12436819.
[39] F. Guay, C.F. Ratelle, J. Chanal, Optimal learning in optimal contexts: the role of self-determination in education, Can. Psychol.-Psychol. Can. 49 (3) (2008) 233, https://doi.org/10.1037/a0012758.
[40] S.C. Cheng, G.J. Hwang, C.H. Chen, From reflective observation to active learning: a mobile experiential learning approach for environmental science education, Br. J. Educ. Technol. 50 (5) (2019) 2251–2270, https://doi.org/10.1111/bjet.12845.
[41] O. Viberg, A. Andersso, M. Wiklund, Designing for sustainable mobile learning–re-evaluating the concepts "formal" and "informal", Interact. Learn. Environ. 29 (1) (2021) 130–141, https://doi.org/10.1080/10494820.2018.1548488.
[42] M. Bond, Facilitating student engagement through the flipped learning approach in K-12: a systematic review, Comput. Educ. 151 (2020) 103819, https://doi.org/10.1016/j.compedu.2020.103819.
[43] C. Fornell, M.D. Johnson, E.W. Anderson, J. Cha, B.E. Bryant, The American customer satisfaction index: nature, purpose, and findings, J. Market. 60 (4) (1996) 7–18, https://doi.org/10.1177/002224299606000403.
[44] F.D. Davis, Perceived usefulness, perceived ease of use, and user acceptance of information technology, MIS Q. (1989) 319–340, https://doi.org/10.2307/249008.
[45] S.S. Liaw, Investigating students' perceived satisfaction, behavioral intention, and effectiveness of e-learning: a case study of the Blackboard system, Comput. Educ. 51 (2) (2008) 864–873, https://doi.org/10.1016/j.compedu.2007.09.005.
[46] X. Hu, Y. Gong, C. Lai, F.K. Leung, The relationship between ICT and student literacy in mathematics, reading, and science across 44 countries: a multilevel analysis, Comput. Educ. 125 (2018) 1–13, https://doi.org/10.1016/j.compedu.2018.05.021.
[47] X. Zhai, J. Gu, H. Liu, J.C. Liang, C.C. Tsai, An experiential learning perspective on students' satisfaction model in a flipped classroom contextm, J. Educ. Technol. Soc. 20 (1) (2017) 198–210.
[48] I. Sahin, M. Shelley, Considering students' perceptions: the distance education student satisfaction model, J. Educ. Technol. Soc. 11 (3) (2008) 216–223.
[49] P.C. Sun, R.J. Tsai, G. Finger, Y.Y. Chen, D. Yeh, What drives a successful e-Learning? An empirical investigation of the critical factors influencing learner satisfaction, Comput. Educ. 50 (4) (2008) 1183–1202, https://doi.org/10.1016/j.compedu.2006.11.007.
[50] C.M. Chiu, M.H. Hsu, S.Y. Sun, T.C. Lin, P.C. Sun, Usability, quality, value and e-learning continuance decisions, Comput. Educ. 45 (4) (2005) 399–416, https://doi.org/10.1016/j.compedu.2004.06.001.
[51] K.Y. Lin, H.P. Lu, Why people use social networking sites: an empirical study integrating network externalities and motivation theory, Comput. Hum. Behav. 27 (3) (2011) 1152–1161, https://doi.org/10.1016/j.chb.2010.12.009.
[52] K. Trigwell, P. Ashwin, E.S. Millan, Evoked prior learning experience and approach to learning as predictors of academic achievement, Br. J. Educ. Psychol. 83 (3) (2013) 363–378, https://doi.org/10.1111/j.2044-8279.2012.02066.x.
[53] J. Bourgonjon, M. Valcke, R. Soetaert, T. Schellens, Students' perceptions about the use of video games in the classroom, Comput. Educ. 54 (4) (2010) 1145–1156, https://doi.org/10.1016/j.compedu.2009.10.022.
[54] K.S. Taber, The use of Cronbach's alpha when developing and reporting research instruments in science education, Res. Sci. Educ. 48 (2018) 1273–1296, https://doi.org/10.17863/CAM.8256.
[55] N. Almusharraf, S. Khahro, Students satisfaction with online learning experiences during the COVID-19 pandemic, Int. J. Emerg. Technol. Learn. 15 (21) (2020) 246–267, https://doi.org/10.3991/ijet.v15i21.15647.
[56] H.F. Kaiser, J. Rice, Little jiffy, mark IV, Educ. Psychol. Meas. 34 (1) (1974) 111–117, https://doi.org/10.1177/001316447403400115.
[57] R.M. Baron, D.A. Kenny, The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations, J. Pers. Soc. Psychol. 51 (6) (1986) 1173, https://doi.org/10.1037//0022-3514.51.6.1173.
[58] X. Zhao, J.G. Lynch Jr., Q. Chen, Reconsidering Baron and Kenny: myths and truths about mediation analysis, J. Consum. Res. 37 (2) (2010) 197–206, https://doi.org/10.1086/651257.
[59] F. Liu, Y. Kang, K. Guo, X. Sun, The relationship between air pollution, investor attention and stock prices: evidence from new energy and polluting sectors, Energy Pol. 156 (2021) 112430, https://doi.org/10.1016/j.enpol.2021.112430.
[60] X. He, J. Shi, The effect of air pollution on Chinese green bond market: the mediation role of public concern, J. Environ. Manag. 325 (2023) 116522, https://doi.org/10.1016/j.jenvman.2022.116522.
[61] M.E. Sobel, Asymptotic confidence intervals for indirect effects in structural equation models, Socio. Methodol. (1982) 290–312, https://doi.org/10.2307/270723.
[62] D.P. MacKinnon, C.M. Lockwood, J.M. Hoffman, S.G. West, V. Sheets, A comparison of methods to test mediation and other intervening variable effects, Psychol. Methods 7 (1) (2002) 83, https://doi.org/10.1037/1082-989x.7.1.83.