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# 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

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ABSTRACT

The present study examines the differential impact of studying in a Flipped Classroom (FC) setting, as compared to a Blended Learning (BL), a Traditional Learning (TL), and an E-Learning (EL) setting on learning performance, self-efficacy beliefs, intrinsic motivation, and perceived flexibility. Participants were second year undergraduate students ($N = 90$), enrolled in the "Invertebrates" course in Can Tho University (Vietnam). Participants were randomly assigned to one of the four experimental conditions (TL $n = 22$, BL $n = 22$, FC $n = 23$, EL $n = 23$). Two instructional elements - (1) lectures and (2) guiding questions - were presented through two different modes (online and face-to-face). In the blended conditions (BL and FC) the mode of these elements were altered. The results show that learning performance was superior in the FC setting as compared to other learning settings TL (*Cohens' d* = 1.58), EL (*Cohens' d* = 1.01) and BL (*Cohens' d* = 0.71). Students in the BL setting had a higher learning performance as compared to the EL setting. In addition, we observed that studying in a FC setting had a positive effect on self-efficacy beliefs and intrinsic motivation, but not on perceived flexibility. These findings suggest that the FC setting could be a promising way of enhancing students' learning performance.



## 1. Introduction

There is a growing body of research focusing on the flipped classroom (FC) design. This design builds on a particular "blend" of e-learning and traditional face-to-face teaching. Although there is an increasing amount of literature about blending these modalities (see e.g., Bliuc, Goodyear, & Ellis, 2007; Garrison & Kanuka, 2004; Owston, York, & Murtha, 2013; Vaughan & Garrison, 2005; Zacharis, 2015), research rarely addresses the precise nature of these "blends" and how different "blends" could have a differential impact on students' learning performance. Moreover, most research contrasts only one particular blend with online and/or traditional learning (see e.g., Ashby, Sadera, & McNary, 2011). FC approaches are a special type of blended learning (BL), whereby students are presented with web-based lectures prior to classroom sessions. Many authors stress how flipped classroom fosters student engagement, resulting in better learning outcomes (Gilboy, Heinerichs, & Pazzaglia, 2015; Tune, Sturek, & Basile, 2013). Research indicates that FC helps to students learn at their own pace, spend more time in preparatory work, and get more involved during classroom activities (Johnson, 2013; Kong, 2014; Roach, 2014).

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In this study, we compared the learning performance of students studying in a FC setting with three other instructional settings: (1) a Blended Learning (BL) setting, (2) a traditional (TL) setting, and (3) an E-Learning (EL) setting. In the FC setting, lectures were given in an online environment and subsequently exercises are given by means of guiding questions (explained below, see 2.2.3). The guiding questions had to be solved individually in a traditional classroom setting. In the BL setting, lectures were given in a traditional classroom setting and subsequently the same exercises were given in an online environment. In the TL setting, both the lectures and subsequent exercises were given in a traditional classroom setting. Finally, in the EL setting, both the lectures and exercises were given in an online setting.

For each particular setting, we make use of two key design elements: (1) lectures and (2) guiding questions. This is in order to address previous views that differences in learning performance should not be linked to the modality of the learning environment, as such (i.e., online versus face-to-face), but should focus on the underlying "pedagogy" that grounds design decisions (Graham, Henrie, & Gibbons, 2013; Means, Toyama, Murphy, and Baki, 2013). In this context, O'Flaherty and Phillips (2015) carried out a review of the literature and conclude that research rarely focuses on explicit design elements associated with educational conceptual frameworks. We therefore build on this gap in the literature. Moreover, next to a differential impact on learning performance, we also address student cognitions involved in these alternative teaching and learning settings (i.e., self-efficacy beliefs (SE), intrinsic motivation (IM), and perceived flexibility (PF)).

## 2. Theoretical framework

### 2.1. Blended learning - flipped classrooms

BL combines traditional face-to-face learning and e-learning (Bonk and Graham, 2006; Garrison & Kanuka, 2004; Osguthorpe & Graham, 2003). Sloman (2007) argues that BL should not simply be considered in terms of delivery and technology, but should also be understood in terms of what motivates learners and how it supports student demands. In terms of the latter, several authors refer to the flexibility of e-learning – in terms of time and place – which is now added to the learning environment (Garrison & Kanuka, 2004; Smyth, Houghton, Cooney, & Casey, 2012). In this respect, Deperlioglu and Kose (2013) stress that BL adds a flexibility dimension to the traditional face-to-face learning process.

Bawaneh (2011) emphasizes the positive impact that providing online resources has on students' academic performance in a BL setting. Moreover, many authors stress that BL has a positive impact on students' perceptions and related academic achievement (Deperlioglu & Kose, 2013; López-Pérez, Pérez-López, & Rodríguez-Ariza, 2011; Owston et al., 2013; Suda, Sterling, Guirguis, & Mathur, 2014). Some studies have contrasted BL with TL or EL courses, and report a significantly higher academic performance in the BL setting (Suda et al., 2014; Vernadakis, Giannousi, Derri, Michalopoulos, & Kioumourtzoglou, 2012). In a review of more recent research, Bernard, Borokhovski, Schmid, Tamim, and Abrami (2014) conclude that BL exceeds traditional classroom instruction in terms of academic achievement (1/3 standard deviation). This is particularly the case if the BL design incorporates cognitive support (content processing support and representational support), as well as an investment in the interaction between students and between students and the teacher. Finally, several authors stress that BL can present a richer range of learning experiences and produce higher levels of student engagement due to its adoption of a range of delivery methods (Bliuc et al., 2007; Ginns & Ellis, 2007; Smyth et al., 2012).

A more recent approach known as "flipped classroom" (FC) or "flipped learning" (FL) is growing in popularity when designing a BL environment. This approach has recently received much research attention (Albert & Beatty, 2014; Kim, Kim, Khera, & Getman, 2014; O'Flaherty & Phillips, 2015). Although the concept has been around for many years (Baepler, Walker, & Driessen, 2014; Gilboy et al., 2015; Lowell, Utah, Verleger, and Beach, 2013), and flipping the classroom can be organized in non-technology supported learning environments, it is mainly found in BL environments. The FC approach builds on web-based lectures that are studied prior to face-to-face classroom sessions. Numerous authors stress that the FC experience has a positive impact on student outcomes as compared to TL (Albert & Beatty, 2014; He, Holton, Farkas, & Warschauer, 2016; Roach, 2014). To explain the potential of FC, research suggests that students are better prepared to engage in face-to-face interactive and higher-order activities, such as problem solving, discussions, and debates (Gaughan, 2014; Lowell, Utah, Verleger, & Beach, 2013). Gilboy et al. (2015) add that during the face-to-face phase of a FC design, teachers are present and can give immediate feedback while students engage in learning activities aiming at higher levels of Bloom's taxonomy. Moreover, recent studies of Roach (2014) and Gilboy et al. (2015) show that students obtain a better understanding of the lectures before attending face-to-face sessions, and are therefore engaged in deeper learning over a focused period of time. Although the available research states that FC results in superior learning performance as compared to TL and EL, it is yet not clear how studying in a FC setting results in better performance as compared to other BL approaches. Below we give an overview of BL design guidelines.

### 2.2. Blended learning design guidelines

Recent overviews stress the complex nature of the BL design, particularly in terms of the multi-dimensional structure of the variables and processes affecting its impact. Hew and Cheung (2014) and Meyen, Aust, Bui, Ramp, and Smith (2002) emphasize the need to consider the nature of the independent variables that define the BL design (such as level of interaction, pedagogical approach, nature of invoked cognitive processing, and media attributes). This highlights the importance of tracking the way one sequences the design elements in a BL environment.

In the present study, we build on the strengths of both EL and TL when developing a potentially rich blend of instructional design elements that build on two evidence-based instructional practices: lectures and guiding questions with feedback. These elements will either be presented online or in a traditional setting. Below we discuss the balance between TL and EL in a BL environment.

### 2.2.1. Balancing TL and EL in a BL setting

With respect to the design of BL courses, Thorne (2003) stresses the balance between e-learning and traditional face-to-face components. This balance might differ depending the study discipline, the instructional goals, student characteristics, the nature of available resources, and a teacher's background (Osguthorpe & Graham, 2003). Allen, Seaman, and Garrett (2007) suggest a balance of 30% TL and 70% EL components. Demirer and Sahin (2013) and Donnelly (2010) prefer a 50%–50% balance. Their approach largely builds on face-to-face components such as classroom discussions, group work, lectures, and problem solving activities along with using synchronous and asynchronous tools enriched with online content, online assignments, chat room, email, and self-assessment tools (Delialioglu & Yildirim, 2008; Thorne, 2003). According to Delialioglu and Yildirim (2008), TL class time should be mainly used for group or individual activities, discussion of homework, assignments and projects, and question-answer sessions with the teacher. In the present study, we implement a 50%–50% balance in BL.

### 2.2.2. Lectures as a learning environment component

Traditional face-to-face lectures are and remain a key component of teaching in higher education (Prober & Heath, 2012). There is plenty of evidence supporting the efficacy and efficiency of the TL environment (Beale, Tarwater, & Lee, 2014; Berkowitz, 2013; Bligh, 1998; Frederick, 1986). Lectures appear to be effective in transferring declarative information to learners. They succeed to invoke critical thinking about a discipline and appear to help students clarify and organize difficult concepts. A review study of Berkowitz (2013) indicates that attending lectures is positively associated with academic performance. Lectures are supported with PowerPoint slides and printed material. In relation to more innovative learning environments, such as FCs, O'Flaherty and Phillips (2015) stress that even when using such alternative approaches, face-to-face lectures are more familiar to both students and staff.

Web-based Lectures (WBL) are the EL-alternative to face-to-face lectures. WBL can be defined as lectures that have been digitally recorded and can be streamed synchronously or asynchronously via the Internet (Gosper et al., 2010). Next to the actual video of the oral presentation, most WBL also use PowerPoint slides and printed learning materials comprising of text and graphics (Ridgway et al., 2007). Some authors stress the need to include other media next to lecture recordings (i.e., text, images and animations, audio, and video) (Lyons, Reysen, & Pierce, 2012). WBL are often adopted as a substitute for – or a complement to – face-to-face lectures. They offer students the opportunity to review difficult concepts, revise for exams, or listen to missed classes (Johnston, Massa, & Burne, 2013). In addition, WBL – particularly in the case of asynchronous streaming – offer students more flexibility in terms of access to resources and the chance to review key concepts and ideas at their own pace (Gosper et al., 2011; Williams & Fardon, 2007). Numerous studies conclude that the provision of digitally recorded lectures is a key solution for students to interact with lecture material in a flexible way (Cooke et al., 2011; Kiteley & Ormrod, 2009; McNulty et al., 2009). Some authors report that video-recorded lectures have a positive impact on learning outcomes (Wieling & Hofman, 2010; Zhang, Zhou, Briggs, & Nunamaker, 2006) and enhance student satisfaction with the learning environment itself (Zhang et al., 2006). Regarding web-based lecture guidelines, Gorissen, van Bruggen, and Jochems (2012) indicate that the length of video-recorded lecture-sections should not exceed 20 min, otherwise student concentration is negatively affected.

In the present study, we compare WBL with face-to-face lectures as design elements in our research conditions. Our expectation that there will be differences in the impact of these "ways of attending a lecture" is based on our assumptions about the extent to which cognitive processes have been successfully supported. Whereas face-to-face lectures facilitate interaction between the students and the teacher (see above), there is an assumption that in the short time span of a lecture (e.g., 45 min) students can successfully process the new learning content. However, this expectation that students have time for extensive note taking, questions, and making mind maps is undermined when we consider the limited capacity model of Moray (1967), which outlines why some students cannot always follow the speed of a lecture and therefore grasp the full meaning of what has been presented. This is closely related to the notion of 'working memory limitations' described by Mayer (2001), which suggests that learning is optimal if students can pause or repeat what they have been listening to or looking at (Schreiber, Fukuta, & Gordon, 2010). In this respect, WBL clearly offer certain advantages to learners, as they have more time to process the information and engage in high level cognitive processing, such as paying attention, organizing information and linking it with previous knowledge. Students can also pause, review, and restart the recorded lecture. In this context, Jensen, Kummer, and Godoy (2015) state that "Improvements from a flipped classroom may simply be the fruits of active learning" (p. 1). Hembrooke and Gay (2003) build on the selective attention hypothesis, and argue that imposing additional work on students while they are listening to a lecture is often unsuccessful, as they have difficulty dividing their attention between listening and other activities such as asking questions, writing, drawing, and summarizing. This brings us to hypothesize that students studying with an online lecture will have higher learning outcomes when compared to face-to-face lectures.

#### 2.2.3. Guiding questions and feedback

Bernard et al. (2014) stress that sufficient attention should be paid to the support of cognitive processing when designing BL. In this context, Traver (1998) argues that presenting guiding questions leads to more meaningful learning and higher levels of achievement. He defines a guiding question as one that pushes students' understanding. According to Blosser (2000), guiding questions help students to review learning content, check their comprehension, stimulate critical thinking, encourage creativity, and emphasize critical points. The also help the teacher to control classroom activities, cut down disruptive behavior, encourage discussion, and discourage inattentiveness. Research indicates that guiding questions have a positive effect on student performance (Budé, van de Wiel, Imbos, & Berger, 2012). In view of designing guiding questions, Traver (1998) puts forward four criteria: guiding questions should be (1) open ended, (2) nonjudgmental, (3) intrinsically interesting, and (4) succinct. Laiken, Milland, and Wagner (2014) have underpinned the positive learning impact of guiding questions in a BL setting. In terms of the role of assignments in BL settings in general, and FC designs in particular, Kim et al. (2014) stress that students should be provided with enough time to carry out assignments. This favors students working in an online environment, as offered in a FC setting.

Nevertheless, presenting guiding questions is but a starting point of the cognitive processing activity in view of a successful question-solution and subsequent learning. The literature is clear as to the critical need for giving feedback to learners after tackling questions. Hattie (2009) reports related effect sizes of up to 0.9 when looking at the differential impact of giving feedback on learning performance. A critical feature of feedback is the time between task execution (e.g., answering questions) and the feedback (Eom, Wen, & Ashill, 2006:; Hattie & Timperley, 2007; Higgins, Hartley, & Skelton, 2002; Nicol & Macfarlane-Dick, 2006). When feedback is given in a timely manner, these researchers report higher learning performance. They explain this by referring to the fact that feedback elicits elaboration and organizational cognitive processes, while restructuring one's schemata after incorporating the feedback (Butler & Winne, 1995; Derry, 1996; Moust, De Volder and Nuy, 1989).

This theoretical basis leads us to hypothesize that, while guiding questions support cognitive processing, learning conditions in which feedback is given in a timely manner will result in higher learning performance (TL settings) when compared to settings in which questions are answered with delayed feedback (EL settings).

### 2.3. Student variables

Next to learning performance (LP) as the key dependent variable, this study also examines the following student variables: self-efficacy (SE), intrinsic motivation (IM), and perceived flexibility (PF).

#### 2.3.1. Self-efficacy

Self-efficacy (SE) refers to an individual's belief in their capacity to execute behaviors necessary to produce specific performance attainments (Bandura, 1982). SE concerns having confidence in one's ability to exert control over one's own motivation, behavior, and social environment. The findings of Wang and Newlin (2002) show that SE in relation to course content and technology predicts student performance. In a BL environment, Lynch & Dembo (2004) report that SE is significantly related to student performance. The same applies to research focusing on the mediating impact of SE in EL contexts (see e.g., Braeckman et al., 2013; Ong & Lai, 2006; Wu, Ed, Tsai, & Ed, 2006). Since SE is linked to expectations about one's future performance, we expect students in a FC environment will have higher SE due to the fact that they will have more opportunities to process the content via WBL and will receive more timely feedback when solving the guiding questions in a face-to-face setting (see above).

#### 2.3.2. Intrinsic motivation

Intrinsic motivation (IM) refers to motivation that comes from an individual's internal desire for self-satisfaction rather than from external rewards such as money or grades (Ryan & Deci, 2000). Ryan and Deci (2000) emphasize that intrinsic motivation largely depends on the extent to which a person's basic psychological needs (BPN) are satisfied: (1) autonomy, (2) belonging, and (3) competence. The literature presents a varied picture as to the impact of learning environments on IM (Martens, Gulikers, & Bastiaens, 2004; Negovan, Sterian, & Colesniuc, 2015).

EL contexts have comparable results. Studying in an EL context seems to influence the IM that mediates the learning process and its resulting academic performance (Giesbers, Rienties, Tempelaar, & Gijselaers, 2013; Joo, Lim, & Kim, 2012). In BL environments, student motivation has been shown to increase due to spending less time in the classroom and its stronger emphasis on self-regulated learning (So & Brush, 2008). Mendez and Gonzalez (2011) stress that compared to TL, IM increases in a BL setting. Other authors emphasize that in a BL setting, students are given the opportunity to regulate their own study, through a stronger interaction with course materials and individual control over their pace of participation in online activities (Poon, 2012; Smyth et al., 2012). The former underpins the expectation that students' IM will be higher when studying in settings building on EL components. However, given the available evidence, BL is considered to be superior to EL settings. In line with Abeysekera and Dawson (2015) we propose that FCs boost students' IM when compared to traditional classrooms.

Moreover, we believe that the FL approach will be superior to the BL approach because the FL approach offers a shared setting at the end of the process, and therefore supports the basic psychological need for "belonging." When it comes to competence, we believe that the FL approach will boost students' "competence" when processing the learning content via web-based lectures. Lastly, we expect that this will also support student "autonomy," as WBL facilitate individual processing when tackling complex learning content.

#### 2.3.3. Flexibility

Flexibility is defined as giving students more choice regarding when, where, and what to learn (Collis, Vingerhoets, & Moonen, 1997). Flexibility is a key dependent variable in most EL and BL research (Dimitrova, Sadler, Hatzipanagos, and Murphy, 2003; Poon, 2012). In BL environments, the face-to-face component supports the choice/preference for social interaction, while the EL component offers more freedom regarding the time and place of study (Garrison & Kanuka, 2004; Deperlioglu & Kose, 2013; Smyth et al., 2012). Students benefit from the ease of access to resources, anytime and anywhere (Poon, 2012), and can also interact with one another (Bijeikienė, Rašinskienė, & Zutkienė, 2011; Smyth et al., 2012). In this respect, we hypothesize that perceived flexibility will be higher in learning settings that build on EL components.

## 3. Research design

A quasi-experimental pretest-posttest research design was set up to study the impact of four different research conditions on students' learning performance. In the research conditions, we manipulate two key instructional design elements (i.e., online or face-to-face settings). In addition, we measure the impact of the research conditions on the following student variables: intrinsic motivation (IM), self-efficacy beliefs (SE) and perceived flexibility (PF).

**Table 1**
Main characteristics of the four research conditions.

| TL – Traditional learning | EL – E-learning | Blended learning conditions | |
|---|---|---|---|
| | | BL – Blended Learning | FC – Flipped Classroom |
| Printed textbook<br>*F2F Lecture*<br>*(classroom)*<br>Guiding questions<br>*(classroom)*<br>*Immediate feedback in class* | Printed textbook<br>*Web Based lecture*<br>*(online)*<br>Guiding questions<br>*(online)*<br>*Delayed feedback*<br>*(online)* | Printed textbook<br>*F2F Lecture*<br>*(classroom)*<br>Guiding questions<br>*(online)*<br>*Delayed feedback*<br>*(online)* | Printed textbook<br>*Web Based lecture*<br>*(online)*<br>Guiding questions<br>*(classroom)*<br>*Immediate feedback in class* |

The four research conditions build on the same key didactical design features: the same printed textbook, the same lecture content, and the same set of guiding questions with feedback. However, the way lectures were delivered and the way students received feedback was different, building on the combination of face-to-face or online participation. This study involved students from the same research population, randomly divided across the four different conditions. Next to the impact on students' learning performance (LP), we explored the effect of these different research conditions on students' SE, IM and PF.

### 3.1. Hypotheses

Our theoretical and empirical basis leads us to present two hypotheses as to the differential impact of particular research conditions on the research variables:

H1: Studying in a Flipped Classroom (FC) setting will result in significantly higher learning performance when compared to studying in a Blended Learning (BL), a Traditional Learning (TL) or an E-Learning (EL) setting.

H2: Studying in a Flipped Classroom (FC) setting will result in larger changes in levels of self-efficacy beliefs (SE), intrinsic motivation (IM) and perceived flexibility (PF) when compared to studying in a BL, TL or EL setting.

### 3.2. Participants

Participants were second-year undergraduate students ($N = 90$), enrolled in the "Invertebrates" course of the School of Education at Can Tho (Vietnam), in the academic year 2014–2015. Student age ranged from 20 to 22 years ($M = 20.48$, $SD = 0.67$) and 61.1% of the students were female. Informed consent was obtained from every student; none of the students requested their data to be excluded from the analysis. Course sessions were set up four times per week and were organized for two parallel groups involving the same teacher.

### 3.3. Instruments

#### 3.3.1. Learning performance

Tests were designed to measure learning performance. Both the pretest and the posttest were designed on the basis of Bloom's Taxonomy to distinguish between mastery at different behavioral levels: knowledge, comprehension, and application. Each parallel test consisted of 20 multiple-choice questions and three essay questions. Test items in both tests reflected the same behavioral levels, despite slight differences in the content of the questions. Test administration took 30 min to determine the pretest and posttest knowledge level.

### 3.3.2. Self-efficacy (SE), Intrinsic Motivation (IM), and Perceived Flexibility (PF) instruments

At the start and at the end of the study, students were presented with a survey to measure their SE, IM, and PF. SE was measured by means of the translated 27-item scale of Zajacova, Lynch, and Espenshade (2005). Students were asked to indicate, on a scale ranging from 0 to 100, the extent to which they felt able to carry out specific tasks (Cronbach's alpha for this scale was $\alpha = 0.90$ for both the pretest and posttest). IM was determined on the basis of the translated 12-item scale of Vallerand et al. (1993) (Cronbach's alpha for this scale was $\alpha = 0.83$ at pretest and $\alpha = 0.91$ at posttest). The PF scale consisted of 15 items, and was based on Bergamin, Werlen, Siegenthaler, and Ziska (2012) (Cronbach's alpha for this scale was $\alpha = 0.70$ at pretest and $\alpha = 0.80$ at posttest). Since – at the time of pretest – students had not yet experienced the flexibility offered by the different learning environments, it is not surprising that the reliability was somewhat lower at this time. We therefore interpret these results with caution. All items of the IM scale and the PF scale were rated on a five-point Likert scale.

## 3.4. Procedure

Fig. 1 outlines the procedure of this study, detailing the differences and similarities between the four research conditions.

The present study was set up in the naturalistic setting of the course "Invertebrates" in Can Tho University (Vietnam). Participants were randomly assigned to one of the four experimental conditions (TL $n = 22$; BL $n = 22$; EL $n = 23$; FC $n = 23$). The first week started with a course introduction and the administration of the pretest and survey to the students. In addition, students in the EL, BL, and FC conditions received a 1-h introduction to the online learning management system. For all students, it was the first time they had access to an e-learning environment. The next four weeks consisted of weekly sessions (16 sessions in total). Each structured session was planned to last on average 90 min and consisted of two parts. The first part (estimated to take 45 min) focused on the delivery of a lecture (WBL or F2F), the second part (estimated to take 45 min) focused on solving guiding questions (individually, on paper or in an online forum; see below), followed by general feedback

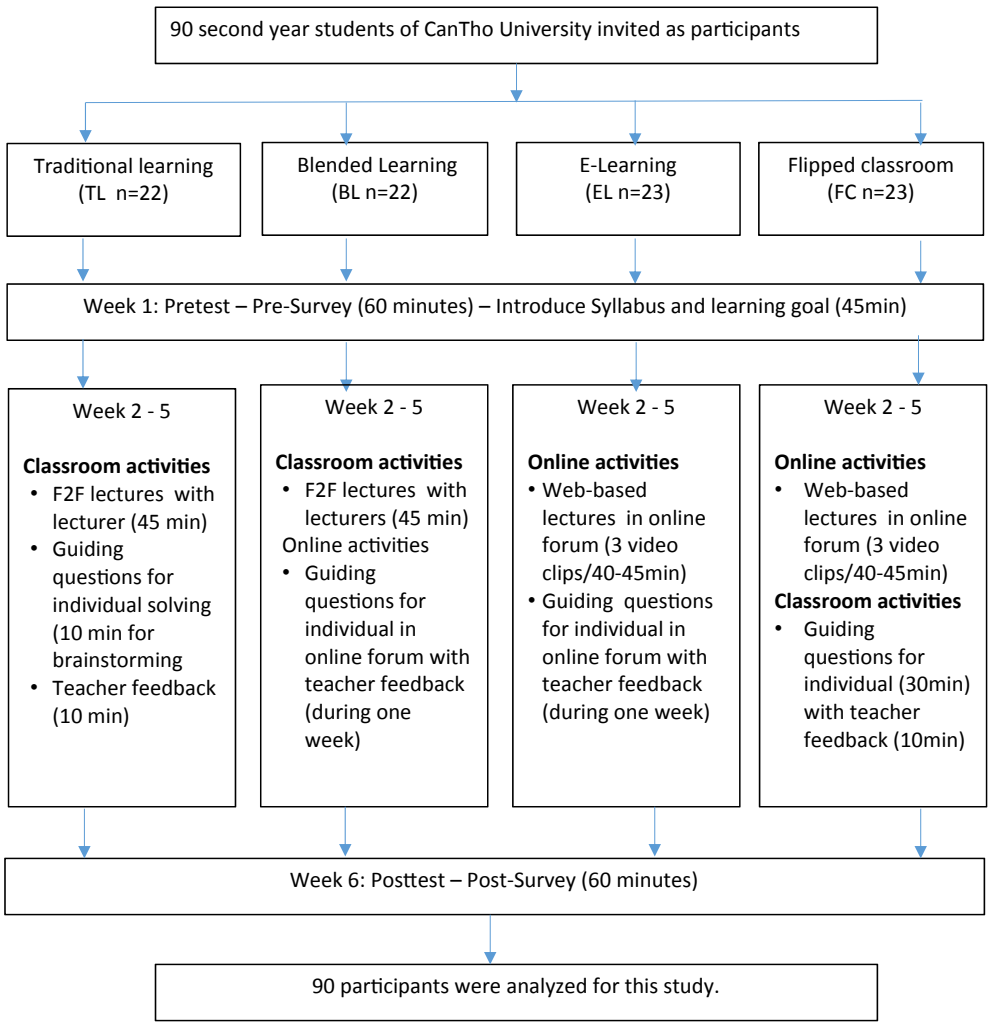


**Fig. 1.** Graphical representation of the research procedure, involving the different samples in the four research conditions.

given by the teacher. In the fourth week, students were presented with the posttest and a final survey. They also participated in focus groups.

### 3.5. Description of the different research conditions

In this study, we contrast traditional learning (TL), e-learning (EL) and two blended learning conditions (BL and FC). Key factors that were kept constant in every condition included the lecture content, the textbook, the guiding questions, and the general teacher feedback. The nature of the lecture and the general feedback differed according to the research condition.

In this study, each lecture cycle was divided into three parts. Before the lecture, students in all conditions were expected to read the relevant textbook section before attending the face-to-face lecture or watching the WBL. Students in both the TL and the BL condition received a face-to-face lecture, while students in the EL and FC condition received WBL, which were uploaded to the LMS one week before the classroom session. After the lecture, all students were asked to solve the guiding questions. Students in both the TL and FC condition solved the guiding questions in a classroom setting (45 min). After a 10-min brainstorming session, students solved the questions individually. A limited number of students received specific feedback from the instructor due to individual requests. In the middle of the session, all students were given general feedback from the instructor, including hints and elaboration. Following this, students continued to solve the guiding questions. During the last 10 min, the instructor again presented general feedback to all students. In the EL and the BL condition, after the lecture students were asked to solve the guiding questions and received general feedback in an online forum. Students had one week to solve the guiding questions. Students posted their answers on the online forum and received general feedback in the middle of the week, with hints that helped them to elaborate their solutions. At the end of the week, all students received general feedback again.

The guiding questions used reflected two levels in Bloom's Taxonomy. Half of the questions focused on students' level of "understanding," e.g., "Why do only protozoa living in freshwater have a contractile vacuole, in contrast to those living in saltwater?" The other half of the guiding questions focused on the level of "Analysis," e.g., "Compare the characteristics of Coelenterata and Platyhelminthes." As hypothesized above, the guiding questions were expected to invoke more meaningful learning (Traver, 1998). The students' work was used as the basis for teacher feedback during the face-to-face sessions.

### 3.6. Data analysis

The Statistical Package for Social Sciences (SPSS) was used to analyze the data. First, descriptive statistics were summarized and screened. The mean Posttest measures (LP_Post, SE_Post, IM-Post, PF_Post) were used as dependent variables, whereas the mean Pretest measures (LP_Pre, SE_Pre, IM_Pre, PF_Pre) were used as covariates in the analysis. Analysis of covariance (ANCOVA) was applied to test the hypotheses. Planned contrasts analyses were carried out to look at the between-group differences in the four research conditions. Assumptions were tested in view of statistical analyses (normality, homogeneity of variance). No problems were encountered. A significance level of $p < 0.05$ was put forward. Given the small samples sizes, we also calculated and reported effect sizes to interpret the results (Cohen's d) when focusing on the analysis of variance results based on difference scores (i.e. Posttest − Pretest). In the interpretation of the effect sizes, we built on the values of Baguley (2009): small effect size (from $d = 0.2$), medium effect size (from $d = 0.5$) and large effect size (from $d = 0.8$).

## 4. Results

### 4.1. Descriptive statistics

Table 2 presents the mean and standard deviation of the dependent variable (Learning performance, LP) and the student variables, SE, IM, and PF. As explained above, the mean scores were calculated to test the impact of the intervention.

### 4.2. Testing hypothesis 1

To test whether studying in the FC setting resulted in significantly higher LP as compared to BL, EL and TL, ANCOVA was carried out with the conditions as factor (TL, BL, EL, and FC). We found that the covariate (LP_Pretest) was significantly related

**Table 2**
The mean and standard deviation of Learning Performance and student variables ($N = 90$).

| | TL ($n = 22$) | | | | BL ($n = 22$) | | | | EL ($n = 23$) | | | | FC ($n = 23$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pretest | | Posttest | | Pretest | | Posttest | | Pretest | | Posttest | | Pretest | | Posttest | |
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| LP[a] | 3.33 | 0.91 | 5.62 | 1.28 | 3.60 | 1.36 | 6.30 | 0.73 | 3.93 | 3.00 | 5.60 | 1.42 | 3.00 | 0.88 | 6.66 | 1.19 |
| SE[b] | 68.8 | 8.97 | 69.4 | 9.69 | 70.2 | 9.06 | 73.5 | 7.49 | 67.6 | 14.1 | 63.8 | 13.0 | 68.8 | 7.06 | 73.7 | 7.97 |
| IM[c] | 3.93 | 0.32 | 3.82 | 0.38 | 4.12 | 0.34 | 3.96 | 0.35 | 3.71 | 3.26 | 3.26 | 0.73 | 3.68 | 0.40 | 3.64 | 0.47 |
| PF[d] | 3.37 | 0.33 | 3.35 | 0.34 | 3.53 | 0.47 | 3.60 | 0.41 | 3.37 | 0.73 | 3.41 | 0.45 | 3.45 | 0.40 | 3.58 | 0.42 |

Note: [a]Maximum LP (learning performance) score = 10; [b]max SE (self-efficacy) score = 100; [c]max IM (intrinsic motivation) score = 5; [d]max PF (perceived flexibility) score = 5.

to the LP_Posttest at ($F$ (1,85) = 10.1, $p < 0.05$, *partial Eta*$^2$ = 0.11). We also observed a significant effect of research conditions on LP after controlling for the LP_Pretest ($F$ (3,85) = 6.61, $p < 0.05$; *partial Eta*$^2$ = 0.19). Studying in a different condition accounts for 22.5% of explained variance in LP. Fig. 2 presents an overview of the pretest and posttest scores of students in the different conditions. Although we conducted an analysis of covariance to cater for potential differences at the pretest level, we will return to the observed differences in the pretest scores in the discussion below.

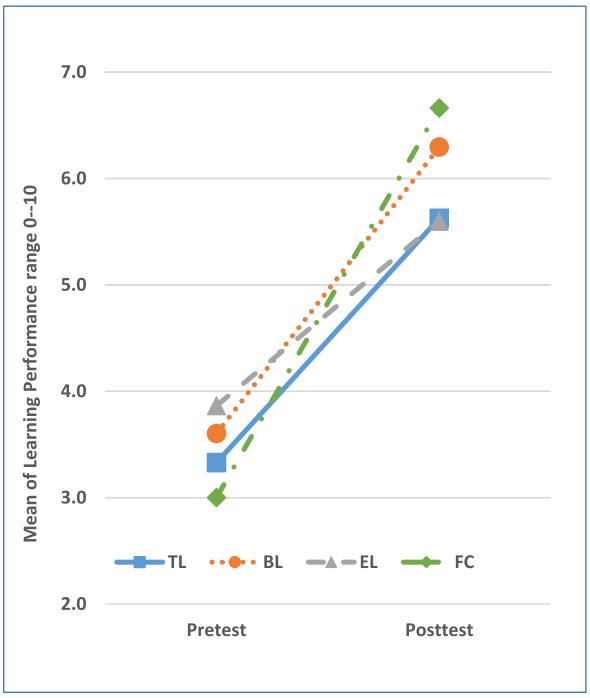


**Fig. 2.** Differences in Pretest and Posttest of learning performance.

A planned contrast analysis indicated that LP is significantly higher in the FC condition as compared to the EL condition ($t$ (85) = - 4.02, $p < 0.001$, *Cohen's d* = 1.58) and the TL condition ($t$ (85) = −3.42, $p = 0.001$, *Cohen's d* = 1.01). Both differences reflect a large effect size. We observed no significant difference between FC and BL ($t$ (85) = - 1.72, $p = 0.088$). Nevertheless, the marginal p-value reflects a medium effect size (*Cohen's d* = 0.71). In view of completeness, we also found that LP is significantly higher in the BL condition as compared to the EL condition ($t$ (85) = - 2.40, $p = 0.018$, *Cohen's d* = 0.81). This reflects a large effect size. However, no significant differences between BL and TL were found ($t$ (85) = −1.66, $p = 0.101$, *Cohen's d* = 0.29). As expected, this reflects a small effect size.

### 4.3. Testing hypothesis 2

To study the differential impact of these variables, ANCOVA was carried out with the conditions as factor (FC, BL, TL, and EL).

With respect to SE, we found that the covariate (SE_Pretest) was significantly related to the SE_Posttest score ($F$(1,85) = *34.8*, $p < 0.001$, *partial Eta*$^2$ = 0.29). We also observed a significant effect of the research conditions after controlling for the SE_Pretest ($F$ (3,85) = 5.9, $p = 0.001$, *partial Eta*$^2$ = 0.17).

Fig. 3 depicts the different changes in SE in the four different research conditions. The planned contrasts analysis confirm significant differences between EL and TL ($t$ (85) = 2.02, $p = 0.046$, *Cohen's d* = 0.38), between EL and BL ($t$ (85) = 3.37, $p = 0.001$, *Cohen's d* = 0.65), and between EL and FC ($t$ (85) = 3.81, $p < 0.001$, *Cohen's d* = 0.79). The first score reflects a small effect size, the second and third scores reflect a medium effect size.

With respect to IM, we found that the covariate (IM_Pretest) was significantly related to the IM_Posttest score ($F$(1,85) = *9.40*, $p = 0.003$, *partial Eta*$^2$ = 0.10). We also observed a significant effect of the research conditions on IM after controlling for the IM_Pretest ($F$ (3,85) = 5.14, $p = 0.003$, *partial Eta*$^2$ = 0.15).

As can be seen in Fig. 4, IM was (slightly) lower at the posttest than at the pretest for all conditions. The planned contrasts analysis showed that there were significant differences between FC and EL ($t$ (85) = −2.74, $p = 0.007$, *Cohen's d* = 0.62) but no significant differences between FC and TL ($t$ (85) = 0.54, $p = 0.591$, *Cohen's d* = 0.18). The first score indicates a medium effect size. To complete the picture, other contrasts were tested. Significant differences were observed between BL and EL ($t$

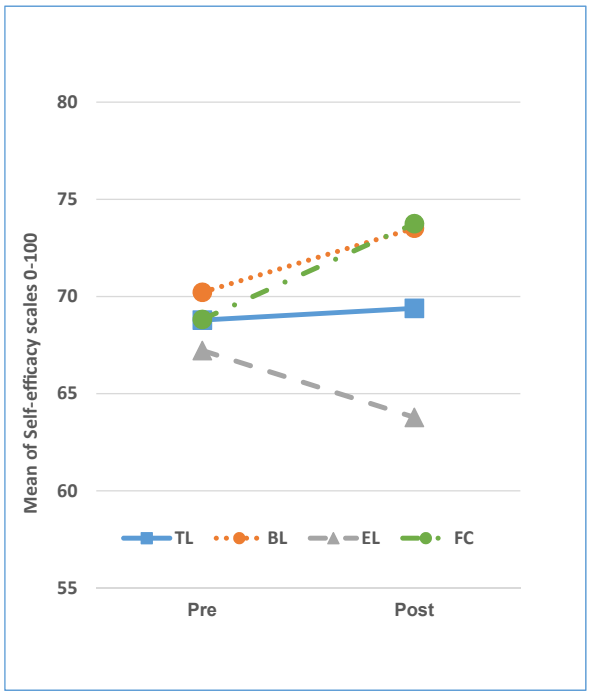


**Fig. 3.** Differences in changes in self-efficacy beliefs between research conditions (Pretest and Posttest).

(85) = −3.46, $p = 0.001$, *Cohen's d* = 0.45), TL and EL ($t$ (85) = −3.21, $p = 0.002$, *Cohen's d* = 0.52), both indicating medium effect sizes. No significant differences were found between BL and TL ($t$ (85) = 0.41, $p = 0.686$, *Cohen's d* = 0.15).

With respect to PF, we found that the covariate (PF_Pretest) was significantly related to the PF_Posttest ($F$ (1,85) = 23.04, $p < 0.001$, *partial Eta*$^2$ = 0.21). With respect to the four different conditions, Fig. 5 indicates that only small changes in PF were observed. In general, no significant differences were observed between the research conditions and PF after controlling for the PF_Pretest ($F$ (3,85) = 1.40, $p = 0.25$, *partial Eta*$^2$ = 0.25).

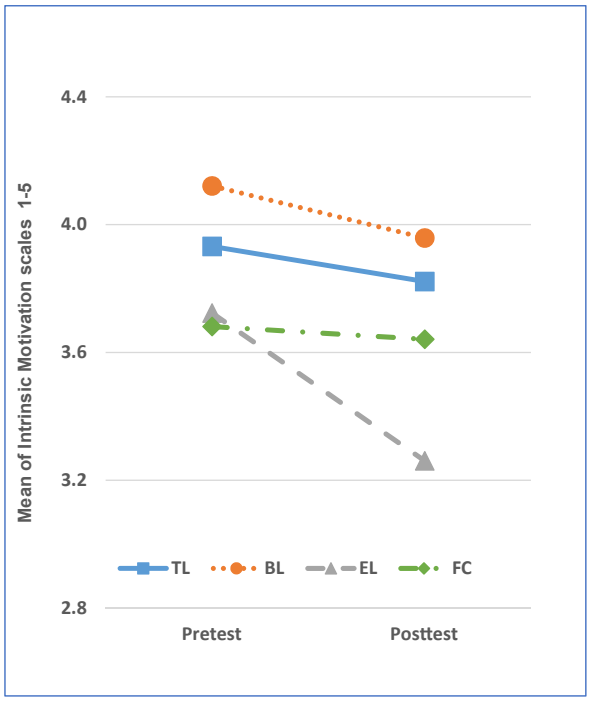


**Fig. 4.** Differences in changes in intrinsic motivation between research conditions (Pretest and Posttest).

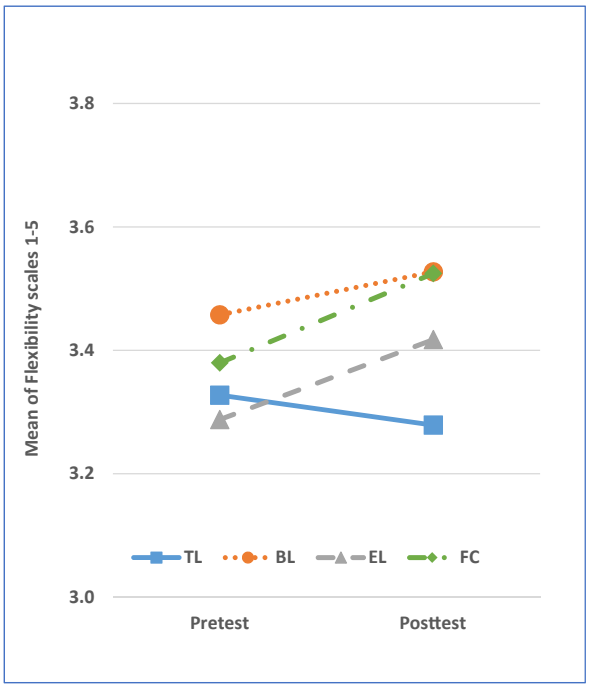


**Fig. 5.** Differences in changes in flexibility between research conditions (Pretest and Posttest).

Therefore, hypothesis 2 can only be partly accepted in terms of the differential impact of studying in a FC setting on the student variables.

## 5. Discussion

Above we have outlined the growing implementation of learning management systems in higher education and the related increase of BL, which builds of a variety in "blends" of face-to-face and e-learning elements. However, empirical studies comparing the variety of blends in comparable research settings is lacking (Graham et al., 2013; Harper, Chen, & Yen, 2004; Kim et al., 2014). The aim of the present study was to evaluate the impact of four different learning environments on learning performance and on students' self-efficacy, intrinsic motivation, and perceived flexibility.

Our findings suggest that studying in a FC environment (i.e. web based lectures followed by exercises (guiding questions) with immediate feedback from an instructor) resulted in a higher LP as compared to studying in an e-learning or a face-to-face setting. This implies that WBL offer benefits to students because they are given more time to process the information being taught (pause, replay, …) and have better opportunities to engage in high level cognitive processing (Hembrooke & Gay, 2003; Schreiber et al., 2010). This finding shows that students in a FC outperform students in a TL setting. This is consistent with previous studies (Albert & Beatty, 2014; Baepler et al., 2014; He et al., 2016; Roach, 2014), that found that students in FC settings attained better academic results as compared to TL settings. In our study, the FC approach proved to be superior to the TL approach in which the same delivery of guiding questions was used (i.e., with timely feedback and guidance from the instructor). The main difference was the switch between WBL in the FC setting and the lectures in the classroom environment in the TL setting. The fact that the WBL has a superior impact is in line with other research findings on WBL versus face-to-face lectures (Wieling & Hofman, 2010; Zhang et al., 2006). Students who studied through WBL attained better learning outcomes as compared to students attending "live" lectures in a TL environment.

The results also show that LP was significantly higher in the BL condition versus the EL condition. This is consistent with the finding of Suda et al. (2014), who reported that students attending BL courses had better results compared to students attending EL or face-to-face courses.

Our results also indicate there are no significant differences between students' LP in a TL setting versus an EL setting. This is also in line with the studies of Suda et al. (2014) and Szeto (2014), who confirm that students studying in EL courses gain similar learning outcomes as compared to TL. Although students in the face-to-face condition might have spent less time solving the guiding questions in our study, they are more familiar with the face-to-face format. Whereas students in the EL condition may have used more time, they were using an unfamiliar EL format. Future research should explore whether students with a higher level of EL experience still have a lower LP when studying in a fully EL setting as compared to students in a BL setting or a FC setting.

With respect to student variables, the expected differences between the research conditions were found with regard to SE and IM. For these variables, the effect of the EL condition was less advantageous than other teaching approaches. With respect to PF, no differences were found between the four research conditions.

A variety of explanations can be put forward for these results. First, changes in the student variables could be marred by the fact students studied in less familiar learning environments (EL, BL, and FC condition). Experience with a learning environment seems critical in view of affecting IM (Rovai, Ponton, Wighting, & Baker, 2007; Lehmann, Hähnlein, & Ifenthaler, 2014; Zhan & Mei, 2013) or PF (Poon, 2012). In addition, the four-week study period (16 sessions) might have been too short to expect a change in PF, especially given that other courses during the research period were still set up along the TL approach. This could also have affected the extent to which students felt boosted in their autonomy, belonging or competence needs, thus not affecting their IM (Niemiec & Ryan, 2009). Though the descriptive statistics and related analyses suggest differences in changes in SE between the research conditions, these changes are small considering the SE scale used in the study (e.g., Fig. 3). Again, the duration of the intervention may have been too short to influence SE. In this context, Shea and Bidjerano (2010) note that online and/or hybrid courses have the potential to affect SE because students experience a stronger sense of "learner presence." However, this may require a substantially longer period of study time.

Finally, there are a number of limitations to this study, some of which have already been addressed above. Adding to these, the short duration of the intervention could also be linked to a lack of experience with the newly introduced LMS at Can Tho University. Although significant differences in LP were observed, we were unable to shed light on the actual differences in the way students studied. Conducting research in an authentic situation also has the drawback of natural fluctuations. For example, although students were randomly divided over different conditions, averages on the pretest were significantly different between conditions ($F(3,86) = 3.27$; $p = 0.025$). Thus, random assignment may still produce non-equivalent groups when sample sizes are too small, as was the case in this study. While we controlled for these differences through an analysis of co-variance, larger sample sizes might help minimize type II errors in the statistical analyses. The sample size was also a limitation with respect to the power of the statistical analyses. Although we could make use of the effect sizes to develop a more in-depth picture of differences between research conditions, future research should use larger sample sizes to check whether the current findings can be confirmed. In terms of the low reliability of the PF scale, students cannot reliably report on the flexibility of settings that they have no prior experience with, which will affect subsequent data analyses. Moreover, we did not focus on student workload and non-compliance with class preparation. With respect to the workload and the time spent in the conditions, He et al. (2016) show that FC settings do not appreciably increased the overall workload of students. However, we could not control how much time students spent watching WBL because they downloaded them to their own computer. We also paid little attention to additional student background variables that might have caused variation in the dependent variables, especially considering the participants circumstances and associated flexibility (e.g., working students, professionals taking HE courses). This study only involved full-time students of a regular Vietnamese university. A study with working students, or a more heterogeneous group with respect to age, could lead to different results. Lastly, this study was carried out in a particular course setting within a particular university program. Replication of this study with students from other courses and other universities is required to confirm the current findings and to evaluate other "blends" in the higher education setting. For example, available research on computer supported collaborative learning (De Wever, Van Keer, Schellens, & Valcke, 2007; Schellens & Valcke, 2005, 2006) could inspire alternative blends to be contrasted with EL and TL.

## 6. Conclusion

The findings of this study highlight the promising differential impact of implementing FCs and BL on LP. A FC design appeared to make a difference in terms of improved student outcomes, with rather large effect sizes when compared to TL (Cohen's $d = 1.58$) and EL (*Cohen's* $d = 1.01$). Students can spend ample time watching lectures, preparing well before attending the face-to-face session in which they are actively involved in solving problems based on the guiding questions. These students received immediate feedback from the instructor with respect to the guiding questions. In this respect, one key strength of our research is that we used the same course design, content, pedagogical activities, and sequence in all conditions, only the delivery mode varied.

In terms of student variables, the FC setting resulted in significantly higher changes in SE as compared to the EL setting (*Cohen'* $d = 0.79$). Changes in IM, if significant, rather pointed at a decrease in motivation. As for PF, no significant changes were observed. Further research in the form of a longitudinal study may be useful in clarifying this relation. Replication studies should be carried out to confirm these findings, bearing in mind the limitations noted, and possibly introducing additional instructional design elements.

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