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# A blended design of game-based learning for motivation, knowledge sharing and critical thinking enhancement

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## ABSTRACT

This study proposed a game-based instruction approach by using bingo games and a mobile application to investigate its effects on motivation, knowledge sharing and critical thinking ability during the learning of information management. The participants were 86 undergraduate students who participated in an 18-week experimental instruction of information management in which bingo games and Socrative were employed. Both the qualitative and quantitative data were analysed. The results showed that while the bingo games may carry more effects on enhancing learning motivation, Socrative may lead to more knowledge sharing and critical thinking. In addition, both instructional methods had positive influences on learning outcomes through different mechanisms and shared mechanisms. The shared mechanisms included focused attention, brainstorming, active participation, interaction and logical thinking. Notably, there were interactions among motivation, knowledge sharing and critical thinking; moreover, the blended approach, which integrated the bingo games and Socrative, improved the participants' critical thinking ability.

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## KEYWORDS

Game-based learning;  
knowledge sharing; critical  
thinking; motivation;  
Socrative

## Introduction

Game-based learning (GBL) is the concept of using any type of game to assist learners in achieving a defined learning outcome in an educational environment (Hainey et al., 2016; Qian & Clark, 2016). Research findings have suggested that game-based learning is more effective than a script-based approach in the classroom and may have a strong positive motivational impact on student learning (Boeker et al., 2013). Although digital game-based learning has caught researchers' attention, most related studies have focused on domain-general investigation of students' motivations, perceptions and attitudes towards digital games (G. J. Hwang & Wu, 2012). To effectively employ game-based learning, identifying critical gaps and opportunities in domain-specific areas is important (Hung et al., 2018). In addition, a review of digital game-based learning between 2007 and 2016 reveals that personal computers were the most common platforms for playing games to support learning (Hung et al., 2018). The emergence of mobile phones and smartphones has been found to be a facilitator for learning in the classroom. It was found that more than 70% of students used smartphones to support their studies, and 94% of students experienced discussion forums in a course (Farley et al., 2015). These results suggest that smartphones are important instruments for student learning, and more domain-specific studies of game-based learning are required. Information management, which emphasises

how to employ technologies to solve problems in organisational contexts, is highly relevant to the emergent technologies; such ability is critical for personal success in competitive working environments. This study therefore tried to employ smartphones in the learning of information management.

Recently, a newly developed mobile application – Socrative – has attracted attention; it is characterised by immediate student–teacher interactions and being easy to use. Although studies involving smartphones are not new, and traditional games have been found to be effective vehicles for enhancing critical thinking (Cicchino, 2015), no studies have attempted to investigate how critical thinking can be improved through the integration of traditional games and Socrative. Previous findings have suggested that a novel and easy-to-use interface contributes to the enjoyment of a mobile learning environment (Merikivi et al., 2017). Moreover, social networking sites (Eid & Al-Jabri, 2016; Moghavvemi et al., 2017) provide an effective interface for knowledge sharing, and knowledge sharing is critical to critical thinking (Huang & Yeh, 2016; Yeh, 2012). Given these findings as well as the recent emphasis on domain-specific, game-based learning and the popularity of smartphones, this study aimed to develop an instructional design for blended game-based learning in which traditional games and Socrative, which was employed through smartphones, are integrated into classroom teaching. Further, to conduct experimental instruction to enhance learning motivation, knowledge sharing and critical thinking during the learning of information management.

### ***Game-based learning and mobile learning***

Game-based learning has been developed and employed in education for engaging learners and enhancing the educational process. Two types of game-based learning are commonly used: traditional and technological games. With regards to the application of traditional games, it was found that students were satisfied with games used in class (Coco et al., 2001). Interestingly, students were fond of the old games – bingo games (card or board games) (Leach & Sugarman, 2005). Bingo games have been found to be effective in enhancing learning motivation and effects (Kirby et al., 1981; Mariscal et al., 2012; Tietze, 2007). EduBingo is one of the successful examples that provide an educational bingo game system in one-to-one classrooms and help teacher monitor the accuracy and speed of the student answers (Chang et al., 2009). Despite the blooming of digital games, standard card and bingo games are still useful and effective for learning (Jacques et al., 2016).

In addition to traditional games, mobile devices are popular in supporting teaching and learning in higher education (Crompton & Burke, 2018; Sung et al., 2016). Existing literature of mobile learning includes the use of mobile instant messaging tools to support teaching and learning (Lai, 2016), the effectiveness of the mobile learning experience (Al-Jundi et al., 2017), positive effects on learning performance by utilising mobile apps (Jou et al., 2016), and the integration of augmented reality and information technology on mobile devices to support collaborative learning (Ke & Hsu, 2015; Rodríguez et al., 2016). It has been suggested that the ‘bring your own device’ (BYOD) concept can boost students’ engagement, motivation and learning (Wang, 2015). Recently, Socrative has been found to be an effective mobile device for achieving teaching goals as well as enhancing learning motivation and outcomes (Chou et al., 2017; McGulloch et al., 2018). Given the advantages of traditional game-based learning and mobile learning, this study tried to integrate these two types of learning to enhance the learning of critical thinking.

### ***Game-based learning, motivation and knowledge sharing***

Game-based learning can be a great tool for enhancing learners’ motivation. It was found that video or computer games in education contributed to high motivation and the flow experience in learning (Admiraal et al., 2011; Leach & Sugarman, 2005; Sera & Wheeler, 2017; Sun & Gao, 2016); moreover, game-based methods led to better learning outcomes and motivation than non-game methods (Hwang et al., 2017; T. Y. Liu & Chu, 2010; Tüzün et al., 2009). Notably, the engagement in games has

positive and strong effects on learning outcomes if students play games for fun (Hamari et al., 2016; Hawlitschek & Joeckel, 2017).

In addition, game-based learning may enhance the knowledge-sharing and learning process through a few mechanisms. Particularly, intrinsic motivation may have the strongest influence on the willingness to share knowledge (W. C. Liu & Fang, 2010). Rewards are also a critical incentive to encourage and influence knowledge-sharing behaviour in different contexts (e.g. Šajeva, 2014; Tietze, 2007). In addition, the use of social networking functions such as chatting and discussion may increase student knowledge sharing and enhance student learning (Eid & Al-Jabri, 2016). Finally, peer learning is important for knowledge-sharing behaviour in a learning environment (Chen et al., 2009; Y. J. Hwang & Kim, 2007). Accordingly, game-based learning that provides incentives of rewards, social network functions and peer learning may lead to strong intrinsic motivation to interact and participate towards knowledge-sharing behaviour.

### ***A blended approach of game-based learning and critical thinking***

Critical thinking skills is a thinking process in which such cognitive skills as identification of assumptions, interpretation, inference, induction, deduction and argument evaluation were employed (Halpern, 2003; Hughes et al., 2010; Moore & Parker, 2009; Yeh, 2012). Empirical findings have revealed that critical thinking can be enhanced through varied types of game-based learning, such as computerised learning games (Halpern et al., 2012), critical thinking cards (Holland & Ulrich, 2016) and the games-based Tic-Tac-Toe computational thinking approach (T. Y. Lee et al., 2014). Such successful experiences have also been found in studies integrating personal response systems into game-based learning (Moss & Crowley, 2011), using classroom response systems to enhance reasoning skills (DeBourgh, 2008) and employing an electronic voting system to immediately show audience responses for lectures (Simpson & Oliver, 2007). Therefore, instant response systems are critical for learning, reasoning and thinking during game-based learning.

Moreover, the use of a game for teaching is more effective in combination with collaborative learning than solo learning (Fung, 2014; H. Lee et al., 2016). It was also found that a case-based learning approach (Hong & Yu, 2017) and online discussions (Swart, 2017) contribute to facilitating reflection and critical thinking. A well-designed teaching-learning approach can enhance critical thinking and the participants' perceptions of becoming a critical thinker by turning the participant into an active learner who eventually achieves self-confidence (Lin et al., 2015). Previous studies (e.g. Al-Jundi et al., 2017; Eid & Al-Jabri, 2016; Moss & Crowley, 2011) have identified critical mechanisms for encouraging students' learning motivation and knowledge-sharing behaviour as well as those for enhancing the learning effects of game-based learning and critical thinking. This study therefore aimed to incorporate these mechanisms into a blended game-based learning approach (traditional games + mobile application) as part of our experimental instruction.

### ***Hypotheses of this study***

This study put emphasis on domain-specific, game-based learning and the employment of blended learning in which traditional games and the Socratic application were employed through smartphones in the teaching of information management. Given this context, the following hypotheses were proposed: (1) a blended game-based instructional approach incorporating traditional games and a mobile application could effectively encourage learners' motivation and knowledge sharing; (2) the blended game-based instruction would improve learners' critical thinking ability; (3) learning motivation and knowledge sharing would contribute to the learners' improvement in critical thinking during the blended game-based instruction.

## Method

### Participants

The participants were 86 undergraduate students in their third year of study for a business degree. The participants were enrolled in the course 'Information Management'. The course was required for third-year students. Of the 86 participants, 58 were female and 28 were male.

### Instruments

#### Socrative

An instant response system (IRS) of a mobile application – Socrative (<http://www.socrative.com>) – was used as the interface for interaction during the instruction period (Figure 1). Socrative allows instructors and students to interact by using Internet-enabled devices. Instructors can design the quizzes before the class in terms of multiple-choice, true/false or short-answer questions. In addition, the questions can be combined with competition by randomly assigning groups. Instructors can control the pace for selected questions and download student reports. Students can simply enter the name of the classroom and student ID to answer the questions that the teacher designs in advance. Moreover, the use of Socrative during class can encourage students to share ideas without revealing their student IDs. Students can also observe the responses of others, which contributes to stimulating and facilitating knowledge sharing. Most importantly, students can use their own smartphones to access the interface. Accordingly, it is not only easy to draw students' attention to the posed questions but also convenient for students to respond from their own devices.

#### Bingo games

In addition to Socrative, a traditional bingo game was used to encourage participation and to share thoughts and ideas (Figure 2). The instructor predesigned several questions and interacted with students through the bingo games. During the games, the instructor controlled how many bingo cards were to be flipped after collecting sufficient ideas or thoughts. If students responded very often, then they had more chances of flipping more bingo cards, and all groups could cross the number on their own cards. For some open-ended (critical thinking-oriented) questions, the students were particularly required to furnish detailed answers with explanations. There was also a rule for the bingo game: the students could not flip the bingo card if the answers made no sense. Hence, more meaningful answers would emerge because the students were eager to achieve a line on the bingo card (vertical, diagonal or horizontal with five numbers). Finally, the instructor determined how many groups could be the winners and who could obtain extra points.

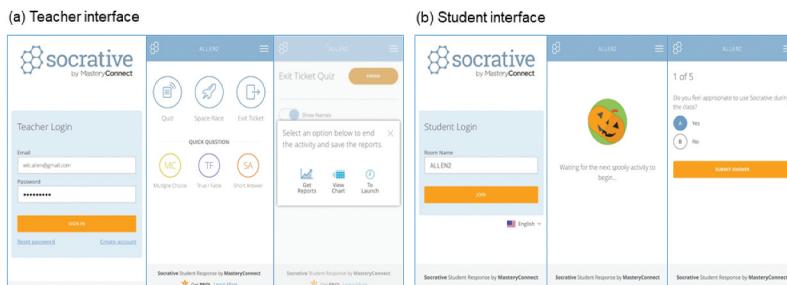


Figure 1. Snapshot of Socrative teacher interface and student interface.



Figure 2. Bingo card set.

### Questionnaires

A set of self-developed questionnaires was employed to measure the participants' reflections on the improvement of their critical thinking ability and on the value of the bingo games and Socrative with regard to learning motivation, knowledge sharing and critical thinking ability.

The questionnaire consisted of four sections. The first section included an item for self-rated critical thinking ability before the experimental instruction (the pre-test) and after the experimental instruction (the post-test). The response options ranged from 1 to 10, representing the degree from low to high. The second section comprised one item for self-reflection on the value of the bingo games employed during the experimental instruction with regard to improvement in learning motivation and critical thinking ability. The third section consisted of two items for self-reflection on the value of Socrative employed during the experimental instruction with regard to improvement in learning motivation and critical thinking ability. Finally, an open-ended question was provided to encourage the participants to provide comments and suggestions with regard to the use of bingo games and Socrative in the experimental instruction (see the Results session for the question items). In this study, quantitative data were cross-referenced with qualitative data from the open-ended questions during the data analyses to address the research questions proposed in this study.

### Instructional design and procedures

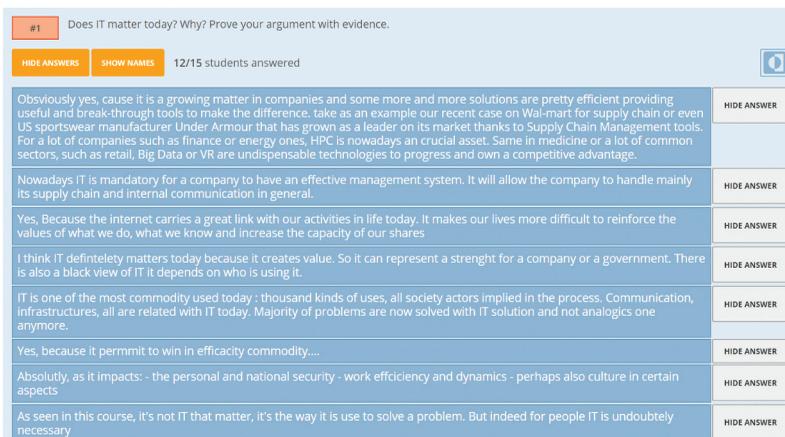
The instructional design in this study was to enhance learning motivation, knowledge sharing and critical thinking ability through a blended design of game-based learning. The entire experimental instruction was employed through the course 'Information Management' (a three-credit course) taught by the first author. The objectives of this course were to learn the basic concepts of information technology, the importance of information technology and the application of information technology in enterprises; additionally, intrinsic motivation, knowledge sharing and critical thinking were encouraged. The course content was selected from the Harvard Business Publishing database; however, the instructor reorganised and integrated the content with new articles, cases and recent news. The learning outcome was evaluated by the midterm exam and the final exam. The types and design of questions for the midterm and the final exams were identical. Specifically, five essay questions were included and four fundamental critical thinking skills, namely assumption identification, inference, interpretation and argument evaluation, were scored. For each essay question, the full score was 20 points. The scoring rubrics were as follows:

- (1) Level 1 (0 up to 10 points): only the main concepts and the lower level of critical thinking skills (e.g. assumption identification and reasoning with no evidence) were provided;
- (2) Level 2 (11 to 15 points): in addition to Level 1 skills, more reasoning with evidences and inferences were provided; and
- (3) 16 to 20 points: in addition to Level 1 and Level 2 skills, new concepts with own opinions were clearly presented.

All participants were required to provide feedback anonymously for the midterm via Socrative and for the final exam via the questionnaire. Giving feedback anonymously can encourage the expression of honest and critical opinions.

The experimental instruction lasted 18 weeks. The process of the lecture was divided into two components: concept delivery and discussion. The two components encompassed the essentials of critical thinking that could ensure the learning outcome of the course. During the experimental instruction, bingo games were provided every week in the class to give opportunities to obtain an extra bonus on top of the final grade. The mobile application (Socrative), however, was only used in the second half of the experimental instruction (after the midterm test). Students were requested to bring their own smartphones to the class every week after midterm. During the learning, all students had their own smartphones with Internet access. They were allowed to use the instructor's desktop if the Internet was disconnected or when the students preferred not to use their own devices.

Specifically, the participants were asked to form groups (mostly five to seven students in each group) in the first week of the semester. From the second week of the semester to the end of the experimental instruction, each group was given two bingo cards for participation and competition each week. Meanwhile, the participants were asked to read the assigned article(s) every week. From the 18 weeks of bingo games and Socrative, interactions were integrated to enhance learning motivation, knowledge sharing and critical thinking ability and, further, to understand the key concepts being taught through peer interactions. The instructor also posted questions with different levels of difficulty on Socrative, and the participants were asked to provide their thoughts using their student ID or anonymously responding on Socrative (see [Figure 3](#)). The examinations were administered in the tenth week (midterm exam) and eighteenth week (final exam). The midterm and final exams each consisted of half of the content of the 18 weeks in terms of short-answer questions.



#1 Does IT matter today? Why? Prove your argument with evidence.

HIDE ANSWERS SHOW NAMES 12/15 students answered

Obviously yes, cause it is a growing matter in companies and some more and more solutions are pretty efficient providing useful and break-through tools to make the difference. take as an example our recent case on Wal-mart for supply chain or even US sportswear manufacturer Under Armour that has grown as a leader on its market thanks to Supply Chain Management tools. For a lot of companies such as finance or energy ones, HPC is nowadays an crucial asset. Same in medicine or a lot of common sectors, such as retail, Big Data or VR are indispensable technologies to progress and own a competitive advantage.	HIDE ANSWER
Nowadays IT is mandatory for a company to have an effective management system. It will allow the company to handle mainly its supply chain and internal communication in general.	HIDE ANSWER
Yes, Because the internet carries a great link with our activities in life today. It makes our lives more difficult to reinforce the values of what we do, what we know and increase the capacity of our shares	HIDE ANSWER
I think IT definitely matters today because it creates value. So it can represent a strenght for a company or a government. There is also a black view of IT it depends on who is using it.	HIDE ANSWER
IT is one of the most commodity used today : thousand kinds of uses, all society actors implied in the process. Communication, infrastructures, all are related with IT today. Majority of problems are now solved with IT solution and not analogies one anymore.	HIDE ANSWER
Yes, because it permit to win in efficacy commodity...	HIDE ANSWER
Absolutely, as it impacts: - the personal and national security - work efficiency and dynamics - perhaps also culture in certain aspects	HIDE ANSWER
As seen in this course, it's not IT that matter, it's the way it is use to solve a problem. But indeed for people IT is undoubtedly necessary	HIDE ANSWER

Figure 3. Snapshot of a student's responses on Socrative.

## Data analysis

To achieve our goals of this study, we employed mixed methods, which refers to a methodology of research that advances the systematic integration by mixing quantitative and qualitative data within a single investigation; such procedures have been developed and refined to suit a wide variety of research questions (Creswell & Plano Clark, 2017). Content analysis (Erlingsson & Brysiewicz, 2017) was employed to analyse the participants' responses on the reflection questionnaires, which measured the participants' feelings on the improvement of their critical thinking ability as well as the value of bingo games and Socrative with regard to learning motivation, knowledge sharing and critical thinking ability. In doing content analysis, we first read and re-read the participants' responses to get a sense of the whole. Then, we divided up the text into meaning units and condensed these meaning units further. Finally, we labelled condensed meaning units by formulating codes and then grouping these codes into categories. To increase objectivity, we also calculated the frequency of each important response to illustrate its strength.

In addition, quantitative data were analysed. Two repeated-measures analysis of variance were employed to examine the improvement in critical thinking based on the self-evaluation pre-test and post-test scores as well as the scores of the midterm and final exams. The within variables included in the two repeated-measures of variance were test (pre-test vs. post-test) and exam (midterm vs. final).

## Results

### Effects of the bingo games on learning outcomes

To examine the effects of the bingo games on the learning outcomes, the following reflection question was posed at the end of the experimental instruction: 'What do you think the bingo games can help with in regard to the learning of this course?' The participant feedback showed certain successful factors regarding the use of the bingo games (Table 1). According to the qualitative analysis, among 86 students, the most frequently noted responses related to motivation were 'drawing attention and being focused on learning' (49%) and 'increasing discussion and participation' (30%). Other responses were 'enhancing joyfulness' (8%), 'enhancing the attractiveness of the course and atmosphere' (8%), 'facilitating brainstorming' (6%) and 'encouraging attendance' (2%).

Moreover, most participants (58%, 50 out of 86) agreed that a break every 15 minutes for bingo games could appropriately prevent them from becoming distracted. The participants also pursued extra points on top of the final grade by active participation, as demonstrated by the higher level of

**Table 1.** Participant reflections on the use of the bingo game.

Identified factors	Count	%	Example of response
<i>Motivation</i>			
• Focused attention	42	49%	'I think using the bingo game with the lecture helps me stay focused and learn joyfully.'
• Discussion and participation	26	30%	'Bingo games can enhance class discussion and participation.'
• Joyfulness	7	8%	'I think the bingo game is really helpful because it not only brings fun but also enhances student engagement in learning.'
• Atmosphere and attractiveness	6	8%	'The bingo games can make learning much more interesting. Students have the chance to have fun and, at the same time, get more involved in the class with questions and answers. It brings the spirit of team work.'
• Attendance	2	2%	'Bingo games can encourage me to attend the class.'
<i>Critical thinking</i>			
• Critical thinking	10	12%	'Bingo games can stimulate interaction and critical thinking in the class.'
• Brainstorming	5	6%	'Bingo games can force me to think and train my logic.'

attendance. A total of 12% of the participants also indicated that the bingo games could improve their critical thinking because they were willing to answer questions. Meanwhile, brainstorming through interaction in the class also contributed to stimulating the participants to propose more different and critical answers.

## Effects of Socrative on learning outcomes

### Socrative and motivation

Since nine participants dropped out after the midterm, only 77 participants were included in the feedback on Socrative. Table 2 shows the identified key benefits of using Socrative from the feedback of 77 participants. A total of 64% of the participants considered that the use of the mobile application could enhance critical thinking skills in terms of interaction and idea sharing. Three reflection questions were posed to examine the effects of Socrative on learning outcomes. The reward system (bonus or extra credit) used in the classroom also encouraged the participants to interact and participate because they felt joyful towards achievement (motivation) and because Socrative allowed them to share knowledge more easily in the classroom. Moreover, 8% of the participants noted that Socrative could enhance their intention of learning, and 8% of the participants indicated that Socrative had fewer limitations on their learning process and knowledge sharing. Moreover, Socrative is an instant mobile application that may stimulate ideas by showing all responses on the board, which 18% of participants noted in the feedback.

### Socrative and knowledge sharing

A total of 70% of participants considered that Socrative helped them share knowledge (Question 2 in Table 2). Moreover, 64% of participants enjoyed sharing ideas, 9% of participants particularly favoured the instant and anonymous knowledge sharing (Question 1 in Table 2), and 23% of participants felt comfortable with sharing ideas (Question 3 in Table 2). Through Socrative,

**Table 2.** Participant reflections on the use of Socrative.

Identified factors	Frequency	%	Example of response
<i>Question 1: Do you think that the use of mobile application for learning purpose in the class can enhance your critical thinking skill? Why?</i>			
• Interaction/Idea sharing	49	64%	'I rarely speak in the class, but Socrative was fun and allowed us to share ideas easily.'
• Instant and anonymous knowledge sharing	7	9%	'I can see many aspects of knowledge from other responses.'
• Intention to participate	6	8%	'I can use the mobile application to share my thoughts without revealing my identity.'
• Fewer limitations to learning	6	8%	'I have a higher intention to participate in the class by using the mobile application.'
			'For me, mobile devices and applications reduce the limitations of the learning process in the class.'
<i>Question 2: Do you think that using the mobile application in the class is useful to you? Why?</i>			
• (Anonymous) knowledge sharing	54	70%	'I can obtain new knowledge from others' responses.'
			'I can share knowledge anonymously, which is close to real thinking.'
<i>Question 3: What aspects of Socrative enhance your critical thinking skill?</i>			
• Brainstorming	55	71%	'Socrative helps brainstorming and allows us to see the responses of others.'
• Interaction	25	33%	'I can review and criticise others' responses critically, and I learned from different aspects.'
• Critical thinking and sharing	18	23%	'I feel comfortable training my logical thinking and sharing with others by using Socrative.'
• Focused attention	14	18%	'Socrative can draw my attention in the class when I am sometimes distracted.'
• Idea stimulating	14	18%	'The use of Socrative is helpful because I can see different ideas and critically stimulate more thoughts.'

participants could observe the responses of others on a projector instantly, which gave them pressure to provide different answers. The participants also responded that Socrative indeed encouraged them to share on their own mobile device because they were very shy to speak out. Moreover, the intention to share and to think actively and independently, with no limitation on the answers and with the intention of learning, was also reflected in the feedback. On the other hand, we used Socrative to encourage knowledge sharing in class for eight weeks after the midterm exam (tenth week), and the average sharing rate on Socrative was 80.5%. The highest rate was 90.9%, whereas the lowest rate was 66.23%. These results indicate that Socrative effectively motivated participants to share thoughts and knowledge.

### ***Socrative and critical thinking***

Most participants (71%) considered that brainstorming was helpful for their critical-thinking process (see responses of Question 3 in Table 2). Moreover, many participants responded that idea sharing (64%) and knowledge sharing (9%) through Socrative contributed to their enhancement of critical thinking (see responses in Question 1 and Question 2). They believed that their logical and critical thinking ability was improved when they observed others' responses. If the answers were something that they had never thought about, they would internalise the knowledge. Notably, 33% of the participants indicated that the interactions helped improve their critical thinking skill, and 23% of the participants considered that Socrative helped them think and share. In addition, 18% of the participants reflected that Socrative indeed drew their attention and forced them to think quickly. Since the quizzes used mostly consisted of open-ended questions requiring short answers, they felt comfortable providing ideas anonymously.

### ***Improvement of critical thinking in self-evaluation and exams***

Moreover, a self-evaluation question, 'Please rate yourself on critical thinking ability from low to high (1 to 10)', was employed to evaluate the participants' improvement in critical thinking ability at the beginning and the end of the experimental instruction. The results of the repeated-measures analysis of variance indicated that the participants' self-evaluation of critical thinking significantly improved after the experimental instruction ( $M_s = 6.02$  vs.  $7.20$ ),  $F = 47.706$ ,  $p < .001$ ,  $\eta_p^2 = .389$ .

In addition, the results of the repeated-measures analysis of variance showed that the participants obtained higher scores on the final exam than on the midterm exam ( $M_s = 68.43$  vs.  $80.89$ ),  $F = 41.965$ ,  $p < .001$ ,  $\eta_p^2 = .336$ . In both exams, the critical thinking skills of assumption identification, inference, interpretation and argument evaluation were integrated. Accordingly, the results revealed that the blended design contributed to the participants' improvement in critical thinking, particularly in assumption identification, interpretation, explanation and reconstruction.

### ***Integrated results***

The participants' feedback, self-evaluation and objective test results showed that the bingo games and Socrative led to positive learning outcomes. The results of the teacher assessment on the blended course by the participants also proved that the blended teaching approach was highly valued by the participants in terms of teaching skills and learning outcomes. The participants scored the instructor's teaching skills at 5.54 points out of 6 points and scored their own learning outcome at 5.63 points out of 6 points. Altogether, the results confirmed that the blended design not only enhanced the participants' learning motivation and knowledge sharing but also improved their critical thinking.

Integrating the findings of this study, both the bingo game and Socrative may contribute to learning outcomes through the mechanisms of focused attention, brainstorming, active participation, interaction and logical thinking. In addition, the bingo games may contribute to the learning outcomes through being willing to discuss and participate; enhancing joyfulness, atmosphere and

attractiveness; and encouraging attendance. Based on the participants' responses, Socrative enhanced the learning outcomes through facilitating interaction/idea sharing and (anonymous) knowledge sharing; reducing limitations of learning; and enhancing idea stimulation. Therefore, the use of bingo games and Socrative may improve the participants' motivation, knowledge sharing and critical thinking. The relationships of the experimental instruction, enhancing mechanisms and three learning outcomes are illustrated in Figure 4.

To summarise, while the bingo games may contribute more to enhancing learning motivation, Socrative may lead to more knowledge sharing and critical thinking. In addition, both approaches had positive influences on learning outcomes through both different mechanisms and shared mechanisms. Notably, there were interactions among motivation, knowledge sharing and critical thinking, and the blended approach, which integrated the bingo games and Socrative, improved the participants' critical thinking.

## Discussion

This study aimed to develop a domain-specific instructional design for blended game-based learning (bingo games and a mobile application) to enhance learning motivation, knowledge sharing and critical thinking ability. All the hypotheses proposed are supported by the findings. Using Socrative, the instructor could provide comments for real-time discussion when the responses were revealed via the projector. The students also indicated that they had a stronger intention to participate because of the bingo games and that Socrative provided an easier vehicle for idea and knowledge sharing than traditional lectures. A great majority of participants responded that Socrative helped knowledge sharing, and they felt comfortable and enjoyed knowledge sharing through this mobile application. Through Socrative, participants could observe the responses of others on a projector instantly, which gave them pressure to provide different answers. The participants also responded that Socrative indeed encouraged them to share on their own mobile devices. Moreover, the intention to share and to think actively and independently, with no limitation on the answers and with the intention of learning, was also reflected in the feedback. Therefore, Socrative provides a great tool for encouraging the intention and outcome of knowledge sharing, especially when learners are afraid of face-to-face sharing in the class. With regard to the effects of the bingo games and mobile application, a great majority of the students believed that bingo games contributed to

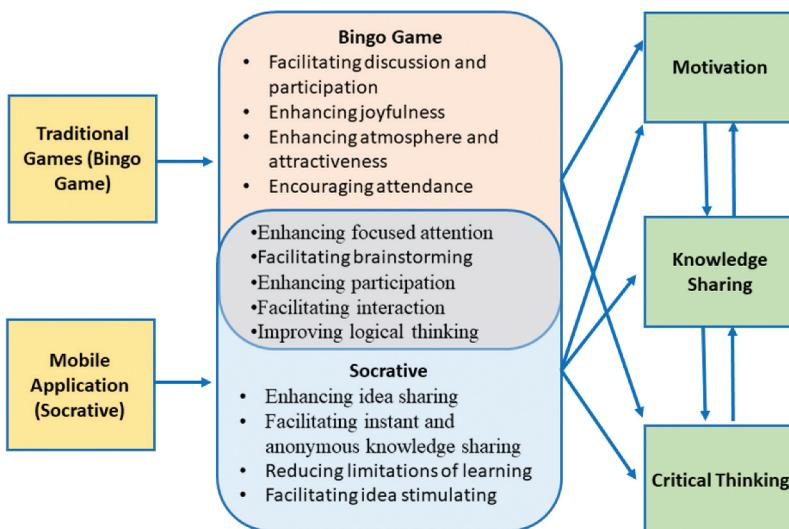


Figure 4. A model of instructional design and integrated results.

drawing attention and being focused on learning as well as increasing discussion and participation. The results suggest that successful games in the class increase fun learning, satisfaction, learning effects, interaction, motivation and learning outcomes. Consequently, the findings of this study support hypothesis 1.

For the students, using Socrative on their own smartphones in class was a new experience. Socrative allowed them to respond in private and revealed all responses without revealing identities. Many students indicated that the employment of mobile applications and Socrative contributed to critical thinking through brainstorming, discussion and interaction, critical thinking and sharing, idea stimulation and brainstorming. The participants also noted that the use of Socrative enhanced their learning motivation and knowledge sharing. The results supported that use of a mobile application enhances learning outcomes and the knowledge-sharing intention; the results also suggest that discussion is critical to knowledge sharing. Moreover, the participants specified that the bingo game and Socrative enhanced their motivation to engage with knowledge sharing, which may potentially stimulate their critical thinking to provide more unique responses to be competitive. Accordingly, the results of this study support hypothesis 2.

The proposed blended game-based instructional approach provides tangible and intangible stimuli for improving critical thinking ability. The participants self-rated that their critical thinking ability improved from the beginning of the semester to the end of semester by 20%. The participants agreed that their critical thinking ability was enhanced by using the bingo game and mobile application during the class. According to the students' feedback, the use of the bingo game was a key factor in motivating them to think critically because they wanted to provide more diverse answers. More answers could lead to more opportunities to flip the bingo cards, which would allow the students to reach a line to obtain a bonus or extra credit. The bingo games may help the students observe each other's responses, while Socrative may encourage conservative students to think and share on their own devices. Moreover, the students' responses revealed that a strong degree of motivation could stimulate knowledge sharing, which further brought about critical thinking. The results suggest that a blended model can stimulate critical thinking and effective outcomes. In summary, the evidence confirms hypothesis 3.

Notably, the blended model proposed in this study highlights the individual features of a single method and the joint features of mixed methods. The use of the bingo game enhanced focused attention, which was identified as the top feature. The intention to discuss in class was also improved because the students could brainstorm and interact when they were sharing ideas and knowledge. On the other hand, opportunities for idea and knowledge sharing and for brainstorming were increased by using Socrative; these were identified as the top factors in the students' feedback. The advantage of Socrative also improved the willingness to interact in class. Accordingly, integrating the traditional bingo game in class and Socrative through mobile devices may amplify learning effects on critical thinking.

## Conclusion

This study proposed a blended instructional approach in which game-based learning and mobile learning are integrated. Compared to a traditional single method, the proposed blended model seems to have greater power in attracting students to engage in learning, interaction and knowledge sharing. In particular, the bingo game may contribute more to enhancing learning motivation and critical thinking, whereas Socrative may lead to more knowledge sharing and critical thinking.

How to decrease distraction and how to increase participation have been the major issues in traditional classroom teaching. The students' feedback reflects a strong and positive impression of the blended design employed in this study. The integration of a traditional game and a mobile application not only provides the advantage of an individual method but also enhances shared features such as focused attention, brainstorming, active participation, logical thinking and

interactions. These findings provide a new teaching approach for improving motivation, knowledge sharing and critical thinking in domain-specific game-based learning.

In this study, we employed blended design which includes a traditional bingo game and a mobile application in the instruction of information management. The positive outcomes provide an example for employing such a blended design in the related instruction of information management. In addition, the identified important mechanisms in this study not only confirm the novelty of this research but also provide practical value for instruction in higher education.

## Limitations and suggestions

Due to the difficulty of obtaining a control group (a class without a blended design) to complete all of the pre-tests and post-tests, this study used a before-and-after design. However, both quantitative and qualitative methods were employed to increase the reliability and validity of the findings. Moreover, such quasi-experimental design makes the instructional design available for direct application in related instruction.

Although the qualitative and quantitative results are consistent and suggest that the blended design employed in this study could be an effective way to improve college students' learning motivation, knowledge sharing and critical thinking, further studies may validate the findings of this study by adding a control group. Moreover, the design of the midterm and final exams in this study was based on short-answer questions related to the learning content; future studies can also use a domain-general critical thinking test to confirm the instructional effects and to compare and contrast the effects of such a blended design on improving domain-specific versus domain-general critical thinking.

Finally, the availability and motivation to use smartphones in learning is critical to the success of employing the blended design of game-based learning. To maximise the learning effects, instructors can break an hour into several learning sessions by deploying the bingo game (to draw attention) and the mobile application (to enhance interaction) in classroom activities, which should enhance the motivation to play and to interact. On the other hand, time management is important for utilising the mixed methods in instruction. Instructors need to plan a waiting time of five to ten minutes, for coming up with responses may need more time than expected. Finally, well-prepared content for interactions is required for the success of the mixed methods. However, it can be a great burden for instructors.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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