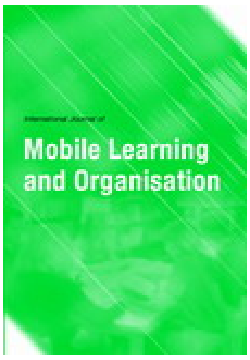

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Predictors of active and inactive learners' intention to use decision tree-based contextual mobile games for cultivating digital citizenship behaviour

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Abstract: Recently, scholars have suggested artificial intelligence to enhance digital game-based learning by considering applications of the decision tree-based method. However, the technology acceptance model still needs to be determined to reveal findings from active and inactive students. With a validated questionnaire, the stepwise multiple regression technique was used to analyse the data collected from 434 samples in secondary school settings. It was found that active students thought an effective mobile game would include particular situations or tasks and the materials and methods influencing the adjustment of their behaviours. It is interesting to note that active students' attitudes toward the decision tree-based contextual mobile gaming system are largely influenced by how easy they perceive the use of the system to be. Regarding the findings, this study discusses further implementation by properly developing and implementing the decision tree-based contextual mobile gaming approach to cultivate students' digital citizenship competencies.

Keywords: AI in education; learning patterns; mobile learning; technology-enhanced learning; intention.

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1 Introduction

Educators have acknowledged digital citizenship as an essential learning activity for developing digital natives' safe computer and communication technology use in their daily lives (Ng, 2012; Ribble, 2011). Recent research has defined digital citizenship as improving online respectful behaviour and civic involvement through a reduction in online harassment and an increase in bystander assistance (Hollandsworth et al., 2017; Jones and Mitchell, 2016; Searson et al., 2015). That is to say, digital citizenship behaviours cover the aspects of knowledge, skills, and characterisation of a responsible, upstanding citizen, being respectful of our rights in accessing, communicating, and participating in the digital world while being empathic, respectful, and actively protective of others' rights as well. Providing digital citizenship learning activities that train students to think critically, exercise effective decision-making, behave safely, and participate ethically in everyday digital world scenarios is a challenge. Scholars have suggested that situating instruction in authentic situations could assist students in applying classroom knowledge to their everyday lives, enhancing their learning incentives and learning achievement (Mayer, 2002; Wang et al., 2018). Therefore, by allowing students to access contextual learning, whether for entertainment or education, they can acquire knowledge for behaving in daily life.

Considering the importance of computer and multimedia technologies in education, several researchers have found that digital games can help students enjoy studying and acquiring knowledge (Erhel and Jamet, 2013; Mayer and Johnson, 2010; Prensky, 2001). Recently, scholars have developed digital games to play on personal computers (PCs) and mobile devices and proved that mobile games lead to positive learning results, but incorporating a suitable pedagogy into the mobile game can also improve learning outcomes. For example, Hwang et al. (2019) integrated concept mapping and mobile gaming approaches for enhancing geology learning activities. Maskeliūnas et al. (2020) applied interactive learning and contextual approaches to implement a serious mobile game supporting computer programming learning. Yadav and Oyelere (2021) employed a contextual learning approach to the mobile game to motivate students to complete computing education. Although previous studies have successfully presented technology-integrated context-based learning to place students in authentic circumstances and motivate them to create knowledge or skills during interactive activities (IAs), it still needs to be improved to deliver quick feedback (Connolly et al., 2012). Therefore, assisting and directing students' learning activities is essential for accomplishing learning.

Artificial intelligence (AI) is a computational machine capable of performing actions that require human intelligence (Chen et al., 2020; Hwang et al., 2020). It has been exponentially recognised as a new means to overcome obstacles in various fields (Aguilar et al., 2021; Chintalapati and Pandey, 2022; Enholm et al., 2021; Nguyen et al., 2021). AI paradigms have been utilised in education for profiling, forecasting, measuring, and evaluating students' performances or academic judgments, either as intelligent tutoring systems or through giving help that is adaptive to students' learning needs (Tang et al., 2021). AI-powered approaches have improved young students' learning performance and resulted in effective adult learning improvement (Chaipidech et al., 2021, 2022; Kajonmanee et al., 2020). It is acknowledged that traditional AI techniques, such as the decision tree approach, can improve students' knowledge construction, affection, and skills. Scholars have proposed integrating contextual learning and decision-making to motivate students to complete game-based learning activities (Hwang and Chang, 2020).

Accordingly, this current study referred to a previous study by adopting the decision tree-based mobile gaming approach (Tapingkae et al., 2020). The previous study statistically examined the successful improvement of good digital citizenship behaviours. Scholars pointed out that mobile game is a part of mobile learning, allowing students to learn anywhere and anytime with their mobile device/tablet/smartphone to accomplish the specific task and learning goal (Daungcharone et al., 2019; Komalawardhana et al., 2021; Bunyakul et al., 2022). With this perspective, the decision tree-based mobile gaming approach could help students practice good behaviours when facing authentic situations. Previous studies suggested that understanding students' attitudinal factors and concerning instructional design would enhance the effectiveness of e-learning instruction (Karimi, 2016; Hou et al., 2022; Northrup, 2001). Understanding students' attitudes (ATs) and learning motivations to use decision tree-based mobile gaming systems is an issue for improving the effectiveness and utilisation of decision tree-based mobile gaming in this study about technology acceptance, gaming environment, and student characteristics, particularly for students' various learning behavioural patterns (Tapingkae et al., 2020). Furthermore, the challenge of the students' frequency of involvement (active/inactive) in mobile learning activities still needs to be investigated to understand the effectiveness of the learning environment (Chang and Lan, 2021). On the other hand, using logs of e-learning to analyse the students' learning behavioural patterns could help teachers and researchers improve e-learning strategies (Hwang et al., 2021). However, the effects of gaming features on students' perceptions, ATs, and learning motivations within the technology acceptance model (TAM) have not been examined using contextual learning and decision tree techniques in mobile games. Consequently, this study aimed to address this uninvestigated area by investigating the gaming environment and students' internal factors influencing their decision tree-based contextual mobile gaming system acceptance. Two research questions guided this study:

1. What are the differences in the behavioural patterns of active and inactive students who adopted a decision tree-based contextual mobile gaming system to learn and interact?
2. What are the predictors of the active and inactive students' acceptance of a decision tree-based contextual mobile gaming system?

2 Literature review

2.1 Teaching and learning of digital citizenship behaviours

Digital citizenship is the concept and behaviour of using computer and communication technology safely, legally, and ethically (Ribble, 2011). The educational goals of digital citizenship include encouraging students' accurate perceptions and use of computer and communication technologies, and preventing them from engaging in inappropriate online conduct, such as cyber-bullying, harmful contact, and harassment. Recently, numerous studies have proposed teaching models and learning resources for the delivery of the concept of digital citizenship (Bolkan, 2014; Common Sense Media, 2016; D'Haenens et al., 2007; Fredrick, 2013; Hollandsworth et al., 2017; James et al., 2009; Jones and

Mitchell, 2016; Ribble et al., 2004). For example, the digital citizenship curriculum from Common Sense Media, for instance, has been widely implemented to assist students in practicing critical thinking and responsible behaviour in the digital world (Common Sense Media, 2016). Students must have digital literacy following the information and communication technology (ICT) course of Thailand's basic education core curriculum AD 2008 and the computing science course of the updated curriculum (OBEC, 2017). Learning scenarios supported by information communication technologies and games were proposed to support students' digital competence in primary and secondary schools in European countries (Maina et al., 2020). Researchers indicated that cyber-bullying is a significant concern, particularly among adolescents aged 12 to 14, seventh to ninth graders (Sittichai, 2013; Tokunaga, 2010). Digital citizenship is the belief that students should learn about digital literacy as part of their 21st-century abilities to utilise them for meaningful goals (Ng, 2012). However, it has not been easy to develop appropriate instruction for cyber-bullying, digital drama, relationships, and online communication. The universal context has been preparing students in the grade range with the greatest cyber-bullying problem to be good digital citizens in real-world settings (Common Sense Media, 2016; Tapingkae et al., 2018). Accordingly, well-designed teaching of digital citizenship has been challenging to facilitate a resourceful, interactive, engaging, and transferable learning environment in which students can participate and rehearse pro-sociality in situations harmonising with their real-world experience (Ferreira et al., 2021).

2.2 Mobile games in education

In the past decade, scholars have recognised that digital game-based learning combines enjoyment and educational objectives to improve knowledge and cognitive changes (Erhel and Jamet, 2013; Mayer and Johnson, 2010; Prensky, 2001). Numerous researchers have examined the actual benefits of digital game-based learning and discovered that it has become an effective learning tool in terms of motivation and learning (Chen et al., 2016; Erhel and Jamet, 2013; Giannakas et al., 2017; Hainey et al., 2016; Hawlitschek and Joeckel, 2017; Khan et al., 2017; Vasalou et al., 2017). With the advantages of digital game-based learning, students can experience curiosity, challenge, novelty, and delight, thereby being motivated to learn. It can be used to measure performance, decision-making, adaptability, and capacity in comparison to learning standards (Hwang et al., 2017; Prensky, 2001; Vasalou et al., 2017) and the impact on students' perceptual, cognitive, behavioural, affective, and motivational results (Connolly et al., 2012; Hainey et al., 2016).

Recently, digital games can be developed as mobile games on mobile devices. Previous studies have proved that mobile games could be used for educational purposes for learning anywhere, anytime. For example, Komalawardhana and Panjaburee (2018) developed a mobile game for a general physics course to increase students' chances of actual practice solving authentic problems. Yadav and Oyelere (2021) utilised a contextual learning-based mobile game to assist students' computing learning in a specific context. Bunyakul et al. (2022) simulated medical technology using a mobile game to foster their clinical chemistry laboratory learning. These studies have pointed out that contextual mobile games could enhance students' learning achievement and motivation by situating them in a context relevant to daily life. Moreover, scholars have revealed the potential for an AI-based approach using the decision tree technique in gamification scenarios to improve learning achievement and motivate students to learn (Sung et al., 2015). Teachers can evaluate students during learning experiences using a decision-making tree framework that identifies the relationships between students' interactions and the assignments (Kelly, 2003). The choice experiences fostered the development of students' critical thinking skills and directed them to form their knowledge (Sung et al., 2015; Vasalou et al., 2017). Taken together, previous studies suggest that using mobile games with a contextual approach and the decision tree technique can be an effective approach to motivate students' learning. However, there are fewer studies to analyse logs for investigating students' behavioural learning patterns influencing their perceptions and acceptance of mobile games.

2.3 Technology acceptance model

The TAM was used to examine the acceptance of technology based on user behaviour (Davis, 1989). Thus, beliefs are defined as the individuals' estimated chance that engaging in a certain behaviour would result in a given outcome (Teo et al., 2009). Perceived usefulness (PU) is a characteristic that influences usage intent directly. A user with a positive AT toward using any technology could then demonstrate the purpose of employing conduct that corresponds to the first relation. In the case of PU, a user who focuses more on cognitive settings, such as improving performance by using the system, could establish the behavioural intention (BI) to employ it, regardless of whether they have a good or negative AT towards it.

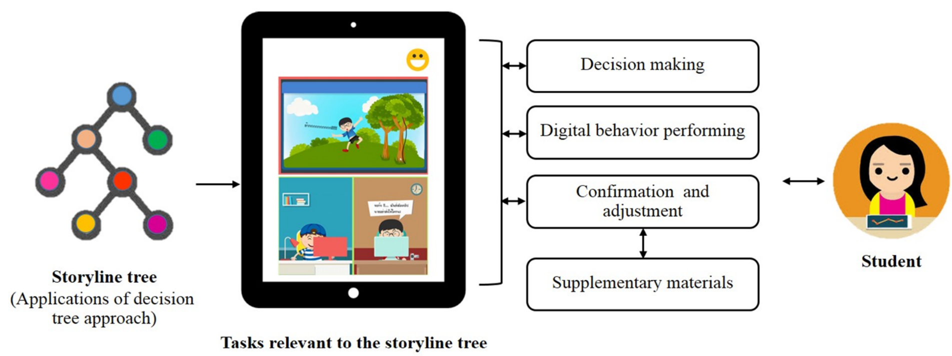
Numerous scholars have extensively investigated TAM in various domains, including learning, focusing mostly on influence intention elements. Cheung and Vogel (2013) used TAM to explain the elements influencing Google Application acceptance for collaborative learning. Similarly, Abdullah and Ward (2016) collected the external elements of TAM often utilised in e-learning adoption and identified the effects of these factors on students' views of e-learning. In digital game-based studies, various works have used TAM as a framework. For example, Chen and Lin (2016) implemented a TAM-based questionnaire to evaluate the usability and students' acceptance of situated digital games in language learning, including the relationship between predictive factors. It was found that PU was crucial to the students' positive ATs toward the digital game-based learning system. Maskeliūnas et al. (2020) modified TAM to model the constructs affecting the adoption of a mobile game for learning JavaScript programming and for analysing and giving suggestions for successful game development. The survey revealed positive connections between PU and ease of use, and between AT towards use and intention to use the mobile game. Yeo et al. (2022) adapted TAM to examine primary school teachers' acceptance of a digital mathematics game and their intention to use it to support mathematics teaching. Their findings also confirmed the correlations between ATs, environmental support, perceived ease of use (PEU), and usefulness with intentions to use the digital game.

Considering the acceptance of technology-enhanced learning, teachers must use appropriate pedagogical methods and technology when building digital learning tools. An interface design also assists users in resolving any technical issues that may develop when using a system (Metros and Hedberg, 2002). If the interface design is not comprehensive or does not fit users' needs, it will not improve their learning outcomes (Wang and Yang, 2005). Moreover, scholars have revealed that students' characteristics and the e-learning environment influence PU's effect on the intention to use e-learning, online games, and mobile learning (Lu, 2012; Sun and Zhang, 2006). However, few learning behavioural patterns have been examined, particularly those of active and inactive learners.

3 Research model and hypotheses setting

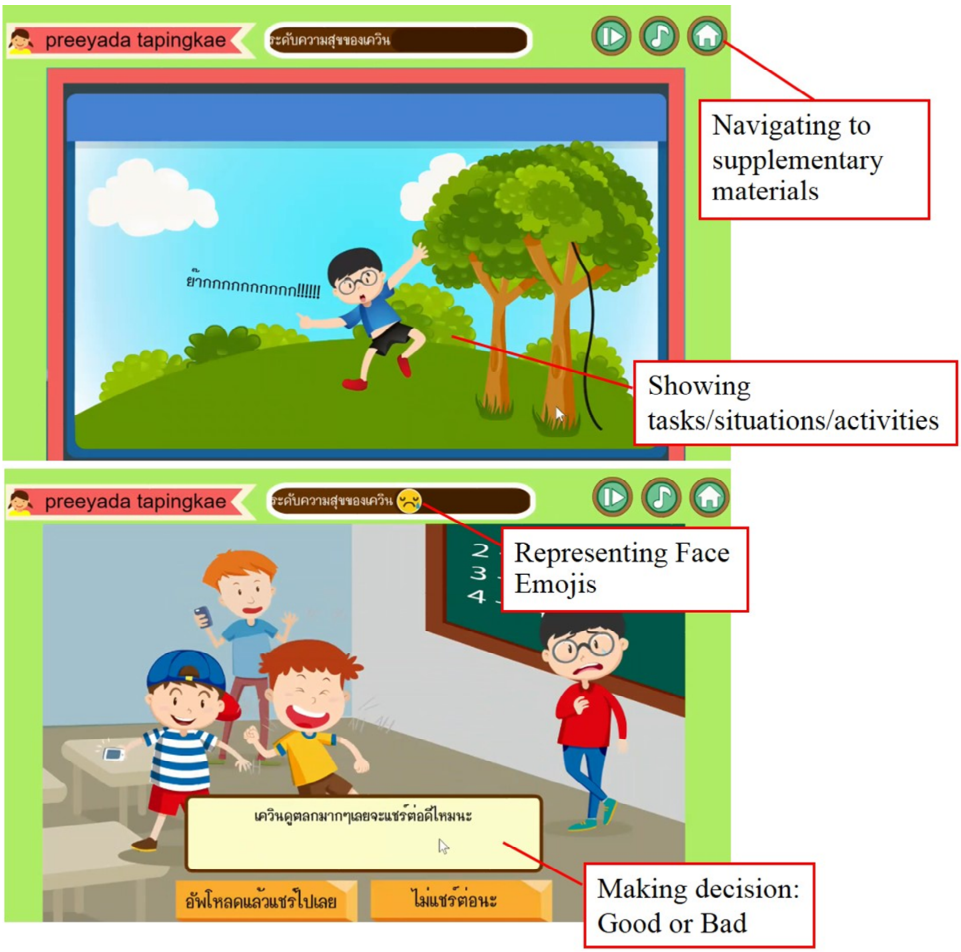
Regarding the challenges from previous studies mentioned above in the literature on mobile games using contextual approach and the applications of AI in education, in particular a traditional method, the 'decision tree approach', few studies have revealed the intention to use a decision tree-based contextual mobile gaming system while considering learning behavioural patterns with different degrees of system attendance. This study presents the key elements of the decision tree-based contextual mobile gaming system in Figure 1, drawing on our previous study (Tapingkae et al., 2020). The previous study evaluated the effects of a decision tree-based contextual mobile gaming system on successfully improving good digital citizenship behaviours, including online respectful behaviour, online civic engagement behaviour, helpful bystander behaviour, online harassment victimisation behaviour, and online harassment perpetration behaviour.

Figure 1 Key elements of the decision tree-based contextual mobile gaming system (see online version for colours)



As shown in Figure 1, digital tools' tasks/situations/activities as computer and technology mediums were designed based on the decision-making tree approach to construct the storyline tree. The tree was used to practice students' good digital citizenship and help them avoid punishment when they exhibited bad decisions in their digital usage. That is to say, the decisions of individual students were used to calculate the rewards by showing happy face emojis when they were perfect upstanders; otherwise, sad face emojis were shown when they were imperfect upstanders or merely bystanders, as shown in Figure 2. The students tested their behaviour again before moving on to the next tasks/situations/activities. If they showed incomplete or partial digital citizenship, even if they received a happy face emoji, the decision tree-based contextual mobile gaming system would automatically navigate to supplementary materials corresponding to incomplete or partial situations. In this stage, the system allowed the students to confirm and adjust their behaviours to be perfect/complete digital citizens. The system could help them practice good behaviours when using digital tools to communicate with others. The system statistically examined the effectiveness of the students' digital citizenship behaviours. In this current study, this system served as a decision tree-based contextual mobile gaming system for in-depth analysis logs during the gaming activities relevant to various learning behavioural patterns of active and inactive learners and a verified TAM.

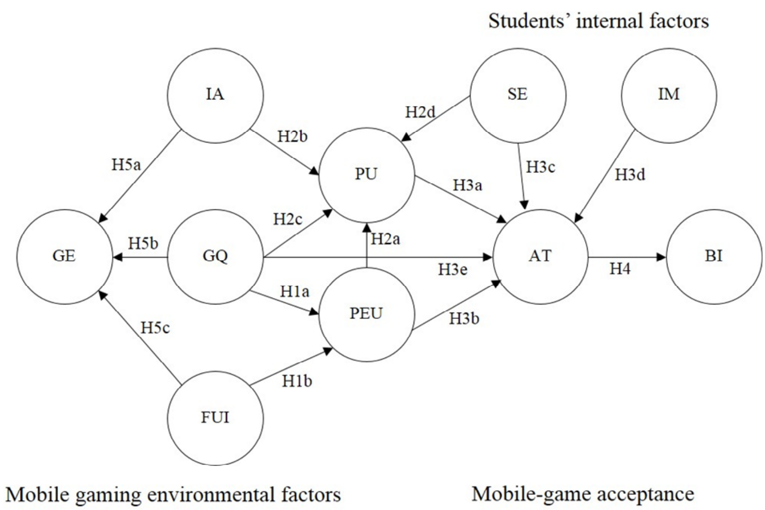
Figure 2 Screenshots of the decision tree-based contextual mobile gaming system (see online version for colours)



Source: Tapingkae et al. (2020)

Based on the study by Tapingkae et al. (2020), three elements factors be considered to predict continuing to use the decision tree-based contextual mobile gaming system, including gaming environment, students' characteristic factors, and perceptions relevant to TAM. In this study, the gaming environment and students' characteristics were external factors of the TAM regarding a mobile game-based learning system based on the key elements of the decision tree applications. In other words, these two external factors will positively predict the students' acceptance of the decision tree-based contextual mobile gaming system. Furthermore, from the instructional design concept, high interactivity and engagement of instruction aim for higher effectiveness of instruction. Previous studies relevant to technology-enhanced learning have suggested that TAM factors include the PEU of the system, PU, AT, and BI to use the decision tree-based contextual mobile gaming system (Lu, 2012; Karimi, 2016). With attitudinal factors of digital game-based learning, students' internal factors consist of self-efficacy (SE) and intrinsic motivations (IMs) when they use the decision tree-based contextual mobile gaming system to cultivate their good digital citizenship behaviours (Hou et al., 2022). Moreover, instructional design of e-learning has been applied for mobile gaming environmental factors, including IAs, mobile gaming system quality (GQ), and features and user interface (FUI) for ensuring mobile gaming effectiveness (GE) (Northrup, 2001; Liaw, 2008). Therefore, the conceptual model of this study is presented in Figure 3.

Figure 3 Conceptual model of research



Accordingly, the following hypotheses helped to frame research question 2:

H1 Perception of ease of use of the mobile gaming system (PEU) will be influenced by mobile GQ (GE: H1a) and the FUIs of the mobile gaming system (FUI: H1b).

H2 Perception of the usefulness of the mobile gaming system (PU) will be influenced by the ease of mobile gaming system usage (PEU: H2a), IA in the mobile gaming system (IA: H2b), mobile GQ (GQ: H2c), and students' SE motivation (SE: H2d).

H3 AT toward the decision tree-based contextual mobile gaming system (AT) will be influenced by the perceptions of its usefulness (PU: H3a) and ease of use (PEU: H3b), students' SE (SE: H3c), IMs (IM: H3d), and mobile GQ (GQ: H3e).

H4 Students' behaviour intention to use the decision tree-based contextual mobile gaming system (BI) will be influenced by their AT toward the mobile gaming system (AT).

H5 The decision tree-based contextual GE will be influenced by IA in the mobile gaming system (IA: H5a), quality (GQ: H5b), and FUIs (FUI: H5c).

4 Research methodology

4.1 Participants

In this study, the decision tree-based contextual mobile gaming system was developed and implemented in two secondary schools in the northern and central parts of Thailand. A total of 460 seventh- and eighth-grade students were recruited to use the decision tree-based contextual mobile gaming system as their primary learning tool in their extra time to foster their good behaviours when using digital tools.

A survey investigated students' perceptions, ATs, and motivations about the decision tree-based contextual mobile gaming system. Therefore, this study adopted and distributed the technology acceptance questionnaire to the students. That is to say, the participants were asked to learn with the decision tree-based contextual mobile gaming system for a month. They were then asked to complete the questionnaire, including ten different dimensions (i.e., PEU of the system, PU of practicing the behaviour, AT, BI to use the system, GE, FUIs of the game, GQ, SE motivation, IM, and IA). The questionnaire with a consent form was administered to participants before using the mobile gaming system. Moreover, their responses to the questionnaire were guaranteed confidentiality regarding the ethical principles of human research.

In all, 434 students responded to the online questionnaire, while 26 failed to complete it; therefore, the data of this study comprised 434 datasets used to test the hypotheses. The behavioural learning usage of the decision tree-based contextual mobile gaming system by those 434 students was analysed to categorise their behavioural learning patterns. With the suggestions of Chang and Lan (2021), the students' frequency of involvement in mobile learning activities could be calculated by considering average attendance. The average attendance of the decision tree-based contextual mobile gaming system was 25.78. Students with attendance exceeding 26 were classified as active students, while those under 26 were classified as inactive students; 210 students were in an active group, and 224 were inactive.

4.2 Research measurement

Regarding research question 1, apart from the attendance of the decision tree-based contextual mobile gaming system, this study categorised possible learning behaviours into decision-making, digital behaviour performing, and confirmation and adjustment. These categories highlight the active and inactive students' learning behavioural patterns under the decision tree-based contextual mobile gaming system. Decision-making collected the students' learning behaviours, such as performing their behaviours related to the tasks/situations/activities in the decision tree-based contextual mobile gaming system. Digital behaviour performing collected the students' learning behaviours, such as showing good or undesirable digital citizenship corresponding to the tasks/situations/activities in the decision tree-based contextual mobile gaming system. Confirmation and adjustment collected the students' learning behaviours, such as receiving more information relevant to the tasks/situations/activities in the decision tree-based contextual mobile gaming system. The coding scheme of learning behaviours using the decision tree-based contextual mobile gaming system is presented in Table 1.

Table 1 The coding schemes of learning behaviours under the mobile gaming system

Learning behaviour	*Sub-learning behaviour*	*Code*	*Description*
Decision making	Listen and read tasks/ situations/activities	LR	Listen to and read situations to analyse and make decisions about their behaviour.
	Make a good decision	GD	Demonstrate good digital citizenship behaviour.
	Make a bad decision	BD	Demonstrate bad digital citizenship behaviour.
Digital behaviour performing	Upstander	UP	Dare to change oneself, not ignore wrongdoings, and fight them purposefully.
	Bystander	BY	Do not dare to change oneself, ignore wrongdoings, and do not fight against them.
Confirmation and adjustment	Watch VDO-based supplementary materials relevant to problems/tasks/ situations/activities	SP	Watch, listen to, and read problem-solving questions to reflect on or affirm good digital citizenship behaviour accurately.
	Reflect on-answer problems/tasks/ situations/activities	AP	Reflect on and answer the problem situation, confirming good digital citizenship behaviour.
	Perfect upstander	HAP	Be a perfect upstander with a Happy face emoji.
	Incomplete upstander	SAD	Be an incomplete upstander with a sad face emoji.
	Request more supplementary materials relevant to problems/ tasks/situations/activities	RM	Request more supplementary materials after being an incomplete upstander with a sad face emoji.
	Return to problems/ tasks/situations/activities corresponding to incomplete upstander with a sad face emoji	RB	Return to problems/tasks/situations/ activities corresponding to incomplete upstander with a sad face emoji to practice being a perfect upstander.

Regarding research question 2, to investigate students' perceptions, ATs, and learning motivations, they were asked to respond to the online questionnaire when they finished activities in this study's decision tree-based contextual mobile gaming system. The questionnaire was adopted from Teo et al.'s (2009) and Panjaburee and Srisawasdi's (2016) TAM about e-learning systems and from Glynn and Koballa's (2006) learning motivation about active learning environments. Therefore, the questionnaire used in this study aimed to investigate the participants' perceptions, ATs, and learning motivations regarding the decision tree-based contextual mobile gaming system to point out the ultimate goal of this study. The 40 questions covering 10 constructs were answered using a 5-point Likert rating scale ranging from 1 'strongly disagree' to 5 'strongly agree'. The following is the objective for each construct; the list of questions can be found in Appendix.

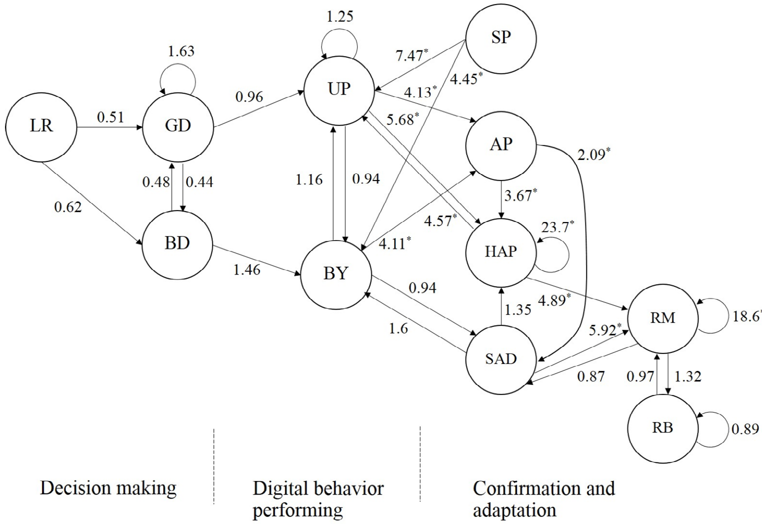
- PEU of the system represents students' belief that directions and instructions in the decision tree-based contextual mobile gaming system were easy to follow (three items).
- PU refers to the degree of students' belief in learning guides to help them decide to practice good/bad digital citizenship behaviours during game playing (three items).
- AT refers to students' feelings about and satisfaction with learning activities and strategies in the decision tree-based contextual mobile gaming system (three items).
- BI aims to elicit students' feeling that they would be satisfied with using the decision tree-based contextual mobile gaming system to cultivate further their behaviours of good digital citizenship (three items).
- GE refers to students' beliefs that the decision tree-based contextual mobile gaming system affects their positive learning performance and that its environment supports their knowledge acquisition (two items).
- FUIs are the degrees to which students perform in an activity of the decision tree-based contextual mobile gaming system to earn a reward when performing good digital citizenship behaviours and to avoid punishment when showing bad behaviours (five items).
- GQ aims to elicit students' feelings about the convenience or complexity of the learning directions and instructions when they use the decision tree-based contextual mobile gaming system (three items)
- SE motivation is the degree to which students have confidence in their abilities to accomplish specific situations in the decision tree-based contextual mobile gaming system (five items).
- IM aims to ensure students attempt to succeed or accomplish in the decision tree-based contextual mobile gaming system for internal rewards (five items).
- IA represent students' belief that specific situations or tasks in the decision tree-based contextual mobile gaming system would efficiently foster their good digital citizenship behaviours or decrease their bad behaviours (eight items).

5 Results

5.1 Analysing behavioural learning patterns

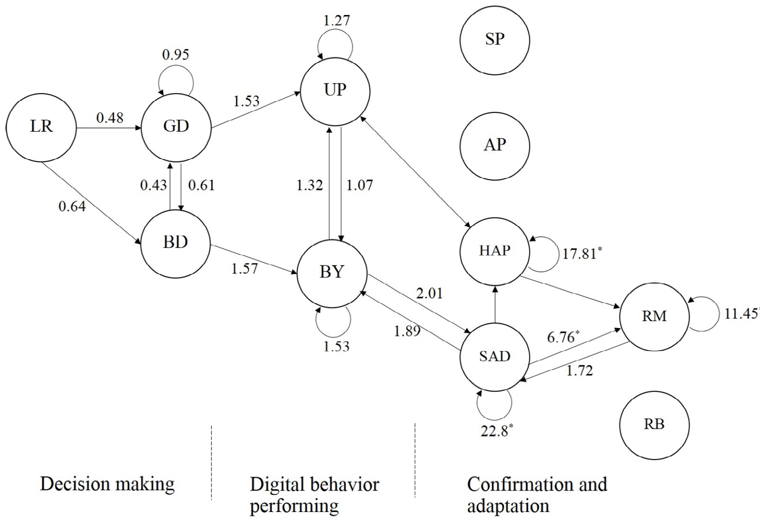
Regarding students' use of the decision tree-based contextual mobile gaming system, this study conducted a generalised sequential querier (GSEQ) to analyse their learning behaviours and gave them codes to reveal their behavioural patterns to answer research question 1. Figures 4 and 5 present the behavioural patterns of active and inactive students, respectively. The behavioural patterns of the two groups were different when they adopted the decision tree-based contextual mobile gaming system to learn and interact during the digital citizenship course.

Figure 4 Behavioural patterns of the active group with adjusted residual results



Note: $*p < 0.05$.

Figure 5 Behavioural patterns of the inactive group with adjusted residual results



Note: $*p < 0.05$.

The active students were found to listen to and read the problem situation questions in the decision tree-based contextual mobile gaming system to reflect the accuracy or confirm they had good digital citizenship behaviour (SP → UP, SP → BY), as shown in Figure 4. However, the inactive system students did not perform these actions, as shown in Figure 5. These actions made active students confirm their good digital citizenship behaviour (UP → AP, BY → AP). They also listened to, read, and studied the relevant situation from additional media in the decision tree-based contextual mobile gaming system (HAP → RM, SAD → RM). After that, they returned to specific situations corresponding to their bad behaviour to remake their decisions to adjust their behaviour (RM → RB) more frequently than the inactive group did. The results confirm that active students have better digital citizenship behaviours. In other words, the active students had more chances to be perfect upstanders with beautiful happy face emojis than the inactive students who were imperfect upstanders with sad face emojis. This difference indicates that more attendance to the decision tree-based contextual mobile gaming system ensured more chances to show good digital citizenship and avoid bad digital citizenship behaviours.

5.2 Analysing hypotheses

Referring to Figure 3, the five hypotheses helped to frame research question 2. In this study, stepwise multiple regression was performed to analyse the path associated with the variables leading to understanding the predictors of active and inactive students' acceptance of the decision tree-based contextual mobile gaming system. Therefore, the internal consistency of reliability of the questionnaire and Pearson correlation coefficients among the variables were checked to ensure adequate scales and bi-variate relations before performing the stepwise multiple regression.

5.2.1 Descriptive statistics and internal consistency of reliability

The questionnaire data were analysed to understand each construct and the question's mean and standard deviation values. The questionnaire measured the internal consistency of item reliability by computing Cronbach's α values. Moreover, the Pearson correlation coefficients were tested to ensure the bi-variate relationships among the variables for further stepwise multiple regression analysis. Therefore, the stepwise multiple regression results would confirm the hypothesis setting.

To understand students' overall perceptions, ATs, and learning motivations after using the decision tree-based contextual mobile gaming system, the descriptive information regarding mean and standard deviation values is presented in Table 2. It was found that all, active, and inactive students' mean values for the ten constructs ranged from BI (M = 3.71) to IA (M = 4.47), BI (M = 4.49) to GQ (M = 4.86), and BI (M = 2.89) to IA (M = 4.10) constructs, respectively. All means of the students are also above a middle-value agreement of 3.00. The results suggest that the students agreed that the decision tree-based contextual mobile gaming system was useful for promoting good behaviours using digital tools. It is easy to use, and it is easy to follow tasks. Moreover, the IA of the decision tree-based contextual mobile gaming system could promote positive learning motivations. Interestingly, the active students showed the highest mean value for the mobile GQ construct; they felt it was convenient to learn the directions and instructions of the decision tree-based contextual mobile gaming system.

Table 2 also reveals the internal consistency of reliability for each question. That is to say, Cronbach's α values show that the reliability of the questionnaire for all, active, and inactive students was highly acceptable, with values of 0.82, 0.90, and 0.91, respectively. The corrected item-total correlation (r) of questions used in the research instrument for all, active, and inactive students ranged from 0.60 to 0.83, 0.53 to 0.78, and 0.51 to 0.88, respectively, indicating adequate reliability and showing the exploratory nature of data for each behavioural learning pattern of this study. Therefore, the questionnaire used in this study is shown to be reliable for further analysis.

Table 2 The descriptive statistics of questionnaire items and reliability values for the two groups

Constructs/ questions	*Overall (N = 434)*			*Active group (N = 210)*			*Inactive group (N = 224)*		
	Mean	*SD*	*r*	*Mean*	*SD*	*r*	*Mean*	*SD*	*r*
Perceived ease of using the system (PEU)	*4.10*	*0.74*		*4.67*	*0.27*		*3.50*	*0.60*	
PEU1	4.01	0.92	0.60	4.61	0.56	0.53	3.39	0.80	0.73
PEU2	4.06	0.92	0.69	4.64	0.48	0.78	3.45	0.87	0.65
PEU3	4.23	0.90	0.68	4.75	0.47	0.69	3.67	0.91	0.57
Perceived usefulness (PU)	*4.20*	*0.76*		*4.82*	*0.26*		*3.55*	*0.53*	
PU1	4.31	0.88	0.64	4.91	0.29	0.63	3.68	0.86	0.68
PU2	4.16	0.87	0.65	4.80	0.40	0.61	3.47	0.68	0.75
PU3	4.14	0.83	0.62	4.73	0.48	0.75	3.50	0.62	0.60
Attitude (AT)	*4.12*	*0.80*		*4.76*	*0.26*		*3.44*	*0.61*	
AT1	4.12	0.91	0.66	4.73	0.48	0.69	3.48	0.81	0.62
AT2	4.08	0.97	0.65	4.71	0.49	0.62	3.40	0.90	0.74
AT3	4.17	1.00	0.66	4.84	0.37	0.64	3.46	0.96	0.55
Behavioural intention (BI)	*3.71*	*0.97*		*4.49*	*0.48*		*2.89*	*0.62*	
BI1	3.82	1.04	0.63	4.55	0.65	0.69	3.03	0.76	0.76
BI2	3.66	1.08	0.66	4.43	0.62	0.69	2.84	0.82	0.51
BI3	3.67	1.17	0.65	4.48	0.66	0.68	2.80	0.94	0.77
Mobile gaming effectiveness (GE)	*4.23*	*0.71*		*4.80*	*0.34*		*3.62*	*0.44*	
GE1	4.27	0.80	0.73	4.78	0.44	0.70	3.72	0.73	0.55
GE2	4.20	0.86	0.63	4.83	0.40	0.61	3.52	0.69	0.51
Features and user interfaces (FUI)	*3.76*	*0.81*		*4.51*	*0.18*		*2.98*	*0.34*	
FUI1	4.03	0.92	0.62	4.69	0.51	0.61	3.32	0.71	0.52
FUI2	3.53	0.90	0.79	3.96	0.64	0.65	3.08	0.90	0.66
FUI3	3.95	1.05	0.82	4.66	0.55	0.69	3.19	0.93	0.81
FUI4	4.06	1.10	0.83	4.86	0.35	0.65	3.21	0.98	0.88
FUI5	3.26	1.42	0.61	4.38	0.58	0.63	2.07	1.03	0.66

Table 2 The descriptive statistics of questionnaire items and reliability values for the two groups (continued)

Constructs/ questions	*Overall (N = 434)*			*Active group (N = 210)*			*Inactive group (N = 224)*		
	Mean	*SD*	*r*	*Mean*	*SD*	*r*	*Mean*	*SD*	*r*
Mobile gaming system quality (GQ)	*4.27*	*0.69*		*4.86*	*0.21*		*3.65*	*0.42*	
GQ1	4.29	0.87	0.61	4.93	0.26	0.65	3.60	0.77	0.52
GQ2	4.34	0.80	0.64	4.94	0.23	0.56	3.71	0.68	0.57
GQ3	4.20	0.79	0.61	4.71	0.45	0.74	3.63	0.67	0.68
Self-efficacy motivation (SE)	*4.26*	*0.56*		*4.74*	*0.19*		*3.74*	*0.31*	
SE1	4.52	0.73	0.61	4.36	0.86	0.63	4.01	0.78	0.65
SE2	3.93	1.00	0.72	4.38	0.94	0.69	3.47	0.94	0.62
SE3	4.68	0.52	0.72	4.97	0.16	0.62	4.33	0.58	0.69
SE4	3.50	1.36	0.64	4.36	0.86	0.62	2.56	1.08	0.61
SE5	4.66	0.55	0.61	4.38	0.94	0.69	4.32	0.61	0.58
Intrinsic motivation (IM)	*4.10*	*0.59*		*4.59*	*0.31*		*3.57*	*0.31*	
IM1	4.30	0.86	0.73	4.76	0.54	0.69	3.79	0.86	0.64
IM2	3.59	1.06	0.74	4.19	0.85	0.64	2.95	0.87	0.69
IM3	4.24	0.79	0.78	4.75	0.52	0.64	3.71	0.68	0.65
IM4	3.97	0.96	0.73	4.58	0.67	0.63	3.31	0.78	0.61
IM5	4.39	0.72	0.72	4.66	0.58	0.68	4.10	0.75	0.67
Interactive activities (IA)	*4.47*	*0.42*		*4.82*	*0.12*		*4.10*	*0.27*	
IA1	4.57	0.69	0.64	4.80	0.50	0.64	4.32	0.78	0.66
IA2	4.65	0.67	0.65	4.54	0.50	0.67	4.28	0.81	0.65
IA3	4.06	0.89	0.68	4.54	0.50	0.67	3.56	0.94	0.62
IA4	4.65	0.67	0.65	4.97	0.19	0.68	4.28	0.81	0.65
IA5	4.06	0.89	0.68	4.74	0.57	0.61	3.56	0.94	0.62
IA6	4.62	0.62	0.61	4.80	0.50	0.64	4.21	0.69	0.64
IA7	4.52	0.72	0.70	4.54	0.50	0.67	4.04	0.76	0.60
IA8	4.62	0.61	0.71	4.54	0.50	0.67	4.50	0.64	0.66
Overall			*0.82*			*0.90*			*0.91*

Moreover, Table 3 shows the Pearson correlation coefficients among the variables for active and inactive students. It was found that all of the variables were significantly correlated with each other. That is to say, this value is given for determining the aims of this study, and there is adequate item reliability for further analysis of each item to answer research question 2.

Table 3 The Pearson correlation analyses among the ten variables for the two groups

Groups	*Variables*	*PEU*	*PU*	*AT*	*BI*	*GE*	*FUI*	*GQ*	*SE*	*IM*	*IA*
Active group	PEU	1	0.959**	0.968**	0.942**	0.891**	0.858**	0.929**	0.931**	0.941**	0.929**
	PU		1	0.958**	0.962**	0.885**	0.772**	0.912**	0.883**	0.931**	0.888**
	AT			1	0.959**	0.913**	0.855**	0.935**	0.938**	0.953**	0.934**
	BI				1	0.870**	0.847**	0.955**	0.935**	0.945**	0.936**
	GE					1	0.828**	0.846**	0.864**	0.882**	0.892**
	FUI						1	0.904**	0.936**	0.867**	0.953**
	GQ							1	0.945**	0.951**	0.953**
	SE								1	0.937**	0.973**
	IM									1	0.936**
	IA										1
Inactive group	PEU	1	0.809**	0.842**	0.942**	0.695**	0.762**	0.802**	0.879**	0.896**	0.854**
	PU		1	0.888**	0.876**	0.881**	0.797**	0.901**	0.657**	0.871**	0.626**
	AT			1	0.917**	0.801**	0.798**	0.806**	0.818**	0.934**	0.757**
	BI				1	0.807**	0.853**	0.863**	0.870**	0.949**	0.840**
	GE					1	0.766**	0.885**	0.568**	0.789**	0.566**
	FUI						1	0.803**	0.745**	0.873**	0.739**
	GQ							1	0.647**	0.843**	0.640**
	SE								1	0.867**	0.940**
	IM									1	0.833**
	IA										1

Note: **$p < 0.01$.

5.2.2 Stepwise multiple regression for the path associated with the variables

This study tested the hypotheses by performing stepwise multiple regression to answer research question 2. Table 4 presents the values of the path associated with ten variables, namely PEU of the system, PU, AT, BI, GE, FUIs, GQ, SE motivation, IM, and IA. H1 was tested by performing a stepwise multiple regression to examine the effect of features, user interfaces, and GQ (independent variables) on the PEU of the decision tree-based contextual mobile gaming system (dependent variable). These variables are about receiving a reward when performing good digital citizenship behaviours, avoiding punishment when showing bad behaviours, and feeling the convenience or complexity of activities in the decision tree-based contextual mobile gaming system. It was found that the independent variables were predictors of the dependent variable for active ($F_{(1,209)}$ = 660.074, p = 0.000, R^2 = 0.864) and inactive groups ($F_{(1,223)}$ = 237.902, p = 0.000, R^2 = 0.683). In this case, the active students revealed that the mobile GQ of the decision tree-based contextual mobile gaming system was the bigger contributor to their perception of ease of use of the system (86.30%); similarly, the inactive students revealed that the mobile GQ was the bigger contributor to their perception of ease of use of the system (64.40%).

To test H2, a stepwise multiple regression was performed to ensure the effectiveness of the PEU, SE motivation, IA, and GQ constructs (independent variables) on the PU of the decision tree-based contextual mobile gaming system (dependent variable). The results revealed that the four variables were predictors of students' perception of the usefulness of the decision tree-based contextual mobile gaming system regarding its guidance, helping them decide to practice digital citizenship behaviours during game playing for active ($F_{(1,209)}$ = 662.569, p = 0.000, R^2 = 0.928) and inactive groups ($F_{(1,223)}$ = 371.860, p = 0.000, R^2 = 0.872). It points out that active students' perception of the ease of use of the decision tree-based contextual mobile gaming system was the biggest contributor to their perception of its usefulness (91.90%), while the inactive students revealed that the mobile GQ was the biggest contributor to their perception of its usefulness (81.10%).

To examine H3, a stepwise multiple regression was performed to evaluate the effect of PEU, PU, SE motivation, IM, and GQ (independent variables) on AT toward the decision tree-based contextual mobile gaming system (dependent variable). It was found that the five variables were predictors of students' ATs towards the decision tree-based contextual mobile gaming system regarding learning activities and strategies in the decision tree-based contextual mobile gaming system for active ($F_{(1,209)}$ = 1,049.467, p = 0.000, R^2 = 0.963) and inactive groups ($F_{(1,223)}$ = 440.463, p = 0.000, R^2 = 0.910). Similar to H2, the active students' perception of ease of use of the decision tree-based contextual mobile gaming system was the biggest contributor to their AT toward the system (93.80%), while the inactive students revealed that their IM was the biggest contributor to their AT toward the system (87.20%).

To evaluate H4, a stepwise multiple regression was performed to check the effect of AT on the BI to use the decision tree-based contextual mobile gaming system. Its results revealed that the student's AT toward the decision tree-based contextual mobile gaming system was a predictor of their acceptance of using the system for active ($F_{(1,209)}$ = 2,362.637, p = 0.000, R^2 = 0.919) and inactive students ($F_{(1,223)}$ = 1,168.266, p = 0.000, R^2 = 0.840) with 91.90% and 84.00% contributions for the active and inactive students, respectively.

To determine H5, stepwise multiple regression was also performed to test the effect of GQ, IA, and feature and user interface variables on the GE variable. The results showed that the three independent factors were predictors of GE for active ($F_{(1,209)}$ = 275.645, p = 0.000, R^2 = 0.801) and inactive groups ($F_{(1,223)}$ = 284.708, p = 0.000, R^2 = 0.795). IA were the biggest predictor, with a 79.50% contribution to GE for the active students, while GQ was the biggest predictor, with a 78.40% contribution to GE for the inactive students.

Table 4 The results of stepwise multiple regression for the five hypotheses

Groups	*Hypotheses*	*Variables*			β	R^2	p
		Dependent		*Independent*			
Active group	H1	Perceived ease of use	a	Mobile gaming system quality	0.929	0.863	0.000*
			b	Features and user interfaces	0.858	0.735	0.000*
	H2	Perceived usefulness	a	Perceived ease of use	0.959	0.919	0.000*
			b	Interactive activities	0.888	0.788	0.000*
			c	Mobile gaming system quality	0.912	0.832	0.000*
			d	Self-efficacy motivation	0.883	0.779	0.000*
	H3	Attitude	a	Perceived usefulness	0.958	0.918	0.000*
			b	Perceived ease of use	0.968	0.938	0.000*
			c	Self-efficacy motivation	0.938	0.879	0.000*
			d	Intrinsic motivation	0.953	0.908	0.000*
			e	Mobile gaming system quality	0.935	0.875	0.000*
	H4	Behavioural intention		Attitude	0.959	0.919	0.000*
	H5	Mobile gaming effectiveness	a	Interactive activities	0.892	0.795	0.000*
			b	Mobile gaming system quality	0.846	0.716	0.000*
			c	Features and user interfaces	0.828	0.695	0.000*
Inactive group	H1	Perceived ease of use	a	Mobile gaming system quality	0.802	0.644	0.000*
			b	Features and user interfaces	0.762	0.580	0.000*
	H2	Perceived usefulness	a	Perceived ease of use	0.809	0.654	0.000*
			b	Interactive activities	0.626	0.392	0.000*
			c	Mobile gaming system quality	0.901	0.811	0.000*
			d	Self-efficacy motivation	0.657	0.432	0.000*

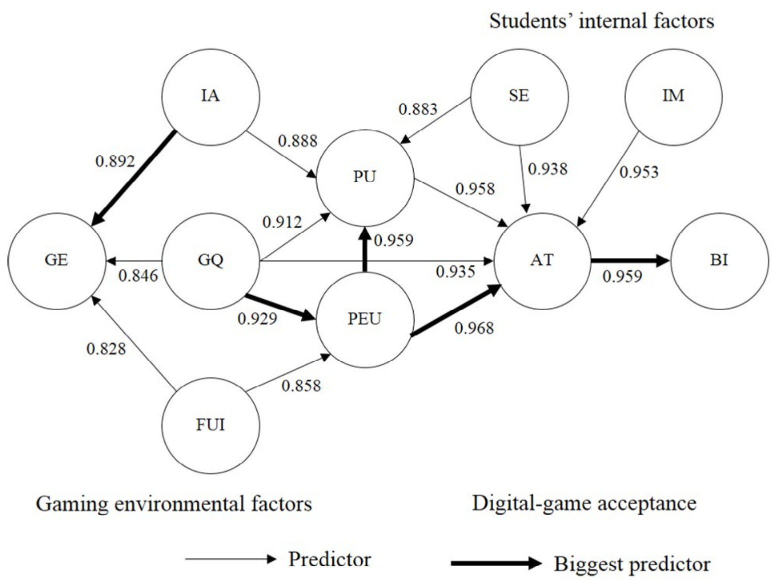
Note: *p < 0.05.

Table 4 The results of stepwise multiple regression for the five hypotheses

Groups	*Hypotheses*	*Variables*			β	R^2	*p*
		Dependent		*Independent*			
Inactive group	H3	Attitude	a	Perceived usefulness	0.888	0.788	0.000*
			b	Perceived ease of use	0.842	0.709	0.000*
			c	Self-efficacy motivation	0.818	0.669	0.000*
			d	Intrinsic motivation	0.934	0.872	0.000*
			e	Mobile gaming system quality	0.806	0.649	0.000*
	H4	Behavioural intention		Attitude	0.917	0.840	0.000*
	H5	Gaming effectiveness	a	Interactive activities	0.566	0.320	0.000*
			b	Mobile gaming system quality	0.885	0.784	0.000*
			c	Features and user interfaces	0.766	0.586	0.000*

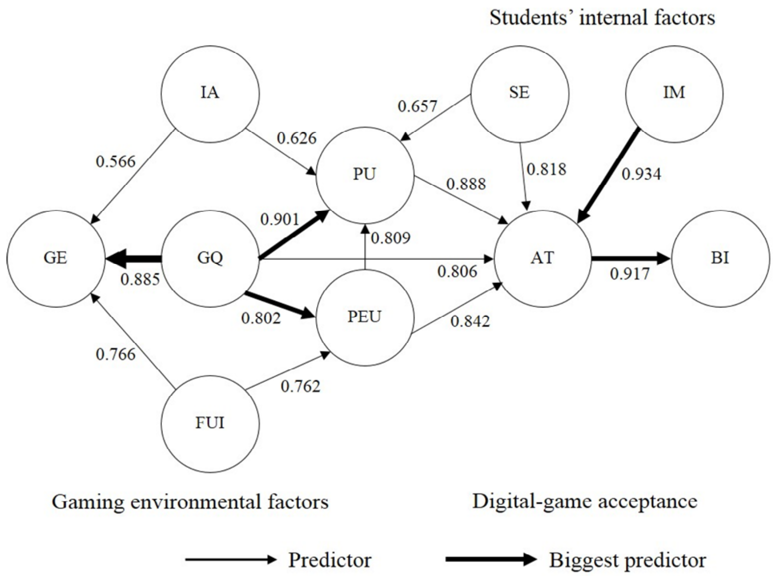
Note: $^*p < 0.05$.

Figure 6 The predictors between variables for the active group with path coefficient results



Regarding the above results, Hypotheses 1 to 5 were supported for the two groups of students (i.e., active and inactive groups). Interestingly, Figures 6 and 7 highlight the bigger contributor of individual groups. It was found that active students' perceptions of GQ influenced their perceptions of ease of use, leading to their positive AT toward continuing to use the decision tree-based contextual mobile gaming system. On the other hand, inactive students need to alter their IMs while participating in the decision tree-based contextual mobile gaming system to promote their positive AT toward continuing to use the mobile gaming system.

Figure 7 The predictors between variables for the inactive group with path coefficient results



6 Discussion

Referring to the mean and the standard deviation values for each construct and question in Table 2, overall, the students showed agreement with the mobile-game acceptance model regarding their perception of ease of use of the decision tree-based contextual mobile gaming system (M = 4.10), the usefulness of the mobile gaming system (M = 4.20), positive AT (M = 4.12), and intention to use (M = 3.71) the decision tree-based contextual mobile gaming system. Similarly, overall, students were satisfied with the gaming environment, including GE (M = 4.23), FUIs (M = 3.76), GQ (M = 4.27), and IA (M = 4.47). Moreover, they showed high motivation when participating in the decision tree-based contextual mobile gaming system regarding SE (M = 4.26) and intrinsic (M = 4.10) motivations. In particular, the active system students agreed slightly more with mobile-game acceptance, the gaming environment, and motivations than the inactive students. These results point out that the decision tree-based contextual mobile gaming system is a potential AI-based mobile gaming system for students' competency domain regarding the capacity of knowledge, skill, AT, and value. In other words, active students are another potential effect for practicing good digital citizenship behaviours. Table 2 also reveals that inactive students only had a middle-level positive perception of the decision tree-based contextual mobile gaming system, from BI to use the mobile gaming system (M = 2.89) to FUIs of the mobile gaming system (M = 2.98). However, most students perceived that the mobile gaming system is useful in several aspects, such as guiding them to practice good digital citizenship behaviours and avoiding bad behaviours, detecting the incomplete and partial behaviour of upstanders, and providing corresponding supplementary materials to adjust behaviours for becoming a perfect upstander. Inactive students are still concerned with system interactivity. While using the decision tree-based contextual mobile gaming system, inactive students indicated that they needed more communicative features/functions to lead them to practice digital citizenship behaviours systematically.

Table 4 shows that gaming environmental factors (i.e., FUIs and mobile GQ) were significant predictors of students' perceived ease of using the mobile gaming system (H1); remarkably, it was most effective for the active students regarding mobile GQ. The results indicated that more attendance to the decision tree-based contextual mobile gaming system leads more frequently to listening to, reading, and studying the relevant situation from additional media for practicing good digital citizenship behaviours with immediate feedback from the mobile gaming system. These findings comply with previous studies, as Harrati et al. (2016) indicated that the user interface is a communicative means between the user and the complex nature of the computer system. It is also the key representation of the system functionalities and how active users can effortlessly interact with them. That is, the effective graphical user interface assists the active user in completing tasks more easily, reflecting the system's usability. In addition, Ashfaq et al. (2020) further supported that even though AI technologies can offer effective solutions, inefficient communication between humans and the intelligent system can also cause frustration to the users. Thus, a learning system capable of supplying the user with sufficient service and support through a user-friendly interface would ease the difficulty in using the innovation, leading to more learning opportunities.

This study also pointed out that PEU was the biggest predictor of PU (H2) of the decision tree-based contextual mobile gaming system among four variables, particularly the active group. In other words, the active students PEU as the better predictor that promoted the decision tree-based contextual mobile gaming system than inactive students. It indicates that the students more often use the functions of the mobile gaming system, leading to more opportunities to construct knowledge/understanding/experience to promote good behaviour and avoid bad behaviour when they use digital tools in their daily life. Similarly, Binyamin et al. (2019) found that PU is affected greatly by the ease of access and navigating the learning system, while Wang and Goh (2017) explained that ease of use is closely associated with users' perceptions of usefulness and enjoyment of a digital game. The less effort or active users put into understanding the mobile gaming system, the more they are influenced by the initial decision to adopt the game.

Similarly, among five variables, active students revealed that PEU was the biggest predictor of AT (H3) toward the decision tree-based contextual mobile gaming system. That is to say, active students care about the PEU of the mobile gaming system, which leads them to have a positive AT toward it. In other words, more frequent attendance of the mobile gaming system results in more enjoyable learning through the mobile gaming system. Previous studies revealed that a carefully designed learning system with an easy-to-use user interface would be able to guide active students to do more practice and achieve the learning outcomes (Shang, 2015), especially the high-performance or active learners whose ATs are affected by context-aware technology (Huang et al., 2012; Wang et al., 2018). According to Lu (2012), individual differences, such as learning styles, can influence learners' perceptions of ease of use, usefulness, willingness, and intention to use technology. This finding has further emphasised that AI-enabled learning systems can serve individuals' different learning needs in achieving learning goals, increasing the fulfilment of learning.

Table 4 also reveals that active students' ATs have a greater influence on intention to use (H4) than inactive students' ATs. This result indicates that more attendance to the decision tree-based contextual mobile gaming system is crucial for accepting the system. The impact of time allows students to train their behaviours by listening to and reading the problem situation questions in the decision tree-based contextual mobile gaming system to reflect the accuracy or confirm they have good digital citizenship behaviour. Therefore, it gives a chance for students to inquire from the source corresponding to their needs; then, they could remake decisions to adjust their digital citizenship behaviours. Similar to the previous study by Tsai et al. (2017), the students who were more actively invested in the learning topic were more likely to express higher satisfaction with the learning approach. Furthermore, the longer the students used the learning system, the more satisfied they were with it and the learning process. The playful elements in game-based learning help increase students' enjoyment and reduce the seriousness while tackling educational content in instructional settings, resulting in a change in ATs and adaptations (Chen et al., 2016; Weng et al., 2018; White and McCoy, 2019).

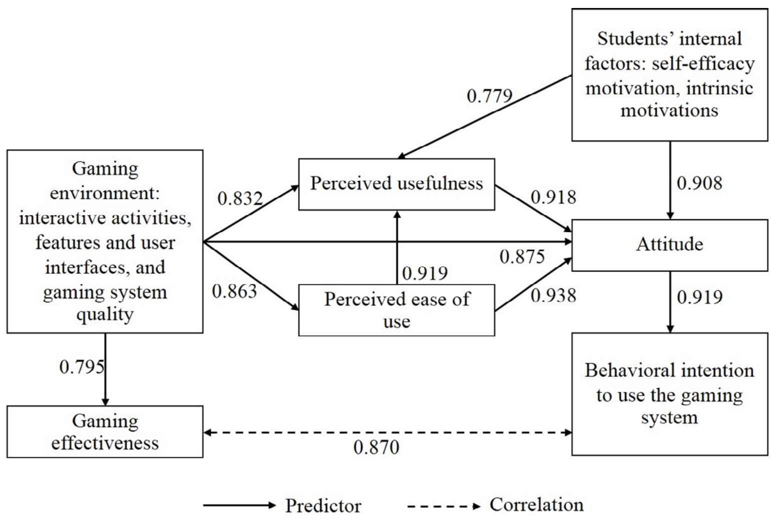
Moreover, this study revealed that the decision tree-based contextual mobile gaming system's IA were the biggest predictor of GE (H5) among three variables, particularly the active group. The active students, who more frequently attended to the decision tree-based contextual mobile gaming system, believed that the effective digital game would include specific situations or tasks and corresponding materials and methods, helping to adjust their behaviours. Similarly, Chung and Chang's (2017) findings revealed that adaptive digital games enhanced learners' motivation to learn through interactivity and helped maximise the learning advantages regardless of gender and individual differences. In other words, IA in the game allow students to actively acquire and apply their knowledge in different situations with immediate feedback to test their learning hypotheses, adjust their behaviours, and improve their performance (Pellas et al., 2019). This result confirmed Lin et al.'s (2022) finding that the factors influencing the adoption of AI-enabled e-learning systems are perceived entertainment, interactive effects, and system functionalities.

7 Conclusions

The results revealed that all hypotheses were supported for active and inactive students. That is to say, FUIs of earning reward and punishment and less complexity of learning directions and instructions of the decision tree-based contextual mobile gaming system will significantly affect the mobile gaming system's PEU. Those attractive features combined with IA could help students gain more confidence in cultivating good digital citizenship behaviours, significantly affecting their PU of the decision tree-based contextual mobile gaming system such that their positive ATs will be significantly affected by those factors, leading to significant intention to use the decision tree-based contextual mobile gaming system in the future. On the other hand, gaming environment factors, including GQ, IA, and FUIs, will significantly predict GE.

Furthermore, there was a significant correlation between the intention to use the decision tree-based contextual mobile gaming system and GE for active (r = 0.870) and inactive (r = 0.807) students. Therefore, the decision tree-based contextual mobile gaming system served as a potential study of the AI-based gaming approach to fostering essential skills for secondary school students. Interestingly, the biggest contributor was the active students' perception of the ease of use of the decision tree-based contextual mobile gaming system to their AT (93.8%). It is recommended that the AI-based gaming system should be developed by considering more students' convenience in following the learning directions and instructions of the mobile gaming system. Moreover, the biggest contributor was the inactive students' IM to their AT (87.2%). It is recommended that the rationale or story of the game should be created by relating to their daily life, as it would motivate them to succeed in the gaming tasks. Figure 8 also summarises the significant predictors and correlations between the variables.

Figure 8 The summary results of predictors and relationships



The results of this study can propose a decision tree-delivered AI-gaming design in future work. The gaming environment can consider more reward-punishment features/functions, systematic instruction, IA, tasks/situations, supplementary learning materials corresponding to students' needs, and opportunities to adjust learning/playing. With the significance of the current findings, this study proposes a conceptual framework for preparing a digital gaming system with the AI-based approach among generalised active and inactive students' learning patterns. Figure 9 shows the learning environment for a practical AI-based gaming system based on the decision tree approach.

In summary, it can be synthesised that the AI-based gaming system, which can analyse students' learning outcomes and learning behaviour, consists of the main components to properly support their learning performance, especially the competency/ literacy domain, as follows:

1 To apply the decision-tree technique for constructing a storyline tree of tasks relevant to digital citizenship behaviours, each task can be designed by applying the contextual-based learning approach to situate the students in scenarios relevant to a good or bad decision. That is, the contextual gaming approach can be designed.

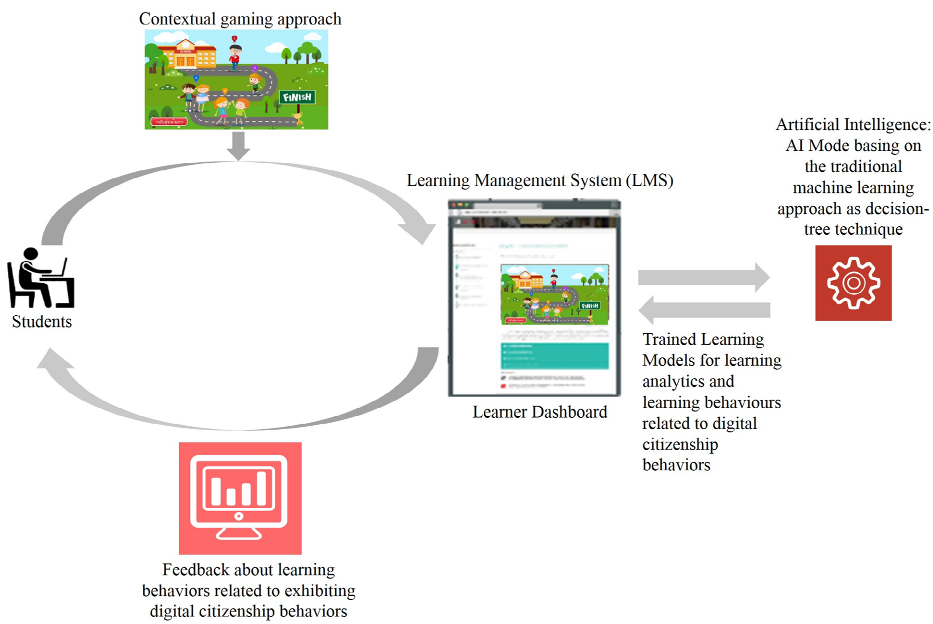
2 To give rewards by applying avatar/face emojis to show the results of students' decisions reflecting their current digital citizenship behaviour.

3 To affirm good digital citizenship behaviour by allowing users to listen to/read problem-solving questions and revisit specific vague situations to reduce undesirable behaviour and increase good behaviour in a learner dashboard.

4 To provide immediate feedback and time to individual students to adjust their undesirable behaviours with supplementary materials and learning guidelines.

5 To design the learner dashboard that visualises students' learning data, such as learning path and progression, for them to review their learning. The learner dashboard should suggest suitable learning materials corresponding to each student's behavioural profile or learning path. The dashboard should allow the students to customise the visualisation of the display to suit each student's learning needs and provide additional collaborative discussion tools to facilitate sharing information between peers-to-peers and student-to-teacher.

Figure 9 A conceptual framework for designing AI in the game-based learning system (see online version for colours)



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Appendix

- PEU
  1. My interaction with this gaming system is clear and understandable.
  2. I find it easy to get the mobile gaming system to do what I want.
  3. The mobile gaming system is easy to use and follow.
- PU
  4. This gaming system would be helpful for me to promote good behaviour and avoid bad behaviour when I use digital tools in my daily life.
  5. The mobile gaming system would be helpful for me to construct knowledge/understanding/experience in my context.
  6. Using this gaming system would enhance effectiveness in my activities-related learning to daily life.
- AT
  7. Gaming systems make learning activities more enjoyable.
  8. I like to follow activities provided by the mobile gaming system.
  9. I am satisfied with using this gaming system as a learning-assisted tool.

- BI
  10 I will use the mobile gaming system to support my learning in the future.
  11 I will use the situations/experiences provided by the mobile gaming system to practice good behaviour using digital tools.
  12 I plan to use the mobile gaming system often.
- Mobile GE
  13 I can solve a problem running the mobile gaming system by myself.
  14 Tasks/situations/activities in the mobile gaming system are relevant to my experience and present the content exactly as digital citizenship is.
- FUIs
  15 This gaming system helps me to perform better and better behaviour.
  16 Earning rewards is important to me for performing good behaviours in this gaming system.
  17 I think that receiving rewards or punishments in the mobile gaming system can help me have good behaviours.
  18 I think about how rewards or punishment in the mobile gaming system will affect my behaviour.
  19 I think about how rewards or punishment in the mobile gaming system can help my behavioural improvement when using digital tools.
- Mobile GQ
  20 I spent less time learning to use the mobile gaming system.
  21 The number of tasks/situations/activities in the mobile gaming system is enough for me to perform good digital citizenship behaviour and reduce my bad behaviour.
  22 The mobile gaming system provides me with feedback immediately.
- SE motivation
  23 I expect to perform behaviour as well as or better than other students.
  24 I am confident I will perform good behaviours using digital tools every day.
  25 I can be a good digital citizen in the digital era.
  26 I am confident I will perform good digital citizenship in the digital era.
  27 I can earn a reward or reduce punishment in the mobile gaming system.
- IM
  28 I enjoy practicing digital citizenship behaviours in the mobile gaming system.
  29 The behaviour I practice is more important than the rewards I receive in the mobile gaming system.
  30 Practicing digital citizenship in the mobile gaming system is interesting.
  31 I like tasks/situations in the mobile gaming system that challenge me.
  32 Practicing digital citizenship behaviours in the mobile gaming system gives me a sense of accomplishment.

- IA
  - 33 I can autonomously interact with what I am doing during the mobile gaming system.
  - 34 I am very focused on the tasks/situations/activities in the mobile gaming system.
  - 35 I found the mobile gaming system's tasks/situations/activities to be fun.
  - 36 I am excited about the tasks/situations/activities in the mobile gaming system.
  - 37 I found the tasks/situations/activities in the mobile gaming system interesting.
  - 38 During the tasks/situations/activities in the mobile gaming system, time passes quickly.
  - 39 The tasks/situations/activities in the mobile gaming system aroused my curiosity.
  - 40 I know what action is right from the mobile gaming system's tasks/situations/activities.