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How to trigger students' interest in digital learning environments: A systematic literature review

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Abstract

Various digital devices not only provide students' Internet connections but also create more opportunities for them to get inspired, motivated, and engaged in learning activities. Recent research has shown that triggering interest can enhance students' self-regulation, collaboration, problem-solving, and joy of learning. Pedagogical use of digital technologies can support student-centered and collaborative learning and develop thinking skills and creativity. However, little is known about the relevance of digital technologies for triggering interest. The aim of this study is to review existing literature in the field of the learning sciences and provide answers for the following research questions: 1) Which factors trigger students' interest in learning in digital environments? 2) What kinds of learning environments have been used for exploring triggers? The systematic literature review (SLR) methodology has been used in this study. The results indicate that three factors employed in computer environments, including scaffolding, collaboration, and perceived ease of use, can be the most efficient ways to trigger students' interest in learning. The findings will be useful for researchers and teachers to discover appropriate methods and approaches in the successful integration of digital technologies in learning environments and the teaching process.

Keywords: *trigger, interest, learning environments, digital technologies, systematic literature review (SRL)*

Introduction

The digital revolution and globalization have had a deep influence on education at all levels. Various digital devices, such as computers, laptops, tablet technologies, and mobile phones not only provide students' Internet connections but also create more opportunities for them to get inspired, motivated, and engaged in learning activities (Nygren & Vikström, 2013; Chen & Wang, 2015; Wang, 2010). Previous studies have shown that the pedagogical use of digital technologies can support student-centered and collaborative learning and develop thinking skills and creativity (Bingimlas, 2009; Arancibia, Oliva, & Valdivia, 2013; Danče, 2010; Thang, Nambiar, Wong, Jaafar, & Amir, 2015). Some educators and researchers also believe that digital technologies can be beneficial for students' learning engagement and motivation; this is because the digital context can motivate students to apply positive emotion in attention, memory, and learning skills during academic engagement (Chang et al., 2016; Vandercruysse, Vandewaetere, Cornillie, & Clarebout, 2013; Chen, Wong, & Wang, 2014). For example, Danče (2010) claimed that the use of digital technologies helped students to recognize connections and behaviors, improve quality of tasks, communicate with others and present ideas, increase efficiency, and be creative and self-confident. Sun and Looi (2013) pointed out that digital learning environments facilitated students' cognitive development and metacognitive strategies and promoted their conceptual understanding, collaborative competence, and self-regulated learning and critical thinking skills. Thang et al. (2015) found that the application of digital technologies brought about students' improved performance, deeper strategies of learning, and a higher level of thinking skills. In addition, the studies indicated that the use of digital technologies to create a comfortable learning environment was able to assist students to practice and think for better learning engagement, while at the same time enabling them to experience, transfer, and demonstrate knowledge in different forms (Silviyanti & Yusuf, 2014; Chen, Lin, Yeh, & Lou, 2013; Thang et al., 2015; Nygren & Vikström, 2013).

Recent research has shown that triggering interest can enhance students' self-regulation, collaboration, problem-solving, and joy of learning (Hidi & Renninger, 2006; Roberts & Ousey, 2004; Renninger & Bachrach, 2015; Siklander, Kangas, Ruhalahti, & Korva, 2017). However, little is known about the relevance of digital technologies for triggering interest; most research has focused on applying digital technologies to create a learning environment to help students' academic performance (Furberg, Kluge, & Ludvigsen, 2013; Chen & Wang, 2015; Pozzi, 2011; Drijvers, Doorman, Kirschner, Hoogveld, & Boon, 2014). This study aims to contribute to the limited literature on triggering interest with digital technologies.

Theoretical framework

Interest, as one of the most significant motivational variables for learning, has been found to influence students' attention, goals, and levels of learning (Hidi & Renninger, 2006; Hidi, Renninger, & Krapp, 2004; Schraw, Flowerday, & Lehman, 2001). Researchers have proposed that triggering students' interest can increase their motivation to organize learning tasks and use strategies in the classroom (Schraw et al., 2001; Krapp, 2007; Hidi et al., 2004). Meanwhile, it

also stimulates them to focus on the task itself and work positively and fully engaged with content (Renninger, 2000).

Trigger

The trigger is the original factor that motivates students to learn and engage (Roberts & Ousey, 2004; Brauer, Siklander, & Ruhalahti, 2017). Many researchers have pointed out that a trigger can change students' learning motivations and result in good engagement in the classroom (Roberts & Ousey, 2004; Annabi, 2007; Lu & Chan, 2015; Määttä, Järvenoja, & Järvelä, 2012; Siklander et al., 2017). As Brauer et al. (2017) claimed in their study, triggers play a pivotal role when facilitating and maintaining students' interest in learning and engagement. The main identified triggers were challenging tasks, progress in learning and gamification. Similarly, Korkealehto and Siklander (in press) found that gamified solutions in language learning contexts are potential for enhancing students' engagement. Obviously, a deep understanding of triggers is beneficial for designing an appropriate environment that maintains students' situational interest in learning as well as supports the development of individual interests (Roberts & Ousey, 2004; Annabi, 2007; Brauer et al, 2017; Renninger & Bachrach, 2015).

In educational conditions, the trigger is used to stimulate the students' motivation and support their learning (Roberts & Ousey, 2004; Annabi, 2007; Lu & Chan, 2015; Siklander et al., 2017). The trigger can be presented in different ways, such as video, slides, computer games, puzzles, written information, problems, and so on (Siklander et al., 2017). The goal of triggers is to help students adapt to the courses and to confront their expectations and, thus, enjoy their learning. It should be noted that triggers process is sometimes transient, but it is also possible to have interest develop and generate maintained situational interest (Renninger & Hidi, 2011; Siklander et al., 2017; Roberts & Ousey, 2004; Annabi, 2007).

Development of the trigger

Triggers are able to develop problem-solving and increase enjoyment in learning (Siklander et al., 2017; Lu & Chan, 2015). For triggers to be interesting and attractive, they must reflect situations in which students prefer to participate, and the students must focus their attention on the learning activity and practice every day (Roberts & Ousey, 2004; Hidi et al., 2004; Siklander et al., 2017). Määttä et al. (2012) categorized and discussed three types of trigger: individual progress trigger, group progress trigger, and contextual trigger. They claimed that the group progress trigger had a significant influence on students' on-task activity. The encouragement and support of peers was helpful for students to maintain efficacious interaction. Meanwhile, task or topic discussion and working together facilitated students' learning interest and engagement.

Triggers provide different types of learning experiences, and, consequently, students acquire various transferable skills, such as problem solving, self-confidence, group work, self-regulation, etc. (Määttä et al., 2012; Roberts & Ousey, 2004; Lu & Chan, 2015). But beyond that, triggers also help students develop their knowledge and understanding of learning materials (Roberts &

Ousey, 2004; Renninger & Bachrach, 2015; Lu & Chan, 2015). Triggers can make students engage in the middle of the learning performance and stimulate an attitude of interest based on their stored knowledge. In this way, students' stored knowledge is used and valued (Roberts & Ousey, 2004; Renninger, 2000). In addition, triggers promote student-generated learning strategies and problem solving (Hidi & Renninger, 2006; Lu & Chan, 2015). However, Siklander et al. (2017) emphasized that the same triggers do not always work well for various students or for the same students in various conditions and, further, that triggers can influence interest both positively and negatively. In summary, if the nature of triggers and the triggering process could be understood well, it would be possible to contribute to the design of a comfortable learning environment for students that effectively promoted their interest and engagement (Renninger & Bachrach, 2015).

Interest

Interest, "a cognitive and affective motivational variable" (Renninger & Bachrach, 2015, p. 59) that is a sustained characteristic resulting in increased engagement and learning of students, is regarded as a key that pushes students into a subject matter and inspires them to develop meaningful connections to a field of study (Mazer, 2013; Schraw & Lehman, 2001; Schiefele, 1999). In general, interest often refers to positive feelings and leads to "an attraction, a preference, and a passion" (Hidi et al., 2004, p. 94). When students experience interest, they engage in intrinsic motivational behaviors, and they can be propelled by enjoyment but not by extrinsic motivations (Siklander et al., 2017; Ryan & Deci, 2000).

Person-object approach to interest (POI)

The person-object approach to interest (POI) is a theoretical framework to structure and clarify interest-related concepts (Krapp, Hidi, & Renninger, 1992; Krapp, 2002).

According to Krapp's (2002) explanation, interest is defined as "a relational concept" (p. 410) that stands for "a relationship between a person and an object" (p. 410), and object of interest refers to a field of study, a special activity, series of question (Renninger & Bachrach, 2015), or "any other content of the cognitively represented life-space" (p. 410). On the basis of these objects, a person can develop a close relationship that could then become an individual interest under definite conditions (Krapp, 2002; Krapp et al. 1992). Meanwhile, the importance of social context cannot be ignored because the environment provides chances for a person to experience object of interest and conducts a structure of conditions to affect interest development involved situational interest and individual interest (Krapp, 2002; Krapp et al., 1992; Hidi & Renninger, 2006; Schraw & Lehman, 2001). The interest relationship between person and object and interest development can be illustrated specifically with the following four-phase model of interest introduced by Hidi and Renninger (2016).

Interest development

Hidi and Renninger (2006) presented a model of interest development comprising the four phases of triggered situational interest, maintained

situational interest, emerging individual interest, and well-developed individual interest, with profound educational significance in current in-school and out-of-school learning.

Table 1 shows the features of each phase, and every phase includes certain forms of knowledge and cognitive procedure (Hidi et al., 2004).

Table 1: Four-phase model of interest development (Hidi & Renninger, 2006)

<table>
<tr><th></th><th>Phase</th><th>Initiation</th><th>Characteristics</th><th>Support</th><th>Facilitation</th></tr>
<tr><td rowspan="2">Situational interest</td><td>1.Triggered situational interest</td><td rowspan="2">External factors:
-environmental factors
-objects
-individuals</td><td rowspan="2">-spontaneous
-transitory
-environmentally activated</td><td>internal/ external</td><td rowspan="2">-group work
-puzzles
-computers
-PBL
-one-on-one tutoring</td></tr>
<tr><td>2.Maintained situational interest</td><td>external</td></tr>
<tr><td rowspan="2">Individual interest</td><td>3.Emerging individual interest</td><td rowspan="2">Intrinsic desire:
-personal experience
-curiosity
-enduring predisposition</td><td rowspan="2">-positive feeling,
-stored knowledge
-stored value</td><td>external</td><td rowspan="2">-instructional conditions
-interaction
-challenge
-self-regulation</td></tr>
<tr><td>4.Well-developed individual interest</td><td>internal/ external</td></tr>
</table>

According to Table 1, the first two phases are types of situational interest. Triggered situational interest is a forerunner for further development of interest (Hidi & Renninger, 2006; Schraw & Lehman, 2001; Siklander et al., 2017). Triggered situational interest can be aroused by environmental elements and contents of learning; meanwhile, maintained situational interest can be pursued by significant tasks or personal participation (Hidi & Renninger, 2006; Schraw & Lehman, 2001). Both phases of situational interest can be triggered by instructional learning environments that supply meaningful activities, including collaborative group work, one-to-one tutoring, etc. (Hidi & Renninger, 2006; Siklander et al., 2017). However, it should be noted that situational interest may not always facilitate further development of interest and sometimes has a negative influence (Hidi & Renninger, 2006; Schraw & Lehman, 2001; Siklander et al., 2017). However, once situational interest is maintained, repeated engagement can be propelled by the environment and lead to the development of an emerging, and then a well-developed, individual interest (Renninger & Hidi, 2011; Renninger & Bachrach, 2015).

The next two phases are types of individual interest. The characteristics of individual interest are positive feeling, stored knowledge, and task value (Hidi & Renninger, 2006; Hidi et al., 2004; Schraw et al., 2001). With emerging individual interest, the student would like to value the task, generate her/his questions, redefine task demands, anticipate succeeding steps, and bring effort. Compared with emerging individual interest, well-developed individual interest involves more stored knowledge and task value for contents (Hidi & Renninger, 2006; Hidi et al., 2004; Renninger, 2000). With well-developed individual interest, the student values and engages in the task again so that she/he can relate and try to find answers to questions. She/he is likely to employ various strategies and provide effort if it is required (Renninger, 2000; Hidi &

Renninger, 2006). Both phases of individual interest need external support and encouragement from experts, teachers, and peers to increase task understanding and opportunity (Hidi & Renninger, 2006; Hidi et al., 2004; Renninger, 2000; Siklander et al., 2017). Additionally, instructional situations and comfortable learning environments are beneficial to develop and deepen those two phases of individual interest for knowledge building and achievement (Hidi & Renninger, 2006; Renninger, 2000; Siklander et al., 2017).

It is clear that interest in the classroom may improve not only students' intrinsic motivational levels but can also stimulate their learning performance and engagement (Roberts & Ousey, 2004; Annabi, 2007; Renninger & Bachrach, 2015). Meanwhile, triggers can profoundly change and influence students' interest in either a positive or negative direction (Siklander et al., 2017; Määttä et al., 2012). Research has shown that interest-triggered learning activities can develop deep learning and engagement and lead to better learning achievement as well (Krapp, 2002; Brauer et al, 2017). Therefore, determining how to trigger students' interest is regarded as one of the most significant elements in learning and development (Hidi et al., 2004; Renninger & Bachrach, 2015). In this study, interest triggering will be applied within digital learning environments, which can support the enhancement of students' academic learning and engagement.

Aim and research questions

The aim of this study is to investigate how students' interest is triggered and positively maintained by applying ICT-based learning environments. The following research questions are examined in particular:

- Which factors trigger students' interest in learning in digital environments?
- What kinds of learning environments have been used for exploring triggers?

Methodology

The systematic literature review (SLR) methodology was used in this study. Compared with a narrative literature review, a systematic review that employs a strict methodology in a documented and structured process results in a more reliable and validated conclusion (Sawyer, 2017). Recognized as an appropriate way to search and analyze large literature databases, the SLR can gather relevant research papers and make essential contributions that provide evidence on the relationship between interest triggering and digital learning (Palsa & Ruokamo, 2015; Borrego, Foster, & Froyd, 2014; Horvath & Pewsner, 2004; Boelens, De Wever, & Voet, 2017).

Search stages

Two search stages were used to obtain research articles relevant to the present study. The first stage used the following search terms: "ICT" AND/OR "interest" AND/OR "trigger," these terms being close to the current article's keywords. For the second search stage, the following seven scientific databases were employed

for information retrieval: 1) ERIC (ProQuest), 2) ScienceDirect (Elsevier), 3) SpringerLink, 4) SAGE Journals, 5) Academic Search Elite (Ebsco), 6) ABI/Inform Global (ProQuest), and 7) Social Science Database (ProQuest). These databases were chosen because of their multidisciplinary ranges and their relevance to digital learning research.

Inclusion and exclusion criteria were used to select appropriate and focused studies (Boelens et al., 2017). The inclusion criteria were:

- peer-reviewed
- journal articles
- published between 2010 and 2016 (the last seven years)
- written in English

The exclusion criteria were:

- short conference articles without clear descriptions
- book or article reviews
- book chapters
- articles published in a language other than English

Based on the search terms, 240 articles were retrieved, and 47 of these were then selected according to the titles, abstracts, and keywords. Through reading all the selected articles (n=47), a total of 20 articles (see Appendix) were finally chosen according to the criteria for inclusion and exclusion.

Analysis

The type of data analysis used in this study was content analysis. Content analysis is a method that can typically be applied both to a qualitative and quantitative path (Seuring & Gold, 2012; Borrego et al., 2017). Seuring and Gold (2012) described two levels of content analysis. The first level was to analyze the apparent content of texts and documents in a statistical way, while the second level was to find out the actual content of texts and documents on the basis of the items and parameters' explanation. The combination of qualitative methods with quantitative analyses appeared helpful for the analyst (Seuring & Gold, 2012; Borrego et al., 2017).

In the educational research context, content analysis often appears as a kind of qualitative research and a method of synthesizing meaning from written documents, transcripts, and other media (Borrego et al., 2017; Seuring & Gold, 2011; Mayring, 2000). Meanwhile, it is also a flexible method that allows researchers to make many decisions based on the research questions and the data (Borrego et al., 2017; Mayring, 2000). If content analysis is applied in the systematic review, the analyst should have a clear intention and basic principle in mind so that the content analysis is able to instruct all the decisions to accommodate the methodology (Borrego et al., 2017; Seuring & Gold, 2011; Mayring, 2000).

In the light of this study's research questions, the analysis focused on factors

that trigger students' interest in learning in digital environments and the learning environments used for exploring triggers. The retrieved articles were analyzed in two phases. In the first phase, a separate document was established based on the research questions and the related data extracted from the articles. The extracted information involved the articles' details (authors, year published), contextual information (subject, course, program), and short-answer items for each research question (factors, learning environments). In the second phase, similar short-answer items were grouped into categories, and closely related items were merged. This distinguished and classified the items into four categories (scaffolding, environment acceptance, learning approach, technology acceptance) for the first research question and three categories (technological tools, game-based learning environments, computer environments) for the second research question.

Results

In this section, an overview of the selected articles (N=20) is provided. Next, the results for each research question are described. Analyses were conducted on fifteen articles (15/20) to answer the two research questions identified earlier in this study, while two articles (2/20) focused on the first research question, and three articles (3/20) focused on the second research question. The contextual information of articles included (a) subjects, for example, chemistry, science, mathematics (pre-algebra, algebra), English or Chinese (as foreign languages), history, geography, etc.; (b) undergraduate courses, such as introduction to management, E-commerce, management information system, etc.; (c) master's programs, for instance, information management, international management, international development, etc.

Which factors trigger students' interest in learning in digital environments?

A detailed overview indicating which factors trigger students' interest in each article is shown in Table 2.

Table 2: Factors that trigger students' interest in learning in digital environments

Study number	Scaffolding	Environment acceptance	Learning approach	Technology acceptance
1	instruction	knowledge construction interaction	–	–
2	instruction	an exploring learning environment	–	–
3	–	interaction collaboration	–	–
4	–	–	–	–
5	–	–	–	–
6	–	a comfortable learning space	–	perceived ease of use self-learning feedback and solution
7	instruction	collaboration	–	–
8	instruction	–	–	–
9	–	–	blended learning	–
10	–	interaction	–	–
11	–	collaboration	–	active students participate perceived ease of use
12	–	collaboration	–	received enjoyment perceived usefulness perceived ease of use self-efficacy
13	support (instruction & supervision)	–	–	–
14	–	a flexible learning context	–	perceived ease of use perceived usefulness
15	–	–	–	–
16	–	collaboration	–	–
17	–	collaboration	blended learning	–
18	–	individual learning style	–	–
19	support	interaction	–	perceived ease of use
20	–	–	blended learning	–
Total	**6**	**15**	**3**	**12**

In Table 2, the four categories of factors are scaffolding, environment acceptance, learning approach, and technology acceptance. The related items that belonged to each factor are presented on the basis of study number.

During the analysis of the included articles, various factors that influenced students' interest in learning in digital environments were found, and these were divided into the four categories presented in Figure 1.

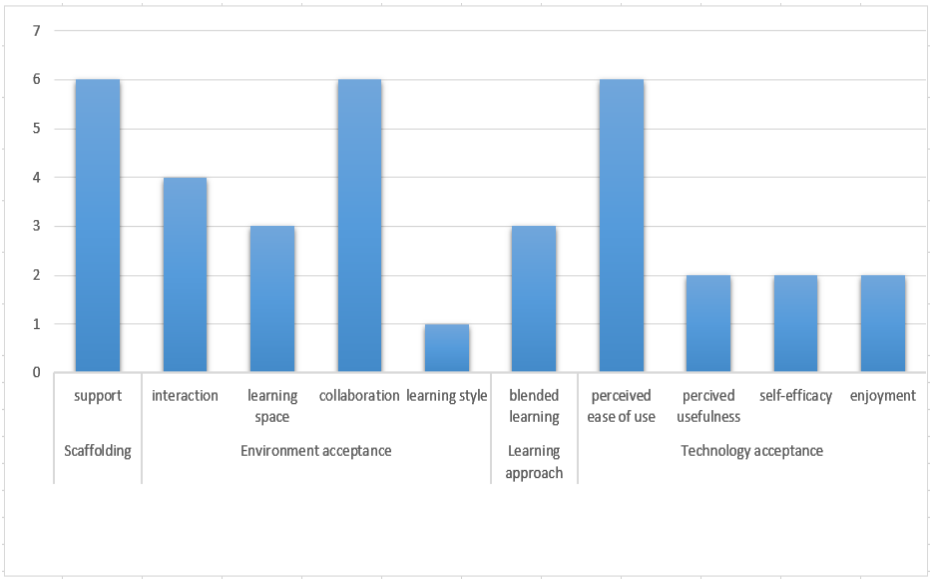

Figure 1: Various factors that triggered students' interest in learning in digital environments (X-axis: factors that triggered students' interest; Y-axis: numbers of articles discussing related factors).

Several articles (n=6) considered support, collaboration, and perceived ease of use to be the main factors that could trigger students' interest in learning in digital environments. Interaction (n=4) was also identified as an important

factor, and learning space (n=3), blended learning (n=3), perceived usefulness (n=2), self-efficacy (n=2), and enjoyment (n=2) were also found to influence students' interest in the activities. Only one article (n=1) identified learning style as having an impact on students' interest in the learning process.

Scaffolding. Support, as a type of scaffolding, may trigger students' interest and engagement in learning (Vandercruysse et al., 2013; Pozzi, 2011). For example, in Vandercruysse et al.'s (2013) study, three types of supportive feedback (correct answer feedback, explicit feedback, and implicit feedback) were provided to students when engaging in a game-based language learning environment, and the types of feedback would withdraw gradually when they engaged in various levels of tasks. Their results showed that the content of instruction was relevant to students' interest and enjoyment, perceived value and usefulness of the task, and level of motivation (Vandercruysse et al., 2013; Pozzi, 2011). Lack of assistance would make students feel anxious and hinder knowledge exchange during the learning activities. However, teachers' instruction and supervision could make tasks more interesting and acceptable, as well as activate students' participation (Sharma, Pandit, & Pandit, 2011; Nygren & Vikström, 2013; Arancibia et al., 2013). For instance, in Nygren and Vikström's (2013) study, upper secondary students pointed out that a teacher's supervision would make a task interesting in history, and without a teacher's instruction, their task would take longer. In addition, detailed guidance and explanation from teachers could give students direction and indicate how they should engage in the performance; it could help them to know how to continue in the activities and progress in them (Furberg et al., 2013; Pérez-Sanagustín, Santos, Hernández-Leo, & Blat, 2012).

Environment acceptance involves collaboration, interaction, learning space, and learning style, closely related to students' interest. Regarding collaboration, various studies have shown that this positively stimulates students' interest in learning activities. Most students thought collaboration provided more chances to experiment or engage in other activities, further discourse, and instructions-afforded (Sun & Looi, 2013; Pozzi, 2011). Silviyanti and Yusuf (2014) mentioned that collaboration directed students to become active participators and contributors, not just passive receivers of knowledge. In other words, students were prompted to share knowledge, discuss, negotiate, support, and appreciate one another in the collaborative setting (Furberg et al., 2013; Silviyanti & Yusuf, 2014). Regarding interaction, this may motivate students' interest in applying active learning strategies for problem solving and help them to acquire and apply knowledge effectively in the digital environments (Chen et al., 2014; Pozzi, 2011). Sharma et al. (2011) stated that interaction and dealings between learners could set up a social atmosphere that encourages knowledge construction and the conservation of learning. Students felt they had a positive effect in the interaction with their peers, which motivated them to participate in the project (Arancibia et al., 2013). Further, various types of interaction, for example online interaction, increased students' interest and motivated their self-learning (Mompean, 2010). Regarding learning space, Wang (2010) found that a comfortable learning space could encourage students to learn actively without needing to wait for others. Bere and Rambe (2016) found that a flexible learning space provided students various choices and convenience in adapting to their learning needs, stimulated their intentions for learning, and allowed students

to choose when, what, and where they study. Chen et al. (2014) claimed that an explorative learning environment could trigger students' motivation, support their active learning, enhance learning influence, and develop their cognitive skills. Lastly, regarding learning style, research has shown that students with different learning styles had various interests in respect to technology (Thang et al., 2015). For example, an analytical student would be interested in the usefulness and ease of use of the technology, differing from the interests of a communicative student (Thang et al., 2015). It should be mentioned that although learning style was explored in the reviewed article, we are aware that there is not scientific evidence for this proposition (Kirschner, 2017).

Learning approach. Blended learning has been found to be a good way to increase students' interest and willingness to learn through integrating traditional learning methods with interactive technologies (Bader & Köttstorfer, 2013; Chen & Wang, 2015; Pérez-Sanagustín et al. 2012). The study by Pérez-Sanagustín et al. (2012) is an example of blended learning practices in which the script blended individual and collaborative activities supported by mobile and computer-based technologies in a geography course in a high school. The findings indicated that computer-supported collaborative learning scripts could promote students' active learning, enhance technological skills, draw more attention to environment, enhance collaborative skills, and increase their enjoyment in geographic learning (Pérez-Sanagustín et al. 2012). In Chen and Wang's (2015) study conducted in two junior high schools, face-to-face activities and hands-on online learning were blended in a regular science classroom. The results showed that most students considered the blended learning to be interesting and valuable and that they preferred to learn in a combination of learning styles.

Technology acceptance includes perceived ease of use, perceived usefulness, self-efficacy, and enjoyment and is also an important factor in motivating students' interest in learning. Perceived ease of use has a positive influence on students' attitudes toward using technology (Bere & Rambe, 2016; Chen et al., 2013). It can trigger students' learning interest, provide chances for self-learning, and supply feedback and solutions for problems immediately (Wang, 2010). Students who perceive technology use to be easy may put in more effort and obtain higher learning outcomes (Vandercruysse et al., 2013). Arancibia et al. (2013) reported that perceived ease of use was a motivational factor that had a profound effect on students' expectations and preferences in learning. Perceived usefulness is one of the most significant determinants of students' use of technology because students could assess the results of their behavior on the basis of perceived usefulness (Chen et al., 2013; Bere & Rambe, 2016). Bere and Rambe (2016) found that if students perceived technology to be useful, this would have an important and positive influence on their attitudes toward and purposes for using that technology in learning. Perceived usefulness could stimulate students to complete learning faster, increase their learning achievement, enhance learning activities, and improve their efficacy of learning (Chen et al., 2013). Self-efficacy is the belief and confidence in using technology efficiently when performing learning tasks (Chen et al., 2013). Further, Wang (2010) claimed that self-efficacy had an important consequential impact on students' behavioral purposes and interests in learning and that it encouraged self-learning as well. Regarding enjoyment, research has found that students'

interest in learning activities could be affected by the extent of enjoyment perceived during the experience of using technology; in other words, enjoyment had a positive influence on students' applications of technology (Chen et al., 2013). If students had more enjoyable experiences during the learning process, they were more likely to use the technology as learning tools, and, as a result, their learning interest and productivity were promoted in the process (Chen et al., 2013; Bere & Rambe, 2016).

What kinds of learning environments have been used for exploring triggers?

To answer the second research question, Table 3 gives a detailed overview of the kinds of learning environments used in each study to explore triggers.

Table 3: Various kinds of learning environments used to explore triggers.

Study number	Technological tools	Game-based learning environments	Computer environments
1	-	-	Moodle
2	-	3D RPG game (role-playing game)	-
3	-	-	SCY-Lab with Internet-mediated information sources
4	-	educational video game: APP	-
5	-	-	DME: digital mathematics environment
6	-	-	multimedia skill-learning platform
7	-	-	Wimvt system: web-based inquirer with modeling and visualization technology system
8	-	GBL: game-based learning environment	-
9	-	-	AR (Augmented-Reality)-embedded instruction
10	blog	-	-
11	web 2.0	-	-
12	-	-	WBI: web-based instruction platform
13	-	-	Indiko: a digital database
14	MIM: mobile instant message, e.g. WhatsApp	-	-
15	GS: Group Scribbles	-	-
16	blog	-	-
17	-	-	4SPPIces-based CSCBL scripts
18	blog	-	-
19	-	-	-
20	-	-	-
Total	6	3	9

In Table 3, the three categories of learning environments include technological tools, game-based learning environments, and computer environments. The related items that belong to each learning environment are presented on the basis of study number.

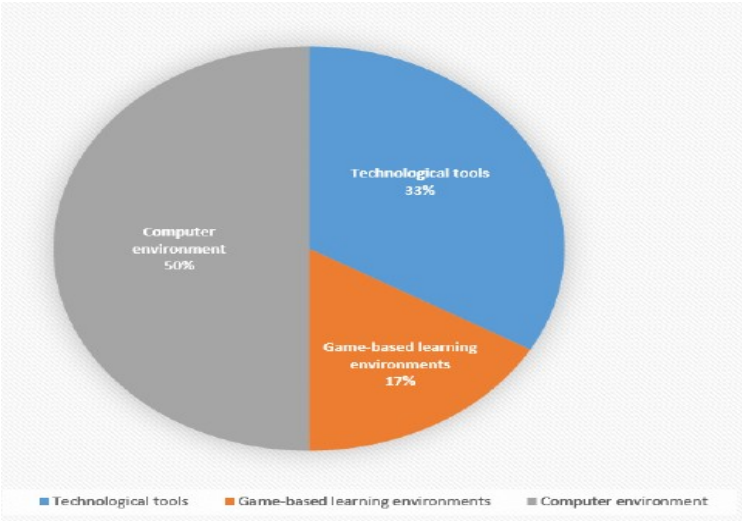

Figure 2: Percentage of studies employing relevant categories of learning environments for exploring triggers.

Technological tools refers to the usage of digital devices engaged in a Web-based environment, e.g. blogs, Facebook, email, Skype, online discussion forums, etc. (Mompean, 2010; Silviyanti & Yusuf, 2014; Thang et al. 2015). These were used by 17% of the studies. Game-based learning refers to employing a digital game for students in a learning context. This was used in 33% of the studies (Vandercruysse et al. 2013; Chen et al. 2014). Computer environments refers to building digital learning contexts where multimedia technologies and Internet-mediated information resources are interacted. These were used in 50% of the studies (Furberg et al. 2013; Wang, 2010; Chen et al. 2013).

Technological tools. Six articles explicitly reported applying four technological tools, including blogs, Web 2.0, MIM (mobile instant message), and GS (Group Scribbles), to explore triggers in learning. Blogs created harmonious atmospheres in learning and provided positive support for students to develop online interaction, exchange knowledge, increase self-confidence, and enhance language skills (Mompean, 2010; Silviyanti & Yusuf, 2014). In Silviyanti and Yusuf's (2014) study, students were seen to engage in situations where they posted their writings, commented, and gave feedback to each other. The information from students' interviews showed that 87.5% of the students enjoyed writing in the blog and said it increased their interest in writing, and all the students agreed that the blog improved their writing ability (Silviyanti & Yusuf, 2014). In Arancibia et al.'s (2013) study, Web 2.0, a tool on the Social Web, offered more opportunities for students to participate in collaborative learning activities (e.g., information selection, interaction with peers) in a geography course. Meanwhile, it also encouraged students' self-regulation in learning processes related to the tasks they carried out with peers (e.g., increase their paces and regulate their learning) (Arancibia et al., 2013). Bere and Rambe (2016) said MIM had the potential to build a flexible learning environment to assist reformation from teacher-centered to student-centered learning in higher education, which could offer students more participation and engagement in tasks, deepening knowledge and prompting interest in learning. Finally, Wen, Looi, and Chen (2015) found that embedding GS, a representational tool, in a collaborative language (Chinese) learning environment enabled junior students to participate equally, collect and share ideas based on individual effort and social sharing, guide collaborative interaction, and facilitate their language learning skills.

Game-based learning environments. Games were considered a good way to catch students' attention and awaken their motivation to learn (Chen et al., 2014; Chang et al., 2016; Vandercruysse et al., 2013). Three articles used game-based learning environments to trigger exploration. First, in Chen et al.'s (2014) study, the innovative and meaningful learning method of a 3D role-playing game (RPG) offered a student-centered immersive learning space to trigger secondary school students' high motivation levels and self-satisfaction in learning chemical formulas. It assisted students in participating actively, better understanding scientific concepts, exploring learning strategies, and combining prior knowledge with new knowledge in an enjoyable environment (Chen et al., 2014). Chang, Evans, Kim, Norton, Deater-Deckard, and Samur (2016) found that the use of educational video games (named APP) could profoundly foster fifth-grade students' active learning and engagement (behavioral, emotional,

and cognitive engagement) in pre-algebraic fractions concepts since it could stimulate both female and male students to employ their cognitive skills and strategies in the process. Vandercruysse et al. (2013) claimed that in a game-based learning (GBL) environment for learning business English conversation skills (age range between 16 and 33), the competition elements impacted the students' motivation and learning outcomes, the supportive information facilitated the students' problem solving, and the immediate feedback encouraged the students to invest more effort. Most of the students reported that learning in a gaming environment could increase their interest and enjoyment and that they valued the accomplished tasks at a high level (Vandercruysse et al., 2013).

Computer environments. Various computer environments were selected by researchers to investigate how students' interest was stimulated in the learning process. Nine learning environments related to computer environments were identified: Moodle, multimedia skill-learning platform, WBI (Web-based instruction platform), SCY-Lab (a computer environment named by Science Created by You project) with Internet-mediated information sources, AR- (augmented reality) embedded instruction, WiMVT (Web-based inquirer with modeling and visualization technology) system, DME (digital mathematics environment), Indiko (a digital database), and 4SPPIces- (a conceptual model involving 4 factors: the Space, the Pedagogical Method, the Participants, and the History) based CSCBL (Computer-Supported Collaborative Blended Learning) scripts.

Pozzi (2011) claimed that Moodle could easily be used for interaction that helped individuals or groups to exchange messages, construct knowledge, facilitate discussion, and provide instruction in an online teacher training course. Wang (2010) found that multimedia skill-learning platforms applied in a vocational course benefited individual students in coping with information easily, accessing learning materials at their convenience, offering independent operation without emotional pressure, receiving immediate feedback and solutions, providing more opportunities for self-learning, and engaging their interest and satisfaction in architectural drawings and designs. Chen et al. (2013) reported that the WBI system could deliver instruction and communication between teachers and students synchronously and asynchronously, which was helpful for students in vocational universities to gain knowledge, control the learning process, manage learning time and space flexibly, practice repeatedly, and experience enjoyment during learning courses supported by the WBI system.

Three articles applied computer environments in the subject of science. Furberg et al. (2013) said that the SCY-Lab environment assisted upper secondary school students in employing multiple representations (science-learning diagrams) effectively, which was beneficial for them in understanding scientific principles and maintaining positive engagement. In Chen and Wang's (2015) study, AR was a practical tool, and most eighth-grade students (from six classes in two secondary schools) felt that it would be profitable for their thinking skills and learning achievement, especially if it was integrated with instructional stages. In a study done by Sun and Looi (2013), modeling and interaction were integrated together in the WiMVT system, which enabled secondary students to

acquire a deep understanding of scientific concepts and develop critical thinking skills. At the same time, different scaffolds in the WiMVT system helped students to explore unknown knowledge and maintain positive learning interest (Sun & Looi, 2013).

DME is an online tasks environment for mathematics education whereby eighth-grade students were found to be able to acquire conceptual understanding and algebraic skills due to the supportive information, immediate procedural and corrective feedback, and valid practice it provided (Drijvers et al. 2014). Nygren and Vikström (2013) found that many upper secondary school students thought it was interesting and instructive to use a digital database (Indiko) in social history learning. Meanwhile, feedback from previous practice, effective scaffolding, and suitable task planning were found to engage students positively in a digital learning environment (Nygren & Vikström, 2013). Pérez-Sanagustín et al. (2012) claimed that the combination of 4SPPIces and computer-supported collaborative blended learning (CSCBL) scripts provided a dynamic and interesting experience for upper secondary school students and had a positive effect on their motivation and knowledge construction in geographic fieldwork. With the support of mobile and computer-based technologies, students could practice their technological and location skills, while the teachers could organize and structure the whole geography activity (Pérez-Sanagustín et al., 2012).

Discussion and conclusion

This section emphasizes the three major findings of this study: (1) most articles mentioned the significance of triggering students' interest in learning, (2) employing a computer environment was considered to be the most efficient way to trigger stimulation, and (3) there were many more articles focused on the development of a digital learning environment in a real learning background.

The first research question inquired into which factors could trigger students' interest in learning in digital environments. The results uncovered three important aspects related to the key points of interest triggering in learning: (a) scaffolding, e.g., teacher–student interaction and teacher intervention and support, (b) collaboration, including face-to-face and online collaborative learning, and (c) perceived ease of use, relating to the attitude toward digital technology use in the learning activities. An obvious finding is that, in many of the articles, these three factors work simultaneously and mutually influence each other. A reasonable explanation for this is that one element alone is not enough to stimulate students' interest and engagement in learning. Collaboration provides more opportunities for students to participate actively, share knowledge, increase self-confidence, and develop interest (Silviyanti & Yusuf, 2014; Furberg et al., 2013; Renninger & Hidi, 2011). Meanwhile, a teacher's detailed guidance and explanations during their individual and group learning can help stimulate students' knowledge construction, facilitate their interest and enjoyment, and help them have a positive experience in the performance (Vandercruysse et al., 2013; Nygren & Vikström, 2013; Chen et al., 2014; Furberg et al., 2013). With group work and teachers' support, students' individual interests can be developed, which will be beneficial for their task engagement. In addition, no matter what students learn individually or

collaboratively, digital technologies that are easy to operate trigger and maintain students' situational interest in learning and engagement in the digital environment (Bere & Rambe, 2016; Wang, 2010).

In relation to the second research question, there were two findings. First, the results indicated that many studies in the articles employed popular and effective computer environments to explore triggers in learning. Most of them were online learning environments, and one was an offline learning environment that integrates with Internet-mediated information resources. Many articles reported that computer environments can support students in acquiring academic knowledge and enhance situational interest within a flexible and comfortable learning environment (Furberg et al., 2013). That is because digital learning environments can offer students opportunities for self-paced and collaborative learning, can provide support and feedback directly, and allow students to experience interesting and engaging learning activities (Wang, 2010; Pérez-Sanagustín et al., 2012; Sun & Looi, 2013). However, it should be mentioned that the use of only digital learning environments does not develop students' situational interest into individual interest in learning and engagement in activities, especially in primary and secondary education. The significance and effectiveness of teachers' scaffolding should be considered and integrated into those digital learning environments. Second, in some articles, the studies integrated social interaction into learning spaces developed with digital technologies (Sun & Looi, 2013; Pozzi, 2011). The combination of digital technologies and collaboration is a potentially beneficial way for students to gain knowledge, develop critical thinking skills, and stimulate motivation and engagement. For further research, a blended learning environment in which face-to-face association is combined with online activities should be considered; this could offer students new opportunities to control their learning environments and could lead to the development of an emerging, and then well-developed, individual interest (Renninger & Hidi, 2011; Renninger & Bachrach, 2015).

Limitations

The first limitation in the study concerns the analysis of the articles in the review. Various elements were found on the basis of the research questions. Although they were categorized as different items, there are also some elements that were not mentioned, for example, systematic characteristics and structuring resources. That is because the review focused on the general and effective elements that were discussed and applied in most of the articles. A second limitation is that the contextual background (subject, course, program) is not presented in the tables but only mentioned in the body of the paper. The contextual background information was not included because the review centered on the factors of and various learning environments for triggering students' interest. A third limitation is that articles written in languages other than English were excluded. Many articles relating to research about the use of digital technologies in education that would be meaningful and beneficial for the review are written and published in Chinese, for instance. However, the role of English in international academic exchange must be considered in the study.

Implications

This study presents a framework for how students' interest in learning is triggered and stimulated in digital environments. The framework is helpful for educators and researchers in designing new technology-based learning environments and in discovering more appropriate approaches to the successful integration of digital technologies in the learning and teaching process. Based on the previous research on digital technologies and interest triggering reviewed in this study, three focuses for future research are identified. First, when designing learning environments based on digital technologies, the teachers' organization and structure of the learning activities should be considered. Second, the students' learning outcomes must be one of the criteria for evaluating the level of interest promotion in digital learning environments. Finally, future research should pay more attention to students who may have low levels of technology acceptance and should seek out effective approaches to triggering their interest and engagement in the learning activities.

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Appendix: List of articles chosen in the study

Study Number	Author details	Year	Title	Subject/Course/Program	Publication title
1	Pozzi	2011	The impact of scripted roles on online collaborative learning processes	educational technology	Computer-Supported Collaborative Learning
2	Chen, Wong, & Wang	2013	Effects of type of exploratory strategy and prior knowledge on middle school students' learning of chemical formulas from a 3D role-playing game	chemistry	Educational Technology Research and Development
3	Furberg, Kluge, & Ludvigsen	2013	Student sensemaking with science diagrams in a computer-based setting	science	Computer-Supported Collaborative Learning
4	Chang, Evans, Kim, Norton, Deater-Deckard, & Samur	2015	The effects of an educational video game on mathematical engagement	mathematics (pre-algebraic fractions)	Education and Information Technologies
5	Drijvers, Doorman, Kirschner, Hoogveld, & Boon	2014	The effect of online tasks for algebra on student achievement in Grade 8	mathematics (algebra)	Technology, Knowledge and Learning
6	Wang	2010	Educational benefits of multimedia skills training	architectural design	TechTrends
7	Sun & Looi	2012	Designing a web-based science learning environment for model-based collaborative inquiry	science	Journal of Science Education and Technology
8	Vandercruysse, Vandewaetere, Cornillie, & Clarebout	2013	Competition and students' perceptions in a game-based language learning environment	business English (second language)	Educational Technology Research and Development
9	Chen & Wang	2015	Employing augmented-reality-embedded instruction to disperse the imparities of individual differences in earth science learning	science	Journal of Science Education and Technology
10	Mompean	2010	The development of meaningful interactions on a blog used for the learning of English as a foreign language	English (foreign language)	ReCALL
11	Arancibia, Oliva, & Valdivia	2013	Meaning processes mediated through a protagonists' collaborative learning platform	geography	Media Education Research Journal

Study Number	Author details	Year	Title	Subject/Course/Program	Publication title
12	Chen, Lin, Yeh, & Lou	2013	Examining factors affecting college students' intention to use web-based instruction systems: towards an integrated model	introduction to management, Chinese, E-Ecommerce, management information system, English (foreign language)	The Turkish Online Journal of Educational Technology
13	Nygren & Vikström	2013	Treading old paths in new ways: upper secondary students using a digital tool of the professional historian	history	Education Science
14	Bere & Rambe	2016	An empirical analysis of the determinants of mobile instant message appropriation in university learning	Internet programming and information system	Journal of Computing in Higher Education
15	Wen, Looi, & Chen	2015	Appropriation of a representational tool in a second-language classroom	Chinese (second language)	International Journal of Computer-Supported Collaborative Learning
16	Silviyanti & Yusuf	2014	A one-stop class blog to promote collaborative writing activities	English writing (foreign language)	Malaysian Journal of ELT Research
17	Pérez-Sanagustín, Santos, Hernández-Leo, & Blat	2012	4SPPIces: a case study of factors in a scripted collaborative-learning blended course across spatial locations	geography	Computer-Supported Collaborative Learning
18	Thang, Nambiar, Wong, Jaafar, & Amir	2015	A clamour for more technology in universities: what does an investigation into the ICT use and learning styles of Malaysian 'digital natives' tell us?	English (foreign language)	The Asia-Pacific Education Researcher
19	Sharma, Pandit, & Pandit	2010	Critical success factors in crafting strategic architecture for e-learning at HP University	personal contact programs (PCPs, a distance education program)	International Journal of Educational Management
20	Bader & Köttstorfer	2013	E-learning from a student's view with focus on global studies	information management program, international management program, international development (Master's programs)	Multicultural Education & Technology Journal