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Evaluation of affective embodied agents in an information literacy game

Yan Ru Guo*, Dion Hoe-Lian Goh

Wee Kim Wee School of Communication and Information, Nanyang Technological University, 31 Nanyang Link, Singapore

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ABSTRACT

Digital game-based learning (DGBL) has become increasingly popular. With elements such as narratives, rewards, rules, and interactivity, DGBL can actively engage learners, stimulating desired learning outcomes. In an effort to increase its appeal, affective embodied agents (EAs) have been incorporated into DGBL as learning companions or instructors. However, claims about the efficacy of using affective EAs in DGBL have scarcely been subjected to empirical analysis. Therefore, this study aims to investigate the influence of affective EAs on students' learning outcome, motivation, enjoyment, perceived usefulness, and behavioral intention in an information literacy (IL) game. In total, 159 tertiary students were recruited and randomly assigned in a pre-test post-test between-subjects experiment with three conditions: affective-EA, neutral-EA, and no-EA. Results suggested that students benefited from interacting with the affective EA in the IL game, in terms of learning motivation, enjoyment, perceived usefulness and behavioral intention. However, there was no significant difference in learning outcome.

1. Introduction

The ever-increasing access to the Internet brought about the proliferation of and increased accessibility to information. People are generating, discovering, gathering, analyzing, translating, and repurposing an enormous amount of information at great speed. With the explosion of such digital information, information literacy (IL) skills - the ability to seek, locate, evaluate and navigate information effectively - have become more important, especially to students. There is a widespread acknowledgement that students need to be supported in the development of their IL skills. Academic libraries have taken the lead in the development of IL programs for students. However, the younger generation of students find traditional face-to-face instruction by librarians not engaging enough, and expect to be entertained while being taught (Shurkin, 2015).

Here, a development that has significantly influenced learning is the use of digital games. Digital games have found a broad audience, particularly for youth, provoking a deep sense of engagement (Olson, 2010). They are known to provide an intrinsically motivating experience and a state of heightened enjoyment that people do “for its own sake” (Sweetser & Wyeth, 2005). They catch the eye, engage the players, and incorporate narrative in ways that make them important teaching tools. Such use of digital games for educational purposes is often referred to as digital game-based learning (DGBL). DGBL can serve not only as an engaging way to entertain players, but also as an innovative tool to help build the players' cognitive abilities, encourage problem-solving, promote collaboration, and increase self-esteem (Felicia, 2009). Although the concept of DGBL

* Corresponding author.
E-mail addresses: W120030@ntu.edu.sg (Y.R. Guo), ashlgoh@ntu.edu.sg (D.H.-L. Goh).

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has influenced education in general, such as in mathematics, history, and computer literacy (Atkinson, 2002; Mayer & DaPra, 2012; van der Meij, 2013), it is relatively unknown to IL education. DGBL presents an opportunity for librarians to rethink and reinvent the IL education.

Concurrently, researchers have realized the important role of affect in learning, and have begun to factor learners' affective states into educational system design. Some common techniques to infuse affect into DGBL include using music, storylines, colors, and narration, but the most effective way is through interface characters, also referred to as "*avatars*" or "*agents*" (Salen & Zimmerman, 2005). The term "*agent*" refers to an autonomous computer program that can*act* on its own (Haake, Silvervarg, & Sjödén, 2010). An embodied agent (EA) therefore refers to a life-like agent, i.e., one with a face and body, and communicates with users via speech, facial expressions and body gestures. Designed with the ability of emotional expression, affective EAs are becoming an increasingly popular technique to incorporate affective elements in computer programs.

Using EAs can make the interactions between humans and computers more natural and enjoyable (Kim, Baylor, & Shen, 2007). In addition, it is believed that EAs' ability to detect and express affective states is crucial for improving their believability and trustworthiness, eliciting affect in the users, as well as contributing to more entertaining interactions. The use of affective EAs in a pedagogical role such as instructors, mentors, assistants, and companions, can also help students overcome negative affect such as boredom or frustration during learning process. Given the potential of both DGBL and affective EAs, the two concepts have been juxtaposed to achieve synergy.

Despite the increasing sophistication of affective EA design, research has focused more on cognitive task goals such as reliable and efficient information delivery, and there is a lack of studies on the motivational or social aspects of their use in educational systems. Motivation is a key ingredient in learning, and social cues play an important role in motivation. It is hence important that both developers and educators realistically assess the potential and limitations of using affective EAs in DGBL. Equally important, affective EAs have rarely been taken into consideration or formally evaluated in IL games. IL education differs from other domains as it involves higher-order thinking skills, skills activated when individuals encounter unfamiliar problems, uncertainties or discrepancies before they start information seeking (Tokuhama-Espinosa, 2014). Thus it requires different teaching strategies and learning environments from lower-order thinking skills. The concern over students' affective states should be reflected in IL games. Additionally, a close examination of the evaluation literature found that most studies compared the affective EAs condition in DGBL against no EA condition or traditional paper-and-pencil lessons condition, making it difficult to determine exactly which factor played a role in the results. More studies that explicitly compare affective and non-affective EAs are required to further our understanding of their effects. Therefore, this study aims to examine the influence of affective EAs in a digital IL game across three conditions: affective-EA (with affective feedback, facial expressions and body gestures), neutral-EA (that retains the same facial expression and body gesture throughout), and no-EA. Specifically, it investigates their influence on students learning outcome, motivation, enjoyment, perceived usefulness and behavioral intention.

The paper is organized as follows. The first section sets the context of this study, stating the research gaps and research objectives. The second section reviews related work in DGBL and affective EAs. This is followed by a description of the IL game used in this study, and the hypotheses development. The subsequent three sections present the research method, results from the data analyses, and discussion. The last section concludes the paper, and points out its contributions, limitations, and future work.

2. Related work

2.1. Information literacy education

Librarians have been at the forefront of IL education to the public and students. This section compares three commonly used methods in IL education: face-to-face library instruction, computer assisted tutorials, and DGBL.

Face-to-face library instruction has been the most common and widely adopted method in IL education. They are typically conducted by subject or reference librarians at the beginning of each academic year, to promote effective use of information, information sources and information systems for students and faculty. However, these face-to-face instruction efforts have repeatedly shown to be insufficient. Students' participation rates are usually low (Smith & Baker, 2011). Some students consider library instruction as unnecessary because they regard their information search and evaluation skills to be better than they actually are (Thomas, Crow, & Franklin, 2011). Further, many students who are most in need of assistance are precisely those who will not ask for help (Kuhlthau, 2004). Another problem is that students do not appreciate the relevance of library instruction to their studies, sometimes due to a lack of coordination in the promotion of the sessions by library and academic staff. Moreover, most librarians are not able to work with students across the entire length of a semester, and are limited to a single session of an hour or two to teach generic library skills (Loo, 2013). Hence the amount of material presented in an hour is usually overwhelming. In addition, since such lessons are arranged in the first week before students receive assignments, librarians tend to focus on teaching general knowledge (e.g., how to use Boolean operators), rather than on addressing specific problems related to coursework or assignments. This potentially reduces their usefulness. A rethink on the timing would be helpful to improve their effectiveness (Van Eck, 2011). Other researchers suggest that more sessions and/or delivery that is more integrated into the curriculum may be the solution (Markey, Leeder, & Rieh, 2014). From another point of view, there may be value in the consideration of alternative delivery methods for IL instruction.

As much of student learning now occurs outside classrooms, face-to-face instruction can only reach a fraction of students. Hence a more efficient method of reaching a large number of students simultaneously - computer assisted tutorials - are increasingly popular (McClure, Cooke, & Carlin, 2011). Once online, the tutorials can be accessed and reused anytime, with the clear advantage of time-savings and cost-effectiveness. Such tutorials can effectively reach out to those students with library anxiety, in case they feel embarrassed to ask for help in face-to-face instruction settings (Kuhlthau, 2004).

For example, Toronto's Seneca College developed an online interactive tutorial called *Library Research Success* for first-year business students (Donaldson, 2001). The tutorial aims to increase students' knowledge of library resources, particularly business resources. It comprises five modules: orientation, information sources, periodicals, research strategy, and databases. The tutorial also incorporates hands-on exercises at the end of each module and two assignments, to be submitted electronically to instructors at the end of the tutorial. The tutorial was evaluated through a short survey and qualitative interviews where students were asked to rate a number of tutorial features in terms of the value, content, presentation, and instructional delivery method. The results showed students received the tutorial very positively.

However, computer assisted tutorials also have drawbacks, such as high dropout rates, absence of personal touch, and the lack of motivation by students to participate when it is not required by the instructors (Loo, 2013). It is not surprising that students who are bored in a library instruction sessions are not likely to recall details about it (Smith & Baker, 2011). DGBL can potentially address these drawbacks. Digital games are able to provide enjoyable experiences so effectively that players often find themselves actively seeking information and solutions (Prensky, 2005). This idea of using DGBL in IL education is explored further in the next section.

2.2. Digital game-based learning

With the popularity of gaming among students, attention has turned to its educational values and positive impact on student learning. Digital game-based learning affords a highly interactive medium with sophisticated pedagogical attributes. Design elements such as narratives, rules, goals, rewards, and multisensory cues can stimulate desired learning outcome (Markey et al., 2014). Unlike classroom instruction, such games can be adapted to the pace of learners, and simultaneously present information in multiple visual and auditory modes, capitalizing on different learning styles (Prensky, 2005). Libraries have tapped on the popularity of DGBL to promote their services and IL education to students.

For example, Carnegie Mellon University designed two IL games, *Within Range* and *I'll Get It* (Beck, Callison, Fudrow, & Hood, 2008). *Within Range* teaches students about how collections are shelved in their libraries. It asks the player to sort three shelves of books into the correct order. As the game progresses, the call numbers become more complicated and precise, and the time limit stricter. The other game *I'll Get It* puts the player in the role of a library staff member at a busy university help desk. While the room is initially empty, after a few seconds, it is filled with students clamoring with information needs. The game requires players to prioritize the library users so that no one is waiting too long and gives up, and fulfill users' information requests by selecting the most appropriate resources.

Utah Valley University also developed two IL games: *Get a Clue* and *LibraryCraft* (Smith & Baker, 2011). *Get a Clue* aims to introduce new students to the physical library, as well as the library services. The game clues are built around a central story, a mystery, and follow a detective through the steps of solving a crime. Students can tour around the library using the clues. To evaluate the game, 229 students were invited to play it and complete a short survey. The results indicated the game reached students who had minimal exposure to the library. Encouraged by the positive results, the librarians went on to develop a second game, *LibraryCraft*, to introduce students to the digital library and digital resources. This game sends students on a medieval quest. Students can visit different parts of the library's website as they progress in the game. *LibraryCraft* ends with a short survey with 52 students as respondents. Although more than half of the participants reported difficulties using the game, confusion about the tasks, or complained that the game was too long, most agreed that the game was easy to follow. Most participants benefited from the game and learnt more about the library resources and how to conduct research. As can be gleaned from the above examples, the evaluation of IL games relied mostly on qualitative anecdotal quotations, and lacked rigorous experimental comparisons and concrete measures on students' learning performance.

An exception is *BiblioBouts*, an IL game developed by the University of Michigan (Markey et al., 2014). As one of the few IL games that were extensively documented and evaluated, it is discussed in more detail here. *BiblioBouts* consists of a series of narrowly focused and successive bouts (mini-games): Closer bout (finding information), Tagging & Rating bout (evaluating information), and Best Bibliography bout (selecting information). The game allows students to search for, compile, and evaluate different information sources to produce a higher-quality bibliography for class assignments. Students can check the sources that other players contribute, to discover sources they would not have found otherwise. To evaluate *BiblioBouts*, students were invited to play the game over a two-week period. The extensive evaluation process included game diary forms, pre-and post-game questionnaires, immediate focus group interviews, follow-up interviews four or more months later, pre-and post-game individual interviews, and game activity logs. While most students reported positive learning experiences during gameplay, some failed to grasp its educational values. To summarize, the aforementioned examples failed to take advantage of affective elements in IL games. They focused more on cognitive aspect of IL knowledge acquisition, while the affective and social aspects were largely ignored (Kuhlthau, 2004; Loo, 2013).

2.3. Affective embodied agents

Among the different game elements, avatars are frequently used in digital games. Depending on the stream of research, avatars are also labeled as autonomous agents, animated agents, embodied agents, and virtual agents. The present study focuses on embodied agents, since they indicate a low level of artificial intelligence (Nunamaker, DErrICk, Elkins, Burgoon, & Patton, 2011).

Studies have discovered that people cannot perceive a difference between mediated images of EAs and real people, and blend the signals from the living and the animated. Nass and Reeves (1996) designed a series of experiments to investigate how people respond to computers (new media) and TVs (traditional media), and discovered that people perceive animated images as real and respond to them as they would to another person. Along the same line of research, Hyde, Kiesler, Hodgins, and Carter (2014) conducted an experiment to investigate whether children interact with EAs and real people differently. An adult confederate conversed twice with the children, once as herself through video and once as an EA image. Results suggested that there was no difference in children's conversation behavior with the real person and the EA image, even among those who said they preferred real person, or when the EA image behaved strangely. These results indicate that children interacted with EAs as they would with another person.

Researchers have explored the use of EAs in various applications. By providing visual cues, well-designed EAs make it easier to attract people's attention, better meet the needs of learners in cognition and affect, thus enriching the learning experience (Kim et al., 2007). To investigate whether using EAs can increase students' learning performance and motivation, Chen and Chou (2015) designed a multimedia instructional database with an EA that teaches force and motion. The EA, *Paul*, is an instructor that can provide related information and guiding instructions. One hundred and thirty-nine middle school students were recruited and assigned to one of the two conditions: the experimental group interacted with the database with EA, and control group interacted with a normal database. Participants completed a pre-test before the experiment, and a post-test two days after the experiment. Results revealed that the EA successfully increased students' knowledge acquisition and learning motivation. Similarly, van der Meij (2013) examined whether using an EA in a print tutorial can enhance learning motivation and learning performance. The EA was designed to motivate students through images and written messages. Data on motivation and learning performances were collected before, during and after the learning. Compared with students who received the tutorial without EA, those in the EA condition performed significantly better in learning outcome.

Nevertheless, empirical findings have not been consistent, and sometimes showed no difference in learning outcome whether students interacted with the affective EAs or not. One such example is reported by Carlotto and Jaques (2013), in which an affective EA *Patti* was designed to teach English as a foreign language. Forty-two Brazilian undergraduate students were divided into two groups: the experimental group interacted with *Patti* in the computer learning program, while the control group did not interact with any EA. The results showed no significant difference in learning performance between the two groups. In other words, using an affective EA failed to improve students' learning performance. Such experimental findings seemed to cast doubt on the effectiveness of affective EAs on improving learning performances in DGBL.

Moreover, as emphasis on Science, Technology, Engineering, and Math initiatives increase, as seen from all above examples, there is very limited literature on its use to teach higher-order thinking skills such as IL skills (Charsky, 2010). IL involves higher-order thinking skills as it teaches important procedural knowledge that synthesizes complex level of thinking and knowledge (Anderson, 2008). DGBL presents an opportunity for librarians to rethink and reinvent IL education. Hence, it will be useful to ascertain whether DGBL can be effectively used in IL education, an area that is replete with higher-order thinking skills.

3. Library Escape

The application used for the study, *Library Escape*, is briefly introduced here. The game was designed by the authors and implemented in Unity 3D with the assistance of a software developer. It is a role-playing game that aims to engage university students in learning IL. The game starts with a comic strip to introduce the backstory. The grades of the last semester have just been released, and the protagonist, Tom, only managed a D for his IL module. Usually a top student, Tom is disappointed with the poor grade (see Fig. 1a). He consults with the IL module instructor, Professor Senka, to find out the reason and asks what he could do to improve his grade (see Fig. 1b). Professor Senka leads Tom to the basement of a deserted library building, and shoves him in, saying that this is the place where he could get some IL education.

There are six missions in the game, corresponding to the six stages in the Information Search Process (ISP) Model (Kuhlthau, 2004). The ISP Model is a seminal work among information behavior models as it focuses on students' affective states during their information seeking process. This model has been replicated and expanded over the course of 30 years (Thomas et al., 2011). It divides a typical information search process into six stages: task initiation, topic selection, prefocus exploration, focus formulation, information collection and search closure. The ISP Model predicts that in the early stages of searching, negative feelings are common, especially when users have little knowledge of what is available or when the search problem is not clear. However, as the search progresses, and the awareness of the process increases, there is a corresponding improvement in the level of satisfaction and confidence. At the end of the search process, the seeker will feel a sense of relief or satisfaction when the required information is found, or disappointment and anxiety when it is not.

Other than using the six stages in the ISP Model as an overarching structure for the mission topics, the game also follows pedagogical principles when designing sub-topics in each mission. According to Bloom (1956), in knowledge acquisition,

(a) Tom is Confused (b) Tom Sees Professor Senka

Fig. 1. Game backstory.

learners need to understand basic concepts before solving actual problems. Therefore, missions that introduce new concepts can only be attempted after students have been exposed to the necessary vocabulary and background knowledge. Further, in *Library Escape*, the sub-topics in each mission are arranged in an incremental manner, from foundational concepts such as what is IL and why is IL important, to practical skills such as how to search for information systematically, and how to evaluate information for academic purposes. Players need to locate different objects in each mission to uncover the learning content. Fig. 2 illustrates some conceptual and practical content, such as the importance of IL to society as a whole from Mission One (Fig. 2a), and a commonly used search strategy of using building blocks from Mission Four (Fig. 2b). Table 1 lists the educational content in each mission, which is explained in more detail next.

Mission One takes place in the closed stacks of the library, which casts an eerie ambience. It introduces background knowledge about IL (see Fig. 3a). Players need to find the relevant objects to reveal the content (see Fig. 3b), for example, the definition of IL behind a dictionary, the ARCL IL standards behind a scale, the importance of IL behind a wheel, and so on. Mission Two takes place in the open shelves. An evil ghost sleeps here and wakes up occasionally. Players need to stop moving when the ghost wakes up to avoid being attacked. This mission teaches players how to select a topic, as well as what library anxiety is, its causes, and how to overcome it. The difficulty level increases as the game progresses, and the learning content becomes more concrete and practical in subsequent missions. Mission Three takes place in the reference section, where the ghost constantly moves and the players need to avoid touching it. It presents the scholarly publication cycle. Different sources of scientific literature are also included, especially journals, to help students understand the range of sources they can refer to when working on academic projects.

Mission Four brings the players to the digital library with a computer virus inside. Players need to quickly find objects hidden with knowledge to prevent the virus from infecting the entire digital library. Practical information search strategies are introduced here, including building blocks, pearl growing, and successive fractions. The evil ghost becomes furious in Mission Five and spews out fire to burn down the library (see Fig. 4a). Players need to put out the fire timely. Here, some objects can only be activated after others have been found. For example, the players have to first find a piano that plays a piece of music, in order to entertain an owl, behind which hides some information on the ISP Model. This mission requires players to evaluate the information retrieved (see Fig. 4b), and to reflect on their information seeking process. Reflection is a critical part of the learning process in DGBL, as it affords a cyclic learning process such as sense making, reflecting, reaching conclusion, formulating strategies, and acting. Two ghosts roam around in the café in Mission Six, and the players have to be strategic in their movements. Mission Six concludes the game by listing the roles and responsibilities of an author, plagiarism, and the importance of making citations.

Additionally, players have to answer three to five quiz questions at the end of each mission before proceeding to the next. The questions take various forms, such as fill-in-the-blank (see Fig. 5a), single-choice, multiple-choice, and sorting questions

(a) Conceptual Content (b) Practical Content

Fig. 2. IL learning content.

Table 1
Venues of educational content in each mission.

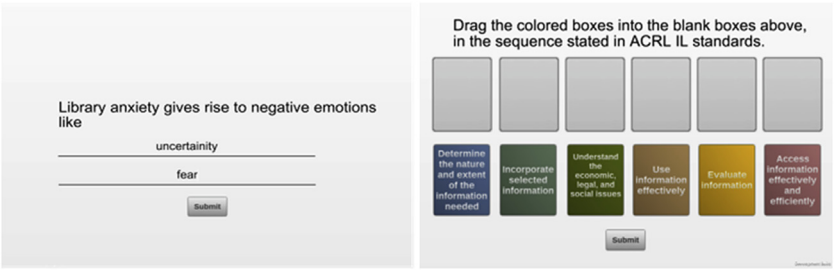
	Venues	Topics	Sub-topics (objects hidden in)
1.	Closed Stacks	Task Initiation	1.1. Birth of IL (dictionary) 1.2. Importance of IL (wheel) 1.3. IL and society (hat) 1.4. ACRL IL standards (scale) 1.5. Stage One in ISP Model (globe)
2.	Open Shelves	Topic Selection	2.1. Uncertainty (magazine) 2.2. What is library anxiety (poster) 2.3. Causes of library anxiety (scroll) 2.4. Dealing with library anxiety (key) 2.5. How to select a topic (stool) 2.6. Stage Two in ISP Model (balloon)
3.	Reference Section	Prefocus Exploration	3.1. Scholarly Publication Cycle (clock) 3.2. Primary sources (French horn) 3.3. Secondary sources (telephone) 3.4. Journals (date stamp) 3.5. Tertiary sources (painting) 3.6. Stage Three in ISP Model (biscuit box)
4.	Digital Library	Focus Formulation	4.1. Building blocks (torch light) 4.2. Pearl growing (Google search engine) 4.3. Successive fractions (library search bar) 4.4. How to select a focus (skating board) 4.5. Stage Four in ISP Model (Internet Explorer search engine)
5.	AV Collection	Information Collection	5.1. Organizing information (disk) 5.2. Evaluating information (umbrella) 5.3. Evaluating authors (mouse) 5.4. Stage Five in ISP Model (toy bear) 5.5. Reflecting on the ISP model (owl)
6.	Café	Search Closure	6.1. Using information (flower) 6.2. Plagiarism (blackboard) 6.3. Citations (crown) 6.4. Stage Six in ISP Model (guitar) 6.5. Start writing (gecko)

(a) Learning Content (b) Player Walks Around

Fig. 3. Screenshots in mission one.

(a) Evil Ghost (b) Learning Content

Fig. 4. Screenshots in mission five.



(a) Fill-in-the-blank Question **(b) Soring Question**

Fig. 5. Quiz questions.

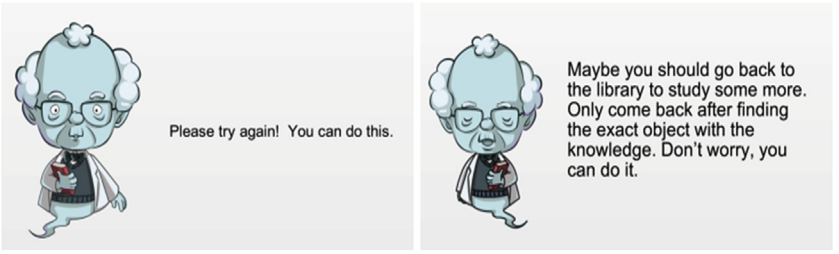
(see Fig. 5b). In terms of content, there are descriptive, applied and reflective questions. Players are given two chances to answer each question, and they cannot progress to the next mission without getting the correct answers. They will be led back to the library if both attempts are wrong, where they will need to find the objects containing the learning content again, and then return to answer the particular quiz question. In other words, players have to answer all quiz questions correctly before progressing to the next mission.

The EA in this game takes the form of a ghost librarian. Affect is expressed through his scripted feedback (Kim, Thayne & Wei, 2016), facial expressions (Zhang, 2013), and body gestures (Lin, Atkinson, Christopherson, Joseph, & Harrison, 2013). Scripted feedback from the librarian is provided when players successfully find an object, or after they answer the quiz questions (see Fig. 6). When the player gets the answer correct, the librarian will give praise by saying "*Good job*", or "*Well done*", and reinforce the knowledge to players. When the player gets the answer wrong the first time, the librarian will display an encouraging smile, explain why that answer is wrong, and encourage the players to try the question again. For example, he would say "*Don't be discouraged. Read the question carefully*". When the player gets it wrong the second time, the librarian will gently remind the player why the answer is still incorrect, and redirect them to the game by saying sentences such as "*Go back to the previous mission and read carefully, I am confident you can do it*". The nonverbal channel is important as it can be used to provide social cues such as attentiveness, liking and attraction (Kartiko, Kavakli, & Cheng, 2010). In terms of nonverbal cues, the affective EA applauds, nods, and praises the players when their answers are correct. He displays a patient smile and one hand is stretched out when the answers are incorrect.

As part of the present study, two other versions of *Library Escape* were developed: neutral-EA and no-EA. All features of the game such as storyline, narrative, rules, educational content in the three versions were the same, except for the EA, the librarian. In the neutral-EA version, the librarian retains the same facial expression and body gesture throughout the game, and his scripted feedback does not include affective encouragement. The librarian only responds whether players' answer is correct (see Fig. 7a) by saying "*Yes, that is correct*", or wrong by saying "*No, that is wrong*" (see Fig. 7b). In the no-EA version, the librarian is absent and all feedback is given in a square text box in the center of the screen with "*Yes, that is correct*" (see Fig. 8a), and "*No, that is wrong*" (see Fig. 8b), depending on players' answers. The feedback contains no affective expressions.

4. Hypotheses development

This section explicates the five major variables: learning outcome, motivation, enjoyment, perceived usefulness and behavioral intention, and presents the hypotheses in this study.



(a) For First Wrong Answer **(b) For Second Wrong Answer**

Fig. 6. Feedback in Affective-EA condition.

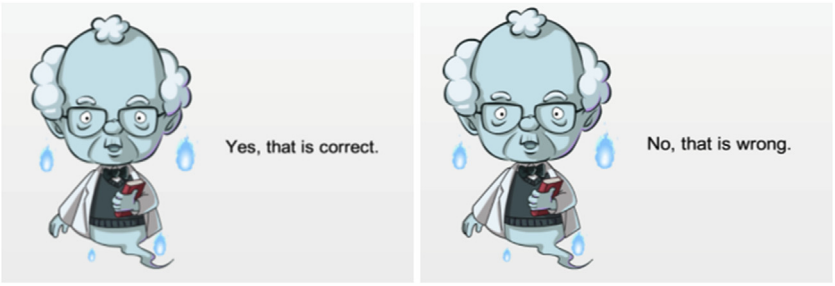


Fig. 7. Feedback in Neutral-EA condition.

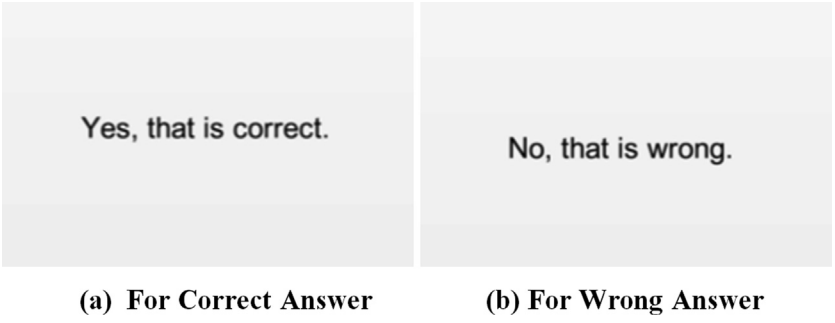


Fig. 8. Feedback in No-EA condition.

4.1. Learning outcome

Learning outcome is important in any educational system evaluation because it is the most direct and immediate result from the intervention (Atkinson, 2002). Integrated with affective instruction delivery, affective EAs can enhance students' learning outcome. Some studies have successfully demonstrated that using affective EAs in DGBL can enhance learners' ability to retain the knowledge and apply it in other contexts, while others have not (Lee et al., 2007). For example, Mayer and DaPra (2012) examined the use of affective EAs with gestures, facial expressions, eye contact and human-like movement on students learning and enjoyment experience. Students who viewed a highly embodied agent also rated the social attributes of the EA more positively than did students who viewed a neutral EA. The results suggested that the social cues in a multimedia message primed a feeling of social partnership in the learner, leading to deeper cognitive processing, and a more meaningful learning experience.

Therefore, we aim to ascertain the amount of knowledge retained by students after playing the IL game, after controlling for prior knowledge difference. We thus propose the following hypothesis:

Hypothesis 1 (H1). Students in the affective-EA condition have significantly better learning outcomes compared to those in the neutral-EA, and no-EA conditions in DGBL.

4.2. Motivation

Motivation may be considered as one of the most important prerequisites in learning, and it is a catalyst to achieving positive learning goals. The use of affective EAs can minimize communication gaps in interactions between human and computers, and increase learners' motivation (Lin et al., 2013). With EAs, learners are more motivated to make sense of what is being presented to them, and more likely to process the information deeply, achieving meaningful learning. Lin et al. (2013) designed an online multimedia learning environment that teaches thermodynamics. A hundred and thirty-five college students participated in a 2 (EA vs. no-EA) $\times$ 2 (simple feedback vs. elaborate feedback) factorial experiment. Results showed that the mere visual presence of an EA did not have significant impact on students' learning motivation or performances. However, when combined with elaborate and affective feedback, students' learning motivation and performances increased significantly. Therefore, an EA's ability to foster learning is dependent on its other features, such as affective and elaborate feedback. When using EAs in DGBL, affective features should be given special attention, to maximize their positive impact on students' learning.

The ARCS (Attention, Relevance, Confidence and Satisfaction) Model by Keller (2009) is used in this study to examine the motivational support from the EA. Attention is regarded as a critical aspect for learning. To sustain learners' attention, instructors should respond to their sensation-seeking needs. The second component is relevance, defined as the extent to which the learners perceive the results to be applicable, usable and helpful. Relevance is commonly used as a criterion to evaluate whether using an educational system can meet learners' utilitarian needs. The third component is confidence, which refers to the learners' positive expectations towards their performance, and their belief that they have the required knowledge, skill or ability to perform certain tasks. The last is satisfaction, which refers to the extent that learners feel good about their accomplishments. The ARCS Model has shown to be widely applicable in interactive online environments. For example, it was used to diagnose motivational problems in instructional programs. Guo, Goh, Luyt, Sin, and Ang (2015) used it to evaluate students' motivation in learning from an IL tutorial where the model showed high reliability. Further, Hirumi, Sivo, and Pounds (2012) used the model to measure the effect of a digital mathematical game on students' motivation. The model can thus be applied to empirically investigate motivational issues in this study. Based on the above discussion, we propose the following hypothesis:

Hypothesis 2 (H2). Students in the affective-EA condition have significantly higher levels of motivation in terms of (a) attention, (b) relevance, (c) confidence, and (d) satisfaction, compared to those in the neutral-EA and no-EA conditions in DGBL.

4.3. Enjoyment

Enjoyment has been well studied in media research. It refers to the extent of using information systems being perceived as pleasant and joyful (Fang, Chan, Brzezinski, & Nair, 2010). Enjoyment is a strong indicator behavioral intention to consume media, as well as actual usage frequency (Venkatesh & Bala, 2008). Using affective EAs can make the interactions between humans and computers more engaging and enjoyable (Kim et al., 2011). EAs' ability to detect and express affective states is crucial for improving their believability and trustworthiness, eliciting affect in the users, as well as contributing to more entertaining interactions. For example, Kopp, Gesellensetter, Krämer, and Wachsmuth (2005) designed a conversational EA, *Max*, as a guide in a public museum. Max can communicate with visitors face-to-face, and provide useful information about the museum. Results from the logfiles showed that people enjoyed the human-like communications with *Max*, and were cooperative in answers his questions.

Enjoyment is a multifaceted concept, encompassing affective, behavioral and cognitive dimensions (Nabi & Krcmar, 2004). Specifically, affective enjoyment refers to the willingness to invest emotionally in the experience, and studies have shown that technology use triggers affective reactions from individuals and influences subsequent actions (Nass & Reeves, 1996; Zhang, 2013). It focuses largely on empathy, as well as positive and negative affective states. Behavioral enjoyment is the effortless involvement in the activity, when people are immersed in the situation (e.g., little or no awareness of their behaviors). Furthermore, cognitive enjoyment is defined as the willingness to develop skills and solve problems. It focuses on experiences gained through personal judgment towards actions or tasks in the media (e.g., judgment about appropriateness of tasks). When cognitive learning results in better outcomes, individual's intention to use increases significantly (Jackson, Chow, & Leitch, 1997). Hence the following hypothesis is proposed:

Hypothesis 3 (H3). Students in the affective-EA condition derive significantly more enjoyment in terms of (a) affective enjoyment, (b) behavioral enjoyment and (c) cognitive enjoyment, compared to those in the neutral-EA and no-EA conditions in DGBL.

4.4. Perceived usefulness

The fourth variable is perceived usefulness, defined as the extent to which people believe that using the system will improve their performance. It has consistently been a strong and fundamental driver of behavioral intention to use a system. From longitudinal studies, Venkatesh and Bala (2008) found that the information systems' perceived usefulness directly impacted organizations employees' behavioral intention. Further, Lee (2010) collected data from 363 users in an online learning program, and demonstrated that perceived usefulness had a significant influence on users' continuance usage intention of the learning program. Thus it is important to understand the determinants of this variable. Using affective EAs may make people perceive the educational systems to be more relevant and useful to their needs. Thus the following hypothesis is proposed:

Hypothesis 4 (H4). Students in the affective-EA condition perceive the game to be significantly more useful than those in the neutral-EA and no-EA conditions in DGBL.

4.5. Behavioral intention

Behavioral intention refers to the degree to which people have formulated plans to perform or not perform specified behaviors in the future (Venkatesh & Bala, 2008). It has frequently been used as a surrogate for actual behavior (Olson, 2010).

In a study to investigate the influence of affective EAs on students' behavioral intention, Guo et al. (2015) developed an online IL tutorial and assigned students into one of the three conditions: affective-EA, neutral-EA and no-EA. The results suggested that students who watched the IL tutorial with affective EAs indicated greater intention to use other IL tutorials in the future.

In this study, behavioral intention refers to students' intention to use similar digital IL games, to further improve their IL knowledge, and to recommend the game to others. Given this discussion, the following hypothesis is proposed:

Hypothesis 5 (H5). Students in the affective-EA condition have significantly higher intention to (a) play similar IL games, (b) learn more about IL, (c) recommend to others, than those in the neutral-EA and no-EA conditions in DGBL.

5. Methods

5.1. Experimental design

A pre-test post-test between-subjects design was used to address the research hypotheses. Recruitment was conducted among university students. Participation in this study was voluntary and confidential. Participants were randomly assigned to one of the three game conditions in a controlled laboratory setting: affective-EA, neutral-EA and no-EA condition.

After the participants arrived at the lab, they were briefed on the study's objective, which was to evaluate a newly developed IL game, and signed the online consent form if they had no objection. The experiment started with a short online pre-test questionnaire to assess participants' prior IL knowledge. Thereafter, they started and played the game on their assigned computers. After the game was completed, they completed a post-test questionnaire. The entire study lasted approximately two hours. In total, 159 students participated, and they were given S$10 as a token of appreciation.

The pre-test questionnaire assessed participants' prior IL knowledge with ten multiple-choice questions. The post-test questionnaire was longer, comprising seven sections. The first section was a single question to assess the EA manipulation. Participants were asked to choose whether the librarian in the game (1) expressed emotion, (2) did not express emotion, or (3) was not applicable. The second section assessed the learning outcome: the amount of IL knowledge that participants retained from the game. The subsequent three sections focused on participants' learning motivations, enjoyment, perceived usefulness and behavioral intention. All items that were used to measure these four variables were formulated based on extant literature, and indicated on a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5), with a neutral response in the middle (3). The penultimate section recorded participants' subjective opinions, asking what they have learnt, what they liked most and least in the game, and how to improve the game. Lastly, information on participants' demographic data such as age, gender, nationality and educational background were collected.

5.2. Operational definitions

Our measurement instruments were developed by adapting valid existing scales where appropriate. Items measuring learning outcome were created to be closely related to the learning content in the game.

5.2.1. Learning outcome

Participants' IL knowledge was tested in pre-test and post-test questionnaires, each comprising ten multiple-choice questions. To reduce testing effects, the two sets of questions were different but matched in terms of topic and difficulty. An expert on IL was consulted to improve the questionnaires, and the items were modified based on suggestions given. Example questions included: "*Which of the following is the best criterion to evaluate the credibility of an Internet site?*", and "*When you are assigned to research a topic that you are unfamiliar with, which of the following sources would you turn to for a brief history and summary about the topic?*"

5.2.2. Motivation

The ARCS scale by Keller (2009) was adapted with minor changes to suit this study's context. Specifically, the original purpose of the scale was to investigate the motivational issues in courses, and used "*modules/courses*" in the items. Our study used the phrase "*IL game*" instead. The scale consisted of 36 items, in which there were 12 items on attention (e.g., "*There was something interesting at the beginning of the game that got my attention.*"); nine on relevance (e.g., "*The content of the game is relevant to my interests*"); nine on confidence (e.g., "*After playing the game for a while, I was confident that I would be able to pass a test on the content*"), and six on satisfaction (e.g., "*Completing the game gave me a satisfying feeling of accomplishment*").

5.2.3. Enjoyment

This was assessed with 12 items based on the tripartite model by Fang et al. (2010): affective enjoyment, behavioral enjoyment, and cognitive enjoyment. Each sub-construct was measured with four items. Example questions included: "*I felt attracted to the game*", "*I lost track of time during the game*" and "*I think it is worthwhile to play the game*".

5.2.4. Perceived usefulness

This was measured using three items (Venkatesh & Bala, 2008). The three questions were "*Playing the game would improve my IL skills*" "*Playing the game would make it easier to learn IL knowledge*", and "*I would find the game useful in my studies*".

5.2.5. Behavioral intention

This was measured with three sub-constructs and nine items, adopted from an existing survey instrument by McCombs (2011). The use of "*system*" was replaced with "*IL game*" to suit the context of this study. The three sub-constructs were: intention to play other IL games (e.g., "*Assuming that I have access to such games, I intend to play*"), intention to learn more about IL (e.g., "*The game made me want to learn more about IL*"), and intention to recommend this game to others (e.g., "*I would recommend this game to others*").

5.3. Data analysis methods

Analyses were conducted using SPSS. Analysis of covariance (ANCOVA) was used to test H1, by controlling for prior IL knowledge differences obtained from the pre-test. The other four hypotheses: differences between affective-EA, neutral-EA and no-EA conditions on motivation, enjoyment, perceived usefulness, and behavioral intention, were tested by one-way between-subject analysis of variance (ANOVA), which was followed by post hoc comparisons using Tukey's HSD test.

6. Results

We will first describe the sample's characteristics and manipulation check. Reliability checking using Cronbach's alpha was performed before the statistical analyses of ANCOVA and ANOVA.

6.1. Sample description and manipulation check

The demographics of the sample are shown in Table 2, including the breakdown within the three conditions. The sample was balanced in terms of gender, consisting of 81 (50.94%) males and 78 (49.06%) females. Their age ranged between 18 and 40, with an average of 22.43 years and standard deviation of 3.35. Regarding their educational background, more than half (61.00%) of the participants were from engineering, 20.13% were from social science, and the rest 18.86% were from the natural sciences and business. The sample can be considered as fairly representative since the data was collected at a technological university that puts heavy emphasis on engineering education. In addition, participants' gameplay experience was polarized: around half of the participants (50.90%) had more than three years of gameplay experience, while 54 (34.00%) had less than one year of experience.

Chi-square analysis indicated that the manipulation was largely successful [$\chi^2(4) = 241.35$, $p < 0.001$]. Those in the affective-EA condition mostly agreed that the librarian expressed emotions (49 out of 53), while those in the neutral-EA condition mostly agreed that the librarian did not express any emotions (42 out of 52).

6.2. Hypotheses testing

The reliability of the measurement instrument was evaluated using Cronbach's alpha as a measure of the internal consistency. As shown in Table 3, almost all values were above the recommended level of 0.7, with one exception of confidence (0.62), which is considered acceptable (Cronbach, 1951). We chose not to remove any items since confidence in the ARCS Model has consistently been found to be the lowest among the four sub-constructs (Choustoulakis & Nikoloudakis, 2011; Keller, 2009). The Cronbach's alpha for learning outcome were not calculated here since the pre-test and post-test were constructed to assess a variety of IL topics. Mastery of distinct concepts and skills may not all be consistent since they are measuring different knowledge units. Since all the measurement instrument items were established and validated over time across different studies, we did not perform factor analysis.

A one-way ANCOVA was conducted to test H1. The independent variable, different EA presentations, included three conditions: affective-EA, neutral-EA, and no-EA. The dependent variable was the participants' learning outcome in post-test,

Table 2
Sample description (N = 159).

	Affective-EA ($n = 53$)	Neutral-EA ($n = 52$)	No-EA ($n = 54$)	Total
Gender				
Female	32 (60.4%)	24 (46.2%)	25 (46.3%)	81
Male	21 (39.6%)	28 (53.9%)	29 (53.7%)	78
Age				
20 and below	11 (20.8%)	14 (26.9%)	19 (35.2%)	44
21–25	36 (67.9%)	31 (59.6%)	28 (51.9%)	95
26 and above	6 (11.3%)	7 (13.5%)	7 (13.0%)	20
Education Background				
Engineering	34 (64.2%)	31 (59.6%)	32 (59.3%)	97
Social science	9 (17.0%)	12 (23.1%)	11 (20.4%)	32
Natural science	5 (9.4%)	4 (7.7%)	10 (18.5%)	19
Business	5 (9.4%)	5 (9.6%)	1 (1.9%)	11

Table 3
Cronbach's alpha coefficient for measuring instruments.

Constructs	Cronbach's alphas
Motivation	0.914
Attention	0.772
Relevance	0.759
Confidence	0.620
Satisfaction	0.817
Enjoyment	0.890
Affective Enjoyment	0.813
Behavioral Enjoyment	0.806
Cognitive Enjoyment	0.989
Perceived Usefulness	0.844
Behavioral Intention	0.914
Intention to Play IL Games	0.889
Intention to Learn IL	0.878
Intention to Recommend	0.894

and the covariate was their prior IL knowledge, assessed in the pre-test. A preliminary analysis evaluating the homogeneity-of-regression assumption indicated that the relationship between the prior IL knowledge and the post-test learning outcome did not differ significantly across the three conditions, $F(2,153) = 0.54$, $p = 0.583$. Table 4 shows the means and standard deviations of participants' IL knowledge performance in pre- and post-tests. The ANCOVA result was non-significant, $F(2,155) = 0.82$, $p = 0.443$ (see Fig. 9). Therefore, H1 was rejected, and there were no significant differences in learning outcome across the three conditions.

Next, one-way ANOVA tests were conducted to evaluate the other hypotheses (see Table 5). Results showed statistically significant differences on attention [$F(2,156) = 4.170$, $p = 0.017$], confidence [$F(2,156) = 9.17$, $p < 0.001$], satisfaction [$F(2,156) = 4.27$, $p = 0.02$], affective enjoyment [$F(2,156) = 4.40$, $p = 0.01$], behavioral enjoyment [$F(2,156) = 3.84$, $p = 0.02$], cognitive enjoyment [$F(2,156) = 6.13$, $p = 0.003$], perceived usefulness [$F(2,156) = 6.70$, $p = 0.002$], intention to play IL games [$F(2,156) = 4.78$, $p = 0.01$], intention to learn IL [$F(2,156) = 6.67$, $p = 0.002$], intention to recommend [$F(2,156) = 4.21$, $p = 0.02$]. However, there was no significant difference in terms of relevance [$F(2,156) = 2.67$, $p = 0.07$]. In other words, H2, H3, H4 and H5 were mostly supported.

Post-hoc analysis using Tukey's HSD was conducted to examine pair-wise group difference, and the error bars with confidence intervals are produced in Fig. 10. Detailed results are presented below.

6.2.1. Motivation

The mean score on *attention* in the affective-EA condition ($M = 3.22$, $SD = 0.43$) was significantly higher than the neutral-EA condition ($M = 2.92$, $SD = 0.62$). *Confidence* in the affective-EA condition ($M = 3.15$, $SD = 0.46$) was significantly higher than both the neutral-EA condition ($M = 2.76$, $SD = 0.48$) and no-EA condition ($M = 2.85$, $SD = 0.53$), *Satisfaction* in affective-EA condition ($M = 3.52$, $SD = 0.66$) was significantly higher than neutral-EA condition ($M = 3.10$, $SD = 0.85$).

6.2.2. Enjoyment

Affective enjoyment in the affective-EA condition ($M = 3.43$, $SD = 0.74$) was significantly higher than no-EA condition ($M = 2.96$, $SD = 0.86$). *Behavioral enjoyment* in the affective-EA condition ($M = 3.40$, $SD = 0.84$) was significantly higher than the no-EA condition ($M = 2.92$, $SD = 0.99$). *Cognitive enjoyment* in affective-EA condition ($M = 3.62$, $SD = 0.71$) was significantly higher than both the neutral-EA condition ($M = 3.04$, $SD = 0.98$) and the no-EA condition ($M = 3.12$, $SD = 1.05$).

6.2.3. Perceived usefulness

Participants from the affective-EA condition ($M = 3.67$, $SD = 0.65$) perceived the game to be significantly more useful than those from the neutral-EA condition ($M = 3.12$, $SD = 0.94$).

6.2.4. Behavioral intention

Intention to play IL games in the affective-EA condition ($M = 3.38$, $SD = 0.80$) was significantly higher than both the neutral-EA condition ($M = 2.80$, $SD = 1.01$) and the no-EA condition ($M = 2.94$, $SD = 1.15$). *Intention to learn IL* in the affective-EA

Table 4
Means and standard deviations of learning outcome in the pre- and post-tests.

Condition	Pre-test		Post-test	
	Mean	SD	Mean	SD
Affective-EA	4.698	1.648	5.000	2.038
Neutral-EA	4.212	1.613	4.462	1.965
No-EA	4.037	1.715	4.833	1.851

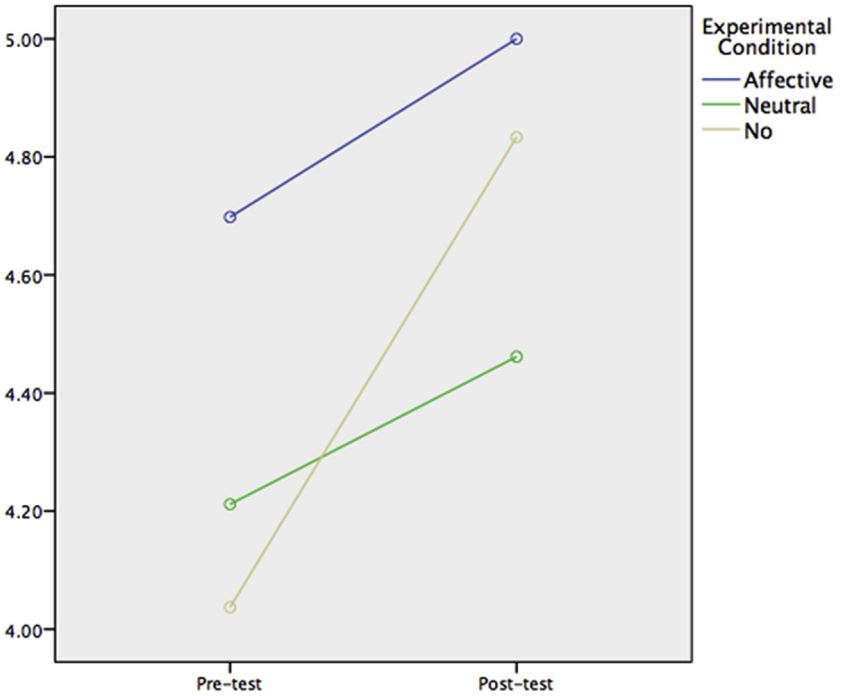


Fig. 9. Plots of learning outcome in pre- and post-tests.

Table 5
Mean (standard deviation) of dependent variables.

	Affective-EA	Neutral-EA	No-EA
Motivation			
Attention*	3.22 (0.43)	2.92 (0.62)	3.01 (0.61)
Relevance	3.53 (0.53)	3.28 (0.62)	3.36 (0.59)
Confidence**	3.15 (0.46)	2.76 (0.48)	2.85 (0.53)
Satisfaction*	3.52 (0.66)	3.10 (0.85)	3.17 (0.84)
Enjoyment			
Affective Enjoyment*	3.43 (0.74)	3.05 (0.98)	2.96 (0.86)
Behavioral Enjoyment*	3.40 (0.84)	3.17 (0.85)	2.92 (0.99)
Cognitive Enjoyment**	3.62 (0.71)	3.04 (0.98)	3.12 (1.05)
Perceived Usefulness**	3.67 (0.65)	3.12 (0.94)	3.23 (0.86)
Behavioral Intention			
Intention To Play Game*	3.38 (0.80)	2.80 (1.01)	2.94 (1.15)
Intention To Learn IL**	3.57 (0.69)	2.93 (0.98)	3.23 (1.01)
Intention To Recommend*	3.59 (0.91)	3.06 (1.02)	3.11 (1.15)

Note: *$p < 0.05$; **$p < 0.01$.

condition ($M = 3.57$, $SD = 0.69$) was significantly higher than the neutral-EA condition ($M = 2.93$, $SD = 0.98$). *Intention to recommend* in the affective-EA condition ($M = 3.59$, $SD = 0.91$) was significantly higher than both the neutral-EA condition ($M = 3.06$, $SD = 1.02$) and the no-EA condition ($M = 3.11$, $SD = 1.15$).

7. Discussion

In summary, our results showed that the affective EA had a strong positive impact on participants' learning motivation, enjoyment, perceived usefulness and behavioral intention, compared with the neutral-EA and no-EA conditions. However, there was no difference in learning outcome across all three conditions.

There are a number of salient findings. First, participants who interacted with the affective EA were more attentive, confident, and satisfied in the game than participants from the neutral-EA and no-EA conditions. This confirms previous studies on using affective EAs to motivate students (Guo et al., 2015; Lin et al., 2013; Mayer & DaPra, 2012), and lends further support to the argument that affective EAs are able to attract and hold students' motivation. Affective EAs can ease possible negative affect during learning, thus positively influencing learning motivation (Chen et al., 2012). It is reasonable to infer that

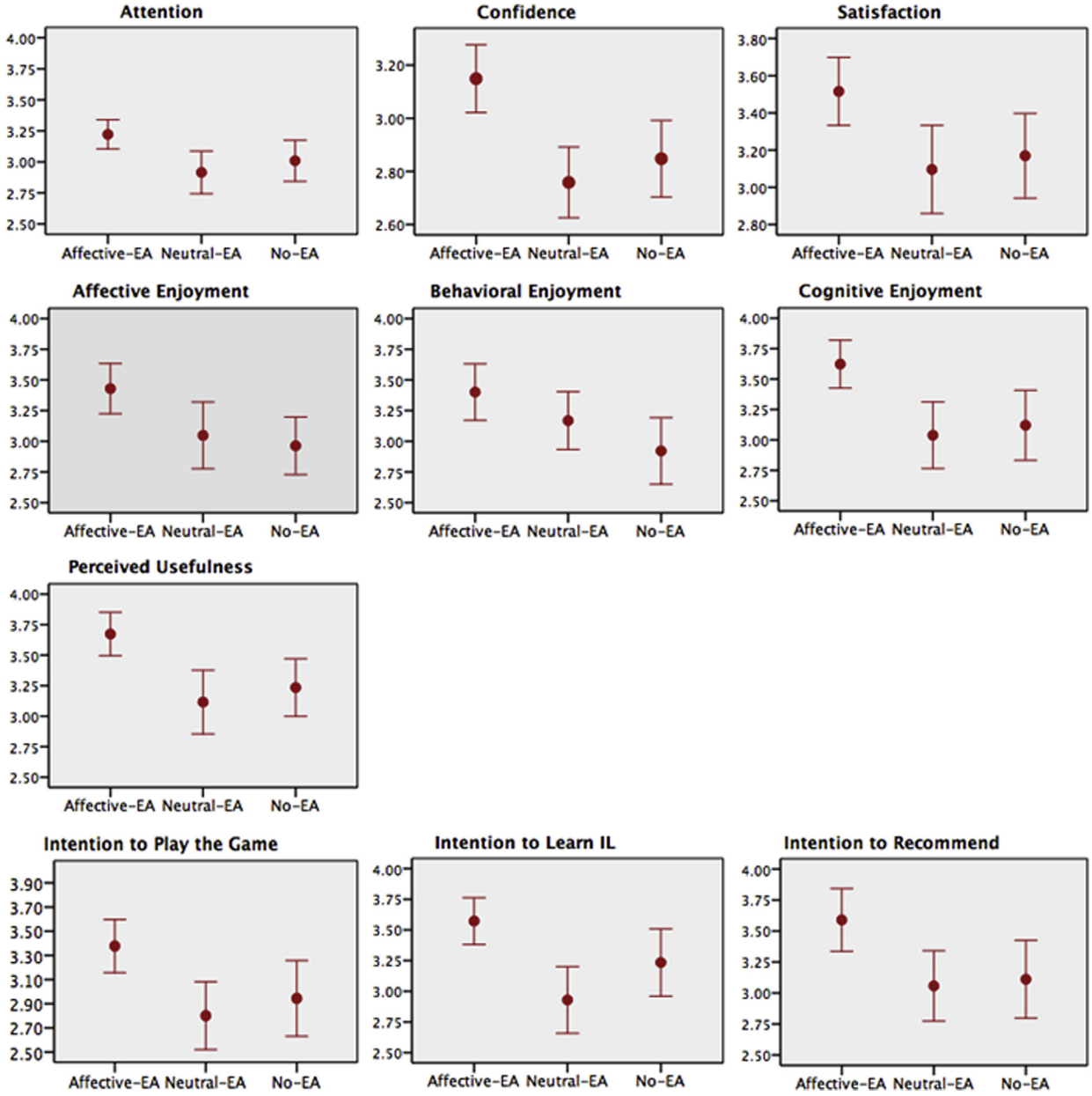


Fig. 10. Error bars for dependent variables.

the behaviors and feedback from the affective EA (i.e., librarian) contributed to the increased attention, confidence and satisfaction of the participants. Participants from the affective-EA condition praised that "*Librarian as ghost, it is eye catching*" (attention), and "*The praises after I find some objects are very encouraging, he told me I am making good progress*" (confidence). In contrast, participants from the neutral-EA and no-EA conditions expressed their dissatisfaction and lack of confidence, with one of them saying "*information literacy is highly sophisticated, my knowledge is not enough to comprehend what it is all about*".

Nonetheless, there was no statistically significant difference on relevance. This is possibly because relevance of the game is determined by its educational content (i.e., IL knowledge), which was the same in all three conditions. Typical comments such as "*I realized how important and relevant IL is in daily learning*" and "*There is nothing that I don't like as I was focusing more on the information provided in the game*" showed that participants found the IL knowledge in the game relevant to their studies. Another plausible explanation might be because participants differentiated the cognitive, educational content from the social, affective gameplay experience. This suggests that participants' perceptions of attention, confidence and satisfaction of the game did not impact how they perceived the educational value. From another point of view, this may also suggest that the game should weave the educational content with gameplay more closely.

As for enjoyment, participants who interacted with the affective EA derived more affective, behavioral and cognitive enjoyment from the IL game, compared with those from the other two conditions. The use of affective EAs in a pedagogical role can help students overcome negative affect such as boredom or frustration during learning process, thus ensuring their high emotional investment in the gameplay (Mumm & Mutlu, 2011). This is confirmed by comments such as "*I liked the fact that learning was made an enjoyable affair. While learning was always the main objective I never felt at any point in time that it was not a game but a mere learning experience. In short I was engrossed in it so much that I never felt time pass by!"* However, many participants from the neutral-EA condition disliked "*the librarian ghost*" and found it "*distracting*" and "*disruptive*"; one commented that "*This librarian does not help much with it, as it is too irritating because there are no hints at all. I prefer a lecture where a teacher guides me on learning information literacy".*

Interestingly, even though participants from all three conditions rated similarly on the game's educational relevance, those who interacted with the affective EA perceived the game to be more useful than others. In other words, the use of affective EAs changed participants' perceptions towards the game's usefulness. This suggests that perceived usefulness is not solely influenced by learning content; other factors brought about by the affective EA were at work. We speculate that using an affective EA may have changed participants' attitudes and increased their trust in the game: they perceived the librarian EA as real and responded to him as they would to another person in real life, thus leading to their more positive perceptions of its usefulness. For instance, while participants from the neutral-EA and no-EA conditions praised the "*content*" to be useful, those from the affective-EA condition further remarked that "*the comments from the librarian are useful*".

The reason for higher behavioral intention from participants who interacted with the affective EA than the others is not difficult to understand. Behavioral intention is to a large extent determined by one's attitude and perceived usefulness towards the system (Venkatesh, Morris, Davis, & Davis, 2003). In the context of this study, participants in the affective-EA condition were more motivated to learn and perceived the game to be more useful. Thus it is natural that they were more willing to play similar IL games, learn more about IL and recommend the game to others in the future. This is confirmed by participants' suggestions from the affective-EA condition such as "*This game could be shared to all, quite enriching*". On the contrary, even though participants from the other two conditions found the game "*novel and applicable*", no one mentioned recommending it to others.

Another point concerns the assumption that affective EAs would improve participants' learning outcome. Although many participants claimed they gained useful knowledge, such as "*I learnt much about information literacy and it was really fun. The game was tough but nice*". Knowledge improvement was unsupported in this study, as in many others (Atkinson, 2002; Guo et al., 2015). This might be due to the cognitive overload on participants' working memory during the gameplay. In other words, with all the activities in the IL game, such as navigating in the environment, finding objects, battling the evil ghost, reading and digesting the knowledge content, answering quiz questions, incorporating the feedback, and finishing within one hour, participants could have been too distracted to focus on the learning content thus their learning efficacy was impeded. Participants from all three conditions made similar complaints such as: "*too difficult*" and "*too much information overload. I couldn't remember all the details*". Further, the game differed from real world settings where librarians use both oral and visual means for communication. It lacked audio cues and all information was presented visually. Some participants expressed the desire that "*I would like to have the content read to me*." Hence, providing audio cues may help reduce cognitive load, potentially improving their learning outcome.

Interestingly, participants from the neutral-EA condition rated lowest on almost every variable, compared with those in the other two conditions. We speculate that the reasons could be explained by people's expectations. Studies found that people cannot perceive a difference between animated images (e.g., EAs) and real ones, thus subconsciously responding to them as if they were human (Hyde et al., 2014). When the EAs exhibit explicit social cues, people expect them to behave naturally as well, such as being polite, cooperative or helpful. In the neutral-EA condition, the presence of the EA may have brought forth the false expectations that it was intelligent and sociable. In our case especially, when the EA claimed that it was a librarian, participants may have regarded him as an authority in library-related matters. However, the librarian in the neutral-EA condition retained the same facial expression and body gesture, and only responded by saying "*yes*" or "*no*", without expressing any emotions as in the affective-EA condition. Therefore, participants perceived this EA as failing to meet expectations, leading them to be disappointed and rating the EA lowly.

Some insights can be obtained from participants' subjective feedback. First, the design of the game and EA was received favorably, given positive comments such as "*the avatar design is kind of cute and appealing!*" and the "*interactive interaction of the ghost (i.e., librarian) is interesting*". Since only participants from the affective-EA condition interacted with the affective librarian, its appealing design might have contributed to their positive ratings in the evaluation. This reaffirms the importance of attractive visual design and enjoyable gameplay to engage students in DGBL. Participants also "*liked the idea of teaching information literacy in a game*", which made the learning process more interesting. These positive attitudes can potentially increase their interest in learning IL and interactions with librarians. However, a lesson learnt here is to balance the amount of educational content in DGBL, as confirmed from both evaluation results and participants' feedback. Many participants lamented that "*There is too much IL knowledge*" and "*the game is too informative*". Related to the educational aspect, participants responded negatively towards the design that they had to answer quizzes correctly before progressing to the next mission. Many wrote that "*It wastes time to come back and answer the questions again*". Educators need to strike a balance between learning and game enjoyment so students will not feel overwhelmed and frustrated. In general, participants' feedback was positive. We believe that the increased learning motivation could reduce students' library anxiety, leading to more interactions with the libraries and librarians in the future.

8. Conclusion

Given the rapid adoption of online learning environments and DGBL in education, the findings from this study have important implications. Theoretically, this study reaffirms the positive influence of affective EAs on students learning, and extends it in an IL educational setting. Most prior studies used affective EAs to teach lower-order skills such as facts and concepts, while this study focused on teaching higher-order IL skills. Put differently, it undertook the first step in formally examining the influence of affective EA in an IL digital game. In addition, using EAs with affective expressions and feedback can significantly increase students' motivation, enjoyment, perceived usefulness and behavioral intention. Librarians and educators can tap on this opportunity to tackle the low interest in IL learning from students.

Some implications on IL game design can also be gleaned from this study. The first is to consider incorporating affective EAs in IL games. In our study, using affective EAs increased participants' learning motivation and enjoyment significantly. Considering that self-efficacy is closely related to learning motivation, the benefit of using EAs in IL games is promising in promoting library instruction. Secondly, using the image of a librarian as a helpful pedagogical EA in the game could potentially increase students' trust and positive attitudes towards librarians. This would help students gain confidence in librarians' inputs and become less hesitant or anxious when approaching librarians for help in the future. Thirdly, simultaneously adhering to pedagogical principles and user needs in DGBL design can be challenging, as the two sometimes contradict with each other. For example, participants complained the game took too long to complete, compromising on game enjoyment, as they could not progress to the next level without answering quiz questions correctly. However, if the game had allowed this, the librarian's feedback would be less effective pedagogically, and participants might have perceived the game less useful. Therefore, instead of adopting participants' suggestions unquestioningly, DGBL designers have to balance learning and player enjoyment when they contradict. For example, this can be achieved by studying the trade-off through iterative evaluation of different game design ideas.

The study is not without limitations. As mentioned in the discussion, there is a lack of audio cues from the EA, which may have resulted in the unsatisfactory learning outcome. Therefore, future research should infuse both visual and audio cues of EAs, to cater to different learning styles and maximize the EAs' positive influence. Relatedly, as the EA employed minimal artificial intelligence, the affective expressions and feedback might not be sufficiently lifelike and believable to participants, which might have resulted in negative responses from those with high expectations. Thus, future work may incorporate more advanced algorithms to increase the perceived believability of the affective EA and improve their interactions with players.

Another fruitful possibility for future research would be to investigate the mechanisms behind these findings in this study. For example, the students may have been overloaded with visual information from the game, resulting in low learning efficacy. Therefore, eye trackers could be used to examine whether students indeed paid less attention to the learning content. Moreover, in-depth qualitative interviews can be conducted to elicit students' perceptions on the affective EA and the game in more detail to derive possible suggestions for improvement. Further, while some researchers have argued that simpler games might work better to attract students, the game *Library Escape* used in this study is quite complicated. It incorporated many game design elements, such as EAs, narratives, characters, and quests. Therefore, future research can compare this game with simpler ones to ascertain whether the added game elements are useful in enhancing students learning.

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