Designing and Evaluating an Affective Information Literacy Game

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ABSTRACT
The objective of this PhD research project is to examine the influence of EA's affective expressions on students' learning motivation, enjoyment and learning efficacy in an IL game. This project combines the concepts of digital game-based learning and affective embodied agents to information literacy education, by using Kuhlthau's Information Search Process Model as a theoretical framework. In this extended abstract, the research gaps and research objectives are first presented, after a brief introduction. Thereafter, related concepts are introduced. The project is divided into three studies, two of which have been completed, and their methodologies and findings are briefly discussed. This abstract ends with contributions, limitations and directions for future work.

Categories and Subject Descriptors
H.4.0 [**Information Systems**]: Information Systems Applications – *General*

K.3.1 [**Computing Milieux**]: Computers and Education – *Computer Uses in Education*

K.3.2 [**Computing Milieux**]: Computers and Education – *Computer and Information Science Education*

General Terms
Measurement, Documentation, Design, Experimentation.

Keywords
Affective embodied agents, ARCS, digital game-based learning, evaluation, information literacy, learning performance, motivation, knowledge retention, participatory design.

1. BACKGROUND
The Internet has brought about the proliferation of and increased accessibility to information. As there is more information available now than ever before, the ability to seek, locate and navigate information effectively has become important. As anyone can publish on the Internet, the ability to assess the accuracy and reliability of information before putting it into use has become a critical enabler. These are the very skills that information literacy (IL) provides – the skills that allow people, whether students, knowledge workers or the general public, to separate the wheat from the chaff in the quest to obtain high-quality content [1].

IL has been of growing concern in education, at workplace, as well as in daily life. The need for IL is also important for students, especially university students, as they routinely search for and synthesize information from multiple sources for various knowledge-intensive tasks such as writing a term paper. Students' academic performances are therefore closely related to their IL skills. To better demonstrate this point, [2] suggested that students can be roughly classified using a simple matrix based on their IL skills and subject understanding (see Figure 1). Those students in Quadrant I are best prepared for life-long learning and in subject understanding. All the other students in the other three quadrants are at risk in an information rich world.

IL Skills \ Subject Knowledge	Poor	Good
Good	A student who knows how to learn, but possesses shallow subject knowledge	A student who is in the best position to learn
Poor	A student who is in trouble, academically	A student who is able to soak up content, but lacks investigative skills

Figure 1. Typology of students [2]

IL education has become the shared responsibility of all educators and information providers, and librarians have been on the forefront [3]. However, young sstudents are increasingly unwilling to initiate interaction with librarians when they encounter difficulties searching for academic resources. They prefer to use information located through search engines instead, despite the uncertain quality and reliability of the sources [4]. This poses an increasing challenge on how to educate young people in today's classrooms.

However, digital technologies have substantially changed education in the last few decades [4] and presented an opportunity for librarians to reinvent library services in support of the library's mission. Specifically, in digital game-based learning (DGBL), students' technological skills are fully utilized to support the learning process. By infusing the elements of challenge, fantasy, control, and social interaction, digital games could immerse players in an educational virtual environment.

The acknowledgment of the user's affective state might play an important role in improving the effectiveness of DGBL. The Information Search Process (ISP) Model is one of the seminal works in IL education [5]. What is unique about the ISP Model is that it takes into consideration the information seeker's affective states. In the case of DGBL, techniques such as narratives, colors, music, backstories, embodied agents (EAs) are often used to express affective feelings. The term "agent" refers to an autonomous computer program that can "act" on its own [7]. An EA therefore refers to a life-like agent, i.e., one with a physical face and body [6]. Accordingly, an affective EA is defined as one that is capable of eliciting certain affective experiences from users through multiple modalities such as

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speech, facial expressions and body gestures [8]. EAs have been frequently used as an effective way [6].

2. RESEARCH GAPS

There are several research gaps that motivate the PhD project.

First, apart from the growing body of literature on the use of digital games to teach lower order thinking skills, facts, concepts, and procedures, there is limited literature on teaching higher order thinking skills such as how to apply, analyze, or evaluate knowledge [9]. Although there have been initiatives to design games that can teach how to apply, analyze or evaluate knowledge, such initiatives have rarely been brought to fruition. Academic information searching involves higher order thinking skills as it teaches important procedural knowledge that synthesizes complex level of thinking and knowledge [10]. It was previously assumed that the information search process is a rules-driven and linear process. Today, we know it to be a messy and iterative process [11]. Especially with the explosion of search engines, social media, and other communication tools, a methodologically rigorous search for information is more confusing than ever.

Second, the main studies on ISP Model were carried out in the 1990s and early 2000s, when most information sources were in print format. With the proliferation of online search engines and database, there is a need to investigate online information seeking behaviors as well. In addition, the lack of conceptual frameworks in IL game design has significantly impeded its adoption in formal learning contexts [12]. The defining characteristic of good educational games is that the gameplay itself informs the pedagogical theory and embodies the learning content [13]. However, to achieve such effects, the gameplay and the educational content must be integrated well, so that students can enjoy the game and at the same time, be able to absorb the concepts and theories presented in the game.

Third, scholarly investigation of EAs in DGBL has been largely focused on the design and engineering of the EAs, and their benefits are mainly anecdotal. There is little empirical evidence to support their positive impact on students' learning performance so far [14]. There is therefore a need to assess their impact on the learning process, and on learning performance. Among the limited empirical studies, several shortcomings of have been identified, for example, small sample sizes (around $n = 20$), lack of control groups, as well as the lack of statistical tests [15].

3. RESEARCH OBJECTIVES

Based on the research gaps identified above, the goal of the present work is to examine the influence of EA's affective expressions on students' learning motivation, enjoyment and learning efficacy in an IL game. To achieve this goal, the research questions proposed in this PhD project are as follows:

RQ1: What role can affective EAs play in an information seeking process?

RQ2: How can students' negative affect in information seeking process be reduced through the use of affective EAs?

RQ3: How do affective EAs influence students' learning motivation, enjoyment, and learning efficacy in an IL game?

These research questions will be answered by addressing the following research objectives:

RO1: To investigate the role of affective EAs in the information seeking process;

RO2: To design and implement a user-centered IL game, incorporating affective EAs that are capable of expressing different affect; and

RO3: To evaluate the influence of affective EAs on students' learning motivation, enjoyment, and learning efficacy.

While RO1 and part of RO2 have been addressed in Study I and Study II from Jan 2013 to Aug 2014, the remaining RO2 is in progress from September 2014 till April 2015, and RO3 will be fulfilled in Study III from May 2015 to Jan 2017.

4. RELATED CONCEPTS

4.1 Information Search Process

One of the seminal works in IL education is the ISP Model [5, 16, 17]. The model consists of six iterative stages: Task initiation, topic selection, prefocus exploration, focus formulation, information collection and search closure. What is unique about the ISP Model is that it takes into consideration the information seeker's affective states; and predicts situations during which information seekers are likely to experience positive affective states such as confidence and assurance, and also situations during which they are likely to experience negative affective states such as anxiety and frustration. Anxiety is regarded as an integral part of the information seeking process, as the feeling of anxiousness is often associated with uncertainty and confusion [5].

The ISP Model claims that in the early stages of searching, negative feelings are common. This is because in these stages, the search problem is ill-defined and the searcher has little knowledge of what information is available. As the search progresses, the understanding of the search problem increases accordingly, thus resulting in a corresponding improvement in the level of satisfaction in the search process. At the end of the search, the searcher will feel a sense of relief or satisfaction when the required information is found, or disappointment and anxiety if it was not.

4.2 Digital Games in IL Education

Digital games present an opportunity for librarians to rethink and reinvent the delivery of library services in support of the library's mission. DGBL, learning by playing digital games has been found to be an effective way of educating the young generation [6, 18]. As an alternative form of learning, DGBL has found a broad audience, becoming a popular activity for people of all ages, especially the young, In America, for example, 99% of the teens and 81% of people between 18 and 29 play digital games [19].

Although the concept of DGBL has deeply influenced education in general, and digital games available that teach math, history, or computer literacy already exist [6, 20, 21], this concept is relatively unknown to IL education. The University of Michigan is one of a handful of libraries that have adopted DGBL to teach IL. They designed and implemented an IL board game called *Defense of Hidgeon*: *The Plague Years* [22]. Austin Community College initiated *Info Game*, an online game where players score by answering questions correctly, based on the content of their library text-based tutorial [23].

4.3 Affective Embodied Agents

It has been observed that in conventional learning environments, expert tutors pay as much attention and spend as much time to help students achieve affective goals when tutoring, as they do to help them achieve of cognitive and informational ones [24]. Because of the important role that affect play in learning, researchers have, over the last few years, attempted to factor in the learners' affective states when designing educational systems [8, 25]. This echoes recent research in affective computing, where scholars have called for the design of systems and devices that can recognize, interpret, process, and stimulate human affect, as well as express affect [26]. Some common ways to infuse emotions into DGBL include the use of music, storyline, background setting, colors, narration, but the most common way is through the use of EAs.

More importantly, it has been found that the manipulation of EAs' affective states in DGBL can significantly influence learners' learning motivation and self-efficacy [27]. In particular, the use of affective EAs in a pedagogical role such as an instructor, mentor, assistant, and companion, has been found to help students overcome negative affect such as boredom or frustration during learning process [28-30]. This is especially important in the context of this PhD project, which is to use affective EAs to ease potential negative affect arisen from information seeking process. Additionally, when people's expectations are not met, affect can help direct people's attention to the preceding or accompanying events and treat them as important lessons to be learnt [31]. In the context of the information search process, when the intended information is not found, negative feelings will arise, and this will trigger the brain to pay more attention to learning. Therefore, timely intervention and guidance from instructors could greatly enhance the learning experience and effectiveness. However, the notion of affective EAs is almost alien to IL education research.

5. METHODOLOGY

There are three studies in this PhD project. Study I addressed RO1, where an online tutorial with EAs was designed and implemented, and empirical evaluation data was collected, in order to validate the initial assumptions that using affective EAs can improve students' learning performance. Study I also provided the motivation for Study II, which addressed part of RO2, where the participatory design (PD) approach was adopted for the IL game design. After the game design and development are completed, Study III will address RO3, to evaluate the effect of EAs' affective expressions on learning motivation, enjoyment, and learning efficacy of the players. The following sections will provide more details on the three studies.

5.1 Study I (Completed)

A tutorial was designed and developed for the purpose of obtaining empirical evidence of actual user evaluations on the impact of affective EAs. Two hundred and eighty-five tertiary students from two major universities participated in the between-subjects experiment. To evaluate the effectiveness of using affective EAs, a between-subjects experiment was carried out, where participants were divided into three conditions: affective EA, neutral EA, and text-only.

The posttest survey questionnaire was adapted from existing literacy, and comprised six sections. The first two sections focused on students' learning motivations and enjoyment, based on extant literature [32, 33]. The questions were measured on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The third and fourth section aimed to test the amount of knowledge that students attained from the tutorial, and their intention to play a game based on the tutorial. In the penultimate section, participants were asked for their opinions of the tutorial, and for suggestions to improve it. Demographic information was collected in the final section.

The results supported the general prediction that students would benefit from the added use of an affective EA in educational systems. It showed that affective EAs significantly increased students' learning motivation and enjoyment, compared to neutral EAs or text-only instructions. However, there was no significant difference in knowledge retention. In terms of intention to use, students in affective-EAs condition were more likely to play an IL game extended from the existing tutorial, than those in text-only and neutral-EAs conditions. The incorporation of both positive and negative affective states in the EAs, which are common during the information search process, can enhance students' learning motivation and enjoyment.

Study I paved the way for a better understanding of embedding affective EAs in online IL education. Furthermore, the result of Study I suggested the direction for Study II, which is to design and develop a full-fledged game that teaches students information seeking skills. Furthermore, part of the results have been written up and submitted to Digital Libraries 2014 Conference, entitled "*Using Affective Embodied Agents in Information Literacy Education*", which was published in IEEE.

5.2 Study II (Completed)

Based on the positive improvement on students' motivation and enjoyment from Study I, Study II was carried out to design a user-centered IL game, by incorporating affective EAs that are capable of expressing different types of affect. The PD approach was used so that insights into the perceptions of potential users of how such a game should be designed, could be obtained.

After the pilot study, a formal PD workshop was carried out, involving seven tertiary students from different educational background and educational levels, and the author as the facilitator. The result is a low-fidelity prototype named *Library Escape* (see Figure 2 and 3). Additionally, the data collected from PD workshop were analyzed based on existing gaming and pedagogical literature. In particular, the game prototype is divided into six missions according to the six stages in the ISP Model.

Figure 2. Protagonist

Figure3. Librarian

Library Escape is adapted from an existing genre of real-world game called "room escape". In *Library Escape*, players need to solve IL mysteries using various in-game clues within a one-hour time limit to escape from a haunted library building. The affective EA appears in the form of a ghost librarian who will offer help and advice to the players. The library building consists of multiple floors and rooms. Each room consists of a locked door, several objects to manipulate, and hidden clues or secret compartments. IL knowledge is acquired by exploring the objects and answering questions correctly.

5.3 Study III (In Progress)

After Study II, professional game designers and developers have been engaged in the design and development of the IL game. User evaluation interviews with ten participants were carried out to refine the game prototype, improving its learning content and gameplay elements (see Figure 4 and 5 for revised character and mission design). Thereafter, iterative tests will be conducted to evaluate the game, so that it can be subsequently refined. This evaluation and refinement process is an iterative process with the goal of increasing the usability of the game. After the iterative evaluation and refinement, the IL game will formally roll out.

Figure 1. Protagonist and Librarian (Revised Design)

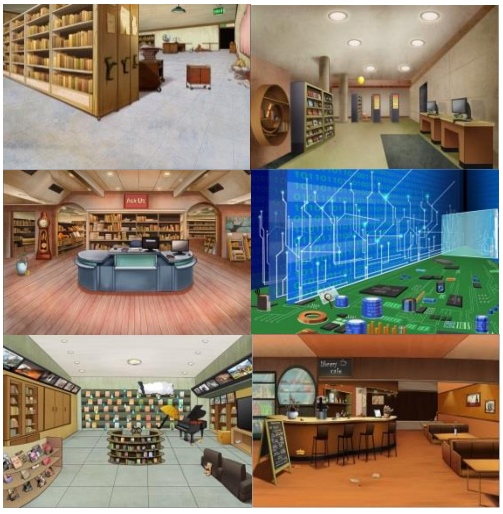

Figure 2. Mission 1-6 (Revised Design)

Study III aims to address RO3, which is to evaluate the influence of affective EAs on learning motivation, enjoyment, and the learning efficacy of the players. The game will be formally evaluated, both quantitatively and qualitatively, in order to triangulate the results. For the quantitative evaluation, pre-test and post-test survey questionnaire will be distributed to participants on a wide scale. The survey instrument will again utilize the same ARCS model and tripartite enjoyment model, to be consistent with Study I.

As for the qualitative evaluation, naturalistic evaluation method, specifically ethnographic evaluation method will be highlighted, which includes observation notes, interviews, focus group discussions and analyses of game activity logs. The use of game activity logs is an unobtrusive method of collecting significant amounts of data on system users, and it is believed to yield a more meaningful picture of the IL game, and produce a rich description in evaluation process compared with using traditional survey questionnaire in lab setting, and would therefore be used [34].

6. RESEARCH CONTRIBUTIONS

Overall, the findings from Study I and Study II have both theoretical and practical contributions, and these are presented in the next two sections.

6.1 Theoretical Contributions

First, Study I affirms the effectiveness of using affective EAs in reducing negative feelings experienced in information seeking process. In particular, the ISP Model was effectively used as the conceptual framework in Study I for the online tutorial, as indicated by the favorable comments from participants. To the best of my best knowledge, this is one of the few efforts in structuring an affective online library tutorial on a theoretically sound framework, which could guide practitioners to base their practice on grounded principles rather than depending solely on intuition or individual experience.

The second theoretical contribution is that while there is a large corpus of literature on the use of DGBL to teach lower order thinking skills such as mathematics, history, and physics, research on using DBGL to teach higher thinking skills such as IL has been minimal. Study II filled this gap by designing and developing an IL game which aims to teach the ISP Model to tertiary students, which can ease anxiety levels associated with academic information seeking.

Additionally, the use of the PD approach in Study II enabled potential users to contribute to the design process. The very fact that participants' discussion matched well with the GameFlow model demonstrated that PD was an effective approach in gathering user requirements from target users.

6.2 Practical Contributions

The first practical contribution is that the tutorial used in Study I was constructed from rudimentary elements of a graphical user interface, such as dialog boxes, buttons, and text. This shows that it is possible to create useful, affective EAs without the need for complex user interface elements. This is important as libraries may not have the resources for expensive software development projects. Study I showed that it is possible to create affective EAs without employing sophisticated technologies and still be effective, illustrated by the improvement in user motivation and enjoyment.

The second contribution for practice is that the evidence-based findings from Study I and Study II, though preliminary, will add to the body of knowledge of using DGBL in IL education in tertiary institutes. In addition, they would have implications for

practitioner such as librarians, curriculum designers as they offer insights on whether to tap on the opportunities offered by the emerging medium of digital games for IL education. The design process and evaluation methods in Study I can be used in future studies.

Furthermore, the prototype and design ideas for participants from the PD workshop in Study II, can be used by librarians as a starting point for exploration of games for IL education to complement traditional face-to-face instructions and online tutorials. The findings of the research will be of interest to educators and faculty members as the lessons learnt can inform and stimulate the further implementation of DGBL in libraries and schools. Moreover, a better understanding of PD process can inform ways of conducting collaborative projects and facilitate sharing.

7. LIMITATIONS AND FUTURE WORK

Although Study I and Study II has yielded valuable insights, there are three major limitations that may reduce generalizability of the results. So this section clarifies the scope and limitations of Study I and Study II, before presenting the directions for future work.

First, given limited time, the topics in the IL tutorial in Study I were limited to the field of storytelling. This means that students with different backgrounds may not be able to relate the subject matter of the tutorial to their existing knowledgebase well. Some participants may prefer the topics to be examples from their own disciplines. Hence, it is important for the IL game to accommodate students with diverse backgrounds and interests, which was discussed in the PD workshop. Nevertheless, the tutorial designed has been carefully designed to be short, which is ideal for the users on the go, and the focus of the Study I was on the effectiveness of using affective EAs in the tutorials, rather than on the subject matter.

Next, the convenience sampling method was employed in the evaluation of the IL tutorial in Study I, and as a result, the participants were mostly from the social science and humanities background. The similarity in background may results in a bias in their perception of the tutorial. This limits the ability to generalize user evaluations as the students from social science may be more receptive to research ideas from social science, compared to students from natural science or engineering. Hence, caution is required in interpreting the results. Despite this bias, these findings will be useful especially in designing new technologies.

Furthermore, the PD approach is continuously faced with many challenges as it is applied in new contexts. Of particular interest to Study II is the fact that the actual stakeholders of the IL game will mainly include students from all disciplines, librarians, and faculty members, whose population is much larger than the seven representative users in the PD workshop. Thus involving the representative users as participants in the design process would potentially bias the design towards the perceptions of them. Study II attempted to mitigate this challenge by recruiting participants from a wide variety of disciplines, nationalities, and educational levels.

This PhD project points out several directions for future research. First, there is an urgent need to apply established learning theories and instructional strategies to guide the design of DGBL in order to maximize their potential. This calls for the development of a theoretical model. Second, this IL game will be launched in the form of computer games, but with the popularity of mobile gaming, efforts could be put in to adapt the game on mobile platform, to encourage more usage. Last, comparison could be carried out to evaluate the effectiveness of learning IL through DGBL against traditional face-to-face learning or online tutorials.

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