An investigation of affective embodied agents in an information literacy game

Guo, Yanru

2017

Guo, Y. (2017). An investigation of affective embodied agents in an information literacy game. Doctoral thesis, Nanyang Technological University, Singapore.

<http://hdl.handle.net/10356/72729>

<https://doi.org/10.32657/10356/72729>

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**AN INVESTIGATION OF AFFECTIVE EMBODIED AGENTS
IN AN INFORMATION LITERACY GAME**

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WEE KIM WEE SCHOOL OF COMMUNICATION AND INFORMATION

2017

AN INVESTIGATION OF AFFECTIVE EMBODIED AGENTS IN AN INFORMATION LITERACY GAME

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A thesis submitted to the Nanyang Technological University
in fulfillment of the requirement for the degree of
Doctor of Philosophy

2017

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ACKNOWLEDGEMENTS

Let us be grateful to the people who make us happy; they are the charming gardeners who make our souls blossom.

MARCEL PROUST

When I first came to NTU as a postgraduate student in 2011, I called it a paradise – there were so many libraries around and they were all filled with so many books. After graduation, an extraordinary confluence of circumstances led me to become a librarian at the Ngee Ann Polytechnic Library, a dream job as a guardian of books in my paradise. Today, I am still fascinated with libraries, and in the PhD program, I research about libraries, and how to promote the libraries which ever fewer students see value in. I hope that the work you are about to read will bring the field forward and show new paths for library science.

The four-year PhD journey was a true battle of endurance that I never could have even dreamed of attempting without an incredible and gracious group of people. I am grateful and hugely indebted to their guidance and wisdom.

One of my greatest gratitude goes to my advisors, Associate Professors Dion Goh and Brendan Luyt, who imparted their knowledge unselfishly and guided me along the way untiringly during the four years. I am thankful for the pointed questions in each meeting to enable me to think carefully about every aspect of the research. Thank you for keeping me in the state of “flow” throughout my candidature.

I have taken and audited many courses in the four years, and I would like to thank the instructors. In Semester One, Professor Emeritus Eddie Kuo and Professor Ang Peng Hwa taught *Philosophy of Research*. This course, which I absolutely enjoyed,

deepened my interest in philosophy. Associate Professor Christopher Khoo taught *Human Information Behavior*, where he presented Kuhlthau's (2004) ISP Model, a cornerstone in the PhD research. In addition, he also gave me the opportunity to volunteer at the IFLA pre-conference, and IFLA2013 Conference. Assistant Professor Marko Skorik and Dr. Mark Cenite taught *Advanced Communication Research*, from which I learnt some useful methodologies. In Semester Two, Professor Charles Salmon taught *Communication Theory*, opening my eye to an extensive amount of communication theories. Associate Professor Brendan Luyt taught *Conceptual Foundations of Information*, which provided me many opportunities to think deeply as he encouraged us to ask "intelligent questions". Assistant Professor Chang Yun-Ke taught *Human-computer Interaction*, during which I was exposed to the basic concepts of HCI such as usability, usefulness, and heuristic evaluation of the system, and some common project management techniques, such as the waterfall method and iterative prototyping. In Semester Four, Assistant Professor Qiu Lin from HSS taught many usability design and testing methods in *Cognitive Psychology*, and allowed me to deliver a guest lecture in his class. Dr. Lim Yang Teck from NIE graciously taught *Curriculum Design for Games, Game-based Worlds & Immersive Environments*, even though I was the only student in class.

Assistant Professors Natalie Pang and Winson Peng kindly allowed me to audit *Qualitative Research Methods* and *Quantitative Research Methods*, which prepared me for conducting Study I and II. Assistant Professor Xu Hong from HSS allowed me to audit *Advanced Research Methods and Data Analysis*, which brushed up my mathematic and calculation skills.

The game programmer, Xu Weida, endured many unexpected changes in the game design and spent hours and hours in developing and redeveloping the game, and

was upbeat through the whole process. The constructive questions and comments from thesis examiners enabled me to locate the blind spots in the thesis. My parents in China were extremely supportive throughout although I was away from them most of the time. And to this specific person I didn't mention: please accept my deep sense of guilt and know that I adore you.

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ABSTRACT

Students need to be supported in the development of their information literacy (IL) skills – the ability to seek, locate, evaluate and navigate information effectively. Usually IL instruction takes the form of traditional face-to-face sessions at libraries. Today, however, young students demand a more engaging form of learning. Recognizing the limitations of traditional classroom instruction, educators have begun to look for alternatives, and have turned to digital games as teaching tools. The use of digital games for educational purposes is often referred to as digital game-based learning (DGBL). However, the affective aspects of learning are often neglected in DGBL. A common way to address the issue is to use embodied agents (EAs), the approach taken in this thesis.

Libraries should actively engage students to understand their needs to better ensure success and high levels of user acceptance to the IL games. However, students as end-users rarely participated in IL game design. Furthermore, there is a dearth of research in the use of affective EAs in DGBL, including its use in IL games. While DGBL has been shown to be an effective teaching tool, its synergy with affective EAs needs to be further examined. Moreover, the benefits of using DGBL or affective EAs in IL education are mostly anecdotal, and there is more speculation than evidence. Hence, research is needed to tease out which aspects are useful to improve students' learning performance. Therefore, this thesis asks two research questions. The first is: how can the participatory design (PD) approach be used to inform the design of an IL game with affective EAs? The second is: how does the use of affective EAs in an IL game influence tertiary students' learning?

Two studies were carried out to address the two questions. Study I addressed the first research question, where *Library Escape*, an IL game that incorporated affective EAs was

designed, based on pedagogical and game design principles. A PD approach was used in the IL game design. Specifically, three rounds of focus group discussion were conducted, which yielded a low-fidelity prototype. Thereafter, individual user interviews with ten tertiary students were held to refine the low-fidelity prototype, resulting in a high-fidelity prototype. Study II addressed the second research question, where the influence of affective EAs in the IL game was examined, in an experiment and supplementary qualitative interviews. In total, 159 tertiary students participated in the pretest-posttest between-subjects experiment. Eight participants were invited for qualitative interviews after the experiment, and their feedback on the IL game and affective EA was gathered and summarized. The results showed that using the affective EA had a strong positive impact on students' learning motivation (attention, confidence, and satisfaction), enjoyment (affective, cognitive and behavioral enjoyment), perceived usefulness and behavioral intention (to learn more about IL, to recommend the game to others, and to play other IL games). However, the affective EA had no impact on learning outcome or perceived relevance.

To conclude, *Library Escape* is one of the few efforts in structuring DGBL on theoretical frameworks, making the game conceptually sound. The research undertook the first step in highlighting the positive influence of affect and affective EAs in an IL game. The game prototype and design insights drawn from *Library Escape* can be used by librarians, educators, and faculty members as a starting point for the use of DGBL in IL education.

CHAPTER ONE

INTRODUCTION

It is hard to imagine any aspect of contemporary life that has not been shaped by information. The formidable growth in the amount of information has become the driving force of the present economy, leading to a manifold increase in the public's access to information (American Library Association, 2017). We enjoy, and suffer from, an overabundance of information that was unthinkable a generation ago. Yet, the incredible range of information has not created a more informed populace, but – quite the contrary – a more disoriented one (Savin-
Baden, 2015). This conundrum is the starting point for the investigation that follows.

1.1 Information Literacy Education

People are generating, discovering, gathering, analyzing, and translating information at great speed. Although the Internet is a valuable information source, it is also a source for misunderstanding, incorrect information, and perpetuation of falsehoods and urban legends (Stanford History Education Group, 2016). The change in the information landscape poses more complexity to effective information search. In this situation, there is an acute need for information literacy (IL) education – the ability to seek, locate, evaluate and navigate information effectively (American Library Association, 2017).

Information literacy combines skills from library literacy, computer literacy, media literacy, information ethics, critical thinking, and communication skills (American Library Association, 2017). The suite of skills is a necessity of modern life. At the individual level, IL skills form the basis for lifelong learning. The knowledge enables learners to master content

and extend their investigations, become more self-directed, and assume greater control over their own learning (Boh Podgornik, Dolničar, Šorgo, & Bartol, 2015). It can also enlarge the personal, family and societal options available to individuals, increase their prospects of locating satisfying jobs and moving up the career ladder, and improve the odds of them fulfilling professional goals and aspirations (Davis-Kahl & Hensley, 2013). At the societal level, the concern over the existence of “fake news” during the recent US Presidential Elections brought prominence to the importance of IL in the general populace (Mitchell, Gottfried, Barthel, & Shearer, 2016). Hence IL skills are critical to a healthy democracy as citizenship involves having the ability to access vital information, and to recognize when that information is misused or abused, such as in distortion and propaganda. Information literacy skills are needed for people to be active, enlightened and effective participants in society (Oberg, 2017).

Information literacy skills are even more critical for tertiary students. Tertiary students thus assume a greater role and responsibility in creating new knowledge, in understanding the contours and the changing dynamics of the world of information, and in using information, data, and scholarship ethically. Tertiary students need to think about the wider issues in knowledge production, be aware of the complexity and social construction of information, and reflect critically and use information responsibly and ethically in an increasingly interconnected world (International Baccalaureate Diploma Program, 2016). This makes being proficient in IL skills even more pressing for them.

Teachers have observed that while students with low IL struggle to understand and complete assignments, those with better IL skills approach these assignments with more confidence and creativity and achieve more success. Many students lack the skills in analyzing the information on the Internet, and in differentiating advertisements from news stories on social media (American Library Association, 2017; Stanford History Education Group, 2016). This can be corrected through IL education and IL skill acquisition. Students could benefit

greatly from library instruction early in their coursework. IL instruction can benefit students early in their coursework, and strengthen the general learning outcomes (Oberg, 2017).

Libraries have been at the forefront in advocating the importance of IL education to the public. The goal of academic libraries is to help students acquire IL skills for academic assignments and life-long learning through IL instruction. Such instruction usually takes the form of traditional face-to-face, lecture-style sessions at libraries (Ragains & Wood, 2015). However, these sessions have limited success (Freeman et al., 2014; Markey, Leeder, & Rieh, 2014). Students today prefer instructional methods that are more engaging. They expect to be entertained when being taught, to have more flexible schedules, and to be able to learn anywhere and everywhere (Shurkin, 2015). Further, young students nowadays are increasingly unwilling to initiate interaction with librarians when they encounter difficulties searching for academic resources (Nicholas, Rowlands, Clark, & Williams, 2011; Oberg, 2017). Thus librarians are not able to reach out to disengaged students who need help the most, but may not bother to participate in the IL instruction. These challenges on how to motivate students to learn and foster enduring curiosity could potentially be resolved through digital game-based learning (DGBL).

1.2 Digital Game-based Learning

Recognizing the limitations of traditional classroom instruction, educators and librarians began to look for alternatives. The last few decades have seen a number of changes in education pulling towards more entertainment (Hamari et al., 2016). With a broad audience, digital games have been explored as educational tools. The use of digital games for educational purposes is often referred to as DGBL. Fueled both by commercial interest and anxious parents, DGBL is

the fastest growing category within the gaming economy, and the DGBL income will be worth \$2.3 billion, 53% increase from 2012 (Games & Learning, 2016).

Digital game-based learning is based on the premise that digital games can serve not only as an engaging way to entertain players, but also as an innovative tool to help build their cognitive abilities, encourage problem-solving, promote collaboration, and increase self-esteem (Chae & Shin, 2016; Nicholson, 2013). Using DGBL in classrooms has the advantages of alleviating the pressure of judgment, evaluation, intra-classroom comparison and competition, and in this way creating a safe environment where the learners can undergo a deep and valuable learning experience (Hamari et al., 2016). For libraries, DGBL may present an opportunity to rethink and reinvent IL education.

The University of Michigan is one of a handful of libraries that have adopted DGBL to teach IL. They designed and implemented two digital games called *Defense of Hidgeon: the Plague Years* and *BiblioBouts* (Markey et al., 2014). The first game put players in the 14th century at the height of the Black Plague, and required them to form a team to navigate around the kingdom while looking for a solution to the crisis. *BiblioBouts* is an online tournament game made up of a series of bouts, each of which teaches some IL skills. In another example, at Arizona State University, librarians created an online game titled *Quarantined: Axl Wise and the Information Outbreak*, where players need to contain a viral outbreak on campus by acquiring IL knowledge (Gallegos, Grondin, Allgood, Duarte, & Rostad, 2008).

Effective DGBL requires the educational content to be weaved seamlessly with enjoyable gameplay experience. Understanding the expectations and concerns from end-users will increase games' likelihood for success. However, students were rarely involved in the design of IL games. Hence, libraries should actively engage students to understand their needs to ensure success and more user acceptance in IL games.

Further, DGBL is not without drawbacks. In traditional face-to-face instruction, teachers pay as much attention and spend as much time to help students achieve affective goals, as they do to help them achieve cognitive and informational ones (Lepper & Chabay, 1988; Lin et al., 2013). The teachers' concern and attention to students' affective states occur naturally in conjunction with the educational content, both verbally and nonverbally (Zhang, 2013). In DGBL, the affective aspects of learning are often unaddressed because there is no teacher. In this case, there is a need to factor the affective aspects into DGBL.

1.3 Affective Embodied Agents

Some common ways to infuse the affective aspects into DGBL include the use of music, background colors, narratives, as well as avatars or agents (Raessens & Goldstein, 2011). Using avatars or agents is an effective way of expressing different affective states in digital games (Burgoon et al., 2016). Depending on the stream of research, avatars are also labeled as: autonomous agents (Leite, Martinho, Pereira, & Paiva, 2008), animated agents (Lin, Atkinson, Christopherson, Joseph, & Harrison, 2013), embodied agents (Kim & Baylor, 2016), and virtual agents (Fridin & Belokopytov, 2014). This thesis uses the term embodied agents, which emphasizes on the graphical representation, rather than sophisticated artificial intelligence or realism (Kim & Baylor, 2016). An embodied agent (EA) refers to a life-like agent, i.e., one with a physical face and body (Krämer et al., 2016). Accordingly, an affective EA is defined as one that is capable of displaying certain emotions through multiple modalities such as speech, facial expressions and body gestures (Corti & Gillespie, 2016). EAs are becoming an increasingly popular technique to incorporate affective elements in computer-based learning environments (Chen & Chou, 2015).

By incorporating features such as facial expressions, voice, and body gestures, affective EAs can make the interactions between computers and humans more natural and enjoyable, build better rapport and trust with users, increasing their perceived usefulness in computer-assisted learning programs (Guo & Goh, 2015). Further, the positive attitudes such as pleasure, trust, and satisfaction brought by using affective EAs can increase people's acceptance and usage behaviors (Zhang, 2013). 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). Affective EAs can also help students overcome negative affects such as boredom or frustration during the learning process (Harrison, Sengers, & Tatar, 2011; Moridis & Economides, 2012).

Despite its potential, research on using EAs in DGBL is rare. In the past, studies mainly used affective EAs in computer-assisted learning programs such as online tests (Moridis & Economides, 2012), tutorials (Mayer & DaPra, 2012), and learning systems (Carlotto & Jaques, 2013), and very few studies have applied them in DGBL. Therefore, the two concepts of DGBL and affective EAs will be juxtaposed to achieve synergy in this thesis.

1.4 Research Gaps

From the introduction above, three research gaps have been identified, and they are presented as follows.

1.4.1 Neglect of user input and iteration in information literacy game design

For DGBL to succeed, the central consideration must be its target users (Charsky, 2010). In the past, many endeavors to create effective DGBL have failed, as it is very difficult to weave educational content into a seamless gameplay experience (Lomas, Patel, Forlizzi, & Koedinger,

2013). Consequently, the field of DGBL has seen many calls to hear from end-users and understand their needs (Rebelo & Filgueiras, 2012). One way to achieve success is to adopt a PD approach, which requires the active involvement of potential users, and the understanding of their expectations and concerns towards DGBL. It is hoped that with the PD approach, the games are more likely to succeed (Baxter, Courage, & Caine, 2015).

Further, game design itself is a complex and endless problem. The solutions and problems mutually define each other, and every proposed solution changes the understanding of the problems (Robert & Lesage, 2012). Therefore, continuous user involvement and iterative process of design are needed. By emphasizing on a cyclic process of prototyping, playtesting, and analyzing, the iterative approach allows the designers to refine the work in progress gradually (Symborski et al., 2016). Iterative design is a typical characteristic of the PD approach, and the best guarantee for success (Arcia et al., 2016).

Despite the advantages of the PD approach, few IL games have been designed in such a way. In the case of *Defense of Hidgeon: the Plague Years*, the librarians only involved end-users after the game had been fully implemented. The user feedback was negative in general, but as it was too late to make changes, the designers had to create an entirely new IL game (Markey et al., 2014). This process was costly in terms of time and effort. A PD approach would have considerably lowered the odds of such failures. Libraries should consider adopting the PD approach to actively engage students to ensure success and user acceptance.

1.4.2 Absence of affective aspects in information literacy games

Very few studies have paid attention to affective aspects in DGBL, let alone in IL games. Information literacy skills learning is an affective process. Students' development of IL skills is often impeded by negative affects such as fear of the library, and the anxiety of not being

able to locate the information needed (Gremmels, 2015). Affective EAs are effective in conveying emotions, and easing the negative affective states experienced by learners (Burgoon et al., 2016; Lin et al., 2013).

The neglect of affective aspects can be seen in existing digital IL games, such as *The Information Literacy Game* by the University of North Carolina (Rice, 2008), or *SCaVeNGeR* from the University of California at San Diego and at Merced (McMunn-Tetangco, 2013). These IL games are primarily concerned with imparting IL knowledge, and affect is often left on the periphery. As such, there is a need to synergize affective EAs with DGBL as a more effective teaching tool.

1.4.3 Lack of evaluation of affective embodied agents in information literacy games

It is important to assess the potential and limitations of affective EAs so that they can be usefully deployed in IL games. It is sometimes challenging to evaluate DGBL, with its many elements such as interactivity, narration, background color, and music. This results in more speculation than evidence on the benefits of using DGBL or affective EAs in IL education (Broussard, 2012). Past evaluation studies relied on anecdotal quotations from user interviews (e.g., in Markey et al., 2014), or short surveys with only two or three questions (e.g., in Broussard, 2010; Smith & Baker, 2011). Hence, experimental research is needed to tease out which aspects are useful to improve students' learning performance.

Further, current investigation on affective EAs are mainly focused on cognitive learning outcomes such as reliable and efficient information delivery. There is a lack of studies on the motivational or social aspects of their use (Krämer et al., 2016). Our knowledge of the learning process will be greatly enhanced if the interplay between learners' affective and cognitive states are better understood (Zhang, 2013). In DGBL, motivation and perceived usefulness are

important to achieving learning goals, while enjoyment is critical for players to continue playing the games (Chae & Shin, 2016; Kim & Baylor, 2016). Positive attitudes such as pleasure, trust, and satisfaction brought by using EAs in DGBL will also increase people's acceptance and usage behaviors (Bickmore, Vardoulakis, Jack, & Paasche-Orlow, 2013). Hence more research is needed to evaluate the influence of affective EAs on students' learning in DGBL.

1.5 Research Questions and Objectives

Based on the three research gaps identified above, two research questions (RQs) are proposed.

RQ 1 is based on the first two gaps, while RQ 2 is derived from the third gap:

RQ 1: How can the PD approach be used to inform the design of an IL game with affective EAs?

RQ 2: How does the use of affective EAs in an IL game influence tertiary students' learning?

The two research questions are addressed through the completion of two research objectives (ROs) below, which can be broken down into a series of steps:

RO 1: To design and implement an IL game with affective EAs using the PD approach:

- (1) to create a low-fidelity prototype using focus group;
- (2) to refine the low-fidelity prototype and create a high-fidelity prototype game through user feedback from evaluation interviews; and
- (3) to analyze the IL game with pedagogical and game design principles.

RO 2: To evaluate the influence of affective EAs in the IL game on tertiary students' learning:

- (1) to create three versions of the game: affective-EA, neutral-EA, and non-EA versions;

- (2) to compare students' learning outcome, motivation, gameplay enjoyment, perceived usefulness, and behavioral intention from each group through pretest posttest between-subject experiment; and
- (3) to assess students' perception about the affective EA using individual interviews.

Figure 1.1 shows the flow of the thesis. The first two research gaps lead to RQ 1 and RO 1, which are addressed in Study I. Similarly, the third research gap is explicated in RQ 2 and RO 2, which is examined in Study II.

Figure 1.1 Flow of Thesis

1.6 Theoretical Foundations

Pedagogical frameworks and gameplay principles are paramount to create an effective learning experience in DGBL (Howell, 2017). However, existing DGBL often fall short when it comes to applying these principles. The lack of conceptual frameworks in DGBL design has significantly impeded its adoption in formal learning contexts (Walsh, Foss, Yip, & Druin, 2013). There is hence a need to integrate such frameworks with current DGBL design.

This thesis uses several theoretical frameworks to guide the investigations, as listed in Figure 1.2. Specifically, the Information Search Process Model was used to structure to design

the IL game in Study I. The Attention Relevance Confidence and Satisfaction (ARCS) and the GameFlow Models were used to analyze the IL game to justify its design decisions. Moreover, the Tripartite Enjoyment Model, User Acceptance Research, and Social Agency Theory, together with the ARCS Model, provide theoretical underpinnings for the survey instruments in the game evaluation in Study II. Together, these theoretical frameworks provide sound theoretical underpinnings for the thesis.

Figure 1.2 Theoretical Foundations for the PhD Research

1.7 Organization of Thesis

Figure 1.3 shows the organization of the seven chapters, followed by references and appendices. This chapter, Chapter One, looks at the problems with current IL education and proposes using an IL game with affective EAs as a possible remedy. It introduces the basic concepts, outlines the theoretical perspectives to draw upon, identifies the gaps in literature, and defines the research questions and research objectives. The next two chapters establish the broader context. Chapter Two explores the literature that has influenced this project, focusing

on IL education, DGBL, and affective EAs in games. Chapter Three introduces the theoretical foundations used in this thesis.

Figure 1.3 Roadmap of Thesis

Chapters Four, Five and Six make up the bulk of the thesis, presenting two empirical studies. Study I that addresses RQ 1 and fulfills RO 1 is discussed in Chapter Four. It documents the PD approach: focus group discussion that yielded the low-fidelity prototype, and individual interviews to improve the low-fidelity prototype to produce the high-fidelity one. Some design insights are shared at the end of Chapter Four. Chapter Five analyzes how the game conforms to pedagogical and game design principles. Chapter Six details Study II that addresses RQ 2 and fulfills RO 2. Mixed methods of quantitative experiment and qualitative interviews were used to investigate the influence of affective EAs on students' learning outcome, motivation, gameplay enjoyment, perceived usefulness and behavioral intention. Finally, Chapter Seven concludes the thesis by summarizing how it has fulfilled its objectives, its contributions to researchers and practitioners, and avenues of future work.

CHAPTER TWO

LITERATURE REVIEW

This chapter reviews the literature and is organized into four sections. The first three sections present three key concepts in this PhD research: information literacy (IL), digital game-based learning (DGBL) and affective embodied agents (EAs). Specifically, the first section explicates what IL is, the three characteristics of IL knowledge acquisition, and the common methods in which IL is taught. The second section discusses the pedagogical values of DGBL, especially with respect to teaching IL, and describes a few existing IL games. The third section presents a short history and development of affective EAs, and their applications in educational settings. The last section concludes Chapter Two with a summary.

2.1 Information Literacy

The term *information literacy* is a neatly packaged phrase not easily interpretable. This section hence first reviews several major definitions of IL, and shows how the term of IL has evolved over time as a response to the changing information landscape. Thereafter, three characteristics of IL are discussed, namely, IL as an affective process, as a constructivist process, and as a higher-order thinking process. The last part compares three methods to teach IL: through face-to-face sessions, computer-assisted tutorials, and digital game-based instruction.

2.1.1 Definitions

The lineage of IL can be traced to the 1870s: it builds on the long-standing library practice of bibliographic instruction, also called library instruction, or library user education (Cox &

Lindsay, 2008). The first person to use the term IL, is Zurkowski (1974), then president of the Information Industry Association. He referred to it as “the techniques and skills for utilizing the wide range of information tools as well as primary sources in molding information-solutions to their problems” (p. 2). Zurkowski discussed IL from a commercial perspective, and placed emphasis on print materials, information products and services such as information banks¹, information bank vendors, and publishers. In 1979, the Association revised this definition of IL, and broadened its scope to the daily practice of the public (Garfield, 1979).

In the 1980s, personal computers began to permeate society. Horton (1982), Zurkowski’s consultant in the Information Industry Association, foresaw the potential of computers as a valuable source of information, and he suggested incorporating computer literacy into IL. He stated that “Information literacy, then ..., means raising the level of awareness of individuals and enterprises to the knowledge explosion, and how machine-aided handling systems can help to identify, access, and obtain data, documents and literature needed for problem-solving and decision-making” (p. 16).

In 1989, American Library Association (ALA) published the *Final Report of the Presidential Committee on Information Literacy*. The report placed IL at the forefront, as a combined issue for educators and librarians. The report gained significant attention worldwide, and identified the actual skills and knowledge to be information literate (Ragains & Wood, 2015). As a result, this definition of IL has become *de facto*. It defined information literate people as being:

“able to recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information. Ultimately, information literate people are those who have learned how to learn. They know how to learn

¹Information banks are sources or repositories of information, such as textbooks, teachers, encyclopedias, videotapes, video discs.

because they know how knowledge is organized, how to find information and how to use information in such a way that others can learn from them. They are people prepared for lifelong learning, because they can always find the information needed for any task or decision at hand.”

In the 1990s, IL became a major issue in librarianship, and libraries began to offer more IL instructional programs. This period thus saw the birth of many IL models and theories, such as the Big6 (Eisenberg & Berkowitz, 1990), Seven Pillars (SCONUL Working Group on Information Literacy, 1999), and Information Literacy Competency Standards for Higher Education (American Library Association, 2000). Given the limitations of space and the models are not the main focus, they will be not discussed here.

Recognizing the rapidly changing higher education environment, American Library Association (2015) published the *Framework for Information Literacy for Higher Education*. The document explored the concept of IL in more depth as part of the wider literacy continuum, encompassing digital, visual, media, data and academic literacies (Collier, 2015). The framework offers a renewed vision of IL as an overarching set of abilities. It promotes and expands upon concepts that reflect various aspects of metaliteracy, and revolves around a series of assumptions and metaphors: authority is constructed and contextual, information creation as a process, information has value, research as inquiry, scholarship as conversation, and searching as strategic exploration.

Other than libraries and library associations, educational institutes also place great emphasis on IL education. For example, the International Baccalaureate Diploma Program (2016) expects information literate students to think about the wider issues in knowledge production, to be aware of the complexity and social construction of information, to reflect critically and to use information responsibly in an increasingly interconnected world (Bastian, Bammi, & Howard, 2008). The Diploma Program embodies a more philosophical perspective

towards IL, focusing on the nature of information, and complexity of using information. In other words, it challenges students to engage in critical thinking, explore how knowledge is created, and how it can be used personally, professionally and politically. By doing so, information literate students could equip themselves with the ability to think about things and find evidence on their own, and hence be freed from the need to rely on authorities.

In sum, from its birth in 1974 to recently, the concept of IL has attracted much attention and scholarly exploration. However, other than that from the International Baccalaureate Diploma Program, all IL definitions adopted a behaviorist approach, specifying what IL comprises, the behavioral indicators of being information literate, the techniques and tools required to complete information search tasks, and the step-by-step guide to search for information (Thomas, Crow, & Franklin, 2011). The behaviorist approach is criticized for reducing IL from a complex set of competences to small linear units (Collier, 2015). In fact, IL is far more fluid and complex than the behaviorist approach suggests (McBride, 2012). Hence, the next section offers three more fluid characteristics of IL knowledge acquisition.

2.1.2 Characteristics of Information Literacy Knowledge Acquisition

As discussed above, IL is an umbrella concept that encompasses a broad set of skills. Hence IL knowledge acquisition has a few unique characteristics: IL knowledge acquisition as a process that involves affective feelings (Nahl & Bilal, 2007), as a process of meaning construction (Piaget, Beth, & Brousseau, 2014), and as a process that involves higher-order thinking skills (King, Goodson, & Rohani, 2009).

An Affective Process

Most of the IL definitions, models and standards focus on cognitive aspects of the skills and techniques, and overlook the affective aspects in IL knowledge acquisition (Cooke, 2014). The academic information search process is cloaked in emotional layers. It is often a messy and iterative process with many failures. Negative feelings, such as fear and uncertainty, have distinct effects on information seekers, and can limit their comprehension and retention of new information (Huddy, Feldman, & Cassese, 2007). Such negative feelings intrude and compete for cognitive resources, resulting in a decrease in task performance (Zhang, 2013). Two well researched negative feelings in IL are library anxiety, and uncertainty.

The first is library anxiety, which refers to the intimidation that students feel towards the library (Mellon, 1986). This intimidation arises because students feel that their library skills are inferior, and is compounded when students are afraid to ask for help from librarians. The experience of library anxiety is prevalent during students' initial IL skill acquisition (Brown, 2011). The second is uncertainty, which is caused by the fact that "document descriptions and query development are indeterminate and probabilistic beyond a certain point" (Bates, 1986) (p. 358). The specialized terms in library catalog records are different from those used by users, and as a result, users are uncertain about the exact words they need to use in a search formulation before they can successfully retrieve any useful documents (Boh Podgornik et al., 2015; Song, Zhang, & Clarke, 2014). The advancement in information search and retrieval techniques has alleviated the problems brought by library catalog records. A new cause for uncertainty nowadays is how to sift through and find gem in the vast amount of information, both online and offline. For some students, such negative affects lead to feelings of inadequacy and incompetence, hampering their information seeking efforts and learning experience (Kuhlthau, 2004).

It is hence important to recognize IL as an affective process, and for students to learn how to manage their anxieties and uncertainties. Such recognition during the IL knowledge acquisition stage can prepare students for some degree of disappointment, and cope with the negative feelings. Such understanding can also lead to better tolerance when the results deviate from initial expectations, and help students establish a higher level of confidence (Cahoy, 2013; Nahl & Bilal, 2007).

As a response to her findings, Mellon (1986) suggested that IL instruction should be more attuned to students' affective needs. What needs to be taught in IL is not only the cognitive aspects such as how to search for information, but also the affective aspects such as the feelings of anxiety and uncertainty that information seekers frequently encounter (Kuhlthau, 2004). Librarians should try to help students acquire a positive perception of IL, lower their library anxiety and better their IL skills. This could be achieved through using DGBL and affective EAs, which encompass many valuable pedagogical characteristics. Moreover, DGBL promotes active learning in a safe environment that lowers the risks of failure, while retaining the appealing qualities of digital games.

A Constructivist Process

Other than overlooking the affective aspects, most IL definitions focus on acquisition of IL skills or tools. The constructivist approach, on the other hand, emphasizes problem solving, concept development, and critical thinking. This approach can lead to better understanding and retention from students.

The constructivist perspective likens the acquisition of knowledge to a process of construction, where learners bring the knowledge from past experience, which has a strong influence upon how they construct meaning and acquire new knowledge (Bingham,

Wirjapranata, Chinnery, Baker, & Baker, 2016). From the constructivist perspective, learners expand their existing knowledge and add new concepts and new relationships among concepts, establishing conceptual frameworks, and venturing into unknown arenas. The constructivist perspective fosters the development of critical thinking skills, leading to higher levels of overall achievement (Piaget et al., 2014).

Admittedly, the constructivist approach is not applicable or possible in every educational setting; nonetheless, it is well suited for IL education. In an information-rich world which supports choices, students “think through issues that do not have prescribed responses or pre-set solutions” (Kuhlthau, 2004). Therefore, IL can be understood as a process of knowledge construction through active interaction and engagement with information (Clyde & Thomas, 2008). Information literate students actively construct meaning in their world. They actively engage in debating issues and problems, raising questions, identifying what they need to know to answer these questions, seeking information from a variety of sources to answer them, changing the questions midway as a response to what they have learnt, and sharing what they have learnt with a community of users (American Library Association, 2015).

The International Baccalaureate Diploma Program’s definition of IL is a good example of using constructivist approach. Instead of specifying behavioral dimensions, it encourages students to be thoughtful and reflective towards the nature of information, to recognize uncertainties and differing points of view from others, and to solve problems and discover their own version of truth (Bastian, Bammi, & Howard, 2008). Librarians should embrace constructivism when designing IL instruction (McBride, 2012). Digital game-based learning can support students’ inquiry and collaborative exploration as advocated in constructivist learning, and this argument will be enumerated in Section 2.2.1 when the pedagogical values of DGBL are discussed.

A Higher-order Thinking Process

The appropriate use of information necessitates the navigating among competing sets of criteria, and the incorporation of multiple perspectives. It hence compels students to think about the many issues and alternatives inherent in the problems, and to recognize that there may be multiple solutions (Reece, 2005). Higher-order thinking skills are skills activated when individuals encounter unfamiliar problems, uncertainties, confusions or discrepancies, such as before they start academic information search (Davis-Kahl & Hensley, 2013). The practice of differentiating between lower- and higher-order thinking skills dates back to Bloom's (1956) Taxonomy of Educational Objectives. Lower-order skills are prerequisites for the higher-order skills. Lower-order thinking skills are not disparaged, but educators should not be content with their students gaining mastery over the lower-order thinking skills (Reece, 2005).

Information literacy involves the higher-order skills of analysis, synthesis and evaluation of information, and the ability to think critically, to construct meaning and to reconstruct understanding in the light of new learning experiences (American Library Association, 2016). An information literate person needs to use logic, judgment, and reflection, all involving higher-order thinking (King et al., 2009). Successful applications of higher-order thinking skills promote continued ability to learn, resulting in better learning experience (Bingham et al., 2016). Information literacy instruction should aim to facilitate the development of higher-order thinking skills, and help students develop into independent learners.

To summarize, IL knowledge acquisition can be understood as a process that involves affect, as a process of meaning construction, and as a process that involves higher-order thinking skills. Information literacy instruction thus requires behavioral, affective, and cognitive engagement from students.

2.1.3 Teaching Information Literacy to Students

What makes teaching IL skills complex is the necessity of using of teaching methods that cater to the three characteristics discussed in the previous section, simultaneously. Several approaches have been used to teach IL skills: face-to-face sessions, computer-assisted tutorials, and DGBL. This section compares three approaches by listing their pros and cons.

Face-to-face Sessions

Face-to-face sessions have been the most common and widely adopted approach in teaching IL (Ragains & Wood, 2015). Face-to-face sessions are typically conducted by subject or reference librarians at the beginning of each academic year (Thomas et al., 2011). They take the form of presentations on the collections and services of the library, tutorials on information search techniques, or tours in the libraries (Collier, 2015). Face-to-face sessions give librarians opportunities to meet the students and build rapport.

Despite their wide use, face-to-face sessions suffer from many problems (Bingham et al., 2016; Freeman et al., 2016; Ragains & Wood, 2015). First, face-to-face sessions can only reach a fraction of students (Davis-Kahl & Hensley, 2013). Studies have shown that many students who are most in need of assistance are precisely those who will not ask for help, so librarians are often not able to reach out to such students (Gremmels, 2015). The low turnout rate of face-to-face sessions severely hampers their effectiveness. For instance, both Nanyang Technological University (NTU)² and National University of Singapore (NUS)³ organize face-to-face sessions at the start of every semester, and both suffer from the low turnout rate (Guo,

² <https://blogs.ntu.edu.sg/lib-happenings/category/library-orientation/>

³ <http://www.lib.nus.edu.sg/ilp/Lib%20Orientation%20Lecture.pdf>

Goh, Luyt, Sin, & Ang, 2015). Similar issues have been reported in other libraries as well (Thomas et al., 2011).

Second, face-to-face sessions usually take an hour or two, so the amount of materials presented in such a short time can be overwhelming. Students may end up buried in an avalanche of new information, leaving them confused, overwhelmed, and more stressed than before they started (Ragains & Wood, 2015). Once the session is over, librarians rarely have the opportunity to observe whether students continue to use the skills they have been taught (Kuhlthau, 2004). Therefore, recognizing these limitations of the face-to-face approach, librarians began to look for alternatives, including using computer technologies and the Internet.

Computer-assisted Tutorials

As much student learning now occurs outside traditional classrooms, a more efficient method of reaching a large number of students simultaneously is computer-assisted tutorials (McClure, Cooke, & Carlin, 2011). Once uploaded online, the tutorials can be accessed anytime and anywhere, with the clear advantage of time-savings and cost-effectiveness. Students could get instruction at the point of need without having to make a trip to a library. Further, 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 sessions (McClure et al., 2011).

The NUS Library (2014) has created a number of online tutorials, covering a wide range of topics, such as how to locate different types of resources using library's online public access catalog, how and when to use the various citation styles, and how to use subject guides and other research tools. The librarians also created a virtual 3D library tour using Google Earth, so students can take the virtual tour on their computers to get familiar with the library's layout and collections. In another example, Western Michigan University (2014) developed

ResearchPath, a computer-assisted tutorial with animation, video, audio, and interactivity. The tutorial covers five modules: college-level research, define and refine topic, using power search, using the Internet, and citing sources.

Computer-assisted tutorials also have drawbacks, such as high dropout rates, the absence of personal touch, and the lack of motivation by students to participate when it is not required by the instructors (Loo, 2013). Further, students demand more engaging and attractive instruction (Smith & Baker, 2011). Although librarians constantly share their best practices in IL education, there has been less consideration of alternative methods (Ragains & Wood, 2015). Digital game-based instruction can address these drawbacks as digital games catch the eye, and engage the players as effective teaching tools (Shurkin, 2015).

Digital Game-based Instruction

Digital games have been increasingly used in teaching, due to their ability to attract and engage people effectively (Maniscalco, 2016). Games used for non-entertainment purposes are called serious games, such as for healthcare (Bickmore, Vardoulakis, Jack, & Paasche-Orlow, 2013), advertising (Mimoun & Poncin, 2015), military training (Smith, 2009), scientific exploration (Maniscalco, 2016) and education (Howell, 2017).

In particular, the use of serious games for educational purposes is known as DGBL (Prensky, 2003). Digital games are able to provide an immersive environment to engage and motivate players so effectively that they often seek information and solutions actively (Howell, 2017). One of the key characteristics of DGBL is the juxtaposition of serious learning and interactive entertainment. Digital game-based learning can transform learning to a more learner-centered, more enjoyable, more interesting, and hence, more effective experience (All, Castellar, & Van Looy, 2015).

To summarize, libraries can tap into DGBL to address the shortcomings from the face-to-face sessions and computer-assisted tutorials. Several academic libraries have developed their IL games to attract attention from students. As the use of DGBL to teach IL is central to this thesis, it will be elaborated in greater detail in the next section.

2.2 Digital Game-based Learning

Games have long been leveraged for various purposes due to the enjoyable experience they provide to players. The use of games for educational purposes can be traced back to the 1800s, where they were used to teach children good moral choices (Pilon, 2015). One of the early examples is the *Mansion of Happiness*, which was published in 1843. The game educates players by rewarding the virtues of honesty, temperance, truth, and hard work, and punishing players for landing on spaces representing vices (Hofer, 2003). Another early example is *The Checkered Game of Life*, published in 1860. Players advance in the game by accumulating points for morally correct behaviors, and move toward jail for immoral actions (Ferrara, 2013).

More recently, some researchers and educators believe digital games are superior than traditional schooling, as learners can be engaged more effectively (Braghirolli, Ribeiro, Weise, & Pizzolato, 2016). In particular, DGBL is one type of serious game that builds on the entertainment value of games to create instructionally sound learning experiences and facilitate sustained learning for a wide variety of audiences (Erhel & Jamet, 2013). It focuses on learning outcomes while preserving playfulness, hence serious learning is made easy and possible (Nicholson, 2013). Digital game-based learning has become a key segment in the games market as well as in academic research. The next section analyzes the pedagogical values of DGBL.

2.2.1 Pedagogical Value

A common justification for DGBL is that digital games can attract learners' attention and engage them in an immersive environment through gameplay (Hamari et al, 2016). This section argues that DGBL is a highly interactive medium that affords many pedagogical benefits.

Attracting Attention

Games can provide an intrinsically motivating experience and a state of heightened enjoyment (Csikszentmihalyi, 2013). By infusing the elements of challenge, fantasy, control, feedback, social interaction, DGBL immerses players in an educational virtual environment (Scott, 2017). Unlike classroom instruction, digital games can be adapted to the preferred learning pace of the learners. The control and autonomy that DGBL provides lead to enhanced learning outcomes, enjoyment and motivation (Howell, 2017).

In DGBL, learning tasks are situated in meaningful and relevant contexts, and they are immediately practiced and applied by learners in the same context (Van Eck, 2011). The rich environment of objects and activities within DGBL provides situated meaning for the information, and reinforces the educational content (Squire, 2015). Games are also particularly adept at dosing information (Broussard, 2012). Complex tasks are presented first as small core tasks which are practiced multiple times, before being progressively extended into longer, more complex tasks (Prensky, 2003). Moreover, DGBL can reinforce information acquisition through multisensory cues. The educational content can be presented in multiple visual and auditory modes simultaneously, capitalizing on different learning styles. A well-constructed game environment will drive learner engagement while achieving pedagogical goals (Novak & Tassell, 2015).

Afari, Aldridge, and Fraser (2012) used DGBL to teach mathematics to tertiary students in the United Arab Emirates. The digital game, *Jeopardy!*, requires two students to form a team, and work together to answer four mathematical questions in each round of the game. To evaluate its effectiveness on students' learning motivation and enjoyment, a mix-method of interviews, observations and pretest posttest surveys were utilized. Ninety students participated in the evaluation study, and the results suggested that the game attracted students' attention, and positively influenced their attitudes of learning mathematics.

Affording a Constructivist Environment

Students learn best through inquiry instead of memorization of facts, and DGBL is an excellent vehicle through which constructivist learning can occur (Lee, Kanakogi, & Hiraki, 2015). Different sources of information are integrated, and different players can have different views about whether, when, and how to use such information (Howell, 2017). The integration of multiple perspectives, the solution of relevant and authentic problems, and active learning advocated in constructivism are identical to what players experience in games (All et al., 2015).

In constructivist environments, new knowledge is typically obtained in five stages, namely, encountering a new experience, initial feelings of confusion, forming a working hypothesis, taking actions that result in either reconstructing a wrong hypothesis or validating a correct one, and finally, synthesizing new information with previous knowledge that results in changes of behavior (Kelly, 2003). Similarly, DGBL provides the environment in which players need to explore the surroundings, form assumptions and hypotheses about how to succeed in the game, experiment through trial and errors, and discover the consequences and possible solutions (Charsky, 2010). The consequences of failure are also lowered in DGBL: when players fail, they can start over.

Constructivist learning advocates simulating real-life learning experiences, and this experience is the heart of the experiential learning approach where knowledge is constructed (Piaget et al., 2014). Such concrete real-life environments can be designed in DGBL. Further, DGBL can support experiential learning by incorporating authentic tasks that focus on knowledge construction rather than reproduction, and facilitate peer collaboration through social interaction between players in games (Habgood & Ainsworth, 2011). Moreover, compared to traditional learning where students passively receive knowledge from instructors, DGBL provides a more interactive learning experience where learners could perform specific tasks in the game environment from a first-person perspective, thus leading to better understanding of the knowledge (Chau et al., 2013).

For example, Braghirolli and asscoaites (2016) developed an educational game for undergraduate students as an introductory activity in industrial engineering program. The game helped to illustrate complex situations with comprehensive and dynamic examples in an integrated manner. Pretest and posttest survey questionnaires were used to assess the effectiveness of the game. Results suggested that students received the game very positively. Further, the constructivist environment allowed students and professors to interact more freely in the game.

In another example, Chau et al. (2013) used Second Life as a virtual game platform to facilitate constructive learning. An office was set up in Second Life for students to apply what they learnt in a management information systems course, to find out the security vulnerabilities of the office. To evaluate how the game influenced students' learning outcomes, a between-subjects experiment was carried out, where 105 undergraduate students were assigned to either watch a video or play the game. Results suggested that using the game improved students' learning outcomes.

Promoting Literacy

Some people think that promoting digital games in education jeopardizes students' literacy skills acquisition (De Grove, Bourgonjon, & Van Looy, 2012); this is not true. As mentioned earlier, IL is a broad umbrella term encompassing digital, visual, media, data and academic literacies. In DGBL, players constantly need to read, understand, and apply information (Novak & Tassell, 2015). The interactive and dynamical environment in DGBL require players to monitor and manipulate multiple sources of information, and make rapid decisions based on options and information offered in the games (Girard, Ecalle, & Magnan, 2013).

In fact, there is a great amount of learning, reflection, problem solving, meaning-making and information seeking in DGBL. Players' behaviors in successful gameplay meet most of the ALA's IL Standards (VanLeer, 2006). Games teach players to "determine the nature and extent of information needed", "access needed information effectively and efficiently", "evaluate information and its sources critically and incorporate selected information into their knowledge base and value system", and "use information effectively to accomplish a specific purpose".

For example, in multi-player adventure games, players have to gather information on how to meet their goal or challenges, to get to the destination quickly, and to maintain their magic or health or energy levels, and not to get attacked by antagonists. Collaboration and coordination with other players are often needed, requiring players to communicate with each other via writing textual messages (Jo, Hupert, & Llorente, 2015). Further, players not only read and digest the information within the games, they also actively search online sources such as websites, discussion forums, and manuals to succeed in the game (Markey et al., 2014; Prensky, 2003).

The potential of DGBL on literacy learning has been recognized by experts from different fields. In 2009, the University of Southern California invited experts in cognition, developmental psychology, educational technology, and game design to develop strategies to use DGBL for primary students on literacy learning (Chiong, 2009). One of the initiatives was to establish a public-private partnership called Corporation for Public Educational Gaming. The partnership was tasked to consolidate educational games, establish a pedagogy for games, manage and track the literacy and learning needs of students, and support students' literacy learning in various ways. Another initiative was to organize game design contests for students to design educational games to basic literacy skills. The process of creating such games requires students to develop IL skills in the first place.

In another example, Cheng, Lou, Kuo, and Shih (2013) employed DGBL to teach environmental literacy to primary students. The game is similar to *Monopoly*, where students formed groups by inviting two to four friends to play together, and answered quiz questions in the game. A total of 32 fourth graders participated in a seven-week DGBL teaching experiment. The evaluation results showed that DGBL was effective for students with different levels of prior knowledge.

To summarize, this section argued that DGBL affords various pedagogical benefits through examples from prior research. The next section takes a closer look into how DGBL has been deployed in IL education.

2.2.2 Information Literacy Games

There are generally two approaches employed by libraries to design IL games: by modifying existing commercial off-shelf games, and creating new games from scratch. For example, the University of Calgary modified the commercially successful game *Half-Life 2* to create

Benevolent Blue. It is a first-person shooter IL game set in a future era where democracy is absent, and players are tasked to uncover the nation's past history (Clyde & Thomas, 2008). Modifying commercial off-shelf games is cost-effective and timesaving. Since these games have already proved popular and engaging to players, libraries can leverage on their market success to increase students' buy-in (Smale, 2011). However, the disadvantage is that these games are not designed to teach IL, the IL content often cannot fit in very well, compromising the educational effectiveness (All et al., 2015). Another approach preferred by many libraries is to create new IL games from scratch, by either collaborating with computer science departments, or designating interested librarians. The next section provides an overview of existing IL games that are created from scratch, and categorizes them based on their purposes.

Library Orientation

The purpose of such games is similar to that of face-to-face library orientation: to get students familiar with the library layout, collections, and services. For example, Utah Valley University developed two such IL games: *Get a Clue* and *LibraryCraft* (Smith & Baker, 2011). *Get a Clue* is built around a mystery with many clues. Players can follow a detective in the game to solve a crime and travel to different parts of the library. In the initial evaluation of *Get a Clue*, almost half of the participants reported the game was confusing. The librarians revised the game, and evaluated it again with over three hundred students using a short survey. Results indicated that most students found the revised game easy to follow, and the game reached students who had minimal exposure to the library. The other game, *LibraryCraft*, aims to familiarize students with the library's website and digital resources (see Figure 2.1). A short survey is attached at the end of the game for evaluation purposes. Among the 52 students who completed *LibraryCraft*, a majority agreed that the game was fun, and they learnt something useful.

Figure 2.1 Screenshots of *LibraryCraft*

Another example is from the University of California at San Diego campus and Merced campus (McMunn-Tetangco, 2013). The mobile game, *SCaVeNGeR*, is a social location-based game that introduces students to the physical libraries in the two campuses. Students can download the game, and then visit the real locations inside the libraries after finding treks within the game. Students were invited to play and evaluate the game. Unfortunately, participation was very low, and only three teams completed the game. It was found out that as the evaluation date was the first day of school, most students were attending classes or other events. Nevertheless, the librarians were encouraged by students' increased interest in library service brought by this game.

Information Retrieval

According to ALA's IL standards, information literate students should be able to retrieve information using a variety of search strategies and techniques (ALA, 2000). With this in mind, Andrew Walsh, an academic librarian from UK developed an IL game, *SEEK!*, through crowdfunding (Walsh, 2014). The game teaches students how to construct search strategies to retrieve useful results for academic information search after receiving an academic assignment. It takes the form of a multi-player card game with three to eight players. In the first part of the

game, players are given some cards with information search tips, and they need to work together to construct a retrieval strategy. The second part of the game involves in-depth discussion with other players or librarians.

Figure 2.2 Screenshots of *Quarantined: Axl Wise and the Information Outbreak*

Over at the Arizona State University, librarians created an online game entitled *Quarantined: Axl Wise and the Information Outbreak* (Gallegos et al., 2008) (see Figure 2.2). It is a single-player digital adventure game where players have to acquire IL knowledge by retrieving, using and evaluating multiple sources of information, in order to contain a viral outbreak on campus. Players can find out the answers to the questions in the game by locating and checking out library resources. To evaluate the game, students were invited to play it during the library's face-to-face orientation. Students' responses were mixed: some liked the game, while some found it too long and complicated.

Next, the University of North Carolina created a Web-based board game called *The Information Literacy Game* (Rice, 2008). Up to four players can play the game by rolling a digital die, and move around the board by answering questions. The IL questions are divided in four categories: selecting resources, searching and using databases, citing sources to avoid

plagiarism, and using library wild card. Students who played the game during library instruction sessions reported that they enjoyed the game and learned more about the library from the game.

Information Access

The ALA's IL standards states that information literate students need to be able to access the information they need from various online and offline sources effectively and efficiently (American Library Association, 2000). Lycoming College developed a Flash-based IL game called *Secret Agents in the Library* (Broussard, 2010) (see Figure 2.3). Multiple-choice questions and drag-and-drop activities are used in the game to teach students how to identify research tools or resources, and to differentiate the characteristics of popular and scholarly journals. The game is linked to external databases, websites, directories, and other online resources to help players find answers to the questions. In the evaluation, quiz questions were administered in three classes. Students performed well in the review quiz, and expressed increased enthusiasm in using such an innovative game to learn IL.

Figure 2.3 Screenshots of *Secret Agents in the Library*

Similarly, Carnegie Mellon University designed two IL games called *Within Range* and *I'll Get It* (Beck, Callison, Fudrow, & Hood, 2008). *Within Range* teaches students how collections are shelved in their libraries, and asks the players to sort three shelves of books. *I'll Get It* puts players in the role of a reference librarian at a busy academic library's information desk. The game requires players to prioritize the library patrons so that no one is waiting too long, and fulfill their information requests by selecting the most appropriate resources for them.

Libraries in China have also tapped DGBL in IL education. Central China Normal University developed *Sailing to the Future*, which comprises ten mini-games based on the ALA's IL standards (Wu, Li, & He, 2015). The librarians evaluated one of the mini-games, *Wisdom Town*, which introduces ten frequently used academic databases. University students were recruited to play the mini-game for 30 minutes, fill in a two-item questionnaire and join a brief interview. Results suggested that students found playing a game was an effective way in IL learning, but most felt overwhelmed by having to learn ten databases in 30 minutes.

Information Citation

Understanding the importance of making citations is another important aspect of being information literate. Lycoming College developed a plagiarism game called *Goblin Threat* to educate undergraduate students on the importance of citations, academic integrity, and ethical use of information (Broussard & Oberlin, 2011). The game is based on the room-escape genre, where players have to save the college campus by finding hidden goblins and answering questions about plagiarism. Players are awarded a certificate after successfully completing the game. The game was well received among faculty and popular among students.

Figure 2.4 Screenshots from *Citation Tic-Tac-Toe*

At James Madison University, all freshmen must pass an IL competency test. From the test results, librarians noticed students' citation knowledge was lacking, hence they developed an IL game, *Citation Tic-Tac-Toe*, to teach information citation (McCabe & Wise, 2009) (see Figure 2.4). The purpose of the game is to teach students how to identify different types of academic resources, and use the correct citation styles accordingly. *Citation Tic-Tac-Toe* is a single-player game with three rounds. Players can click on a blank square on the tic-tac-toe board to get a question. A multiple-choice question for citing different types of resource pops up on the screen for players to answer. The librarians reported students' citation skills increased after playing the game. *Citation Tic-Tac-Toe* is freely accessible, and Long Island University Library also made use of it in their IL education (Tewell & Angell, 2015).

Further, the University of Michigan created *BiblioBouts*, a game that allows students to search for, compile, and evaluate different information sources to improve the quality of the bibliography in their assignments (Markey et al., 2014). It is one of the few IL games that were extensively documented and evaluated. The game consists of three bouts (mini-games): closer bout is on finding information, tagging & rating bout is on evaluating information, and best bibliography bout is on selecting information. Players can also check the sources that other players contribute to the game, and discover sources they would not have found otherwise. To

evaluate *BiblioBouts*, students were invited to play it over two weeks. The extensive evaluation process involved game diary forms, pre-and post-game survey questionnaires, immediate focus group interviews, follow-up interviews four or more months later, pre- and post-game individual interviews, and game activity logs. Most students reported positive learning experiences; however, some failed to grasp its educational value.

To summarize, a few libraries have utilized DGBL in IL education, and the evaluation results were mixed. One possible reason for the unsuccessful IL games might be due to the minimal user involvement in the game design process. Among these IL games, only *BiblioBouts* incorporated user feedback in the design stage, since it was developed in response to users' negative feedback towards their previous IL game. Students were not involved in the design of the other IL games. It is not easy to weave IL content with enjoyable gameplay in DGBL. One way to achieve better design is to actively involve end-users, the students (Ciolfi et al., 2016). Understanding the expectations and concerns from end-users will increase games' likelihood for success. Further, when end-users are involved in the design of a product, they feel that their ideas and suggestions contributed to the process (Lukosch, van Ruijven, & Verbraeck, 2012). Hence, libraries should actively engage students to understand their needs to ensure success and more user acceptance in IL games.

2.3 Affective Embodied Agents

Existing IL games are mainly focused on imparting cognitive IL knowledge, such as how to locate (e.g. *Within Range*), access (e.g., *Secret Agents in the Library*), or cite information (e.g., *BiblioBouts*). As argued in Section 2.1.2, IL knowledge acquisition is also an affective process. Negative affects such as fear and anxiety, have detrimental influence on information seekers and limit their comprehension and retention of new information (American Library Association,

2016). Hence IL games that pay attention to affective aspects are needed. Affective EAs are effective in conveying emotions. Research into affective EAs has become a burgeoning research area, and they are frequently used in computer-mediated environments such as digital games, e-commerce websites, and educational software. hence its synergy with DGBL is needed to maximize the positive influence on students (Salen & Zimmerman, 2004). This section presents a short history and development of affective EAs, and their applications in educational settings.

2.3.1 History and Development

The advancement of computer technologies saw a shift from the text-only medium to an increasingly visual one in the 1980s (Coleman & Shirky, 2011). Embodied agents are digital, humanlike representations controlled by computers (Krämer et al., 2016). Affective EAs started from avatars (Chae, Lee, & Seo, 2016). The term avatar originates from Sanskrit: *ava* means down, *tarati* means base. *Avatar* means the manifestation of a deity, notably Vishnu, in a human, superhuman or animal form (Bélisle & Bodur, 2010). An avatar is the descent of divinity from heaven to earth, and is typically used to describe an incarnation of God. The word entered the English language at the end of the 18th century and lost its spiritual meaning. It refers to a visible manifestation of abstract concepts and ideas.

In computing use, an avatar is an embodied representation of users (Coleman & Shirky, 2011). Avatars can take on different levels of embodiments, ranging from a talking head with upper torso and arms, to fully embodied 3D forms (Coleman & Shirky, 2011). They are more commonly referred to as embodied agents in the computing literature, defined as visual digital representations of an interface in a human form. Adding an embodied face to a computer or software was expected to enhance the communication process (Mayer & DaPra, 2012). In the

1990s, researchers engaged in a concerted effort to investigate the influence of EAs in human-computer interaction (Picard, 2000). However, results from initial studies were unsatisfactory. The embodied face failed to make the interactions with computers more effective or pleasant (Prendinger & Ishizuka, 2013).

Cassell (2000) made a breakthrough after developing an EA capable of making basic conversations and body gestures. It was found out that having a human-like appearance was not sufficient. Embodiment also means behaving in human-like ways, to provide a richer and more robust channel of communication, otherwise the feeling of connection cannot be achieved. In other words, the affective qualities of face-to-face conversations must accompany the EAs so that users' expectations regarding intelligence, feedback, and responsiveness of a humanlike interlocutor are met. It is the combination of the EAs' appearance and behavior that makes for the most evocative results (Moridis & Economides, 2012).

Armed with such knowledge, researchers were able to improve the design of EAs. Different abilities are incorporated in EAs to express emotions, through textual content, speech, body gestures, and facial expressions (Mimoun & Poncin, 2015). For example, Corti and Gillespie (2016) used *Cleverbot*, a text-based chat bot to investigate whether people would repair misunderstandings when communicating with EAs. Evaluation with 108 adults showed that participants made more effort to clarify misunderstandings when talking with the EA with human voice, as in face-to-face human social interactions.

Next, Hyde, Kiesler, Hodgins, and Carter (2014) conducted an experiment to investigate whether children would interact with EAs and real people differently. An adult confederate conversed twice with the children aged between four and ten years, once as herself through video, and once through an EA. Results suggested that there was no difference in children's conversation behavior with the EA image and the real person, even among those who preferred the real person, or when the EA image exhibited altered motions. These results

suggested that children would interact with EAs as they would another person. The next section explores how EAs can be used in education.

2.3.2 Applications in Educational Settings

By providing visual clues, well-designed affective EAs could make it easier to attract and retain their attention, thus enrich their learning experience in DGBL. Affective EAs in pedagogical roles can provide support for learners. As the second research objective in this doctoral research aims to investigate the influence of affective EAs in five aspects: learning outcome, motivation, enjoyment, perceived usefulness and user acceptance, the literature review below categorizes existing works on EA based on these five aspects for the ease of reading.

Improved Learning Outcome

With affective EAs, learners are more motivated to make sense of what is being presented to them and more likely to process the information deeply, and in doing so, achieve meaningful learning (Krämer et al., 2016). For example, Graesser, Li and Forsyth (2014) designed an EA which simulated human tutors and was sensitive to students' cognitive and emotional states. The EA was used to teach adults with low literacy to read better and improve their lives, through speech, facial expressions, and some gestures. Result suggested that the EA helped students to learn more effectively.

Further, Lin et al. (2013) designed an affective EA to teach thermodynamics in an online multimedia learning environment. Evaluation results with 135 college students showed that the visual presence of an EA did not have significant impact on learning motivation or performances. However, when combined with elaborate and affective feedback, the EA was able to significantly increase students' learning motivation and performances. Similar to what

Cassell (2000) found, 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.

Empirical findings on EAs' effectiveness to improve learning have not been consistent: some studies showed that there was no difference in learning outcomes whether students interact with the affective EAs or not. One such example is the study by Carlotto and Jaques (2013), in which an affective EA *Patti* was designed to teach English as a foreign language. In their study, 42 Brazilian undergraduate students were divided into two groups: the experimental group interacted with *Patti* in a computer learning program, and the control group learnt from the same computer learning program without any EA. The results showed no significant difference in learning performance between the two groups, which meant that the affective EA failed to improve students' learning performance. Similar unsatisfactory learning outcomes were also reported by Guo et al. (2015). Hence more research is needed to investigate the EAs' effectiveness on learning.

Heightened Learning Motivation

Motivation is the catalyst to achieving learning goals, and may be considered as one of the most important prerequisites in learning (Keller, 2009). Affective EAs could effectively motivate learners and thus increase the chance of continuous interaction with the learning programs (Chen & Chou, 2015).

To investigate whether using EAs can increase students' learning motivation, Chen and Chou (2015) designed an EA that teaches force and motion in a multimedia instructional database. 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 either the experimental group to interact with *Paul*, or control group to interact with a normal database. Participants completed a pretest before using the database, and a post-test two days after the experiment. Results revealed that using the EA successfully increased students' learning motivation and knowledge acquisition.

Further, Krämer et al. (2016) devised an EA that could display positive listening behaviors (posture shifts, nodding and smiling), and other non-verbal behaviors (eye blinking and breathing). To investigate whether EAs helped enhance students' learning performance and motivation in mathematics, they conducted a 2 (student gender) $\times$ 2 (agent gender) $\times$ 2 (rapport behavior present or absent) between-subjects experiment. In total, 128 young adults participated in the study. Results suggested that participants' performance and effort were significantly enhanced when the EA of opposite gender displayed rapport.

Enhanced Enjoyment

The social cues from EAs can enhance and foster social interactions between the computers and users, making the interactions more engaging and enjoyable (Harrison, Sengers, & Tatar, 2011; Nass & Reeves, 1996). Affective EAs that express joy and empathy enable users to interact with them more comfortably (Chen et al., 2012; Moridis & Economides, 2012).

For instance, Krämer, Kopp, Becker-Asano, and Sommer (2013) analyzed the effect of an EA's smile on participants' perceptions and behaviors. With a humanoid appearance, the EA, *Max*, is capable of verbal and nonverbal skills of gaze, gestures, and facial expressions. In the between-subjects experiment, 104 participants were invited for an eight-minute small talk conversation with *Max* that: either did not smile, or engaged in casual smiles, or displayed frequent smiles. The authors observed that when *Max* smiled, it evoked a smile in the participants and increased their enjoyment more successfully.

Bickmore, Pfeifer, and Schulman (2011) designed an EA as a virtual guide in the Boston Museum of Science. The EA, *Tinker*, is capable of engaging museum visitors using various human relationship-building behaviors, such as empathy, social dialogue, reciprocal self-disclosure and other relational behavior to establish social bonds with users. A pilot evaluation with 72 visitors found that most participants found *Tinker* fun and enjoyable to interact with. Thereafter, a between-subjects experiment was carried out, where 1607 visitors were randomly assigned to interact with relational *Tinker* and neutral *Tinker*. Results found that the relational behaviors significantly enhanced visitors' enjoyment and learning experience.

Increased Perceived Usefulness

By incorporating features of speech, feedback, and nonverbal behaviors of facial expressions and gestural animation, affective EA can build rapport and trust with users, increasing their perceived usefulness (Krämer et al., 2016). In a study to investigate the influence of affective EAs on students' IL learning, 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 perceived the IL tutorial to be more useful.

Moreover, Berry, Butler, and De Rosis (2005) used GRETA, a realistic 3D EA, to persuade people to adopt healthy eating behaviors. One hundred and forty-four participants were randomly assigned to one of the six conditions: GRETA (consistent affective expressions) vs. GRETA (inconsistent affective expressions) vs. GRETA (neutral) vs GRETA (voice only) vs. human (neutral) vs. text only. Results suggested that when GRETA's additional emotional expressions were consistent with the content of the verbal messages, participants from the consistent affective expression condition perceived GRETA to be more helpful and trustworthy.

Higher User Acceptance

The positive attitudes such as enjoyment, trust, and satisfaction brought by using EAs will also increase people's acceptance and usage behaviors (Kim & Baylor, 2016). For instance, Chae et al. (2016) investigated how learners' perceived trust in EAs influence their behavioral intention to engage in e-learning activities. Two hundred students were recruited and assigned to one of the two conditions: expert EA (knowledgeable) vs. attractive EA (good-looking). Results suggested that social presence brought by both EAs significantly improved students' behavioral intention. Compared with the expert EA, the attractive EA had a stronger effect on behavioral intention.

Further, Bickmore et al. (2013) reported a new education system that teaches patients about their post-discharge self-care regimen, to reduce the workload of nurses (many nurses refused to adopt the new system, because they were afraid the system would take away their jobs). In order to increase acceptance, the authors incorporated an EA in the system, capable of personalized one-on-one conversation with nurses through a dialogue script. An experiment was conducted, where nurses were randomly assigned to an experimental group that included a presentation of the new information system and an additional one-to-one conversation with the EA. The control group only had the presentation. Results showed that the EA's rapport and trust-building dialogue was successful in increasing nurses' trust, and they expressed a significantly greater intention to use the system, compared to those in the control group.

From the literature above, it can be seen that affective EAs is useful in DGBL. Students' development of IL skills is often impeded by negative affects such as fear of the library, and anxiety of not finding the information needed (Gremmels, 2015). Therefore, using affective EAs in IL games may provide students with an enjoyable learning experience, and influence their learning motivation and performance in IL knowledge acquisition (Lin et al., 2013). However, such studies are lacking. Prior research focused on using affective EAs to teach

subjects such as biology (Robison, McQuiggan, & Lester, 2009), physics (Lin et al., 2013), programming (van der Meij, van der Meij, & Harmsen, 2015). Problems in these subjects have single correct answers, even though one could use different methods or paths. The nature of the problems in IL is different from that of these subjects. For IL, students with the same assignment may search for different information, or they may have different perspectives, thus possibly arriving at contrasting conclusions given the same topics to start with. In other words, there can be an infinite number of possible different answers that are all equally correct. Moreover, IL education is common to all disciplines, and students need IL skills to prosper in academic studies. It will be useful to ascertain whether affective EAs can be used in IL games.

2.4 Chapter Summary

This chapter reviewed the existing corpus of literature on three concepts: IL, DGBL and affective EAs. The first section introduced definitions on IL, summarized three characteristics of IL knowledge acquisition, and compared three methods in IL education. Despite libraries' efforts to impart IL skills to students, many times such efforts have limited success. The second section thus proposed DGBL as a potential solution, and examined its pedagogical values, and the extent to which it has been used in IL education. It ended with a reinforcement of the first research gap, which was the neglect of user input and iteration in IL game design. The third section began with the second research gap: the absence of affective aspects in IL games. The section then detailed the history and recent studies on affective EAs, especially the use of affective EAs to improve learning outcome, foster learning motivation, enhance enjoyment, increase perceived usefulness, promote user acceptance and reduce negative affect. It concluded that more research on the evaluation of affective embodied agents in IL games were needed, which was the third research gap. These gaps will be addressed in Study I and Study II respectively.

CHAPTER THREE

THEORETICAL FOUNDATIONS

This chapter outlines the theoretical foundations for this PhD research. There are six sections. The first section introduces the Information Search Process (ISP) Model, which was used as the structure of the information literacy (IL) game in Study I in Chapter Four. The subsequent two sections present the Attention Relevance Confidence and Satisfaction (ARCS) and GameFlow Models, which were used to analyze the IL game in Chapter Five. Sections Five, Six and Seven review the Tripartite Enjoyment Model and Social Agency Theory, which together with the ARCS Model, provided theoretical underpinnings for the survey instruments in the game evaluation in Study II in Chapter Six. Each section begins with a description of the original model or framework, followed by a short comparison with other similar models in the field, and ends with validation in subsequent studies. The last section concludes the chapter.

3.1 Information Search Process Model

There is lack of conceptual framework in existing IL games. The defining characteristic of good DGBL is that the gameplay itself informs the pedagogical theory and embodies the learning content (All, Castella, & Van Looy, 2015). Therefore, sound theoretical frameworks are paramount to create an effective learning situation in DGBL (Habgood & Ainsworth, 2011). However, existing educational games often fall short when it comes to applying these principles. The lack of conceptual frameworks in DGBL design has significantly impeded its adoption in formal learning contexts (Walsh, Foss, Yip, & Druin, 2013). There is hence a need to link such frameworks with current software development practices.

This thesis bridges the above gap by adopting Kuhlthau's (1993, 2004) ISP Model, one of the seminal works on IL and information search behavior. Kuhlthau (2004) observed that students' affective states usually change from ambiguity to specificity, uncertainty to understanding in the information seeking process. The ISP Model regards anxiety and uncertainty as an integral part of the process. It emphasizes the "interplay of thoughts, feelings and actions" (p. 206), and incorporates three realms on the affective, cognitive and behavioural aspects. The model divides a typical information seeking process into six stages: *task initiation* (preparing to decide on a topic), *topic selection* (deciding on the topic), *prefocus exploration* (examining the information available to find a focus), *focus formulation* (formulating the focus), *information collection* (gathering information that defines, extends, and supports the focus) and *search closure* (concluding the search for information). Each stage represents the tasks considered most appropriate to move the information seeking process on to the next.

In the early stages of searching, negative feelings are common, because the information seekers have little knowledge of what information is available, and because 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, and the negative feelings begin to subside. At the end of the search process, the information seekers will feel a sense of relief or satisfaction when the required information is found, or disappointment and anxiety when it was not. The search process is iterative, and information seekers can repeat previous steps to ensure that the materials retrieved are relevant as their requirements become clearer.

The reasons why the ISP Model was chosen to structure the IL game were twofold. First, the other IL models such as the Big6 (Eisenberg & Berkowitz, 1990), Seven Pillars (SCONUL Working Group on Information Literacy, 1999), and Information Literacy Competency Standards for Higher Education (American Library Association, 2000), all adopt

a behaviorist approach and emphasize on the cognitive aspects of IL education. The ISP Model employs a constructivist approach, and considers learners' affective states during information search process. The model is thus in line with the focus of this thesis, which is the affective aspects of IL education.

Second, the ISP Model focuses on students' academic writing tasks, where they have to complete assignments within a given period of time, instead of general information search by the public (Case & Given, 2016). Although the ISP Model describes the information search process as an individual experience and ignores potential social contexts of information seeking such as when people are working collaboratively with classmates and friends (Hyldegård, 2006), the ability to complete assignments independently is a still common and necessary skill. Hence, the ISP Model is suitable to structure the IL game: a single-player game to teach IL to university students in an academic setting.

The ISP Model has been empirically tested in various studies. For example, Kracker (2002) investigated whether a 30-minute presentation of the ISP Model would influence students' perceptions of research and research anxiety. In the study, students initially experienced a rise in anxiety level during the information seeking process, which was consistent with what the ISP Model predicts. The students were then introduced to the ISP Model. A significant decrease in anxiety levels was detected after the presentation, suggesting that even a familiarity with the ISP Model helped to reduce students' anxiety. Further, Bilal, Sarangthem, and Bachir (2008) employed the ISP Model as the guiding theory in examining Arabic-speaking children's behaviors when searching for digital resources. Ten young children were invited to use the digital library to find information for assigned and self-generated tasks. Findings confirmed the ISP Model as the children showed uncertainty and anxiety in the beginning, and certainty and satisfaction upon completing the tasks.

At Arizona State University, the ISP Model was employed to create a one-hour course to support a writing curriculum, and the model was fully integrated into their IL education and reference service in the library (Isbell & Kammerlocher, 1998). Although no quantitative data was collected as formal evaluation, librarians found the ISP model “immediately applicable” (p. 36), and students found the model useful and reassuring. In addition, librarians and faculty members observed that the students’ information search process and the feelings they experienced resembled those predicted by the ISP Model to a large extent. Such observations and findings also helped the librarians to pay more attention to students’ affective states when providing IL instruction or reference support.

In sum, by identifying the information seeker’s affective states, the ISP Model is a holistic model in IL education that has been extensively validated on various academic information search tasks in both off-line and online environments. Therefore, the ISP Model was adopted as the pedagogical framework to structure the IL game in Study I.

3.2 Attention Relevance Confidence Satisfaction Model

Using affective EAs in DGBL offers an attractive way to engage learners and foster their learning motivation. Motivation is an important component and a catalyst in learning, leading to greater knowledge acquisition and retention (Keller, 1993). A high level of motivation is often a prerequisite for success; conversely there is a high probability that learning will not be successful if there is a lack of motivation (van der Meij et al., 2015). However, some scholars are skeptical of the motivational effectiveness of DGBL, and argue that the increased level of motivation and learning performance is due to the novelty effects, where the student is rewarded by the use of the game itself (Chen & Chou, 2015; Lin et al., 2013). Therefore, in this study, it is necessary to analyze how the IL game provides motivational support to players.

There are a number of potential motivation models that can be used for analysis, such as the expectancy/valence model (Tannenbaum, Mathieu, Salas, & Cannon-Bowers, 1991), intrinsic and extrinsic motivation model (Malone & Lepper, 1987), and need gratification model (Pintrich & Schunk, 1996). These models may help instructional designers understand motivation in diverse ways; however, they do not provide systematic guidelines for instructional design. An exception is the ARCS Model by Keller (2009), which provides an adaptive approach based on an assessment of learners' motivational states, and can be embedded in a variety of types of instructional strategies. Further, the ARCS Model is not only a tool for measuring the motivational support provided by instructional programs, but also useful for diagnosing motivational problems and prescribing motivational strategies (Choustoulakis & Nikoloudakis, 2011). It includes sets of strategies to enhance the motivational appeal of instruction, and incorporates a systematic design process that can be used effectively with other pedagogical models (Keller, 2009).

The ARCS Model suggests that learning motivation is dependent on four perceptual components: attention, relevance, confidence and satisfaction (Keller, 2009). First, the instruction should gain and sustain the learners' *attention*, which refers to their response to perceived instructional stimuli. It is hence important to vary the instructional approaches and change the pace to sustain learners' attention throughout the instruction. Second, the educational materials should have a high degree of relevance to the learners' prior learning. The instructional requirements need to be consistent with learners' goals and connected to their past experiences so that they will perceive the learning content more useful and be more willing to learn. Third, to promote a high degree of motivation on the part of the learners, their confidence should be boosted, increasing their positive expectation towards their performance. Good instruction should help learners establish positive expectations for success. Fourth, the learners' level of satisfaction, which is their positive feelings about the learning experiences,

should be enhanced. Here, positive rewards and recognition can be used, and learners should be given opportunities to practice what has been learnt. When all these four components are met, learners are likely to have a high level of learning motivation.

Although the ARCS Model was first developed to design and evaluate the motivational stimuli in classroom settings, its validity has been evidenced across various learning environments such as computer-assisted instructions, DGBL, as well as in studies with EAs. In this research, the ARCS Model is used both as a theoretical frame to analyze the IL game, and a survey instrument to measure the impact of affective EA on students' learning motivation. Hence the review below lists examples of ARCS Model used in both DGBL and EA research.

For example, Hirumi, Sivo, and Pounds (2012) used the ARCS Model to evaluate students' learning motivations in two online courses, and supported the applicability of ARCS Model as an instrument to measure learning motivation in online instructions. Further, Kaneko and colleagues (2015) developed a mobile educational game application for IL instruction based on the ARCS Model. The ARCS Model was used to provide instructional design guidelines to sustain students' learning motivation throughout the game, and the evaluation results showed that the students could recognize the ARCS Model components in the game. Moreover, van der Meij et al. (2015) designed an affective EA to teach physics to secondary school students. The ARCS Model was used to design the EA's feedback, and evaluation results showed significant increase in students' self-efficacy.

3.3 GameFlow Model

The concept of enjoyment has been well studied by communication researchers. Enjoyment refers to a general positive disposition toward and liking of the media content (Nabi and Krämer,

2004). Similarly, Pezalla, Pettigrew, and Miller-Day (2012) described enjoyment as “having been placed in a lingering, highly desirable mood state” (p. 559). The concept of enjoyment can reflect reaction to both the media messages and the overall experience, such as situational and contextual elements. Studies on enjoyment also allow researchers to consider how various media experiences contribute to enjoyment as well as how such enjoyment impact audience reactions towards the media messages and subject matter (Nabi & Krämer, 2004).

Digital games are an interactive medium, as the gameplay experience resembles media consumption in many aspects, such as the hedonic gratification, enhanced attention, and empathy with characters (Erhel & Jamet, 2013; Sherry, 2004). Player enjoyment is an important goal for game design, and enjoyment is a strong indicator of media consumption intention (Fang, Chan, Brzezinski, & Nair, 2010). Put simply, players will not play the game if they do not enjoy themselves. Enhancing player enjoyment becomes a critical goal for DGBL (Gunter, Kenny, & Vick, 2008). Enjoyment is important to DGBL because it enables players to have fun in the game, and attracts their attention to the educational content (Sherry, 2004).

Based on Csikszentmihalyi’s (1997) Flow Theory, Sweetser and Wyeth (2005) created the GameFlow Model by incorporating existing usability and enjoyment heuristics in game studies. The GameFlow Model comprises eight elements mapped to the concept of flow: concentration, challenge, player skills, control, clear goals, feedback, immersion, and social interaction. The definitions and criteria are provided below.

- *Concentration.* A game must be able to keep the players focused in order to be enjoyable. But in order to grab players’ attention, the game must provide something worth attending to, such as detailed game worlds and engaging stories.
- *Player skills.* Player skills must be matched with the challenges in games. Players should be taught how to play the game through interesting examples at the beginning.

- *Challenge.* As mentioned above, an enjoyable game should also provide appropriate challenges to the players. In particular, the challenge level must be matched with the players' skills to achieve flow, or the result will be anxiety (too challenging), or apathy (too easy). Good games should have various levels of difficulty to meet individual player's needs, and an increase in difficulty level for players to develop their skills.
- *Control.* Players must be allowed to exercise control over the game interface, characters, and happenings. Games should hide the linear structure from players so that they can probe and experiment in the game world at their will.
- *Clear goals.* Games should provide players with a clear and unambiguous overriding goal in the early stage of the game. The goals can be delivered through narrative or background story.
- *Feedback.* It is important to send continuous feedback to players so that they understand what actions have been taken and what have been accomplished. Feedback allows players to correct mistakes if any, and move on in the right direction.
- *Immersion.* Immersion refers to the experience of deep yet effortless involvement from players. To fully enjoy the game, the players must immerse themselves through the pleasurable surrender of the mind to the game world.
- *Social interaction.* Options should be provided for players to interact, cooperate, or compete with each other. Such interactions can happen inside and outside the games.

With detailed heuristics on how to create an enjoyable player experiences, the GameFlow Model is a useful framework to analyze the level of enjoyment experience in DGBL. The Model has been widely adopted by researchers in game enjoyment studies. For example, Jennett et al. (2008) used the GameFlow Model to conceptualize and investigate the level of immersion experienced by game players. Through three experiments, they found that being

immersed in a game can be both positive and negative experiences for players. Further, Lomas, Patel, Forlizzi and Koedinger (2013) focused on the relationship between challenge and enjoyment. They used an online math game to investigate when maximum game engagement could occur. Results suggested that players seemed to enjoy more when the games were easier and slower in learning curve. Because of its relevance to game design, the GameFlow Model was used to analyze how the IL game provides enjoyment to players.

3.4 Tripartite Enjoyment Model

Enjoyable entertainment experiences are complex, dynamic, and multifaceted (Tamborini, Grizzard, Bowman, Reinecke, Lewis, & Eden, 2011). Prior research has well established the affective dimension in enjoyment. Nabi and Krämer (2004) further found that cognitive judgments and behaviors were also important in enjoyment during media consumption. Superimposing these relationships, they proposed a tripartite enjoyment model, including affective, cognitive and behavioral dimensions. In this thesis, the Tripartite Enjoyment Model is used as a survey instrument to measure the influence of affective EAs on students' gameplay enjoyment, so the three dimensions are discussed in view of affective EAs.

Affective enjoyment focuses on the individual's willingness to invest emotionally in the experience. It focuses on people's experiences of emotional arousal towards the media at hand (e.g., positive or negative moods), centering on empathy, as well as the positive and negative affective states (Sherry, 2004). Similar to traditional media such as TV dramas, the social cues from affective EAs can foster a sense of partnership, and appeal to users at an emotional level (Krämer et al., 2016). Next, *cognitive enjoyment* refers to the willingness to develop skills and solve problems. It focuses on experiences gained through personal judgment relative to actions or tasks from the media (e.g., judgment about appropriateness of tasks). In DGBL with

affective EAs, learners can interact with the affective EAs while using their cognitive capabilities to acquire the educational content. The interactions can help learners to be mentally involved, potentially increasing their cognitive enjoyment (Krämer et al., 2013). The last dimension in the Tripartite Enjoyment Model is *behavioral enjoyment*, which refers to the effortless involvement in the activity on a kinesthetic level, when people are immersed in the situation (e.g., when they experience little or no awareness of their behaviors during gameplay). This dimension is connected to the audience's viewing intention and behaviors during media consumption, including the act of viewing itself. In DGBL with affective EAs, players who are immersed in the gameplay will have a distorted sense of time and be less self-conscious in the learning process (Lin et al., 2013).

The Tripartite Enjoyment Model has been widely acknowledged in research, and validated with empirical evidence. Fang et al. (2010) used the Tripartite Enjoyment Model to develop a questionnaire instrument to measure players' flow experience in computer games. The authors contended that the Tripartite Enjoyment Model provided a strong conceptually sound and easy-to-operationalize framework for the survey instrument. Further, Tsay-Vogel and Nabi (2015) used the Tripartite Enjoyment Model in a survey instrument to examine the influence of affective, cognitive and behavioral enjoyment on behavioral intention. The results supported the three dimensions of enjoyment.

The Tripartite Enjoyment Model is similar to the GameFlow Model in that both were derived from Flow Theory and aim to understand enjoyment. Their difference lies in the perspectives on how to understand enjoyment. The GameFlow Model sees enjoyment as an inherent attribute in the game itself. It was devised with a view to better positioning flow as part of the gaming experience, and details the heuristics to create an enjoyable player experiences. Thus the GameFlow Model is more suitable as a framework in the design process (Hamari et al, 2016). The Tripartite Enjoyment Model, on the other hand, constructs enjoyment

as player experience, and conceptualizes enjoyment into three dimensions (affective, cognitive and behavioral). It is hence more suitable to be used as a survey instrument to evaluate enjoyment from users (Fang et al., 2010). Therefore, in this research, the GameFlow Model was used as a framework to analyze how the IL game provided enjoyment to players, while the Tripartite Enjoyment Model was used as a survey instrument in the game evaluation in Study II.

3.5 Acceptance Research

Measuring users' perceptions is a common practice to assess the adoption and acceptance of new information systems, including in educational research (Cheng et al., 2013). The investigation of how individuals adopt and use information systems is broadly called acceptance research in information systems literature (Hirschheim, 2007). Researchers have identified various factors that influence students' acceptance of educational systems. They include instrumental factors such as perceived usefulness (Abdullah & Ward, 2016), and perceived enjoyment (Padilla-Meléndez, del Aguila-Obra, & Garrido-Moreno, 2013); personal factors such as self-efficacy (Celik & Yesilyurt, 2013), and learning motivation (Kim, Kim, & Wachter, 2013); as well as social factors of teachers' attitude (Fridin & Belokopytov, 2014), and subjective norm of peers (Schepers & Wetzels, 2007).

One of the most well-known study in acceptance research is the Technology Acceptance Model (Venkatesh & Davis, 2000). The Model contended that users' acceptance of an information system was based on two antecedents: perceived usefulness and perceived ease of use. Specifically, perceived usefulness refers to people's perception that using the system can increase their efficiency, while perceived ease of use means that people believe using the system makes the tasks easier. Additionally, drawing on concepts such as absorption, flow, enjoyment, and engagement, Agarwal and Karahanna (2000) provided an alternative

perspective to acceptance research. They introduced the construct of cognitive absorption as the main determinant of behavioral intention. Cognitive absorption is defined as the state of deep involvement in the tasks. Further, Zhang, Li, and Sun (2006) focused on the affective aspects of acceptance research, and proposed the construct of perceived affective quality of the information system as a predictor of behavioral intention. Perceived affective quality is the users' perception of the information system's ability to change their core affects, which leading to changes in their subsequent interactions with the system. The authors argued that users form perceptions of the affective quality of an information system very quickly, even before they evaluate the functionality and usability, hence designers need to pay attention to the pleasant and interesting aspects of information system design.

Studies have also been conducted to investigate the influence of EAs on user acceptance. By providing visual clues, well-designed affective EAs can enhance the communication process in human computer interactions, thus increasing learners' acceptance and usage behaviors (Mayer & DaPra, 2012). For example, Tegos, Demetriadis and Tsiatsos (2014) explored the use of affective EAs in computer-supported collaborative learning. They developed a dialogue-based EA in an educational system for computer-assisted second language learning. The EA can provide appropriate feedback to students' discussions. Results showed that students were more willing to use the learning system when the EA provided directed feedback than undirected one. Measuring user acceptance is important to ascertain the success of any information systems. Therefore, in this PhD research, user acceptance on the IL game was investigated in Study II.

3.6 Social Agency Theory

In face-to-face instruction, verbal and nonverbal social exchanges occur naturally between teachers and students in the learning process. However, such exchanges are often nonexistent in computer-based learning environments (Lee, Kanakogi, & Hiraki, 2015). Hence this section introduces Social Agency Theory, the theoretical lens to explain how using affective EAs in DGBL can positively influence students' learning experience.

Social agency refers to the degree to which the EA is perceived as a social entity, and being capable of social behaviors as in human-human interactions (Roubroeks, Ham, & Midden, 2011). Social Agency Theory originates from the Media Equation Theory by Nass and Reeves (1996), which states that people treat and respond to computers as they do to other people, even when they know they are interacting with machines. When computers offer cues that signal human characteristics, people apply social rules to respond to them. Hence, computer-assisted learning environments should incorporate features such as chats with EAs and delivery of affective feedback. Therefore, the use of verbal and nonverbal social cues by EAs in DGBL can foster the development of a partnership by encouraging learners to consider their interaction with the computers to be similar to what they would expect from human-to-human conversations (McLaren, DeLeeuw, & Mayer, 2011).

The Social Agency Theory posits that when learners interact with the EAs in a computer-assisted learning environment, the virtual relationships between EAs and learners become a substitute for face-to-face interactions. The EAs can establish a social agency, and learners will establish a social relationship with the EAs (Kim & Baylor, 2016; McLaren et al., 2011). The sense of social presence provided by EAs could enhance and foster social interactions and to enable a sense of connection between the system and learners.

Social Agency Theory has been employed and validated in many studies. For example, Schneider, Nebel, Pradel, and Rey (2015) investigated how the different styles of feedback from EAs in a web page influenced students' learning outcome. Consistent with the Social Agency Theory, students who received polite feedback reported significantly higher learning interest, likelihood of success, and learning assistance, and lower extraneous cognitive load and mental effort, compared to those who did not.

Based on Social Agency Theory, Ryu and Baylor (2005) proposed the Agent Persona Instrument, a survey instrument to assess affective EAs. Through a series of experiments, a confirmatory factor analysis and cross validation, the survey instrument comprised four factors: *facilitating learning* (e.g., the EA's ability to present the material effectively, and helped learners concentrate on the presentation), *credible* (e.g., the EA's knowledge and instructional authenticity), *human-like* (e.g., the naturalistic movements and emotions displayed by the EA) and *engaging* (e.g., enthusiastic and friendly communication between EAs and learners).

In this thesis, the Social Agency Theory was used as the theoretical framework to explain the effectiveness of using affective EAs in DGBL, for three reasons. First, while Media Equation Theory establishes that people respond to computers in the same way as they do to humans, Social Agency Theory takes it further, by examining how different features such as gender, voice, appearance, communication strategies from affective EAs impact the learners. Second, compared with Media Equation Theory that is generally applicable to any form of media, Social Agency Theory focuses on computer-assisted educational settings in particular (Ryu & Baylor, 2005). Third, cognitive learning outcome is an important evaluation criterion for affective EAs (Krämer et al., 2016). Social Agency Theory also pays attention to cognitive learning outcomes brought by affective EAs, while Media Equation Theory mainly focuses on affective responses. Therefore, Social Agency Theory is more aligned with this research.

3.7 Chapter Summary

This chapter presented the theoretical foundations used in this PhD research, including the PD approach, ISP Model, ARCS Model, GameFlow Model, Tripartite Enjoyment Model, Technology Acceptance Model and Social Agency Theory. Specially, the ISP Model was used as the conceptual structure to design the IL game in Study I. The ARCS and GameFlow Models were used to analyze how the IL game provided motivational and enjoyable learning experiences. The Tripartite Enjoyment Model, user acceptance research, and Social Agency Theory, together with the ARCS Model, were used as the conceptual underpinnings for the survey instruments in the game evaluation in Study II. With this, the theoretical foundations for this thesis are all in place, and the next three chapters will discuss the empirical studies.

CHAPTER FOUR

STUDY I – GAME DESIGN

Study I aims to fulfill the first research objective, to design an IL game that incorporates affective EAs, using the participatory design (PD) approach. This chapter documents the two stages in Study I: a focus group study that yielded the low-fidelity prototype, followed by user interview study that refined the low-fidelity prototype to a high-fidelity one. This chapter is divided into six sections. The first section discusses existing approaches in IL game design, and clarifies three research decisions in Study I. The research methods are presented in the second section, including focus group discussion and user interviews. The third section discusses the low-fidelity prototype derived from the focus group, while the fourth section describes how the low-fidelity prototype was transformed to the high-fidelity prototype using the feedback gathered during the user interviews. The penultimate section discusses some design insights gleaned from the game design process, followed by a brief summary.

4.1 Introduction

There are generally two approaches employed by libraries to design IL games. The first is to modify existing commercial off-shelf games. For example, the University of Calgary modified the commercially successful game *Half-Life 2* to create an IL game *Benevolent Blue*, a first-person shooter action game set in a future era where democracy is absent, and players are tasked to uncover the nation's past history (Clyde & Thomas, 2008). This approach is cost-effective and timesaving. Since these games have already proved popular and engaging to players, libraries can leverage on their market success to increase students' buy-in (Smale, 2011). The

second approach is to create new games from scratch, such as *LibraryCraft* from Utah Valley University (Smith & Baker, 2011). This approach is more expensive and time consuming, but may produce better games that are more suitable to teach IL.

In both approaches, although students are the end-users of the game, they have rarely been involved in the design process. This entails high design risks, and low user acceptance from target users. This was the case with *Defense of Hidgeon: the Plague Years*. The IL game was designed by the University of Michigan, and the librarians only involved the end-users to assess their IL game after it had been fully developed. The user feedback was negative in general, but as the game had been fully completed, the librarians had to abandon it and create an entirely new one (Markey, Leeder, & Rieh, 2014). They could have lowered such design risks and avoided a waste of time and effort if the PD approach had been adopted and end-users were involved in the early design stage.

Before presenting Study I, three research decisions are clarified here. The first is the research decision to create a new IL game from scratch, instead of using commercial off-the-shelf IL games, or non-commercial IL games developed by other researchers. As mentioned above, commercial off-the-shelf IL games are designed primarily for entertainment, not education. For such games, the incorporation of formal learning pedagogy is unlikely be a deliberate design decision. Hence, a theoretical IL model such as Kuhlthau's (2004) Information Search Process (ISP) Model, is unlikely to be the basis of their design specifications. In other words, the IL content cannot fit in very well, compromising the educational effectiveness (All, Castellar, & Van Looy, 2015). In addition, several shortcomings in existing IL games have already been identified from the literature review in Section 2.2.2, such as lack of conceptual frameworks, minimal user involvement in the design process, and absence of the affective intervention of the IL learning process. Because of these reasons, they are not suitable to be used in this thesis.

The second research decision is to target the IL game to tertiary students, although IL skills are important to everyone (Ragains & Wood, 2015). It should be noted that different age groups require different levels of IL education. While primary school children may be taught how to look up a dictionary as part of their IL education, more advanced concepts such as library anxiety, Kuhlthau's ISP Model, publication cycle, the importance of making citations are more appropriate for tertiary students (American Library Association, 2017). Further, students now enter universities with more diverse education background and varying levels of information search skills (Thomas, Crow, & Franklin, 2011). According to *Researchers of Tomorrow*, UK's largest study on the research behaviors of people born between 1982 and 1994, these people were insufficiently trained to take full advantage of the latest opportunities in the digital information environment, such as rich library collections and subscriptions (Carpenter, Wetheridge, Smith, Goodman, & Struijvé, 2010). It is important to develop tertiary students' ability to use research tools, to understand the increasingly social nature of the information ecosystem, and to give credit to the original ideas of others through citations (American Library Association, 2017).

The third decision to be clarified is the use of focus group before individual interviews, although both are equally important research methods in the PD approach. This decision was made because the first stage of Study I aims to create a game prototype from scratch, which poses a greater challenge to participants and places a heavier emphasis on creativity. Focus groups provide a more comfortable and relaxing setting for discussion, where participants' anxiety and pressure are lower. Such a setting allows participants to bounce ideas with each other, and to design the game collaboratively (Krueger & Casey, 2014). Individual user interviews are more suitable for obtaining more detailed, in-depth understanding (Ritchie, Lewis, Nicholls, & Ormston, 2013). Hence focus group discussions are useful for exploring

general game design ideas and generating the low-fidelity prototype, while individual user interviews are better for refining and enriching the low-fidelity prototype.

4.2 Research Method

Participatory design is a broad term that describes the design approach where users collaborate with designers, developers and researchers, and influence how the results takes shape (Waddington, Linehan, Gerling, Hicks, & Hodgson, 2015). By giving potential users a voice to communicate their ideas and concerns with designers and experts in the design process, PD aims to make technologies and systems more useful and useable (Guo & Goh, 2014b). In the context of DGBL design, one of the difficulties is that students, as end-users are often neither able nor permitted to participate in the design of such games (Rebelo & Filgueiras, 2012). This results in a lack of communication between students and designers, and designers sometimes turn a deaf ear to user inputs (Gunter, Kenny, & Vick, 2008). Therefore, to improve the educational effectiveness and gameplay enjoyment of DGBL, the PD approach can be used to involve potential users.

Despite having many strengths, the PD approach has also been questioned. For instance, one challenge to designers using the PD approach is the need for effective communication with users to elicit useful insights (Verne & Braaten, 2014). To produce meaningful results, on one hand, PD facilitators need to actively engage participants so that they can contribute useful ideas and suggestions. On the other hand, participants need to be interested and committed to contribute useful ideas in the discussion for the results to be effective. Sometimes participants might not have the subject knowledge, or not able to articulate their ideas clearly, hence this demands the facilitators to be sensitive and quick to interpret users' input, and prevent miscommunication. It also requires facilitators to establish rapport with participants, which

sometimes is not easy. Another problem is that while the PD approach needs continuous involvement of users, many PD projects only invite users for a one-time discussion at the beginning of the design stage, and the ideas and recommendations from users gradually become detached in the subsequent rounds of iterative design (Salgado & Galanakis, 2014). Hence a sustained and ongoing implementation of user feedback is critical. These challenges are, to some extent, all present in Study I. Controls were put in place in Study I to ensure maximal benefits could be harnessed.

Nonetheless, there is no doubt that PD has a lot to offer for designing new information systems. The major advantage of the PD approach is that by involving users, designers can have a deeper understanding of the psychological, organizational, and social impact of the new systems (Guo & Goh, 2014b). The involvement of users assures that the systems are suitable for their intended purposes in the environment where they will be used (Asaro, 2000). When users are involved in the design of a system, they know from an early stage what to expect from a system and they feel that their ideas and suggestions contributed to the process (Salgado & Galanakis, 2014). Understanding users' opinions early on can help designers manage user expectations of the new system. It also brings a sense of ownership from the end-users for the final systems, often leading to higher user satisfaction and smoother integration of the systems into the environment (Ciolfi et al., 2016; Lukosch, van Ruijven, & Verbraeck, 2012).

To be useful, the PD approach needs to be built upon and used within the context of research methods, such as focus group discussions and individual interviews (O'Kane, 2008). The practice that is frequently associated with iterative design is prototyping, which refers to the creation of a draft version of a product. Prototyping allows designers to explore different ideas before investing substantial time and money into further development (Quiñones, 2015). Prototype fidelity measures how authentic and realistic a prototype is, compared to the final product (Sim, Cassidy, & Read, 2013). Specifically, the fidelity is said to be low if the

prototype only partially represents the final product without full details. Conversely, the prototype fidelity is said to be high if it is the closest possible to the final product, or almost in the same representation type (Quiñones, 2015). Low-fidelity prototypes are created at an early design stage, typically using materials such as paper, pencils, cardboards and so on; while high-fidelity ones are built at a later stage, typically using the same technologies or software as in the final product (Baxter, Courage, & Caine, 2015). Study I followed industry convention, where a low-fidelity game prototype was first created. It was thereafter transformed to a high-fidelity one, before the game was implemented.

This section describes the two stages in Study I: a focus group that resulted in a low-fidelity game prototype, and user evaluations that refined the low-fidelity prototype. This approach is consistent with that suggested by Baxter et al. (2015), and used by Quiñones (2015).

4.2.1 Focus Group

The participants in PD were selected from the games' target end-users. Hence the participants in Study I were tertiary students, including both undergraduate and graduate students. The study proposal and focus group protocol (Appendix A-1) was first submitted to Nanyang Technological University (NTU) Institutional Review Board for review. Upon approval (Appendix A-2), a pilot study was carried out with three university students (one undergraduate and two graduate students). Participants were paid \$10 at the end as a token of appreciation. The pilot study served as a "dry run" for the researcher to get familiar with the focus group procedures and to identify any potential problems with the research protocol.

After the pilot study, three formal rounds of focus group discussions were held. To recruit participants, mass emails were sent out, and advertisements were posted at various locations in two major local university campuses. The recruitment emails and advertisements

stated the purpose of the study, which was to design an IL game. Specific requirements were made for those who wanted to participate. First, they must be tertiary students who have done academic assignments and searched for academic information. Second, they should be willing to contribute to a new game design and share innovative ideas. To gather diverse opinions and maximize the range of perspectives, the researcher selected participants from different education background and programs. This gave the participants an opportunity to discuss how IL is taught in their programs, how much they understand IL, and what IL skills they value in different programs.

The study adhered to the best practice on focus group studies, as suggested by Krueger and Casey (2014). The ideal size of focus groups should be four to eight people, and the duration should be one to two hours. The number of rounds of focus group should depend on the discussion outcome, and the study only stop when useful ideas emerge.

The first two rounds of focus group discussions involved 15 undergraduate and graduate students. However, the results were not satisfactory as some participants were reticent and the facilitator was not able to encourage them to participate in the discussion or contribute to the game design. Hence more rounds of focus groups were conducted. The third round of focus group discussion was satisfactory, as participants were more responsive and contributed many useful insights. Hence no more focus groups were conducted afterwards. Ideas from the final focus group were adopted and reported here.

A total of seven tertiary students were recruited to represent the end-user group, comprising three males and four females, aged between 21 and 30. Furthermore, all participants reported that they played games at least an hour per week, with three avid gamers playing more than four hours per week. Their demographic information is summarized in Table 4.1.

The focus group discussion was held in a focus group laboratory in NTU, and lasted approximately two hours. During the discussion, the researcher introduced the study objectives, guided the course of discussion, and recorded all conversations. To prepare her for these roles, the researcher was trained in interviewing techniques in a qualitative research method class, and spent time playing video games to understand them from the players' perspective, rather than from the researcher's perspective.

Table 4.1 Participants' Demographics in Focus Group ($n = 7$)

	<i>n</i>
Gender	
Male	3
Female	4
Age	
21 to 25	4
26 to 30	3
Education Background	
Engineering	3
Social science	2
Business	1
Arts	1
Educational Degree	
Bachelor	3
Masters	1
Doctor of Philosophy	3
Time Spent Playing Games Per Week	
Less than 4 hours	4
More than 4 hours	3

Figure 4.1 shows the flow of the focus group discussion. At the start, participants were briefed on relevant IL knowledge, its importance, and the current problems in IL education. The objective of developing an engaging digital game to teach IL skills to tertiary students in Singapore was explained to them. They were told the game needed to use the ISP Model as the overarching structure, with affective EAs to provide feedback to players. The game should have basic elements such as a backstory, some rules, rewards, and so on. After that, they were asked to read the consent form, and to sign it if they had no objections.

Figure 4.1 Procedure for Participants in Focus Group

After the briefing, participants were given 15 minutes to play two IL games (*Secret Agents in the Library* and *The Information Literacy Game*), in order to familiarize with the idea of IL games. Among the many IL games reviewed in Chapter Two, because some IL game design initiatives were not implemented (e.g., *Benevolent Blue* from the University of Calgary),

some were no longer accessible to the public (e.g., *BiblioBouts* from the University of Michigan), and some taught library-specific information and were not useful to students from other universities (e.g., *Get a Clue* from Utah Valley University). Hence these two games were chosen. Also, both had been evaluated and received positively by students. They were also freely accessible on the respective libraries' websites. Further, the two games share the same aim as that of the game in this study: to teach general IL knowledge with a variety of IL topics.

The two games are briefly introduced here. *Secret Agents in the Library* (Figure 4.2a) is designed for the freshman composition course at Lycoming College (Broussard, 2010). Most of the game's activities focus on one of the IL Standards by American Library Association (2000): the ability to locate and access information effectively and efficiently. Multiple-choice questions and drag-and-drop activities are used as assessment throughout the game. The second game, *The Information Literacy Game* (Figure 4.2b), is an online board game for first-year students in the University of North Carolina (Rice, 2008). It allows up to four players to play together by rolling an electronic die. Players score points by correctly answering IL questions. The game covers four IL topics, namely, selecting appropriate information, using different databases, citing sources and avoiding plagiarism, and searching with wild cards.

(a) *Secret Agents in the Library*

(b) *The Information Literacy Game*

Figure 4.2 Screenshots of Games Used in Focus Group

Participants' feedback on what they liked and did not like about the games was gathered. Overall, the students found both games were acceptable, as they understood that librarians were not professional game designers. Nonetheless, they were disappointed with the gameplay experience. Table 4.2 summarizes their remarks, including unattractive interface, lack of motivation, unclear instructions, and poor design.

Table 4.2 Participants' Comments on the Two Games

Reasons	Remarks
Unattractive interface	<ul style="list-style-type: none"> • <i>It seems like I am taking a test. Like taking a quiz.</i> • <i>Not very interactive, it's like what you see in a textbook, you see the questions and answer, it is like an assessment book.</i>
Lack of motivation	<ul style="list-style-type: none"> • <i>There is nothing to motivate me to play.</i> • <i>There are not many surprises to spur me on. No element of surprise.</i> • <i>I don't know what I am playing this game for.</i>
Unclear instructions	<ul style="list-style-type: none"> • <i>The objective is not very clear. Is it a test or am I supposed to learn something?</i> • <i>No clear instructions, so very confusing.</i> • <i>Only after the whole game until I realized what's going on.</i>
Poor design	<ul style="list-style-type: none"> • <i>I think the UI is too simple and the game is too buggy.</i> • <i>The interface color is purely black and white.</i> • <i>It is all over the place.</i> • <i>The time limit is a problem. But when you play, you cannot see the time.</i>

After giving their feedback on the two games, the participants watched a YouTube video by Maker (2012) as an example of how emotions can be expressed in digital games through affective EAs. The game in the video used cues such as eye movements, voice tones, facial expressions, and body gestures. This was followed by a short introduction to the ISP Model. They were told to use this model to structure the game.

The main task for the participants was to jointly develop a game prototype as a team. This meant that they had to decide on genre, backstory, characters, setting, music, and so on, and that consensus had to be reached on these game elements. At the end of the focus group discussion, one participant who was graphically adept drew the storyboard sketches based on the ideas generated. Finally, the participants were debriefed and thanked for their participation and contribution to the game design. They were paid S\$15 each as a token of appreciation.

4.2.2 Individual User Interviews

In the second stage, individual user interviews were conducted, to evaluate and refine the low-fidelity prototype. The study proposal and user interview protocol (Appendix A-3) was approved by NTU Institutional Review Board (Appendix A-4). Two batches of invitations were sent. The first batch was sent to participants who attended the previous focus group discussions, so they could have another opportunity to provide further feedback. The second batch was sent to recruit new participants, who could provide fresh and new perspectives.

In total, ten university students from NTU were recruited, among whom four attended the previous focus group discussions and six participated for the first time. Their demographics are summarized in Table 4.3. The group consisted of six males and four females, aged between 21 and 29. Participants reported being experienced gamers, who played digital games at least an hour per week, with three participants playing more than six hours per week. All participants had searched for academic information and had written academic assignments in the past. The main task of the interviewer was to introduce relevant background knowledge of using digital game-based learning (DGBL) in IL education, state the interview objectives, present the low-fidelity prototype, elicit feedback from participants, and take notes to capture participants'

ideas timely and accurately. After each interview, the interviewer would summarize the participant's ideas, and present them to subsequent participants for their feedback as well.

Table 4.3 Participants' Demographics in User Interviews ($n = 10$)

	<i>n</i>
Gender	
Male	6
Female	4
Age	
21 to 25	5
26 to 30	5
Education Background	
Engineering	4
Social science	3
Business	1
Arts	2
Educational Degree	
Bachelor	2
Masters	4
Doctor of Philosophy	4
Time Spent Playing Games Per Week	
Less than 6 hours	7
More than 6 hours	3

All the interviews were held in a meeting room in NTU, each lasting approximately one hour. At the beginning of each interview, participants were briefed on the research objective, which was to refine a low-fidelity game prototype that developed previously. After that, the interviewer showed them the storyboard sketches of the low-fidelity prototype, and explained all game scenarios and specific design decisions from the previous focus group discussion. Participants were encouraged to articulate what they thought about the prototype, what they did and did not like, and to suggest ways of improving it. The interviewer summarized participants' comments at the end of each interview. Each participant was thanked and given

\$10 as a token of appreciation. The comments from participants were consolidated and summarized to generate ideas for the high-fidelity prototype.

4.3 Low-fidelity Prototype

This section presents the low-fidelity game design produced by the participants in the focus group. The section is divided into three parts: overview, backstory and characters; mission design; as well as ending. The description is interspersed with participants' remarks to demonstrate how the design ideas came about.

4.3.1 Overview, Backstory, and Characters

Participants decided on the room escape game genre, given its popularity and attractiveness. One participant remarked: *"I am thinking about the escaping room, or those kinds. First of all, it is a level-up game. When you escape, you need to obtain some information, so this becomes something necessary. When you are searching for stuff, you can get some information, then from there you can learn something."* Compared with the board or puzzle genre games such as *Secret Agents in the Library* and *The Information Literacy Game*, participants believed that the room escape genre game could increase the level of participation and concentration from players. As the game aims to engage tertiary students to learn IL knowledge, other participants came up with the idea of a haunted library escape scenario. One said: *"You are trapped in a library, and you have to find something to get out"*. It is supported by others, who said *"If it is a haunted library, it becomes more interesting"*. Another participant further elaborated that *"It can be a treasure hunting game, but a treasure hunting in books. You have to find the clues in books"*. Following the discussion, they decided to name the game *"Library Escape"*. Figure 4.3 shows the first storyboard sketch, where the protagonist finds himself trapped in the library.

Figure 4.4 shows that he needs to acquire IL skills to find the information and escape from the haunted library.

Figure 4.3 Protagonist is Trapped (Low-fidelity Prototype)

Figure 4.4 Protagonist Needs to Escape (Low-fidelity Prototype)

Library Escape is a single-player game. At first, all participants except one were attracted to the multiplayer option, so they can play together with friends. They suggested, “*I think you can invite your friends, so that more people will play it. So maybe at first one person goes through an adventure in the first stage, for the second stage, you need two persons to stay together, and the third stage you need three persons*”. However, one participant preferred the single-player option, as she thought learning was an individual activity. She reasoned that “*because personally for me, I don’t like to invite other friends to play, it is very troublesome.*

So if you want to do the publicity, you can do this. This (multiplayer) makes people don't want to play such games, because they need somebody to help them, and cannot be done by themselves. It is better if they can do it alone". In the end, her argument swayed the others. Moreover, the single-player option is suitable for point-and-click type of games, which is the case for *Library Escape* (Adams, 2013).

As to the difficulty level, some participants proposed making it very difficult, while others objected to the idea. One participant argued since this is an educational game for students to learn, it should be difficult. He reasoned that *"Actually we can borrow something from Flappy Bird ⁴because it is very frustrating and challenging. When you play, you keep on advancing your skills. You will actually achieve more. So maybe we can apply this to educational game, to assign a challenging task, to engage people"* Another participant also liked *Flappy Bird* and agreed to the suggestion. She said *"We must have a very challenging task for people to be interested in"*. However, most participants were opposed to this suggestion and thought the game should be not be too difficult, so players can have confidence to continue playing and learning. One participant reasoned *"It cannot be so challenging that game over after just one point or two points"*. Another also explained that *"I think it cannot be too difficult because it is educational. So that is a turnoff already to have it so difficult"*.

Participants proposed three characters in the game. For the protagonist, participants suggested using a university student's image, as the game targets tertiary students. Therefore, the protagonist, who was given the name Tom, is designed to look like a university student, as shown in Figure 4.4. The second character, the affective EA, took the form of a librarian in this game, Ms. Senka, an old lady who will help Tom along the way (see Figure 4.5). Participants agreed that using a librarian was congruent with the setting of a library, and librarians were

⁴ *Flappy Bird* is a mobile game released in 2013. Players control a bird that flies between rows of green pipes without dashing against them.

supposed to help students. At the same time, most of the participants suggested depicting the librarian as an old lady wearing spectacles. The third character is Professor Babbage, the IL module instructor who leads Tom to the library to start the game.

Figure 4.5 Ms. Senka the Librarian (Low-fidelity Prototype)

For the backstory, one participant made up a story where a student gets a low grade for his IL module, goes to consult the IL instructor for advice on how to improve. The instructor then leads him to the library. Here is her original input: *“In the beginning, the guy looks so sad because he cannot score better for the paper. In the end he goes to consult with the professors, then the professor says the problem is because he cannot use the citation or searching properly. You need to make sure that your source is credible. Then he asks the professor ‘How can I get proper research?’. Then the professor just pushes him to the room, and locks the room. Then the game starts”*. Other participants filled in more details. One participant suggested creating some tension by limiting the game to one hour: *“Imagine that a report is due in one hour’s time, and time is very precious”*. Another wanted to create a more horrible experience, and he said *“[the game] can use ambush as surprises, such as corpse, bloody knives, or something like*

that". Other participants agreed it was a storyline worth pursuing, and decided to continue the game design based on this plot.

4.3.2 Mission Design

As was decided prior to the focus group, the ISP Model was used to structure the game. The ISP Model divides a typical information seeking process into six stages: task initiation, topic selection, prefocus exploration, focus formulation, information collection, and search closure (see section 3.2 for a detailed explanation on each stage). To mediate the insufficient IL knowledge from participants, one IL expert was consulted after the focus group discussions, and the subsequent user interviews focused on the learning aspects of the game.

Participants identified with the ISP Model as they recalled their own experiences of searching for information when completing their assignments. In agreement with Kuhlthau's (2004) findings, participants were not aware that others also had negative feelings during information seeking process, and thought that they were alone in experiencing difficulty and anxiety. Hence, participants felt reassured when they learnt the ISP Model, and discovered that negative feelings were actually common among novice information seekers.

Participants proposed designing the game in six missions to represent the six stages of the ISP Model. One participant stated that *"I am thinking for the six stages, you can just design six different scenarios. Since they have logical relations to each other, so first you go to the first scenario, you have several tasks to do, all these tasks are related to how you can search for information for example. So when they finish one task, you can go to the next task. Then when you finish this scenario, you can go to the next scenario, to make the story flow better"*. Each mission is set in different locations in the library for the players to explore. Within each mission, the players have to complete the tasks and quiz questions, with the help of the librarian,

Ms. Senka. Players have to complete one mission before proceeding to the next. One participant raised the question that since this game is about learning, she would like to revisit some important knowledge in the previous missions. Hence she suggested making it possible to revisit previous missions, and said *“You can go back to any stage to find the information that you want”*. This participant also said that *“It is like in a real library, with the books, that you can click on them, or take the books out from the shelf to get useful things.”* Hence, each mission comprises four IL topics, which the players can access by clicking on different objects (e.g., books, computers).

Mission One of the game is about the first stage of the ISP Model is task initiation, in which students become aware of the information need. This is a stage when the students first become aware of their lack of knowledge or understanding, so feelings of uncertainty and apprehension are common (Smith, Given, Julien, Ouellette, & DeLong, 2013). One participant was a freshman in sociology, a program that demands heavy reading, and she wholeheartedly agreed with this stage. She said *“I feel very jia lat when getting the assignments”*. So in the same way, in Mission One, Tom is depicted as being apprehensive and uncertain towards the task ahead, especially with the low grade for the IL Module. Participants thought Ms. Senka could make a brief appearance in Mission One, to assure the players that they were not alone in the game. Just as Tom feels apprehensive and confused, Ms. Senka speaks up, *“Don’t worry, the answer is within this room, you can explore the room to find the clues”*. This mirrors the real-life situations where the librarians are always ready to help students in face of difficulties.

Mission Two is about the second stage of the ISP Model, topic selection. Here students need to identify and select a general topic to be investigated or the approach to be pursued (Kuhlthau, 2004). Students confer with others to discuss possible topics and approaches, while others may make a preliminary search of information available by themselves (Ragains & Wood, 2015). One participant mentioned that *“I like to discuss with my friends about which*

topic to select for assignment”, and another shared her tips to talk to seniors: *“I like to ask seniors for tips”*. To mirror this, in Mission Two, Tom is taught how to select a topic in this mission. One participant suggested that Tom can be provided with a lot of information to sieve through. To select an appropriate topic, Tom needs to initiate a conversation with Ms. Senka. After understanding Tom’s situation and getting to know his IL module grade, Ms. Senka recommends Tom to select information seeking behavior as the topic for his report.

Mission Three of the game is about the third stage of the ISP Model, prefocus exploration. In this stage, students are required to locate more information about the topic. However, students often feel confused, uncertain, and doubtful due to their inability to express precisely what information is needed, and to retrieve adequate amount of information (Bates, 2007). This is especially true for foreign students, who have to contend with a foreign language in addition to information seeking. One participant from China recounted that he was in such a situation constantly. He lamented that *“I am often at a loss at how to search, what key words to use, especially because it is in English”*. Another participant also recalled his own experience in writing an academic paper. He shared that *“When I was writing a meta-analysis paper, I spent more than two months looking for relevant articles by myself. It is like looking for a needle in the literature ocean. Until you (the facilitator) told me to ask for help from our librarians.”* Kuhlthau (2004) suggests that the librarians should be ready to offer help when students are in this stage. Hence, in this mission, Ms. Senka tells Tom not to worry, and assures him that such negative feelings are common when most people search for information. She also reminds Tom about the library anxiety and uncertainty.

Mission Four of the game is about the fourth stage of the ISP Model, focus formulation. This stage marks a turning point in the search process and involves forming a focus from the information encountered. After identifying and selecting ideas from the information sources, a more focused perspective of the topic could be formulated (Kuhlthau, 2004). The topic

becomes more personalized at this stage. One participant said that *“Yes this is when things start to fall into place, or, things have to fall into place ...”* One participant shared that he was often very anxious before writing. He said *“I am not very good at writing, and it takes a lot of effort for me to prepare to write”*. Hence, in this mission, Tom recalls how painful his previous writing process was for the IL module assignment, and how struggling with the topic make it personal to him.

By Mission Five, which is about the fifth stage in the ISP Model, information collection, students would normally have a clearer sense of direction, can precisely specify the information they need, and locate useful information effectively and efficiently. Feelings of confidence increases as uncertainty subsides (Thomas et al., 2011). One participant said when he was at this stage, the workload was usually intensive: *“If it is a group project, we will divide the tasks and each of us will look out for different sources of information in two or three days”*. Hence in this mission, Tom is busy finding enough information (see Figure 4.6). He realizes that the library has subscribed to thousands of ebooks and ejournals. Due to the sheer volume of the material he has to sift through, he has to speed up the search and find ways to work more efficiently. Ms. Senka cheers him up, and she teaches Tom some searching techniques.

Figure 4.6 Protagonist Collects Information (Low-fidelity Prototype)

In Mission Six, the final stage of the ISP Model, the search comes to a close. Feelings of relief coupled with a sense of satisfaction is common if the search had gone well, or disappointment if it had not (Kuhlthau, 2004). Sometimes this stage sees a deepening interest in the project, but at a time where the submission deadline looms, the focus is more on developing a personalized synthesis of the topics. One participant said he would sometimes be in a flow experience, and said *“I get really skilled and excited so the writing cannot stop!”* Other participants said they were extremely happy and relieved just to complete the assignments. In *Library Escape*, Mission Six is a summative stage for the game to end. Ms. Senka tells Tom that *“There is much more about IL than what is presented here”*, as an exhortation for Tom to learn more about IL.

4.3.3 Ending

The game ends when players finish all six missions or when the one-hour time limit is reached. The focus group participants suggested that if players successfully complete all six missions, Ms. Senka issues two certificates, one with a grade, depending on players’ performance in the quiz, and the other a completion certificate indicating that players have finished the game and completed all the tasks given (see Figure 4.7). They also suggested making the certificates gold in color, and enabling players to post their certificates on social media. Further, one participant suggested the IL instructor Professor Babbage could come back at the end to check on the protagonist’s progress. She said: *“After one hour the professor will come to the room.”* Hence, Professor Babbage comes in to check on Tom, and is very happy to see him complete the game.

Figure 4.7 Two Certificates after Completion (Low-fidelity Prototype)

4.4 From Low- to High-fidelity Prototype

The low-fidelity prototype was refined based on the aggregated feedback from individual user interview with ten participants. As most participants commented thematically, rather than by mission, this section is organized in the same manner, highlighting how the low-fidelity prototype was transformed into the high-fidelity one. The game will be described in its entirety in Chapter Five.

4.4.1 Overview

The backstory remained largely unmodified, except that the presentation format was changed from a video clip to comic strips (see Figure 4.8). Participants from the user evaluation suggested that although a video clip affords a smoother and more immersive experience, it is time-consuming to go through. Impatient players may skip the video and start the game immediately. In addition, comic strips are easier to design, clearer in presentation, and faster to view, so that players can understand the story and proceed to the game quickly.

Figure 4.8 Backstory (High-fidelity Prototype)

The low-fidelity prototype imposes an overall one-hour time limit to complete the entire game, but players can decide how long they want to spend in each mission. One participant thought it was problematic, as players may not be able to keep track of the time. If they spent too much time in the earlier missions, they would not have enough time for the remaining ones. She thus suggested imposing a time limit for each mission to make sure players have enough time for all missions. She reasoned that *“there should be a time limit in each mission. For example, Mission One and Two are easier, so maybe they can take seven minutes each. And the other missions can take longer. In this way, players can also pay more attention with the time limit in every mission. Or they may wander in the game aimlessly.”* This suggestion was adopted, and the high-fidelity prototype fixes the maximum completion time allowed in each mission at ten minutes. To make players aware of this limit, a ten-minute countdown timer is shown in each mission as a reminder.

The low-fidelity design did not have indicators for players’ progress, and this was pointed out by one participant during the interview. He said *“You need to have a progress bar so they can check”*. When asked how, he suggested using stars, a common progress indicator

in games: *“Maybe just some stars, because you don’t have that many things here”*. Hence in the high-fidelity prototype, a progress bar is included at the right top corner of the screen.

The high-fidelity prototype also increased the number and variety of objects used to hide the IL knowledge, from only library related items (e.g., books, computers) to other more interesting items (e.g., trumpet, flowers), as suggested by several participants. They pointed out that *“It is very boring because players will just mechanically interact with the objects to uncover the IL knowledge. So I think you can add in some very cute or very horrifying objects to excite players”*.

The final reward was also slightly changed. Participants deemed using two certificates, one graduation certificate and one completion certificate, as *“unnecessarily complicated”*. The revised design issues a single completion certificate with grade. Furthermore, some participants suggested that the grade should be based on players’ performance, such as the number of incorrect attempts (the fewer wrong answers, the higher the grade), and the time taken to complete the game (the shorter time taken to complete the game, the higher the grade). One reasoned that *“It will prompt the players to be more attentive”*. Another participant further suggested that: *“The final reward can be a golden colored e-certificate. Players can print out if they want”*.

4.4.2 Characters and Their Relationships

The high-fidelity prototype included one more character, an antagonist, which took the form of an evil ghost. Participants from the interviews pointed out that the proposed gameplay experience was quite monotonous, as players only need to locate the objects, learn IL knowledge and answer quiz questions correctly to finish all six missions. To make the game more fun, participants suggested adding an antagonist for players to battle with. For example,

the evil ghost occasionally wakes up from his nap and moves around to disturb the players' progress in Mission Two. The ghost moves constantly in Mission Three and spews fire in Mission Five, as obstacles to players.

Participants also suggested changing the gender of the librarian from female to male. The change would force the players to confront the stereotypical idea that librarians are female (Baylor & Kim, 2009). The librarian's name was thus changed from Ms. Senka to Mr. Babbage. Figure 4.9 shows the protagonist and librarian design in the high-fidelity prototype. Further, the relationship between protagonist and the librarian becomes more intertwined. In the low-fidelity prototype, their relationship is simple: The librarian provides guidance and encouragement when Tom needs it. This was criticized by some participants at the interviews. They regarded it as "*too simplistic*", making the librarian's role "*insignificant and dispensable*". Thus in the high-fidelity prototype, their relationship becomes more interdependent.

(a) Protagonist (b) Librarian

Figure 4.9 Character Design (High-fidelity Prototype)

The revised story goes like this. Tom meets Mr. Babbage, who introduces himself as the guardian of the library. Unfortunately, the antagonist evil ghost broke into the library and threw everything into disarray. In the chaos, Mr. Babbage's magic wand was lost (see

Figure 4.10). The lost magic wand is somewhere in the library and Mr. Babbage needs it to restore the library back to its former glory. Tom can help by going around and finding it. In return, Mr. Babbage can help Tom improve his IL grade. One participant remarked that “*The player will be more like a hero, people like to be a hero*”. In addition, Mr. Babbage helps Tom to interpret the map of the library at the end of each mission, in order to progress in the game (see Figure 4.11). Participants commented that the revised storyline was richer and more interesting. One participant noted that “*The new story is much better than the previous one, and it tells players what’s been going on*”.

Figure 4.10 Evil Ghost and the Magic Wand (High-fidelity Prototype)

Figure 4.11 Map to Select the Venue for Next Mission (High-fidelity Prototype)

To make the role of the librarian even more prominent, participants suggested various ways in which the librarian Mr. Babbage could help players during the game (see Figure 4.12). Mr. Babbage affirms players when they successfully locate objects or answers quiz questions correctly, and encourages players to continue exploration and not give up. Specifically, when players answer correctly, Mr. Babbage gives praise by saying “*Good job*” or “*Well done*”, and reinforce the knowledge to players. However, when players answer wrongly, some encouragement will be given. For example, Mr. Babbage says “*Don’t be discouraged. Read the question carefully*” or “*Go back to the previous mission and read carefully, I am confident you can do it*”.

Figure 4.12 Feedback from Mr. Babbage to Quiz Questions (High-fidelity Prototype)

4.4.3 Missions

The low-fidelity prototype lacked details on the learning content. Participants at the focus group were more engrossed with game design ideas and less with the learning content in the game. This is understandable as they were neither subject matter experts in the area of IL, nor teachers who were well grounded in the pedagogical principles. To correct the inattention to the learning content, two steps were taken after the focus group, as recommended by Ciolfi et al. (2016) and Kaner, Lind, Toldi, Fisk, and Berger (2014).

First, after the focus group, an IL expert was consulted on the learning content in the game. The expert has ten years' experience in teaching library science in tertiary institutions. The expert suggested that be to systematic, the content of the game should draw from existing IL instruction syllabus such as those from the libraries. He advised that *"You can also look at the IL standards as a start, it is widely validated, the libraries also structure their IL instruction based on the IL standards"*. He also reminded that a deeper coverage of the subject matter should be emphasized, rather than the breadth. As a result, the IL content in the game was drawn from ALA's (2000) IL standards, and includes three or four IL topics in each mission. Second, during the subsequent user interviews, the interviewer gathered more feedback by emphasizing on the pedagogical aspects of the game by nudging the participants to contribute to the learning aspects of the game.

The six-mission structure of one mission per ISP Model was maintained, but the names of the six missions were changed from the venues to the six stages of the ISP Model, in order to reinforce the link between the mission and the ISP Stage (see Table 4.4). Moreover, the venues in which each mission takes place were modified. The previous arrangement was questioned by one participant: *"Why is the game arranged in such places in such sequence?"*, and he suggested a new order. Specifically, he suggested replacing the exhibition area with the audio visual (AV) collection to better reflect the collections and services provided by libraries. A digital library was used as the location in Mission Four. The sequence of venues was adjusted so that similar services were placed together, from those students were most familiar with (i.e., physical books in closed and open shelves), to increasingly important resources (i.e., e-resources in digital libraries), to amenities afforded by libraries (i.e., café). His suggestion was supported by others, and they also preferred the new order and thought it made more sense.

Figure 4.13 show the game's interface graphics before they were developed with programming tools, hence the characters were not integrated here.

Table 4.4 Knowledge Content in *Library Escape* (Revised)

Mission: ISP* Stage (Venue)	Topic	IL Knowledge (objects hidden in)
1: Task initiation (Closed Stacks)	Starting Out on Your Journey	1.1. Birth of IL (dictionary)* 1.2. Importance of IL (handwheel) 1.3. IL and society (hat) 1.4. ALA IL standards (scale) 1.5. Stage One in ISP Model (globe)
2: Topic selection (Open Shelves)	Selecting Your Topic	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: Prefocus exploration (Reference Section)	Discovering What's in a Library	3.1. Scholarly Publication Cycle (grandfather 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: Focus Formulation (Digital Library)	Looking for a Needle in a Haystack	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 (IE search engine)
5: Information Collection (AV Collection)	Focusing on What's Important	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: Search Closure (Café)	Writing Up	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)

Figure 4.13 Six Missions (High-fidelity Prototype)

Mission One: Task Initiation

In Mission One, students should recognize a need for information (Kuhlthau, 2004). Following the ALA's (2000) IL standards, this mission introduces foundational IL knowledge: the definition, importance and standards of IL. Such conceptual knowledge will help students familiarize with and form some basic understanding of IL. The definition of IL is hidden behind a dictionary, the ALA's IL standards behind a scale, and the importance of IL behind a handwheel. The participants thought an easy start was important. One participant said that “I

wouldn't continue if I die in the first quest or within one minute". The easy game learning content is designed to help players begin the game with confidence (Keller, 1993).

The gameplay is also the easiest among the six missions. The evil ghost is absent here, so the players only need to find those objects containing the IL knowledge. This again is to ensure that players can learn the rules of the gameplay unimpeded. Moreover, because of the apprehension and uncertainty that students may feel, the use of comforting monologue will be effective (Mellon, 1986). For example, when players make the first mistake, Mr. Babbage gives them assurance that completing the game is not difficult. Mr. Babbage has a grin on his face, and his mouth is slightly turned up, with an open posture, which indicates that he is friendly, open, and willing to help. When players find the first object, Mr. Babbage cheers "*Great! You have found one object!*".

Mission Two: Topic Selection

As mentioned, the venue of Mission Two was changed from the reference desk to the open shelves at the suggestion of one participant to group library venues with related services together. Like the closed stacks, open shelves also house the physical books. In this stage, students sometimes feel anxious before committing to any topic (Kuhlthau, 2004). The IL expert advised that to mirror the ISP Model, students in this mission could be taught about library anxiety and uncertainty, as well as the causes. Specifically, the knowledge on how to select a topic is hidden behind a key on the floor, types of scientific literature behind a stool, and the library anxiety related knowledge behind a magazine on a bookshelf. Mr. Babbage reassures the players that three quarters of library users experience library anxiety, and that it was normal for them to experience it.

Participants suggested some variations in the way the evil ghost moves. Some remarked that *“It will make it more challenging and interesting, so that players won’t get bored”*. In this mission, the evil ghost occasionally patrols around the place and the players have to stop moving when he does. If not, the players have to restart the mission. Different strategies are needed to combat the evil ghost in the subsequent four missions to keep the players alert and interested in the game.

Mission Three: Prefocus Exploration

In Mission Three, students need to gather information on the general topic in order to extend their existing knowledge. If they encounter difficulties in finding relevant materials, they may find the situation quite discouraging and threatening, causing a sense of personal inadequacy as well as frustration (Smith et al., 2013). Two participants jointly suggested the learning content in this mission. The knowledge about scholarly publication cycle is hidden behind a grandfather clock, Google Scholar behind a painting, and the library online public access catalog (OPAC) behind a date stamp on the table. Others remarked that the knowledge content were useful. One said that *“I didn’t know that there are so many different types of resources and they should be used differently. It’s great”*.

Mr. Babbage tells Tom not to worry, and reassures him that such negative feelings are common when most people dig deeper for information. The use of arm gestures such as pointing is important to convey emotions, and it is also effective in attracting learners’ attention, thus increasing the players’ level of active listening and learning (Beale & Creed, 2009). Participants at the interviews suggested using an additional progress indicator here. As players would have finished half of the game by the end of this mission, it is a noteworthy milestone. Hence after players complete this mission, Mr. Babbage congratulates them: *“Fantastic.*

You've reached the halfway point in your journey to learn more about IL". Other participants at the interviews regarded it a good way to encourage players in case they lose interest during the gameplay. In terms of gameplay, the evil ghost patrols the place constantly, so players have to avoid colliding into him.

Mission Four: Focus Formulation

Students' search focus comes into clearer focus by this stage (Kuhlthau, 2004). One participant said by this time, she could "*search and write quickly*". This mission teaches three practical information search strategies, as participants at the interviews preferred practical IL knowledge than concepts. One said "*I want to learn hands-on skills I can use immediately, to help me in the information search or completing assignments*". She suggested information searching techniques would be very helpful. Hence this mission teaches building blocks (hidden behind a scooter), pearl growing (behind a search engine), and successive fractions (behind a torch light). The knowledge in this mission is an extension from what was learnt in Mission Three, and these search techniques can be used when searching in Google Scholar and Library OPAC. Mr. Babbage tells Tom to be patient in this stage, as time is needed to produce good work.

Online resources are increasingly popular and frequently used by students, and its importance was also mentioned by participants. So Mission Four is set in the digital library, represented by a computer circuit board. One participant suggested that "*You can use circuit board of computers, so that players can move back and forth following the routes in the circuits. This is also a change in the setting as the previous ones are all in physical library*". One participant suggested that a computer virus was more suitable in a virtual setting than an evil ghost. She said "*The overall setting is important, things should seem natural to appear together. A virus is better than an evil ghost here*". Therefore, the evil ghost sends a virus to the digital

library. To make the game more exciting, the virus becomes more desperate and moves faster as player finds each object and gets closer to completing the game.

Mission Five: Information Collection

Mission Five is the emotional turning point in the information seeking process, as the feelings of uncertainty diminishes and confidence increases (Kuhlthau, 2004). Elements of critical thinking and reflection are included in Mission Five, to reinforce the cyclic learning process of sense making, formulating strategies, taking actions, reaching conclusion, and reflecting (Bloom, 1956). The IL knowledge in this mission is derived from the ALA's (2000) IL standards on evaluating information and using information critically. Players are taught to evaluate the information retrieved (hidden behind a disk), and to reflect on information seeking behaviors (behind an umbrella) and how the ISP Model (behind an owl) has helped improve their information seeking skills. Participants agreed that reflection is a critical part of the learning process. One commented that *"I think it is very good to reflect during the game, it helps us reinforce the whole thing"*. This statement is also supported by findings from Leinonen, Keune, Veermans and Toikkanen (2016). When students reflect, they recapture their experience, think about it, and evaluate it. Reflection helps transform experience into knowledge, and is a stage in the latter stage of the learning process.

In terms of gameplay, one participant suggested using fire in this mission, as fire is a common hazard in libraries. Hence, the ghost, who has become angry that the players managed to reach this far in the game, ignites fire around the place. Players have to get the fire extinguisher to put out the fire in five seconds before the fire spreads and burns the library down. Further, one participant suggested to make the process of finding objects more difficult, by mandating a specific sequence. She said *"You can provide brush and mirror, so players*

need to collect the brush to dust the mirror to reveal something. This will make the game more interesting, but will not distract too much on the learning, as it is not complicated". Such variations are signature of good game design (Fullerton, 2014). Hence, some objects can be activated only after others have been clicked. For example, to find the knowledge behind the owl, players need to click on the piano to play a piece of music to entertain the owl first.

Mission Six: Search Closure

In the last stage of search closure, feelings of relief are commonly accompanied by a sense of satisfaction if the search has gone well, or disappointment if it had not (Kuhlthau, Heinström, & Todd, 2008). As suggested by one participant, the location of Mission Six was changed from the exhibition area to the library café, a place where library users relax and chat. The three IL knowledge topics in this mission include: the roles and responsibilities of an author (hidden behind a flower), plagiarism (behind a blackboard), and the importance of making citations (behind a menu). One participant thought that *"These knowledge may sound cliché, but it is very important. It is also good to wrap up the game with these kind of things"*. Other participants remarked that it was mandatory for tertiary students to have such knowledge.

The participants also noted that as this is the last mission, the players would be very excited that they are near victory. One said that *"You can make this mission difficult, as players will do all they can to complete the game at this stage"*. Hence there are two ghosts patrolling in this mission, and players have to move more cautiously. This also ensures the gameplay experience is different from the previous ones.

4.5 Design Insights

The interaction with end-users during the focus group discussion and individual user interviews yielded many valuable insights on how a PD approach can inform DGBL design. This section presents a discussion on three design insights from the process.

4.5.1 *Being Accommodating yet Pragmatic*

It is important to meet users' needs and adopt their suggestion in participatory game design; however, this becomes difficult to achieve when different participants offer suggestions that contradict each other. For instance, in the focus group, two participants suggested making the game very difficult, while others opposed the idea. The two participants suggested borrowing ideas from *Flappy Bird*, an extremely difficult but popular game. They stated that "*The game is frustrating and challenging. When you play, you keep on advancing your skills. You will actually achieve more*". Other participants who were opposed to the idea argued that they would not want to play such a game to learn. One said "*That is a turnoff already to have it so difficult*". In the above case, the game was made relatively easy in the beginning, so that players could attain a level of confidence that would ensure that they continued playing and learning. After that, the difficulty level was increased in each mission, as the players progress in the game and increase their skills. By doing this, suggestions from both camps were accommodated.

Another challenge that participants faced in Study I is their limited subject knowledge on IL education and on good pedagogy. This issue was highlighted by a participant in the interview. Being a pragmatic learner, she contended that players would expect immediate improvement and practical hands-on skills. Due to her training in journalism, where the most important news is always put in the first line of a story, she suggested that the most useful and important knowledge should be placed in the first mission, to attract the attention of players.

She said “*You need to attract people’s attention within the first three seconds, or people will soon lose interest*”. Admittedly, her perspective is probably correct in marketing and media reporting, however this goes against the order of learning from easy to difficult. Pedagogical principles, such as Bloom’s (1956) taxonomy, recommend students should understand the “what” (concepts) before the “how” (hands-on skills), although the “what” knowledge may not be the most important or interesting. This issue also underscores the importance of knowing the participants, and knowing where their perspectives come from, such as through their education, work, and other background information (Arcia et al., 2016).

The multiplicity of views from participants is what the PD approach seeks, and they are essential for the design process because they enable the discovery of new and different perspectives on design issues. The researcher needs to, on one hand, respect all participants to encourage divergent thinking for good ideas to emerge; and on the other hand, to help participants converge to reach a consensus in the final decision (Kaner et al., 2014). The PD literature seldom discusses how to reconcile multiple perspectives and different ideas from participants to arrive at the final design. When participants fail to reach agreement, the researcher can gather the different opinions, revisit the project objectives, and engage participants to explicate the assumptions and rationales for their proposals. The researcher also needs to recognize that there exist several possible solutions to any design issue. Hence an inclusive solution that incorporates different perspectives may be developed. The process of developing such a solution can help designers to think about the trade-offs in design, achieve better design consistency, and foresee the potential consequences after system implementation.

Many PD studies have found that designers exert too much control in the process and end-users are still at a disadvantage, making it difficult for their ideas to be utilized eventually (Bergvall-Kåreborn & Ståhlbrost, 2008). The recommendation is that researchers should pay greater attention to ensure effective communication with participants, and adopt participants’

input as much as possible (Guo & Goh, 2014b). However, given the imbalance in the knowledge base, the question regarding the extent to which input from participants be accommodated, and the extent to which researchers and designers take their own stand, remains. Therefore, although PD is a model that seeks to involve users and understanding their needs in the design process, the designer should be pragmatic in adopting suggestions and balancing different views, and constantly being aware of potential biases.

4.5.2 *Balancing Enjoyment and Learning*

There are two complementary purposes in DGBL: enjoyment and learning: the more players enjoy the game, the more motivated they are to learn; the more intensively they learn, the better they can play in the game. Conversely, players will not be attracted to playing the game if there is too much learning but not enough fun, while the educational intent is lost if there is so much fun that players forget, or fail to learn during the gameplay.

Striking a balance between game enjoyment and learning is a challenging issue in educational game design (Van Eck, 2010). To weave the learning content and gameplay enjoyment together, a captivating backstory is used in *Library Escape*. This allows the game rules to be incorporated into the backstory seamlessly so students can learn and acquire skills in the context the backstory provides (Guo & Goh, 2014a). The fictional backstory derived from the focus group was relatively simple: Tom is trapped in a haunted library, and he can only escape by correctly completing all six missions, with the help from a librarian, who happens to be a ghost. During the user evaluation, participants pointed out that this backstory was unconvincing. One participant noted that “*It is boring because players will just mechanically interact with the objects to uncover the IL knowledge*”. This pointed to the fact that the learning-enjoyment balance was tilted too much towards learning in the design.

In the user evaluation, while the learning content was retained, the element of enjoyment was intensified by refining the backstory, enriching the game rules, and setting more challenges. First, upon entering, a ghost asks the protagonist for help to find his magic wand in the library. In exchange, the ghost promises to provide help in learning IL knowledge along the way. Thus the protagonist has a dual mission in the game: to acquire IL knowledge with the help of the ghost, and to find the wand in exchange for his help in learning the IL knowledge he needs to master, in order to escape. Second, the protagonist now needs to find clues that will activate the objects, and from Mission Five onwards, to determine the sequence in which they have to be activated. In other words, players will no longer *mechanically* interact with the objects. The participants praised the revised game story. They liked it and said “*It is more gripping and suspenseful*”, and “*learning will be more fun*”.

Besides using interesting backstories and rules, balance can also be achieved by close integration of the educational content with challenges in gameplay. For example, in Mission Five, some objects can only be activated after others have been found. The players have to activate the piano that plays a piece of music to entertain an owl, in order to learn more about the ISP Model. They need to pick up a piece of cheese on the floor for the mouse, to reveal the knowledge on how to evaluate authors. In this way, learning and enjoyment complement each other.

Given the number of IL topics covered in each mission, the game demands intensive learning from the students during gameplay, and the difficulty level of the game is not adjustable. A better solution to sustain players’ enjoyment and continuous learning is to make the game adaptable, which means adjusting the difficulty of the educational content to match the player’s skills (Adams, 2013). For example, if the player spends too much time locating certain objects, or submits wrong answers to the same quiz question repeatedly, the game can lower the difficulty level, by providing hints, or making the subsequent questions easier.

Successful adaptive educational games provide a tailored, inherently motivating learning experience to players. Such adaptability can enhance player satisfaction and potentially improve the educational effectiveness of DGBL (García-Vergara, Chen, & Howard, 2013). As game design is an iterative process, this feature could be incorporated as part of future work.

4.5.3 *Being Guided yet Flexible*

To be pedagogically effective, the content of educational games needs to be built on sound theoretical frameworks (Walsh, Foss, Yip, & Druin, 2013). *Library Escape* adopted Kuhlthau's (2004) ISP Model to structure the mission design. Using a sound theoretical model in DGBL design enables practitioners to base their content on grounded principles, rather than on intuition or individual experience (Beale & Creed, 2009). This decision was also welcomed by participants during the focus group and interviews, as they liked the idea of breaking a large topic into smaller sub-topics., which is what happens when a theoretical model is applied.

However, theoretical frameworks from different fields may provide principles that pull the game design in opposing directions. Such is the case with how to design control in the game. Scholars of game design have argued that players should be allowed to exercise control in the game, such as that over game characters and events (Kim, Schmierbach, Chung, Fraustino, Dardis, & Ahern, 2015). According to them, game designers should hide the linear structure from players and allow them to freely probe and experiment in the game world. Players should also be given the freedom to choose the difficulty levels, so that they feel a greater sense of control. These opinions contradict the guidelines given by scholars of pedagogy literature, who suggest that dictating the “correct” sequence is desirable, as missions that introduce of new concepts can only be attempted after students have learnt the necessary vocabularies and background knowledge.

Interestingly, participants voiced both viewpoints during the focus group and interviews. When the researcher introduced the ISP Model to participants, they could relate the stages depicted in the model to their own experiences. Some participants liked it because it made the game better-organized. For example, one participant praised that *“It broke down the process of academic writing into smaller, more manageable steps. It was easy to understand”*. Others, however, preferred giving more control and freedom to players. One participant suggested that *“For example, if I have completed two missions, I can ask other players to help me. It would make the game more engaging. Maybe I would play it longer”*.

The lesson learnt here is that sound theoretical frameworks (e.g., ISP Model for IL games, or Bloom’s taxonomy more generally) should be used when designing DGBL, as they can guide the flow of learning in DGBL. Nonetheless, it is not always possible or feasible, nor does it guarantee the game’s success. Designers should also give control and freedom to players in the game world, to achieve a more immersive gameplay. Thus in *Library Escape*, the differences are reconciled by fixing the overall structure of the game in the form of six missions (i.e., being guided by theoretical frameworks), but simultaneously allowing players to control the game within each mission (i.e., giving more control to the players). For example, the players can only start *Library Escape* from Mission One, and then proceed to Mission Two, and so on. They are not allowed to skip missions or change the sequence, as the topics in each mission follow the ISP Model and the content increases from easy to difficult. However, within each mission, players can freely explore different parts and activate the objects without following any particular order, and this gives them a sense of control. The level of acceptance of this idea was validated with the participants in the user interviews, where they agreed such a structure is beneficial to players from an educational perspective. For instance, one participant noted that *“I think it is good and systematic, I support this design”*.

4.6 Chapter Summary

Chapter Four describes Study I that addresses the first research objective, to design an IL game with an affective EA using the PD approach. As a first step, three focus group discussions involving end-users were conducted to create a low-fidelity prototype. In the second step, the low-fidelity prototype was further refined through individual user interviews. Feedback from participants was summarized and used in designing a high-fidelity prototype. Study I offers empirical evidence for the value of DGBL design in IL education. The process provides insights into the perceptions of potential users on how such games should be designed. The next chapter will discuss how *Library Escape* adheres to pedagogical and game design principles to bolster its effectiveness.

CHAPTER FIVE

LIBRARY ESCAPE

The previous chapter reported how *Library Escape* was transformed from a low- to high-fidelity prototype, using focus group and user interviews under the participatory design (PD) approach. This chapter gives a full description of the entire game and how it is played. The chapter is divided into three sections. The first section recapitulates the complete game design of *Library Escape*. The second and third sections review the Attention Relevance Confidence Satisfaction (ARCS), and GameFlow Models, followed by an analysis of how the game design adheres to these two pedagogical and game design models. A more substantial evaluation of *Library Escape* is provided in Chapter Six. The last section ends with a brief summary.

5.1 A Description of *Library Escape*

After the high-fidelity prototype was generated, the game was implemented in Unity3D⁵ over six months. Figure 5.1 shows the user interface. Players use arrow keys on the keyboard to control the protagonist's movement in the game, in order to locate objects containing IL knowledge. These objects are scattered around the game space, and activated when the players mouse over them. Auditory cues are given as a hint to players when they are near an object. On the top left corner of the screen is a one-hour countdown timer, while on the top right corner is a status bar with stars and a number, showing players how many objects they have found, and how many they need to find in each mission (Figure 5.2). At the end of each mission, a portal appears on the screen for players to exit the venue (Figure 5.3). Players are

⁵ A multi-platform game development tool. Visit <https://unity3d.com/> for more information.

required to choose the venue of the next mission from a map (Figure 5.4). Table 5.1 provides an overview of the IL knowledge in each mission, including the objects it is hidden within. Each mission is described in more detail in the following.

Figure 5.1 Game Cover

Figure 5.2 Screen Layout

Figure 5.3 Portal

Figure 5.4 Map at the End of Each Mission

Mission One takes place in the closed stacks of the haunted library (Figure 5.5). Players can move around freely as the evil ghost is not in this mission. It introduces background knowledge about IL. At the front of the closed stacks, a globe in front of the bookshelf conceals information on Stage One in ISP Model; the handwheel at the side of the bookshelf, the importance of IL; and the hat on the floor, the relationship between IL and society. At the back is a scale, which conceals the knowledge on the American Library Association's (ALA's) IL standards, and the dictionary on the table conceals knowledge on the birth of IL. After locating

all the objects and learning the associated knowledge, players are led to answer three quiz questions: the year in which the term IL was coined, IL standards, and Stage One in ISP Model.

Table 5.1 Overview of Each Mission

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

*Notes: Information Search Process (ISP) Model (Kuhlthau, 2004)

Italics indicates the IL knowledge tested in the quizzes at the end of each mission.

Figure 5.5 Screenshots of Mission One

Mission Two brings the players to the open shelves (Figure 5.6). The evil ghost sleeps here and wakes up to move around occasionally. Players need to stop moving when the ghost wakes up to avoid being attacked. Players need to find and click on a magazine on the bookshelf to reveal IL knowledge on feelings of uncertainty in information search process, and look for a scroll on the wall for the causes of library anxiety. Moving around, players can find a golden key on the floor that conceals information about how to deal with library anxiety, and a stool at the corner on how to select a topic. At the back, a poster on the bookshelf conceals knowledge on what library anxiety is, and a floating balloon for Stage Two in the ISP Model. After finding the objects, players are given four quiz questions: on the basis for selecting a topic, negative feelings associated with library anxiety, causes of and how to deal with library anxiety.

Figure 5.6 Screenshots of Mission Two

Mission Three takes place in the reference section of the haunted library. In this mission, the ghost constantly moves in the center and the players need to avoid colliding into it (Figure 5.7). On the left side of the room, players encounter a grandfather clock that conceals knowledge on the scholarly publication cycle, and pick up the biscuit box on the floor to access knowledge on Stage Three in the ISP Model. They need to enter the room at the back where a French horn is lying on the shelf for knowledge on primary sources of information. In the center of the reference section is a table with a date stamp and a telephone, which conceal knowledge about journals, and secondary sources of information, respectively. The painting on the wall reveals information about tertiary sources of information. Thereafter, players answer three quiz questions on scholarly publication cycle, secondary and tertiary sources of information.

Figure 5.7 Screenshots of Mission Three

Mission Four brings the players to the digital library, a virtual space represented by an enlarged computer circuit board. They can enter the digital library through a shattered touch screen that displays many ebooks (Figure 5.8a). The computer circuit board contains a computer virus, instead of the evil ghost inside (Figure 5.8b). As the virus moves faster as players locate more objects, players need to locate objects quickly to prevent the virus from infecting the entire digital library. Information search strategies are introduced in this mission.

On the left side of the circuit is the library search bar where players can find information on successive fractions, and the Internet Explorer for Stage Four in ISP Model. On the right is a torch light that can reveal IL knowledge on the search technique of building blocks. At the far back is a skating board that conceals knowledge on how to select a focus, and Google search engine that conceals knowledge on the technique of pearl growing. Thereafter, players answer four quiz questions on how to apply the search strategies in different situations.

(a) Shattered Screen

(b) Computer Chip Circuit

Figure 5.8 Screenshots of Mission Four

In Mission Five, the evil ghost becomes furious and spews fire to burn down the library in the AV Section (Figure 5.9). Before locating and activating the objects, players should get the fire extinguisher first, as they only have five seconds to put out the fire with the fire extinguisher. If not, the fire spreads quickly and burns down the whole AV section, in which case the players have to start the mission over. At the same time, players also need to locate and click on a disk in the shelf to obtain IL knowledge on how to organize information, and an open umbrella against the wall for how to evaluate information in general. A toy bear tossed on the floor conceals knowledge on Stage Five in ISP Model. Players need first to pick up a piece of cheese on the floor to feed the mouse, before it can be activated and reveal knowledge on how to evaluate authors. Knowledge on reflective information about the ISP Model is

hidden behind the owl. Similarly, players have to click on the piano that plays a piece of music to entertain the owl before it reveals the knowledge. The three quiz questions include how to evaluate authors, information sources, and how to organize collected information.

Figure 5.9 Screenshots of Mission Five

Two ghosts roam around in the café in Mission Six, so players have to be very alert when moving around (Figure 5.10). On the left side near the bar table, players need to locate the flower vase to obtain IL knowledge on the ethical use of information, the blackboard with café menu, information on plagiarism; and the crown on a chair, citations. A guitar at the back of the stage conceals knowledge on Stage Six in the ISP Model, and a gecko on the table leg on how to start writing. After all the objects are found, the magic wand reveals itself on the floor. This is the wand that Mr. Babbage needs to restore the library. Players need to pick the wand up before they can get to the final quiz. The three quiz questions include: the six stages in the ISP Model, the actions that amount to plagiarism, and reasons for making citations.

Figure 5.10 Screenshots of Mission Six

After players successfully complete all six missions and retrieve the wand, Mr. Babbage is released from the haunted library. He thanks players for finding the magic wand, and hands over a certificate as the reward, indicating that they have finished the game (Figure 5.11a). After that, Mr. Babbage presents their performance at the quiz questions, which is calculated based on their answers and differs from each player (Figure 5.11b). However, if players fail to complete the six missions in an hour during the gameplay, they lose the game and start over from Mission One. Otherwise, they will be forever trapped in the haunted library.

(a) Certificate

(b) Quiz performance

Figure 5.11 Ending

For DGBL to succeed, two polar opposite criteria should be met: its capacity to improve students' learning performance and help them transfer the knowledge into other contexts, as

well as the capacity to provide enjoyable and engaging experience for continuous gameplay (Novak & Tassell, 2015; Hamari et al, 2016). These two criteria need to be provided in a coherent and consistent manner (Ak, 2012; Markey et al., 2014). Therefore, theoretically sound frameworks should be used in justify the design decisions of DGBL (All et al., 2015). Unfortunately, such research is scarce. The next two sections justify how *Library Escape* meets both the pedagogical and game design principles, using the Attention Relevance Confidence and Satisfaction (ARCS) Model and the GameFlow Model.

5.2 Attention Relevance Confidence Satisfaction Model

The ARCS Model (Keller, 1993) suggests that learning motivation is dependent on four perceptual components:

- *Attention* is what captures players' interest and stimulates their curiosity to play the game.
- *Relevance* motivates players because it ensures the game meets their needs and goals.
- *Confidence* compels the players to continue playing as they feel competent to complete the challenges.
- *Satisfaction* reinforces accomplishments with internal or external rewards for players.

The four components are explained below in context of *Library Escape*.

To help practitioners apply the ARCS Model, Keller (2009) provided more detailed guidance and sub-categories for analyzing the motivational characteristics. They are listed in Table 5.2.

Table 5.2 Subcategories of ARCS Model

Subcategories	Explanations
Attention	
Capture Interest	How can <i>Library Escape</i> capture players' interest?
Stimulate Inquiry	How can <i>Library Escape</i> stimulate an attitude of inquiry?
Maintain Attention	How can <i>Library Escape</i> use a variety of tactics to maintain players' attention?
Relevance	
Relate to Goals	How can <i>Library Escape</i> best meet players' needs?
Match Interests	How and when can <i>Library Escape</i> provide players with appropriate choices, responsibilities, and influences?
Tie to Experiences	How can <i>Library Escape</i> tie the instruction to players' experiences?
Confidence	
Success Expectations	How can <i>Library Escape</i> assist in building a positive expectation for success?
Success Opportunities	How will the learning experience support or enhance players' beliefs in their competence?
Personal Responsibility	How will the players clearly know their success is based upon their efforts and abilities?
Satisfaction	
Intrinsic Satisfaction	How can <i>Library Escape</i> provide meaningful opportunities for players to use their newly acquired knowledge/skill?
Rewarding Outcomes	What will provide reinforcement to the players' success?
Fair Treatment	How can <i>Library Escape</i> assist the players in anchoring a positive feeling about their accomplishment?

5.2.1 Attention

Educational games must gain and sustain the learner's attention (Keller, 2009). By providing something worth attending to, such as detailed game worlds or suspense, games should grab the player's attention quickly and maintain it throughout the gameplay. Even when a game is interesting at the beginning, players get used to it and gradually lose interest over time, so variation and changes are necessary to sustain players' attention and interest (Fullerton, 2014).

Capture Interest

Library Escape falls into the genre of role-playing room escape games, where the protagonist has to escape from a haunted library. This genre is popular and attractive to young adults, which is similar to the target audience of this game (Nicholson, 2015). Moreover, *Library Escape* attracts players' attention through its visually appealing and interesting characters. Although Mr. Babbage is a librarian, he is not a human-being as players might have expected. Instead, he is a ghost in the haunted library. The other character, the protagonist Tom, is a fashionable university student cartoon character. Mr. Babbage tells a sad story about how the evil ghost raided the library, stole his magic wand, and imprisoned him in the haunted library. Mr. Babbage pleads with Tom for help to find his magic wand so that he can break the evil ghost's spell. The story grabs the players' attention, making them sympathize with Mr. Babbage's situation, and be more willing to help him find his magic wand as they acquire IL knowledge. Further, Mr. Babbage is able to display many different affective states: he applauds, nods, and praises the players when they succeed; and displays an encouraging smile with one hand stretched out when calling for players' attention.

Stimulate Inquiry

Keller (2009) suggested using conflicts, statements or facts that may be contrary to what the learners knew or believed to be true, to stimulate learners' inquiry. Hence, a backstory incorporating conflict is presented before the game starts: the protagonist Tom believes his IL skills are excellent so he could not have possibly obtained a D for his IL module. When Professor Senka asks Tom what he thinks IL is, Tom replies it is the capability to search in Google. This echoes many students' mindset that as long as they can search in Google, their IL skills are fine. But Tom's idea is refuted by Professor Senka immediately, and she tells Tom

it is not true. By creating conflicts at the start, the game can arouse players' curiosity and grab their attention to continue the game in order to learn more about what IL really means.

Maintain Attention

In *Library Escape*, the six missions are set in different locations of the library as a source of variation to maintain players' attention. Players need to find different objects with learning content and activate them to acquire knowledge. The way to battle the evil ghost also varies in every mission. For example, in Mission Two, when the evil ghost wakes up from his nap and floats, around. players need to pause their movement. In Mission Three, the ghost moves constantly and arbitrarily, so players should plan their movements carefully to avoid colliding into the ghost.

5.2.2 Relevance

Good educational games need to be relevant to the players' learning needs. The learning content must be aligned with players' goals, and connected to their prior experiences or skills (Keller, 2009). Players need to use relevant skills to complete the tasks so that their attention is completely absorbed in the gameplay. The characters, settings, and objects in the games should also be relevant to the players' experiences.

Relate to Goals

As IL is a broad topic, selection of appropriate and relevant learning content was important for *Library Escape*. The learning content in *Library Escape* is based on the ISP Model. To ensure more students find the game relevant, *Library Escape* teaches general IL knowledge rather than

program-specific or library-specific knowledge. Moreover, the order of the educational content is arranged in such a way that students find logical, as recommended by Braghirolli, Ribeiro, Weise and Pizzolato (2016); and Walsh, Foss, Yip, and Druin (2013). It starts from conceptual foundations, then goes to practical IL knowledge, and ends in reflection of the learning process. Practical tips on information search strategies and how to use the library catalog are taught, which are perceived to be useful and relevant by students.

Match Interest

As a central element in the game, the protagonist's image in *Library Escape* is a cartoon character of a young Asian university student. Studies have found that students identify more strongly with EAs with similar demographics such as ethnicity and age, perceiving them as more engaging and relevant (Kim & Baylor, 2016; Mimoun & Poncin, 2015). The profile of the protagonist hence matches those of the target audience of *Library Escape*: tertiary students in Singapore, which matches their interest and increasing the game's relevance. Using a cartoon character rather than a realistic one can transport players out of the reality and engage in an immersive gameplay experience (Hamari et al., 2016; Rodríguez-Ardura & Meseguer-Artola, 2016).

Tie to Experience

The game characters also need to be contextually relevant and tied to players' experience (Veletsianos, 2007). Compared to board games (e.g., the *Information Literacy Game* from the University of North Carolina), or games in other settings (e.g., *Quarantined: Axl Wise and the Information Outbreak* from Arizona State University), *Library Escape* is set in a library building. The theme is more relevant to IL knowledge acquisition, potentially increasing

players' awareness of libraries. Almost every participant at the interviews supported this design idea and considered it attractive and innovative.

5.2.3 Confidence

Good educational games should provide immediate recognition for players' progress, helping them believe in themselves, and establish confidence (Ertmer & Ottenbreit-Leftwich, 2010). To build positive expectancies for success, the game should let players know in advance what exactly they have to achieve, and that they can succeed if they pay attention.

Success Expectations

In *Library Escape*, Mission One is the easiest in terms of both gameplay and learning content, so that players can familiarize themselves with the setting and rules in the game. They only need to locate all the objects and answer the quiz questions correctly to progress to the next mission. Mission One introduces general background IL knowledge, also called the "what" knowledge in the bottom of Bloom's (1956) taxonomy, such as what IL is, why it is important, IL standards, and so on. Mission One establishes the confidence of players to ensure they will continue playing the game.

Success Opportunities

To grab players' attention, *Library Escape* requires them to perform many tasks at the same time – to locate the objects, to learn IL knowledge, to answer quiz questions, to make sense of librarian's feedback, and to battle the evil ghost – all within the one-hour limit. Moreover, for players who have not understood the learning content and cannot answer the quiz questions

correctly, Mr. Babbage kindly gently urges them to return to the mission to relocate the objects and read the content all over again.

Personal Responsibility

The subsequent missions gradually become more challenging and players have to spend greater efforts to master the content. Here, the affective EA gives feedback to ease the possible negative feelings and build their confidence from time to time. He affirms players when they successfully locate objects or answers quiz questions correctly, and encourages players to continue exploration and not give up (see Figure 5.12). This process may become frustrating to some players. Hence some encouragement is offered by Mr. Babbage, such as “*Don’t be discouraged. Read the question carefully*” when players answer incorrectly.

Figure 5.12 Mr. Babbage Encourages Players

5.2.4 Satisfaction

Players need to have satisfaction and positive feelings about their experiences (Tamborini et al., 2011). To achieve this end, extrinsic reinforcements, such as rewards and recognition, can be used. Further, players should be given opportunities to immediately apply what they have learned, which leads to a higher level of satisfaction.

Intrinsic Satisfaction

User satisfaction regarding EAs' abilities are largely derived from EAs' visual appearance. Therefore, the EAs' characteristics should conform to the educational content under which the EA purports to function (Kim & Baylor, 2016). *Library Escape* employs the image of a librarian as the affective EA. To provide intrinsic satisfaction, Mr. Babbage gives encouragement and learning guidance when players encounter difficulties. He also provides scripted feedback that is tailored according to players' progress and previous attempts. For example, when the players get the answers wrong the first time, Mr. Babbage explains why that answer is wrong, and encourage the players to attempt the question again. When the players get it wrong the second time, Mr. Babbage will gently explain why their answers are still incorrect, redirect them back to the game, and remind them to relearn the IL knowledge content more carefully.

Rewarding Outcomes *Library Escape* provides two types of rewarding outcomes: immediate praises from the librarian after they succeed in some tasks, and a final certificate upon completing the entire game. For example, when players successfully locate some objects, Mr. Babbage makes statements such as “*This is not easy to find. Good job!*”, or “*You found another object, excellent!*”. After players complete all six missions, Mr. Babbage congratulates the players and issues a certificate, showing that they have escaped from the library, rescued the librarian, and become more competent in their IL skills.

Fair Treatment

The quiz questions provide opportunities for players to apply what they have learnt, and the outcomes are fair. Players can obtain a sense of satisfaction when they have mastered the learning content and are able to answer the questions correctly, thus progressing to the next

mission. When players answer correctly, Mr. Babbage gives praises such as “*Good job*” or “*Well done*”, and reinforces the knowledge to players. He also acknowledges players’ efforts in learning, and makes exclaims such as “*You are making good progress*”, and “*I have confidence in you*”. If the players fail to answer the questions correctly for two times, they will be led back to the game to understand the IL knowledge again.

5.3 GameFlow Model

The GameFlow Model was developed to design, evaluate and understand enjoyment in games (Sweetser & Wyeth, 2005). It encompasses eight components:

- *Concentration* refers to the game’s ability to keep the players focused. To capture players’ attention, the game must provide something worth attending to, such as detailed game worlds and brilliant stories. It is similar to “attention” in the ARCS Model.
- *Player skills* must be commensurate with the challenges in the game. Good games should teach players how to play the game and support their skills development through interesting examples.
- *Challenge* should be provided to the players at appropriate times. It should be balanced against player skills. Games should have various and increasing levels of difficulty to meet player’s needs and develop their skills.
- *Control* over the game interface, character, and happenings must be given to players. Players should feel that they are in charge, and they can probe and experiment in the game world at their will.
- *Clear goals* must be stated in the early stage of the game, and established through subsequent narrative or backstory.

- *Feedback* should always be provided so that players understand what actions they have completed and accomplished, allowing them to correct mistakes if any, and proceed in the right direction.
- *Immersion* happens when players fully enjoy the game through the pleasurable surrender of the mind to the game world, hopefully to the point of achieving flow.
- *Social interaction* enables players to interact, cooperate, or compete with each other, both inside and outside the game.

5.3.1 *Concentration*

It overlaps with “attention” in ARCS Model: both suggest that games should quickly capture and retain the players’ attention. As Section 5.2.1 has explained how *Library Escape* attracts and sustains players’ attention, this section will not repeat the discussion.

5.3.2 *Player Skills*

Games should support player skill development and mastery. Players need to have enough information, or be taught how to play games through interesting and absorbing tutorials, so that they can start to play the game quickly and easily (Macvean & Riedl, 2011)). Further, it is important to offer rewards so players are motivated to develop their skills in the game.

To allow players to start the gameplay easily, *Library Escape* introduces the backstory, overall goal, and demonstrates how to play the game in a series of comic strips. The interface of *Library Escape* is simple enough for players to start exploration straight away without having to read a manual. Besides the game world, the screen layout only contains a status bar on the top right corner, and a timer on the top right corner. The basic rules follow human-

computer interaction conventions: use arrow keys on the keyboard to move the protagonist, and click on the mouse to open or close dialog boxes.

Library Escape rewards players for their effort and skill development. This is achieved through the librarian's feedback to players. Mr. Babbage gives encouragement and cheers them on after each quiz question as well as at the end of each mission. For example, when the players answer all questions in the mission correctly at one go, Mr. Babbage says "*Well done. I have confidence in you!*" In another example, when players complete Mission Three, which is half way into the game, Mr. Babbage says "*Fantastic. You've reached the halfway point in your journey to learn more about IL*".

5.3.3 Challenge

Challenge is essential for good game design. Games should start easy, and increase the level of challenge as the player progresses during gameplay. New challenges should be provided at an appropriate pace that are matched with player skills, so player skills can rise in tandem. Players could derive satisfaction and enjoyment from accomplishing challenges, even when such challenges are difficult and taxing (Su, Chiang, Lee, & Chang, 2016).

Library Escape adheres to this recommended guideline, and increases challenges gradually. The first mission is designed with a low level of challenge, so that players can familiarize themselves with the activities and rules easily. The evil ghost does not appear here, so players only need to locate the objects and answer quiz questions correctly to progress to the next mission. The challenges vary and become more difficult in subsequent missions. In Mission Two, the evil ghost wakes up occasionally from sleep, so players need to pause their movement to avoid attracting its attention and being attacked. In Mission Three, the evil ghost moves constantly, so players need to be avoid colliding into the ghost while looking for objects. In Mission Four, the virus moves randomly, and increases its speed as players locate more

objects. This requires players to be fast and attentive. The evil ghost becomes furious in Mission Five and spews out fire that can burn down the library. Players need to put out the fire in a timely manner. In Mission Six, two evil ghosts float around, and players have to be strategic about their routes.

The learning content also becomes more challenging as the players progress through the missions and improve their skill level. The first two missions introduce foundational knowledge (e.g., what IL is), before analytical and procedural knowledge is taught in subsequent missions (e.g., how to evaluate information). To ensure players have sufficient time to read, digest and understand the IL knowledge, the one-hour timer pauses when players are reading the content. *Library Escape* allows players to go back to previous missions so they can review what was learnt, and use the knowledge in subsequent missions.

5.3.4 Control

Players should feel a sense of control over their actions and that can make an impact in the game (Prandi, Salomoni, Roccetti, Nisi, & Nunes, 2016). For example, players should be able to move the characters effectively at will. The changes that players make to the game world need to be consistent and noticeable. At the same time, the controls should be simple to learn and easy to use. When players make mistakes in the game, they should receive feedback to help them recognize, diagnose and correct the mistakes.

Library Escape allows players to exercise control in several ways. First, they can easily control the movements of the protagonist by using the arrow keys on the computer keyboard. They can use the mouse to click on the objects to access the learning content, and click on the close button when they finish reading. The one-hour timer pauses so players can read the

content at their own pace. The background music can be turned on and off by clicking a button beside the count-down timer.

Further, players have the freedom to explore the game space and select objects as they wish. Those objects that have been activated are indicated in the status bar as a reminder for the players. However, they can activate the objects again to access the learning content if they wish to do so. Moreover, when players answer the quiz questions wrongly, the librarian asks them to try again. If players still cannot get the correct answer, they can go back to the previous mission to learn the IL knowledge content again.

5.3.5 Clear Goals

Games should provide the player with clear goals at appropriate times. Specifically, the overall goals should be presented clearly at the start of the game, as they are important and central to the game and storyline (Zain, Jaafar, & Razak, 2012). The game can also have multiple sub-goals for the players to achieve in each mission.

Library Escape presented the overall goals of at the start: to escape from the haunted library, and find the magic wand to liberate Mr. Babbage from the evil ghost. To achieve these two goals, players need to learn and improve their IL skills by finding different objects and answering the quiz questions correctly. The goals are presented through the narration by Mr. Babbage in the backstory. Both text and images are used so that players can understand easily and quickly.

There are various sub-goals in *Library Escape* for players to complete within each mission. At the beginning of each mission, Mr. Babbage instructs the players what to do to complete it. For example, in Mission Two, players need to survive by not moving when the evil ghost awakes. Mr. Babbage warns the players that “*The evil ghost is here! Stop moving*

and keep still when he wakes up from his nap”. In Mission Five, players need to put out the fires in time to prevent the library from being burnt up, so Mr. Babbage reminds the players that *“The ghost is furious as he has not been able to thwart your progress, and his anger is causing him to breathe out fire! Use the fire extinguisher to put out the fire as soon as is possible, or the whole place will burn down”*.

5.3.6 Feedback

Players should receive frequent and appropriate feedback immediately after their actions, so players can determine how far they have progressed towards their goals (Pagano, 2013). Scores and status bars are common indicators, and they should be easily visible during gameplay. Games should also provide players with feedback when they make mistakes. Such feedback can be delivered in multiple forms, such as through the changes in interface or sound.

Library Escape provides feedback to players through both auditory and visual cues. Players receive feedback on their progress, and find out their status easily during the gameplay. To be specific, the left top corner of the screen displays a count-down timer, so players can check how long they have spent and how much time is left. On the right top corner of the screen, there is a status bar with a stars and numbers. The total number of the stars indicates the total number of objects players should locate (see Figure 5.2). The number is zero at the beginning, and increases by one after players successfully find one object. In this way, players know how many objects they have located, and how many they are short of to complete the mission. Further, a short bell-like sound is played as auditory feedback, and the object is enlarged visually whenever players walk nearby.

Scripted feedback from the affective EA is given immediately after the players submit answers to each quiz question. By using different modalities such as text in dialog boxes, facial

expressions, and body gestures, *Library Escape* provides appropriate feedback. For example, Mr. Babbage applauds, nods, and praises the players when players' answers are correct (see Figure 5.13a). He displays a patient smile with one hand stretched out when the answers are incorrect (see Figure 5.13b).

(a) Feedback for Correct Answers (b) Feedback for Wrong Answers

Figure 5.13 Affective Feedback from Mr. Babbage

5.3.7 Immersion

Good games draw players into the game world and keep them engaged and immersed, through cues such as sound effects and background music (Jegers, 2007). The objects in the game need to make sense and be consistent with the game environment, so players have an altered feeling of being transported to the game environment. Immersion can also be achieved through narrative presence. For example, narrative through storyline or conversations is also important for immersion, telling players who their characters are, and the roles they play, which makes the players feel that they are part of the story.

To create an immersive experience for players, *Library Escape* provides multiple channels of sensory cues, such as color, music, a backstory, and game characters. The library is dimly lit, the furniture is broken, an evil ghost floats around, and the background music is

mysterious and creepy. The character design of Mr. Babbage also increases players' immersion and is consistent with the game environment. He is designed as a ghost who floats around in the haunted library. All these design decisions create an eerie, haunted atmosphere in an abandoned library.

Library Escape also creates an immersive experience through detailed design of the game world and objects. Each mission is set in different locations of the haunted and dilapidated library, where the objects are covered with spider webs and dust, and where geckos and mice roam. Mission Three, for example, is set in a reference section of the library where the wooden floor has cracked, computers rusted, and clock stopped. Mission Six is set in the library café, an increasingly common inclusion of libraries. The flowers on the desk have withered, the menu written on the blackboard has faded, and the glass door of the fridge is dirty. The attention to design details maximizes players' immersion.

5.3.8 Social Interaction

Library Escape was designed as a single-player game, hence social interaction is not supported in the game. There are three reasons. First, the element of social interaction was not in the Flow Theory from Csikszentmihalyi (1997). Although it was added into the GameFlow Model given the rise of massively multiplayer online games, the authors also noted that sometimes social interaction during gameplay can interrupt immersion, as real people provide a link to the real world and this can dislodge players from their fantasy game worlds (Sweetser & Wyeth, 2005). Second, participants from the PD study (see Section 4.3.1) regarded learning as a solitary activity, rather than a social one. Third, designing a multi-player game that supports social interaction among players would significantly increase the cost and time for the game, which

was practically not feasible for this PhD research. Hence, it was decided that *Library Escape* should be a single player game.

5.4 Chapter Summary

This chapter describes *Library Escape*, and justifies its game design decisions based on pedagogical principles of the ARCS Model, and game design principles of the GameFlow Model. *Library Escape* teaches general IL knowledge rather than library or institution specific knowledge, making it relevant to more students. The challenge level increases gradually, and is matched to players' knowledge gain in the game.

The affective EA, in the form of a ghost librarian, contributes to the game in different ways. For example, a ghost librarian is consistent with the theme of the game, which is about escaping an eerie and haunted library. The story told by Mr. Babbage at the start of the game sets clear goals for the players, and pulls them from reality into the game world. Mr. Babbage is also capable of displaying different body gestures to attract players' attention, such as applauding, nodding, and displaying an encouraging smile with one hand stretched out. The affective feedback from Mr. Babbage is relevant to the game, and establishes players' confidence and satisfaction. For instance, he affirms players when they successfully locate objects or answers quiz questions correctly, and explain why players' answers are wrong, and encourage the players to try the questions again, or revisit the previous missions.

Further, it is worthwhile to note that *Library Escape* has met the three characteristics of information literacy (IL) knowledge acquisition mentioned in Section 2.1.2: as a process that involves affective feelings, as a process of meaning construction, and as a process that involves higher-order thinking skills. First, the affective feedback from the embodied agent (EA) could address the affective feelings of players. For example, the encouragement and

acknowledgement when players make mistakes will help boost their confidence. Second, *Library Escape* gives freedom to players to construct their own IL knowledge in the game, where they can explore different concepts at their own pace. Third, the IL knowledge in the last two missions in *Library Escape* supports higher-order thinking skills, as players can apply the conceptual knowledge to solve the quiz questions.

In sum, *Library Escape* adheres to all the criteria in the two models with the exception of social interaction, thus ensuring its pedagogical effectiveness and enjoyable gameplay experience for players. The game evaluation will be reported in Chapter Six.

CHAPTER SIX

STUDY II – GAME EVALUATION

This chapter discusses Study II, which fulfills the second research objective: to examine the influence of affective embodied agents (EAs) in the information literacy (IL) game on tertiary students' learning outcome, motivation, enjoyment, perceived usefulness and behavioral intention. This chapter is organized into five sections. The first section briefly introduces the three versions of the IL game for the experimental evaluation. The next section describes the research design of the pretest-posttest between-subjects experiment, as well as the supplementary qualitative interviews. The third section details the experiment results. The penultimate section provides an in-depth discussion based on results from the experiment and the qualitative interviews. The last section concludes this chapter with a summary.

6.1 Introduction

Library Escape was used to investigate the influence of using affective EAs in IL games. Three versions of the game were created for comparison: affective-EA, neutral-EA and no-EA. Specifically, the original *Library Escape* game described in Chapter Five is used as the experimental condition (i.e., affective-EA condition). Two more versions were created as control conditions: neutral-EA and no-EA conditions.

In the affective-EA version, the EA (i.e., the librarian) displays affective feedback through verbal and nonverbal cues of scripted dialogues, facial expressions, and body gestures (see Figure 6.1). First, in terms of scripted dialogue, when players locate different objects containing IL knowledge, the librarian praises the players with statements such as “*Great, you have found an object*”, or “*Awesome, one more object is found, and we are closer!*” Elaborate

feedback is considered as a characteristic of affective interactions (Lin et al., 2013). Therefore, when the players answer correctly, the librarian praises the players, such as “*Well done*”, “*Good job*”, or “*Excellent*”, and then explains in detail why the answers are correct. When the players get the answers wrong the first time, the librarian explains why that answer is wrong, and encourages the players to try the question again with phrases such as “*Try again, you can do it*”. When the players get it wrong the second time, the librarian reminds them to read the content more carefully, and redirects them back to the game. Second, in terms of facial expressions, the librarian displays smiles to show that he is happy, excited and pleased when the players find objects or answer the questions correctly. Finally, in terms of body gestures, the librarian claps his hands to praise the players, raises up the hands to call for attention when he explains to the players, or puts down the hands by the side when the players keep getting wrong answers.

Figure 6.1 Affective-EA Version

The neutral-EA and no-EA versions differ from the affective-EA version in the librarian character. All other aspects remain the same, including missions, objects, educational content, rules, time limits, and the antagonist. In the neutral-EA version, the librarian maintains a neutral

facial expression and body gesture throughout the game, and the scripted feedback is factual, without affective cues (see Figure 6.2). Specifically, after the players submit answers to quiz questions, the librarian will say “*Yes, that is correct*” when the answers are correct; or “*No, that is wrong*” when the answers are incorrect. In the no-EA condition, the librarian is absent and all factual feedback is displayed in the center of the screen (see Figure 6.3).

Figure 6.2 Neutral-EA Version

Figure 6.3 No-EA Version

6.2 Research Methods

This section explicates the quantitative experimental evaluation procedure and hypotheses formulation. Thereafter, the supplementary qualitative interview procedure is presented.

6.2.1 Experiment Procedure

Recruitment commenced upon the approval of the study's application by Nanyang Technological University (NTU) Institutional Review Board (see Appendix B-1). Convenience sampling was employed, where people who were available and willing to participate in this study were recruited (Shadish, Cook, & Campbell, 2002). Although results from convenience sampling are not generalizable to the entire population, this method is most commonly used, and has the advantage of being easy and fast to obtain participants at low cost (Creswell, 2013). Further, NTU is a large public university that offers a variety of education programs, hence the students matched the intended audience of the IL game: tertiary students with different education backgrounds. Their insights can hence be used to explore the influence of affective EAs in an IL game as the first step.

Study II used a pretest-posttest between-subjects design. Although the between-subject design approach has the disadvantages of individual variability and confounding variables. Such an approach was chosen over within-subjects design as it would take at least three hours for each participant to play through all three versions of the game, and the fatigue effect would pose threats to internal validity of the survey instrument (Creswell, 2013). Further, the pretest-posttest between-subject design approach is consistent with other studies such as that of Lin et al. (2013), and Mayer and DaPra (2012).

The evaluation was conducted in a controlled laboratory setting, and participation in this study was voluntary and confidential. Participants were randomly assigned to one of the three conditions: affective-EA, neutral-EA and no-EA conditions. After the participants came to the laboratory, they were briefed on the purpose of the study, which was to evaluate a newly developed IL game, and signed the online consent form if they had no objections. The online consent form stated that participants had the right to withdraw from the experiment at any point, and they could obtain further information from the researchers. No participant withdrew during

the study. The experiment started with a short online pretest questionnaire. Thereafter, they opened the IL game file stored on the local computer and played the game. After that, participants completed the posttest questionnaire. Both the pretest and posttest questionnaires are found in Appendix B-2. The entire study lasted approximately 90 minutes, depending on participants' progress in the gameplay. In total, 159 students participated, and each was given S\$10 as a token of appreciation.

The pretest questionnaire contained ten multiple-choice questions, which aimed to assess students' prior IL knowledge. The ten questions covered various IL topics, such as how to access information, how to use Boolean operators, and evaluate information sources.

The posttest questionnaire for the neutral-EA and no-EA conditions comprised seven sections, while that of affective-EA condition comprised an additional section on participants' perceptions of the affective EA. The first section assessed the effectiveness of the EA manipulation with one question. Participants were asked to choose whether the librarian in the game: (1) expressed emotions, (2) did not express emotions, or (3) was not applicable. The second section assessed participants' learning outcome: the amount of IL knowledge that they retained from the game. The subsequent four sections measured students' learning motivation, enjoyment, perceived usefulness, and behavioral intention, respectively. Participants rated their level of agreement to the statements on a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5), with a neutral response in the middle (3). In the penultimate section, participants were asked to write down the knowledge they had learnt from the game, as well as their subjective opinions of the game, and how to improve it. The final section collected demographic information, including age, gender, nationality and education background.

There was one more section in the posttest question for the affective-EA condition: their perceptions of the EA. The Agent Personal Instrument (API), developed by Ryu and Baylor (2005) was used to measure learners' perception towards EAs in educational systems.

The API was developed based on prior studies, and comprises four observable sub-constructs: facilitating learning, credible, human-like, and engaging. The API has been validated in other studies. It showed high construct validity when used to investigate *Survey Sam*, an affective EA that delivered affective messages (apologetic or empathic) when students felt frustrated (Baylor & Rosenberg-Kima, 2006). Similarly, the API showed good face and construct validity when used to evaluate a simulation-based training system with an EA that delivers explicit feedback to support training events in the absence of live instruction (Goldberg, 2013). Further, Shiban et al. (2015) translated the API items into German language to evaluate an EA that can offer learning cases to help university students prepare for exams, and the scale showed high internal consistency and reliability (Cronbach $\alpha = .94$).

6.2.2 Hypotheses Development

As discussed in Chapter Two, using affective EAs in digital game-based learning (DGBL) has positive impact on students, such as improving their learning outcome, heightening motivation, enhancing enjoyment, increasing perceived usefulness and user acceptance, as well as reducing their negative affect in the learning process. Therefore, this section explicates the hypotheses based on these five major variables: learning outcome, motivation, enjoyment, perceived usefulness and behavioral intention.

Learning Outcome

Learning outcome is an important measurement in the evaluation of any educational system. Higher learning achievement is both the most important reason for, and direct result of any learning intervention (Krämer et al., 2016). Positive affect is critical to enhance effective learning as it encourages creativity and exploration of alternatives (Schneider et al., 2015).

Further, the social cues in EAs prime a feeling of social partnership in learners, leading to deeper cognitive processing and better learning (Kim & Baylor, 2016).

Some studies have successfully demonstrated that using affective EAs in DGBL can lead to deeper understanding of the educational content, and enhance learners' ability to retain the knowledge and apply it in other contexts (Chen & Chou, 2015; Krämer et al., 2016). For example, Lin et al. (2013) found that the mere visual presence of an EA did not have significant impact on learning performances. However, when combined with elaborate and affective feedback, the EA was able to significantly increase students' learning outcomes. Further, Mayer and DaPra (2012) examined the use of affective EAs with gestures, facial expressions, eye contact and human-like movements on students' learning outcome and enjoyment experience. The social cues in the EAs led to deeper cognitive processing, and a more meaningful learning experience for the students. Therefore, the following hypothesis is proposed to examine the influence of affective EA in an IL game on students' learning outcome. Specifically, this hypothesis is concerned with how well students retained the knowledge after playing the game, while controlling for their prior IL knowledge:

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

Motivation

Motivation may be considered one of the most important prerequisites in learning, and affective EAs can increase learners' motivation by minimizing the communicative gaps in interactions between human and computers (Lin et al., 2013). With affective EAs, learners are more motivated to make sense of what is being presented to them, thus achieving meaningful

learning. The four perceptual components of motivation: attention, relevance, confidence and satisfaction, are discussed below (Keller, 1993, 2009).

Firstly, the social presence of EAs can actively engage students, and increase their interest and attention in learning (Kim & Baylor, 2016). For example, Cassell (2000) developed an EA as a humanlike interlocutor, which was capable of making basic conversations and body gestures (such as the movements of head and body). Furthermore, it is important to consider both verbal and nonverbal behaviors in EAs, as nonverbal behaviors from EAs can add information on what is conveyed by speech (Lin, Atkinson, Christopherson, Joseph, & Harrison, 2013). In this aspect, Lee, Kanakogi, and Hiraki (2015) developed a three-dimensional male EA, which was voiced by a male Korean-Japanese bilingual speaker, and was able to simulate gazing and different facial expressions. The result revealed that students who interacted with the EA paid more attention to the educational content, and scored considerably higher. Therefore, incorporating functions such as conversations, facial expressions and body movements in EAs has positive effect on attracting users' attention, and the following hypothesis:

Hypothesis 2A: Students in the affective-EA condition pay significantly higher levels of attention, compared to those in the neutral-EA and no-EA conditions.

Secondly, the visual appearance and aesthetic characteristics of EAs may influence learners' perceptions of EAs' relevance, an idea that is closely related to the first impression and stereotypes (Fox et al., 2015; Veletsianos, 2010). In other words, the EAs that are portrayed to fulfill the functions they are designed to will be perceived more relevant. Conversely, EAs that do not have lower relevance, and may disrupt learning. In this aspect, van der Meij and colleagues (2015) designed a young female EA that teaches kinematics, and results suggested participants who interacted with the EA found the learning tasks to be more relevant. Based on the above discussion, this study posits the following hypothesis:

Hypothesis 2B: The IL game is perceived to be significantly more relevant by students in the affective-EA condition, than those in the neutral-EA and no-EA conditions.

Thirdly, as with human instructors and teachers, the feedback and support from EAs can help learners pursue and conquer learning tasks, increasing their efficacy and confidence in the process (Lin et al., 2013). To investigate this point, Doumanis and Smith (2013) found that participants who used the tour guide application with the EA retained learning content of variable difficulty more consistently, than those who used the application without the EA. More interestingly, the qualitative interviews with participants indicated that the use of EAs positively impacted their perception of the difficulty of the learning content, which can potentially lead to enhanced confidence to learn more difficult content. Further, affective EAs that are able to give affective feedback can increase learners' confidence by reinforcing positive thinking and rapport building (Kim & Baylor, 2016). For example, affective EAs that are enthusiastic and energetic can establish learners' confidence very effectively (Lane, 2015). The following hypothesis is thus proposed:

Hypothesis 2C: Students in the affective-EA condition have significantly higher levels of confidence, compared to those in the neutral-EA and no-EA conditions.

Fourthly, feedback serves as a bridge between students and teachers. Good feedback delivers high-quality information to students about their learning, and encourages positive motivational beliefs and self-esteem of students (Orsmond & Merry, 2013). Hence proper feedback is important to enhance the learners' satisfaction towards the EAs in DGBL (Schroeder & Adesope, 2014). Affective feedback such as encouragement, praise and reinforcement from affective EAs will decrease negative emotions and frustrations, and make learners feel appreciated, thus leading to higher satisfaction. For example, Robertson et al. (2015) designed an EA as a health decision aid that used recorded voice-over audio

clips, synchronized with nonverbal cues such as mouth motions, eyebrow raises, head nods, facial emotions (concern, empathy, hope), and body postures. They found that participants had higher levels of satisfaction and acceptance after interacting with the EA. Accordingly, the following hypothesis is posited:

Hypothesis 2D: Students in the affective-EA condition have significantly higher levels of satisfaction, compared to those in the neutral-EA and no-EA conditions.

Enjoyment

Enjoyment is a critical element in hedonic systems such as games (Kim et al., 2015). The ability to provide enjoyable and entertaining interactions is crucial for improving EAs' believability and trustworthiness (Chen et al., 2012). The social cues from EAs, such as joy and empathy, can enable users to interact with them more comfortably, thus making the interactions more engaging and enjoyable (Corti & Gillespie, 2016; Krämer et al., 2016). The three hypotheses on affective enjoyment, cognitive enjoyment and behavioral enjoyment are presented below.

For affective enjoyment, the presence of affective EAs can provide companionship and support for students (Chen et al., 2012). For example, Ring, Barry, Totzke, and Bickmore (2013) developed an affective EA that was capable of simulating human conversational behaviors through synthesized voice and synchronized non-verbal behaviors such as hand gestures, head nods, posture shifts, and facial expressions. The affective companionship and social support from the EA were effective in easing negative affects of loneliness and sadness. Further, affective EAs that are empathic can mediate the negative feelings such as boredom and frustration during the learning process, thus positively influencing students' emotional states (Krakowiak & Oliver, 2012). Arroyo and associates (2016) found that using an emphatic EA

reduced boredom and anxiety from students and provided emotional benefits in the learning process. Thus the following hypothesis is proposed:

Hypothesis 3A: Students in the affective-EA condition derive significantly more affective enjoyment, compared to those in the neutral-EA and no-EA conditions.

Affective EAs can enhance the cognitive enjoyment by creating social agency environment for students, where students can exchange social interaction and receive social support from EAs (Roubroeks, Ham, & Midden, 2011). Students may perceive such learning process to be easier. For example, Jin (2010) evaluated an EA to convey health-related educational messages via a text-modal dialogue box to users. Results suggested that participants who took the online test with EA perceived the test process more enjoyable than those without. The interactions with EAs can engage learners mentally, potentially increasing their cognitive enjoyment (Schroeder & Adesope, 2014). The discussion leads to the following hypothesis:

Hypothesis 3B: Students in the affective-EA condition derive significantly more cognitive enjoyment, compared to those in the neutral-EA and no-EA conditions.

For behavioral enjoyment, with the positive attitudes brought by EAs, learners become more interested in the learning process. From the behavioral level, students may become more excited about playing the game, and more thoughtful in considering the IL knowledge in the game (Tsay-Vogel & Nabi, 2016). For instance, Tegos, Demetriadis, and Tsiatsos (2014) designed *MentorChat*, a dialogue-based EA that could support students in collaborative learning. Most students felt more engaged, and perceived their learning experience more useful when *MentorChat* provided directed interventions. Moreover, in the face of obstacles and challenges during learning, students are likely to experience frustration and boredom. Using affective EAs can effectively engage learners, pull them out of the state

of negative emotions, and help them regain the state of flow (Taub, Martin, Azevedo, & Mudrick, 2016). Thus, this study offers the following hypothesis:

Hypothesis 3C: Students in the affective-EA condition derive significantly more behavioral enjoyment, compared to those in the neutral-EA and no-EA conditions.

Perceived Usefulness

The fourth variable is perceived usefulness, defined as the extent to which people believe that using the system will improve their performance. Using affective EAs may help people perceive the educational systems to be more useful in meeting their learning needs (Lin, et al. 2013). Learners' first impression towards the EAs comes from their characteristics such as appearance, body gestures, or facial expressions (Fox et al., 2015; Veletsianos, 2010). Similar to the idea of first impression, these characteristics have an immediate impact on learners' perceived usefulness of the EAs (Nass, & Reeves, 1996). A study conducted by Romero-Hall, Watson, Adcock, Bliss, and Tufts (2016) found that both experienced and novice workers found the EA to be more useful and engaging when its characteristics display affects. Further, Lee (2010) found that perceived usefulness had a significant influence on their continuous usage intention of the learning program. Thus the following hypothesis is proposed:

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

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). Behavioral intention has frequently been used as a surrogate for actual performance (Bickmore et al., 2013). The

EAs with human-like features can influence users' perceptions of trust, enjoyment, which in turn their intentions to use (Schroeder & Adesope, 2014). For example, Chae, Lee and Seo (2016) found that the social presence of EAs had significantly influence on people's usage intentions. Additionally, the positive attitudes such as pleasure, trust, and satisfaction brought by using EAs in DGBL will increase people's acceptance and usage behaviors (Kim & Baylor, 2016; Liu & Picard, 2005). As a result, the chance of users' continuous interaction with the learning content, and recommending their positive experience to others, will also be increased (Chen & Chou, 2015). In this study, behavioral intention comprises three dimensions: intention to play other IL games, intention to learn more about IL, and intention to recommend this game to others. Given this discussion, the following hypothesis is proposed:

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

6.2.3 *Supplementary Qualitative Interviews*

To elicit more detailed feedback on the IL game and EA design, individual interviews were conducted in addition to the experiment. The interviews also served to triangulate and enhance the validity of findings from the experimental evaluation. The interview protocol was submitted in the same Institutional Review Board application as that of the experimental study (see Appendix B-1).

After the experiment, heterogeneous purposive sampling was used to select participants from the affective-EA condition for the interviews, as participants of heterogeneous profiles were more likely to contribute diverse ideas and maximize the range of perspectives that could be captured in the discussion (Seidman, 2013). Specifically, participants were selected by their

observed engagement level during the gameplay in the experiment, ranging from those minimally engaged (those who appeared impatient and exited the game within 30 minutes after they failed to answer the questions several times), to those deeply engaged (those who looked excited and completed all the missions at one go), to those persistent ones (those who took more than two hours to complete the entire game). Further, participants from different education backgrounds and programs were selected (Collier, Moffatt, & Perry, 2015). The sample size for interviews was not predetermined: the data collection stopped at the point of saturation (Seidman, 2013). In other words, when the comments from participants could not provide new insights anymore, no more interviews were held.

To create a conducive environment that participants feel relaxed and comfortable to talk, various locations were used for the interviews, such as meeting rooms, Starbucks cafes, McDonalds restaurants, lecture theaters, and private homes. Each interview lasted for approximately one hour, and were all audio-recorded. The interviews were carried out according to the instructions on the protocol in the application to Institutional Review Board.

At the start of each interview, participants were briefed on the research objective, which was to freely discuss the IL game that they had played, especially on the affective EA (i.e., the librarian). After that, they were asked to read the consent form, and to sign it if they had no objections. The interviewer first refreshed their memories about the game by showing them some screenshots in each mission. The interview started with three simple questions: “*What do you like in the game?*”, “*What do you dislike in the game?*”, and “*What and how can it be improved?*” Participants were also asked to elaborate on how they perceived the librarian, how the librarian helped them, or why the librarian failed to help them in the game. After these questions, the interviewer probed for in-depth explanations and constructive suggestions from participants, mission by mission. Thereafter, the interviewer went on to ask: “*Why do you think your suggestion will work?*”, “*What are the advantages of your suggestion?*”, “*Are there*

potential problems?”, “*How will you implement it?”*, and so on. After each interview, the participant was thanked and each paid S\$10 as a token of appreciation for his/her contribution.

6.3 Results

This section describes the results of the experiment, by first presenting the sample characteristics and manipulation check. The second section details the results from validity and reliability testing, and the operational definitions of each measurement instrument. The third section presented data analyses procedure of the quantitative experiment in SPSS. Analysis of covariance (ANCOVA) was first used to test Hypothesis 1. The other four hypotheses were tested by one-way between-subject analysis of variance (ANOVA). This was followed by post hoc comparisons using Tukey’s HSD test.

The qualitative interviews were transcribed to a Microsoft Word document, constituting 68 pages. However, as the interviews aimed to supplement findings from the quantitative experiment, the transcription was not coded or analyzed for recurring themes. Participants’ insights were used to enrich the discussions for the experiment in Section 6.4.

6.3.1 Sample and Manipulation Check

Table 6.1 shows the demographics of the quantitative experiment sample, including the breakdown across the three conditions. The sample was balanced in terms of gender, consisting of 81 (50.94%) male and 78 (49.06%) females. Their age ranged between 18 and 40, with an average age of 22.43 years and standard deviation of 3.35. With regards to their education background, more than half (61.00%) were from engineering, 20.13% from social science, and the rest 18.86% from the natural sciences and business.

Table 6.1 Sample Description for Quantitative Experiment ($n = 159$)

	Affective-EA ($n=53$)	Neutral-EA ($n=52$)	No-EA ($n=54$)	Total
Gender				
Male	32 (60.4%)	24 (46.2%)	25 (46.3%)	81
Female	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

Chi-square analysis indicated that the manipulation was largely successful, with $\chi^2(4) = 241.35$, $p < .001$. Participants 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).

For the qualitative interviews, four males and four females, aged between 21 and 35 were selected (see Table 6.2). Four participants studied arts, humanities and social science, three studied computer engineering, and the other two studied medical science and business respectively. All the participants reported that they played digital games for at least an hour per week. Among the five participants who played more than four hours per week, two were heavy gamers playing more than fifteen hours per week.

Table 6.2 Participants' Demographics in Qualitative Interviews ($n = 8$)

	<i>n</i>
Gender	
Male	4
Female	4
Age	
21 to 25	3
26 to 30	3
Above 30	2
Education Background	
Social science	2
Computer engineering	2
Humanities	2
Business	1
Medical science	1
Music	1
Educational Programs	
Bachelor	4
Masters	3
Doctor of Philosophy	1
Time Spent Playing Games Per Week	
Less than 4 hours	3
More than 4 hours	5

6.3.2 *Reliability and Validity*

In the first step, the factorability of the constructs was examined. The Kaiser–Mayer–Olkin measure of sphericity was 0.915, which well exceeded the threshold of 0.60. The Bartlett's test of sphericity was significant at $p < .001$ level. Both results suggested that the sampling was adequate (Dziuban & Shirkey, 1974). Principal component analyses with varimax rotation was used to test the external validity of all constructs. Oblique rotation method was selected to facilitate the interpretation of results. In the second step, the reliability of the measurement instrument was evaluated using Cronbach's alpha. The details are presented below, as well as the operational definitions of the measurement instruments.

Learning Outcome

Students' IL knowledge was tested twice, in the pretest questionnaire, and the second section of the posttest questionnaire. Each set of questions comprised ten multiple-choice items. To reduce testing effects, the two sets of questions were different but matched in terms of topic and difficulty (Schneider et al, 2015; Atkinson, 2002). An expert in library science and experimental studies was consulted to improve the questionnaires. The questionnaires were modified based on suggestions given.

The items were based on American Library Association's (ALA's) IL standards (2000). More specifically, three items were asked on the IL standard of *information access*, including how to get started with academic information search, how to use OPAC, and the publication cycle. On the standard of *information search*, three items were asked: how to perform keywords searching, how to use Boolean operators, and how to combine different search techniques. For *information evaluation*, two items were asked on how to evaluate journals, and how to evaluate websites. Finally, two items of copyright and plagiarism were asked on the standard of *information citation*. For example, the question of "*Which of the following is the best criterion to evaluate the credibility of an Internet site?*" was asked on information evaluation, 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?*" on information search strategies. The Cronbach's alpha for learning outcome was not calculated here since the pretest-posttest were constructed to assess a variety of IL topics measuring different IL knowledge units (Lin et al., 2013).

Motivation

Learning motivation was measured in the third section in the posttest questionnaire. The ARCS scale by Keller (2009) was adapted with minor changes to suit Study II's context. Specifically, the original purpose of the scale was to investigate the motivational issues in courses, and used "modules/courses" in the items. Hence, the posttest questionnaire here changed to "IL game". The scale consisted of 36 items (see Table 6.3).

- **Attention.** It measures the interest and response displayed by learners during the learning process. Twelve items were utilized to assess students' attention, and they had a mean value of 3.05 (SD = 0.57, Cronbach α = .772).
- **Relevance.** Learners should be familiar or can relate to the language and examples used in the educational content. Relevance was measured with nine items, with a mean value of 3.39 (SD = 0.59, Cronbach α = .759).
- **Confidence.** It is about learners' positive expectation towards their performance. The nine items used to measure confidence had a mean value of 2.92 (SD = 0.52). The Cronbach α value was .620, which is below the recommended .70 threshold. However, the sub-construct of confidence in the ARCS scale has consistently been found to be the lowest among the four sub-constructs in prior studies (Choustoulakis & Nikoloudakis, 2011; Keller, 2009). Hence, all the items were kept.
- **Satisfaction.** It refers to learners' positive feelings about the learning experience, which could be obtained from a sense of achievement, praise from a higher-up, or rewards. The sub-construct was assessed with four items, and the mean value was 3.26 (SD = 0.80, Cronbach α = .817).

Table 6.3 Principal Component and Reliability Analyses for Motivation

Scale Items	Components				α
	1	2	3	4	
Attention					.772
• There was something interesting that got my attention.	.694	-.060	-.129	.038	
• The interface design is eye-catching.	.765	.023	.069	-.005	
• The quality of the game helped to hold my attention.	.720	.035	.084	-.041	
• The game was so abstract that it was hard to keep my attention on it.	.686	.093	.060	-.226	
• The design of the IL game looks dry and unappealing.	.644	-.033	-.111	-.010	
• The way the information is arranged in the game helped keep my attention.	.803	-.080	.125	-.071	
• I learned some things that were surprising/unexpected.	.781	-.025	-.051	.090	
• The amount of repetition caused me to get bored sometimes.	.574	.012	-.098	-.097	
• The variety of knowledge helped keep my attention on the game.	.580	-.076	.008	-.114	
• The game has things that stimulated my curiosity.	.556	-.109	.098	.025	
• The style of writing in the game is boring.	.734	.032	-.023	-.010	
• There are so many words on each screen that it is irritating.	.729	.039	-.068	.047	
Relevance					.759
• I could relate the content in the game to things I have seen, done or thought about on my own.	.141	.029	.634	.162	
• It is clear to me how the content is related to things I already know.	-.041	-.256	.799	.169	
• There were examples that showed me how the game could be important to some people in the learning setting.	.207	.085	.872	.379	
• Completing the game was important to me.	.020	.139	.740	-.147	
• The content is relevant to my interests.	.230	.023	.570	.333	
• There are explanations or examples of how people use the knowledge in the game.	.062	.163	.546	-.303	
• The content conveys the impression that its content is worth knowing.	.002	.200	.620	-.231	
• The game was not relevant to my needs because I already knew most of it.	.142	.036	.647	.241	
• The content will be useful to me.	.179	.081	.720	.107	

Scale Items	Components				α
	1	2	3	4	
Confidence					.620
• The game had so much information that it was hard to pick out and remember the important points.	.009	.588	-.021	.297	
• After playing the game for a while, I was confident that I would be able to pass a test on the content.	-.128	.786	-.143	.030	
• As I played the game, I was confident that I could learn the content.	.073	.581	.051	-.025	
• The game was too difficult.	.091	.751	.160	-.075	
• When I first played the game, I had the impression that it would be easy for me.	.128	.745	-.069	.013	
• The game was more difficult to understand than I would like for it to be.	-.103	.744	.013	-.114	
• After reading the introductory information, I felt confident that I knew what I was supposed to learn from the game.	-.056	.660	-.080	.024	
• I could not really understand quite a bit of the material in the game.	-.124	.752	-.090	-.056	
• The good organization of the content helped me be confident that I would learn this material.	-.056	.624	-.076	.024	
Satisfaction					.817
• It was a pleasure to play such a well-designed game.	.179	-.028	-.097	.597	
• I enjoyed the game so much that I would like to know more about this topic.	.175	.088	.014	.421	
• It felt good to successfully complete the game.	.206	.094	-.244	.575	
• I really enjoyed learning with the game.	.330	-.098	.014	.730	
• Completing the game gave me a satisfying feeling of accomplishment.	.298	.342	.188	.840	
• The wording of comments in the game helped me feel rewarded for my effort.	-.067	-.152	-.270	.497	
Variance Explained (%)	29.19	15.02	7.68	6.35	
Eigenvalue	6.38	4.41	2.76	3.91	

Enjoyment

Enjoyment was measured in the fourth section in the posttest questionnaire. This was assessed with 12 items based on the Tripartite Enjoyment Model scale by Fang, Chan, Brzezinski, and Nair (2010). Each dimension was measured with four items (see Table 6.4).

Table 6.4 Principal Component and Reliability Analyses for Enjoyment

Scale Items	Components			α
	1	2	3	
Affective Enjoyment				.813
• I felt attracted to this game.	.419	.561	.064	
• I felt emotionally attached to the game.	.027	.927	-.045	
• I felt emotionally affected while playing the game.	-.033	.933	-.017	
• I felt emotionally involved in the game.	.056	.869	.008	
Cognitive Enjoyment				.989
• I think this game is an effective way of learning IL skills.	.928	-.137	.029	
• I think this game is a good way of learning IL skills.	.896	-.049	.023	
• I think it is worthwhile to play the game.	.799	.140	.009	
• I think this game is an interesting way of learning IL skills.	.847	.096	-.024	
Behavioral Enjoyment				.806
• I was less worried about my life while playing the game.	-.010	.427	.529	
• I became less aware of my surroundings because I was engrossed in playing the game.	.005	.113	.715	
• I lost track of time while playing the game.	-.034	.027	.855	
• I was less self-aware while playing the game.	.086	-.154	.860	
Variance Explained (%)	45.58	14.34	11.69	
Eigenvalue	5.47	2.72	2.16	

- **Affective Enjoyment.** It is the individual's willingness to invest emotionally in the experience. The sub-construct had a mean value of 3.15 (SD = 0.88, Cronbach α = .813).
- **Cognitive Enjoyment.** It refers to the willingness to develop skills and solve problems. The mean value was 3.26 (SD = 0.96), and the Cronbach α value was .989.
- **Behavioral Enjoyment.** This refers to the effortless involvement in the activity on a kinesthetic level, when people are immersed in the situation. The items had a mean value of 3.16 (SD = 0.91, Cronbach α = .806).

Perceived Usefulness

Perceived usefulness was in the fifth section of the posttest questionnaire. It was measured using three items (Venkatesh & Bala, 2008). The three items 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*”. The mean value of the three items was 3.34 (SD = 0.85), and the Cronbach α value was .844.

Behavioral Intention

The sixth section in the posttest questionnaire was on behavioral intention. Behavior intention measures the learners’ self-reported subjective willingness to perform or not perform specified behaviors in the future. It was adopted from an existing survey instrument by Bourgonjon, Valcke, Soetaert, de Wever and Schellens (2011). The use of “system” was replaced with “IL game” to suit the context of Study II. It included three sub-constructs, each of which was measured with three items (see Table 6.5).

- **Intention to Play this IL Game.** It measures how likely learners will play this IL game again in the future. The mean value was 3.04 (SD = 1.02), and the Cronbach α value was .889.
- **Intention to Learn IL.** It assesses learners’ willingness to learn more about IL in the future, based on today’s experience. The mean value was 3.24 (SD = 0.93), and the Cronbach α value was .878.
- **Intention to Recommend.** It measures whether learners are willing to recommend this IL game to others in the future. The items had a mean value of 3.25 (SD = 1.05, Cronbach α = .894).

Table 6.5 Principal Component and Reliability Analyses for Behavioral Intention

Scale Items	Components			α
	1	2	3	
Intention to Play This Game				.889
• Assuming that I have access to this game, I intend to use it.	.844	.277	.211	
• Given that I have access to this game, I predict that I would use it.	.876	.249	.216	
• When presented with this game, I am willing to use it.	.743	.300	.332	
Intention to Learn IL				.878
• The game made me want to learn more about IL.	.459	.735	.204	
• Based on my experience today, I will consider learning more about IL.	.240	.887	.176	
• At the next available opportunity, I intend to learn more about IL.	.147	.837	.297	
Intention to Recommend to Others				.894
• I would recommend this game to others (e.g., friends, classmates).	.317	.198	.836	
• If my friends were looking for IL games to improve their IL knowledge, I would tell them to play this game.	.216	.229	.877	
• I would spread positive word of mouth recommendations about this IL game.	.255	.232	.808	
Variance Explained (%)	59.35	12.46	10.63	
Eigenvalue	5.34	1.39	1.12	

Agent Persona Instrument

Participants' perceptions of the affective EA were measured as an additional section in the posttest questionnaire in the affective-EA condition. It consisted of four sub-constructs and 25 items in total, adopted from an existing survey instrument by Ryu and Baylor (2005). The use of "agent" was replaced with "librarian" since the EA took the form of a ghost librarian in this IL game. Table 6.6 lists the items used in this measurement instrument, and results from principal component and reliability analyses.

Table 6.6 Principal Component and Reliability Analyses for Agent Persona Instrument

Scale Items	Components				α
	1	2	3	4	
Facilitating Learning					.841
• ... led me to think more deeply about the game.	.841	-.173	-.207	.286	
• ... made the instruction interesting.	.889	-.295	-.114	.020	
• ... encouraged me to reflect what I was learning.	.843	-.307	-.149	.047	
• ... kept my attention.	.874	-.236	-.222	-.071	
• ... presented the material effectively.	.850	-.147	-.156	.184	
• ... helped me to concentrate on the game.	.872	-.075	-.192	.089	
• ... focused me on the relevant information.	.849	-.284	-.226	-.099	
• ... improved my knowledge of the content.	.837	-.136	-.134	-.065	
• ... was interesting.	.840	-.195	.203	-.257	
• ... was enjoyable.	.791	-.259	.209	-.351	
Credible					.802
• ... was knowledgeable.	-.406	.672	.506	.159	
• ... was intelligent.	-.373	.709	.476	.137	
• ... was useful.	-.285	.855	.017	-.032	
• ... was helpful.	-.178	.848	-.089	-.155	
• ... was instructor-like.	.279	.687	.204	-.241	
Human-like					.758
• ... has a personality.	.250	.030	.707	-.067	
• ...'s emotion was natural.	.436	.101	.775	-.202	
• ... was human-like.	.479	.220	.716	-.095	
• ...'s movement was natural.	.309	.054	.763	-.030	
• ... showed emotion.	.390	.057	.796	-.092	
Engaging					.745
• ... was expressive.	-.066	.323	-.063	.834	
• ... was enthusiastic.	.237	.370	-.176	.726	
• ... was entertaining.	.098	.138	-.164	.794	
• ... was motivating.	.169	.286	-.226	.686	
• ... was friendly.	.275	.236	.392	.589	
Variance Explained (%)	33.32	19.41	13.83	5.47	
Eigenvalue	15.58	7.26	5.21	1.96	

- **Facilitating Learning.** It refers to how well the EA can present the material effectively, and help learners to concentrate on knowledge acquisition and reflection. Ten items were used, which had a mean value of 3.28 (SD = 0.94, Cronbach α = .745).

- **Credible.** It evaluates the EA's knowledge and instructional authenticity, as well as value of the instruction or feedback from the EA. Five items were used to measure the sub-construct of credible, which had a mean value of 3.49 (SD = 0.83, Cronbach α = .841).
- **Human-like.** This sub-construct focuses on the naturalness of the EA's nonverbal communication such as gestures, movements, and emotional expressions. The five items had a mean value of 3.32 (SD = 0.91, Cronbach α = .802).
- **Engaging.** This sub-construct emphasizes on the enthusiastic and friendly communication between EAs and learners. There were five items, with a mean value of 3.40 (SD = 0.87, Cronbach α = .758).

6.3.3 Hypotheses Testing

A one-way ANCOVA was conducted to test Hypothesis 1. The independent variable had three conditions: affective-EA, neutral-EA, and no-EA. The dependent variable was participants' learning outcome in the posttest questionnaire, and the covariate was their prior IL knowledge obtained in the pretest questionnaire. A preliminary analysis evaluating the homogeneity-of-regression assumption indicated that the relationship between the prior IL knowledge and the posttest learning outcome did not differ significantly across the three conditions, $F(2,153) = 0.54, p = .583$. Table 6.7 shows the means and standard deviations of participants' IL knowledge performance in pretest-posttests. The ANCOVA result was non-significant, $F(2,155) = 0.82, p = .443$ (see Figure 6.4). Therefore, Hypothesis 1 was rejected, and there were no significant differences in the means of students' learning outcome from students in the three conditions.

Table 6.7 Means and SD of Learning Outcome in Pretest and Posttest

Condition	Pretest		Posttest	
	Mean	SD	Mean	SD
Affective-EA	4.70	1.65	5.00	2.04
Neutral-EA	4.21	1.61	4.46	1.97
No-EA	4.04	1.72	4.83	1.85

Figure 6.4 Plots of Learning Outcome in Pretest-Posttest

Next, as participants performed equally poorly in all three conditions, their prior IL knowledge was not used as the covariant in subsequent analyses. One-way ANOVA is frequently used to compare means between groups to determine whether they are statistically significantly different from each other (Shadish, Cook, & Campbell, 2002). Further, this method is consistent with those used in similar studies, such as in Castella, All, De Marez and Van Looy (2015), and Derrick and Ligon (2014). Therefore, one-way ANOVA tests were conducted to evaluate the other hypotheses, as shown in Table 6.8. Results showed statistically significant differences on attention [$F(2, 156) = 4.170, p = .017$], confidence [$F(2, 156) = 9.17, p < .001$], satisfaction [$F(2, 156) = 4.27, p = .02$], affective enjoyment [$F(2, 156) = 4.40, p = .01$], cognitive enjoyment [$F(2, 156) = 6.13, p = .003$], behavioral

enjoyment [$F(2, 156) = 3.84, p = .02$], perceived usefulness [$F(2, 156) = 6.70, p = .002$], intention to play IL games [$F(2, 156) = 4.78, p = .01$], intention to learn IL [$F(2, 156) = 6.67, p = .002$], and intention to recommend [$F(2, 156) = 4.21, p = .02$]. However, there was no significant difference in terms of relevance [$F(2, 156) = 2.67, p = .07$]. To summarize, except Hypothesis 1 and Hypothesis 2B, the other hypotheses were supported.

Table 6.8 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)
Cognitive Enjoyment**	3.62 (0.71)	3.04 (0.98)	3.12 (1.05)
Behavioral Enjoyment*	3.40 (0.84)	3.17 (0.85)	2.92 (0.99)
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: *, $p < .05$; **, $p < .01$.

Post-hoc analysis using Tukey's HSD was conducted to examine pair-wise group differences, and the error bars with confidence intervals are produced in Figure 6.5. The details are presented in the following.

- **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 ($M = 3.10, SD = 0.85$).

Figure 6.5 Error Bars for Dependent Variables

- Enjoyment.** *Affective enjoyment* in the affective-EA condition ($M = 3.43$, $SD = 0.74$) was significantly higher than the no-EA condition ($M = 2.96$, $SD = 0.86$). *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 ($M = 3.12$, $SD = 1.05$). *Behavioral enjoyment* in the affective-EA condition ($M = 3.40$, $SD = 0.84$) was significantly higher than the no-EA condition ($M = 2.92$, $SD = 0.99$).

- **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 ($M = 3.12$, $SD = 0.94$).
- **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 ($M = 2.80$, $SD = 1.01$) and the no-EA condition ($M = 2.94$, $SD = 1.15$). *Intention to learn IL* in the affective-EA 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 ($M = 3.06$, $SD = 1.02$) and the no-EA condition ($M = 3.11$, $SD = 1.15$).

6.4 Discussion

Taken together, these results showed that using an affective EA in an IL game had a strong positive impact on participants, compared to the neutral-EA and no-EA conditions. However, there was no significant difference in learning outcome or relevance. These findings are discussed next.

6.4.1 Learning Outcome

Hypothesis 1 stated that using affective EAs in an IL game would improve participants' learning outcome. However, this was unsupported from the statistical analyses. In fact, participants from all three conditions performed equally poorly in the IL knowledge tests. Similar findings were encountered in other studies as well. For example, Guo et al. (2015) designed a between-subject experiment that randomly assigned students to learn from an IL tutorial. Results showed no significant differences in learning performance whether

participants interacted with the EA or not. Likewise, Lin et al. (2013) examined the impact of using affective EAs on students' learning, and found similar learning performance among students who interacted with the affective EA and those who did not. In the context of Study II, the reason might lie in the amount of learning content. Many participants remarked about the large amount of learning content in the game, such as: *"There is too much IL knowledge"*, *"There is too much content. There should be some highlight on the more important stuff"*, and *"the game is too informative"*. Relatedly, the game ruled that players had to answer the quiz questions correctly before progressing to the next mission. Participants showed strong dislike for this rule. Example remarks included *"It wastes time to come back and answer the questions again"*, and *"I lost interest and became very impatient after coming back again and again"*. The lesson learnt here is to balance the amount of educational content and enjoyable game play, so students will not feel overwhelmed and frustrated.

Another possible explanation for the low learning performance might be the cognitive overload on participants' working memory. There were various tasks for players 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, understanding the feedback, and completing the game within one hour. Participants may have been too overwhelmed to focus on the learning content, thus learning was impeded. The same issue was reported by Atkinson (2002) as well. Participants from all three conditions made similar complaints such as: *"It is too difficult"*, *"I kept on running into the ghost, very annoying"*, and *"Information overload. I couldn't remember all the details"*.

Further, in real world face-to-face instruction, librarians use both auditory and visual cues. In *Library Escape*, there was a lack of audio cues, where all the information was presented visually. Some comments supported this explanation, such as *"I would like to have the content*

read to me.”, and *“It would be nice to have voice over”*. Hence, providing voiceovers for the dialog may help reduce cognitive load, potentially improving students’ learning outcome.

At the individual interviews, participants were asked to comment on the educational aspects of the IL game. All the participants found the knowledge content very difficult, except for one participant. This participant pointed out that the problem lay in the integration of the learning content with the game, and not the content itself. He explained: *“I think the IL content and the quiz questions should be better integrated. Now the game is still merely presenting the information and expect players to remember them. They are too separated.”* When asked about how to improve this aspect, he suggested linking the tasks with game stories to create a more holistic game: *“Maybe you can have some tasks that are linked to the stories. Take information evaluation for example, maybe you can give them some misleading information in the game, and they have to use the knowledge learnt from the game to separate the weeds from the wheat. In this way, the knowledge and the game are more connected, and I think players will be more attentive to learn”*.

However, there was a discrepancy between the actual learning performance and the perceived knowledge gain, as many participants reported that they benefited by playing the game. This was reflected from comments such as *“I learnt much about information literacy and it was really fun. The game was tough but nice”*, and *“It’s refreshing and educating, so it’s a great benefit to played the game and I get to gain knowledge about information literacy”*. Some enumerated the IL knowledge they learnt from the game, for example: *“I learnt about forward and backward searching”*, and *“Now I know how to evaluate information”*. The discrepancy might be due to the novelty effect of using DGBL to teach IL (Atkinson, Mayer, & Merrill, 2005). For example, participants thought the learning process was made more interesting with DGBL, and some remarked: *“I like the idea of teaching information literacy in a game”*, and *“This is a more interesting way to learn about information literacy. It can hold*

my attention better than the lectures". Furthermore, the perceived knowledge gain and self-efficacy could reduce possible library anxiety, and increase their confidence and interest in learning IL (Kuhlthau et al., 2008; Mellon, 1986). This is supported by participants' comments such as *"It's enriching, the librarian is helpful for me to learn more about IL"*, and *"It is useful to me. I didn't know the term library anxiety at first but after knowing it, I find it very informative and applicable"*.

6.4.2 Motivation

Participants who interacted with the affective EA were more attentive, confident, and satisfied in the game than those from the neutral-EA and no-EA conditions. However, there was no difference in the perceived relevance of the game. As the only difference among the three conditions is the use of affective EA, it is reasonable to infer that the behaviors and feedback from the affective EA (i.e., the librarian) contributed to the increased attention, confidence and satisfaction of the participants. This result confirms previous studies on the positive influence of using affective EAs in DGBL (Guo et al., 2015; Lin et al., 2013; Mayer & DaPra, 2012).

Firstly, the affective EA was able to attract and hold students' attention (Hypothesis 2A). To guide students' attention, the librarian stimulated senses and thinking from players. The stimuli came from the librarian's presence, as well as his verbal (scripted dialog) and non-verbal feedback (e.g., body gestures, facial expressions). This was well received by participants, and some wrote: *"Librarian as ghost, it is eye catching"*, and *"The design and the moving characters were entertaining and made the game slightly more challenging, and the designs of each activity is different"* in the subjective comments. Further, although all participants in the three conditions played the game, those who interacted with the librarian found the game more attractive. This insight was derived from the number of remarks on the game (Neuendorf, 2016). A majority of participants (47 out of 53 participants) in the

affective-EA condition praised that “*the game is engaging*”, or “*Playing a game is definitely an interesting way to learn*”. In contrast, participants in the other two conditions (12 out of 106 participants) made very few references to the game in their comments.

Secondly, although the game presented equal amounts of knowledge content and gameplay challenges, participants in the affective-EA condition were more confident that they could master the content and complete the game successfully (Hypothesis 2C). This finding highlights the importance of affect in DGBL, which was previously much ignored. Put simply, with the absence of affective feedback, students are more likely to lose their interest and confidence quickly (Zhang, 2013; Krämer et al., 2016). This was supported by comments from the user interviews. One noted that “*Information literacy is very important and helps in doing effective research. I’ve learnt a lot*”, and another one enumerated what he learnt from the game “*[I learnt] how to learn to look correctly from the right sources, the different sources of info and how reliable they are. Library anxiety is at the start of the research, we’ll feel anxious, which’s absolutely true*”. Further, at the interview, one participant pointed out the affective feedback from the librarian greatly boosted her confidence. She said: “*After I find one object, the librarian will say something like ‘this is difficult to find’, or ‘you are one step closer’, and I felt quite motivated. I like this*”. In contrast, participants from the neutral-EA and no-EA conditions showed a lack of confidence and asked for help in the game. For instance, some commented “*information literacy is highly sophisticated, my knowledge is not enough to comprehend what it is all about*”, and “*Please give some hint as the questions are confusing*”.

Thirdly, participants in the affective-EA condition were more satisfied than those from the other two conditions (Hypothesis 2D). The librarian’ feedback may have contributed to a more pleasant learning experience, and higher intrinsic reinforcement for participants in the affective-EA condition (Chae & Shin, 2016). Specifically, the librarian affirmed participants when they made progress, and cheered for them when they made mistakes. Such affective and

empathic feedback fostered the positive emotions during the learning process, thus leading to greater satisfaction from students. Participants' feedback at the user interviews helped explain why they were satisfied with the IL game. For example, some mentioned that *"I like the characters in the game. It is enriching that I am able to learn more about IL which I do not understand earlier on"*, and *"It's refreshing and educating so it's somewhat a great benefit to played the game"*. On the other hand, participants from the neutral-EA condition expressed dissatisfaction towards the librarian. For example, one pointed out that *"the librarian does not have other suggestions and feedback"*, while another lamented that *"I don't know why there has to be a ghost librarian, it delays the game"*.

Lastly, there was no statistically significant difference on relevance (Hypothesis 2B). This could be because relevance of the game is determined by its educational content (Keller, 2009). The educational content was the same in all three conditions, hence it is not surprising that participants rated similarly on relevance. They found the IL knowledge content in the game relevant to their studies. Typical comments included *"I realized how important and relevant IL is in daily learning"* and *"It is useful and relevant to daily life. I didn't know the term information literacy at first but after knowing it, I find it very informative"*. Given the significant differences in attention, confidence and satisfaction, the nonsignificant results in relevance may also suggest that participants differentiated the cognitive content of the game from the gameplay aspect. In other words, participants' perceptions of attention, confidence and satisfaction of the game did not impact how they perceived its educational value. From another point of view, it also suggests that the game should weave the educational content with gameplay more tightly.

6.4.3 *Enjoyment*

Participants who interacted with the affective EA derived more affective, cognitive and behavioral enjoyment from the IL game, compared with those from the other two conditions. Using the Tripartite Enjoyment Model, the results from this study provided a more nuanced view on the three different dimensions of enjoyment.

Firstly, the affective EAs increased participants' affective enjoyment in gameplay (Hypothesis 3A). Given that the three conditions were exactly the same except for the affective EA, it is reasonable to infer that the difference in participants' ratings was brought by the librarian and his feedback. In other words, the affective feedback from the librarian led to greater affective enjoyment. One plausible reason is that affective enjoyment of the game characters is largely concerned with empathy, which can mediate the negative feelings from participants (Krakowiak & Oliver, 2012). In the context of this study, participants expressed their negative feelings through comments like *"The level gets harder which affects my play"*, and *"The content is difficult, I felt bored in the process"*. The empathy from the librarian's affective feedback reduced players' feelings of apprehension and uncertainty in the learning process. This was supported by comments such as *"I feel happy about the librarian and his feedback provided after each tasks"*, and *"His feedback is encouraging"*. In contrast, many participants from the neutral-EA condition mentioned the librarian was what they disliked about the game. They thought using the librarian was redundant, and they did not derive any affective enjoyment or felt supported by the librarian. Some participants noted that *"The librarian really is not useful and in fact very very disruptive in the learning process"*, and *"The tasks get harder, and the librarian is still not useful, and it affects the emotions of players"*.

Secondly, the higher cognitive enjoyment from participants in the affective-EA condition stemmed from the cognitive appraisals of EAs in the game (Hypothesis 3B). Cognitive enjoyment focuses primarily on judgments of game characters, such as perceived

realism, coherence, feedback quality, and relevance (Nabi & Krämer, 2004). For example, players' cognitive enjoyment increases when the EAs are considered ethical, interesting, intelligent, and credible (Fang et al., 2010). In the context of Study II, the instructions, feedback and facial expressions from the librarian may have increased its perceived intelligence and credibility, contributing to higher levels of cognitive enjoyment (Krämer et al., 2016). Participants from the interviews remarked that they were cognitively stimulated in the game: *"I have learnt a lot about the IL and also how I would use in future situations", and "It is a very good game to learn things that we want to know, like IL. It helps the students to learn things in life"*. On the other hand, the librarian in the neutral-EA condition retained the same facial expression and body gesture, and only responded by saying *"Yes, that is correct."* or *"No, that is wrong."*, without other helpful feedback. This may have contradicted with participants' expectations that the librarian was polite, cooperative or helpful (Burgoon et al., 2016). Hence participants were disappointed at the librarian. They suggested improving the game by removing the librarian: *"perhaps can remove the moving librarian ghost?"*, and *"Instead of telling players yes or no, librarian should explain about information literacy"*.

Lastly, the affective EA increased players' behavioral enjoyment in the game (Hypothesis 3C). Behavioral enjoyment take place when players like the characters in the game (Nabi & Krämer, 2004). The librarian character was well received by participants. For example, one participant from the affective-EA condition said that *"I liked the fact that learning was made an enjoyable affair. The librarian was encouraging and motivating. In short I was engrossed in it so much that I never felt time pass by!"*. Another possible reason for the difference was that portraying the librarian character as a ghost contributed to an immersive narrative game world, enabling players to have an altered sense of time during gameplay (Kim et al., 2015). This is reflected from comments by participants from the affective-EA condition

such as “*The interaction between game-ghost-human is good, it looks similar to crime solving game*”, and “*I like the interactive interaction of the characters in the game*”.

6.4.4 Perceived Usefulness

Participants who interacted with the affective EA in the game also reported higher perceived usefulness compared to those from the other two conditions (Hypothesis 4). This result was in agreement with findings from Qiu and Benbasat (2010) that using affective EAs would increase participants’ perceived usefulness of the information system.

It is interesting that participants from all three conditions rated similarly on the game’s relevance (Hypothesis 2B), but differently on perceived usefulness. This suggests that perceived usefulness was not solely influenced by learning content; other factors, such as verbal and nonverbal cues brought about by the affective EA, were also at work. To demonstrate this point, participants from the neutral-EA and no-EA conditions focused on the *content* and praised the content to be useful, for example they wrote “*The game teaches useful information literacy skills. I learnt backward and forward searching*” and “*There is a lot of depth to the subject matter than I initially thought and I realize that the information in the game is useful towards the writing of my lab journals and papers*”. In contrast, participants from the affective-EA condition noted that the librarian’s comments were useful, and said that “*I like the interaction, the visuals and feedback given*”, and that “*The feedback is too long to read, but it is useful*”.

Additionally, it is also possible that participants from the affective-EA condition found the game more useful as the librarian adapted to their performance by displaying different affective feedback. Compared to the librarian in the neutral-EA condition that maintained the same facial expressions and body gestures, the librarian in the affective-EA condition displays

various affective verbal and nonverbal cues such as clapping, nodding, and smiling. Studies show that EAs with appropriate affective behaviors are preferred over monotonic ones, and perceived to be more credible and useful (Chen & Chou, 2015; Mayer & DaPra, 2012). This is supported by comments from participants in the affective-EA condition, such as *“The animation of the game was wonderful. The character also expressed emotions”*, and *“The librarian is motivating and encouraging”*. Some participants from the neutral-EA and no-EA conditions requested for more elaborated feedback to assist them in answering the quiz questions. Some wrote that *“there should have some help when we answer the quiz questions, they are very difficult”*, and *“I think some more features can be added to the librarian to make it more useful. For example, some animation work and some hints”*.

6.4.5 Behavioral Intention

Participants who interacted with the affective EA had higher behavioral intention to play the IL game, to learn IL knowledge and to recommend the IL game to others than the other participants. The reason is not difficult to understand. Behavioral intention is to a large extent determined by one’s attitude and perceived usefulness towards the system (Venkatesh & Bala, 2008). 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, and hence had higher behavioral intention. The findings are supported by participants’ comments from the affective-EA condition such as *“This game could be shared to all, quite enriching”*, and *“I have learnt a lot about information literacy and would continue to read up on it”*.

Conversely, even though participants from the other two conditions found the game novel and applicable, no one mentioned recommending it to others. Moreover, as these participants were less motivated and perceived the game to be less useful, they also rated lower

on behavioral intention. One potential mechanism at work is the participants' parasocial interactions with the affective EA during the gameplay (Nabi & Krämer, 2004). Participants' behaviors of listening to the stories and instructions, and helping the librarian in the game may have increased their behavioral intention. This can be gleaned from comments such as "*I can relate to the game*", and "*It is fun to help the librarian get rid of the evil ghost*" from participants in the affective-EA condition. Participants from the neutral-EA condition reported no such relationship with the librarian. Instead, they remarked that "*The ghost in the game is exactly like the librarian that we met in the library. it make us feel hard to approach*", and "*It is dumb*".

6.4.6 Perceptions of the Affective Embodied Agent

Participants' perceptions of the affective EA (i.e., librarian) supported results from the hypotheses testing. The design of the affective EA was received favorably, and typical comments from participants included "*the avatar design is kind of cute and appealing!*" and "*interactive interaction of the ghost (i.e., librarian) is interesting*". This finding reaffirmed the importance of attractive visual design and enjoyable gameplay experience to engage students in DGBL. The four sub-constructs of API (credible, humanlike, engaging and facilitating learning) are discussed below.

Participants liked the image of the librarian in the IL game, and regarded it as *credible* and trustworthy. Embodied agents are perceived to be more credible when they are competent, knowledgeable and experienced (Burgoon et al., 2016). Some participants viewed the librarian as an authority that can be trusted to learn IL from. Some exclaimed that "*The librarian is friendly and entertaining, it is certainly knowledgeable*", and "*It's interesting the librarian is friendly and helpful for me to learn more about IL*".

The *human-likeness* of EAs is mainly derived from the feedback, facial expressions, and body gestures (Baylor & Kim, 2009; Mayer & DaPra, 2012). The human-like emotional reactions by EAs can lead to higher perceived support and encouragement by users, which further lead to a positive influence on their motivation (Krämer et al., 2013; Shibani et al., 2015). This may be true in this study, which are supported by participants' comments such as "*The librarian expresses similar emotions and created some emotional attachment, when my answer is correct, he is also happy. When my answer is wrong, he encourages me*", and "*I like the empathic looks from Mr. Babbage*". Participants at the interview also praised that the librarian's feedback, facial expressions and body gestures were natural and well-coordinated. Some pointed out that "*The librarian looks quite real, the body movement, the hands, the eyes, and all that*", and "*I like the librarian character design and the different expressions, he looks like a gentleman*".

Furthermore, participants from the affective-EA condition reported being *engaged* in the game. In DGBL, players can actively interact with the game, increasing their engagement level. In the case of *Library Escape*, interacting with the helpful EA increased participants' engagement level (Ring, Barry, Totzke, & Bickmore, 2013). For example, participants praised that "*The librarian ghost would help me to get closer to the answer to each question if I fail to answer it in the first time*", and "*The librarian is kind of cute, which made the user more eager to play the game*". This result was in line with studies that found that students' engagement with EAs increased when the EAs were helpful or relevant (Szafir & Mutlu, 2012; van Vugt, Hoorn, & Konijn, 2009). In other words, the enhanced engagement brought by affective EAs may help students achieve better learning performances in DGBL.

Among the four sub-constructs in the API, participants rated lowest on *facilitating learning*. This is unexpected because learning facilitation is the most important purpose of using affective EAs in DGBL (Krämer et al., 2016). This attitudinal rating was consistent with

the behavioral performance on learning outcome (Hypothesis 1). One possible reason could be gleaned from the participants' comments: the overwhelming amount of learning content. For instance, some participants lamented that *"There is too much information in the game"*, and *"the information is complex and it's too much"*. Another possible reason for the low rating is that they had to frequently go back to the mission, due to their wrong answers to the quiz questions. For example, participants made similar complaints that *"It is very annoying to go back to the mission again and again"*, and *"It's very demoralising to be forced to go back"*. Some participants at the interviews suggested to adjust the difficulty level of the questions based on performance, so that players will not feel so frustrated. For example, one participant suggested that *"The game can be improved that when I cannot get the answers correctly after several attempts, the quiz questions become easier. Maybe the question can be on the same topic, but just easier, so that I have interest and confidence to continue"*. This task-manipulation approach could be effective to enhance players' gameplay enjoyment, but from a pedagogical perspective, it prevents students from developing skills to deal with failure and frustration (Keller, 2009). Hence, this game's approach of using feedback from the affective EA is a better way to encourage students to persevere and remain motivated through failure (Kim & Baylor, 2016).

6.5 Chapter Summary

This chapter presents Study II that addressed the second research objective of investigating the influence of using affective EAs in the IL game, on tertiary students' IL learning outcome, motivation, gameplay enjoyment, perceived usefulness, and behavioral intention. A pretest-posttest between-subjects experiment was carried out, where 159 tertiary students were randomly assigned to affective-EA, neutral-EA or no-EA conditions.

Results showed that participants benefited from interacting with the affective EA in the IL game. Participants who interacted with the affective EA rated significantly higher on attention, confidence, satisfaction, affective, cognitive and behavioral enjoyment, perceived usefulness, and behavioral intention to play other IL games, to learn IL knowledge, and to recommend the game to others, compared to those from neutral-EA and no-EA conditions. However, there were no significant differences in learning outcome or perceived relevance of the IL game. In terms of the participants' perceptions of the affective EA, participants rated highest on its credibility, followed by being engaging, and human-like, and lowest on learning facilitation. To supplement the quantitative experiment, eight participants from the affective EA condition were invited for individual interviews after the gameplay. Their feedback on the IL game and affective EA was gathered and summarized. The participants found the game design attractive, and noted that using DGBL was an innovative way of teaching IL. They also provided useful suggestions for further improvement of the game and the EA.

CHAPTER SEVEN

CONCLUSION

This chapter concludes the thesis by summarizing the work done to address the research questions and objectives during the PhD candidature. There are five sections. The first section provides an overview of the PhD research, and the second discusses its contributions to research and practice. The third section list its limitations, while the fourth section suggests future research directions. The last section concludes with some final thoughts on the thesis.

7.1 Review of PhD Research

The thesis started with an introduction on information literacy (IL) education, digital game-based learning (DGBL), and affective embodied agents (EAs). Three key research gaps pertaining to using DGBL with affective EAs in IL education were identified.

The first gap is the neglect of user input in existing IL game design. As it is not easy to blend the learning content into games to make them fun and educational at the same time, opinions from students should be taken into consideration when designing DGBL (Markey et al., 2014). To achieve this, a participatory design (PD) approach with continuous user involvement can be used to produce effective DGBL. However, libraries have rarely involved students in IL game design so far, which in part explained the low acceptance and frequent failures of these IL games. The second gap is the absence of affective aspects in IL games. Information literacy knowledge acquisition is associated not only with cognitive ability but also with affects, and affective EAs can be used in DGBL as they are effective in conveying emotions (Krämer et al., 2016). However, there is limited literature on using affective EAs in

DGBL, including in IL games. While DGBL has been shown to be an effective teaching tool, how affective EAs can be weaved into DGBL needs to be further evaluated. Third, the benefits of using DGBL in IL education are mainly speculative, hence rigorous research using experimental evaluation is needed to tease out different aspects of DGBL intervention, to ascertain whether using affective EAs or DGBL has a positive effect on learning.

Based on these three gaps, the following research questions (RQs) were proposed. RQ 1 is based on the first two gaps, while RQ 2 is derived from the third gap:

RQ 1: How can the PD approach be used to inform the design of an IL game with affective EAs?

RQ 2: How does the use of affective EAs in an IL game influence tertiary students' learning?

The two research questions were addressed through the completion of two research objectives (ROs), in a series of steps:

RO 1: Designed and implemented an IL game with affective EAs with the PD approach:

- (1) Created a low-fidelity prototype using focus group;
- (2) Created a high-fidelity prototype game by refining the low-fidelity prototype, through user feedback from evaluation interviews; and
- (3) Analyzed the IL game using theoretical frameworks from pedagogical and game design literature.

RO 2: Evaluated the influence of affective EAs in the IL game on tertiary students' learning:

- (1) Created three versions of the game: affective-EA, neutral-EA, and non-EA versions;
- (2) Compared students' learning outcome, motivation, gameplay enjoyment, perceived usefulness, and behavioral intention from each group through pretest posttest between-subject experiment; and

- (3) Assessed students' perception about the affective EA using individual interviews.

Chapters Two and Three set the context for the PhD research. Chapter Two reviewed existing literature on IL education, DGBL, and affective EAs in games. Chapter Three laid the theoretical foundations for the research methods and instruments in the PhD research, including the Information Search Process (ISP) Model, the Attention Relevance Confidence and Satisfaction (ARCS) Model, the GameFlow Model, the Tripartite Enjoyment Model, User Acceptance Research, and Social Agency Theory.

Chapters Four, Five and Six formed the backbone of the thesis with two empirical studies. Chapters Four and Five reported Study I that addressed RQ1 and fulfilled RO1, where an IL game that incorporated affective EAs was designed based on pedagogical and game design principles. Specifically, Chapter Four presented the PD approach in the IL game design. Three rounds of focus groups were first conducted, which yielded the low-fidelity prototype. Thereafter, individual user interviews with ten tertiary students were held to refine the low-fidelity prototype, resulting in a high-fidelity prototype. The game, named *Library Escape*, is structured based on the six stages from the ISP Model by Kuhlthau (2004). Thereafter, the high-fidelity prototype was implemented in Unity 3D. Chapter Five detailed how *Library Escape* is played, and analyzed how the design decisions adhered to each elements of the pedagogical and game design principles in the ARCS and GameFlow Models.

Chapter Six explicated Study II that addressed RQ2 and fulfilled RO2, where the influence of affective EAs in the IL game was examined. The evaluation process involved an experiment and supplementary qualitative interviews. Using the original game as the affective-EA version, two more versions of *Library Escape* were created for the experimental comparison purpose: the neutral-EA, and no-EA versions. In total, 159 tertiary students participated in the pretest-posttest between-subjects experiment and were randomly assigned to one of the three conditions. Eight participants from the affective EA condition were invited

for qualitative interviews after the gameplay, and their feedback on the IL game and affective EA was gathered and summarized. The results showed that using affective EA had a strong positive impact on students' learning motivation (attention, confidence, and satisfaction), enjoyment (affective, cognitive and behavioral enjoyment), perceived usefulness and behavioral intention (to learn more about IL, to recommend the game to others, and to play other IL games), compared with the neutral-EA and no-EA conditions. However, there was no difference in relevance or learning outcome.

During the PhD candidature, four journal papers and ten conference papers were published. They are listed in Appendix C.

7.2 Contributions

This PhD research has made several contributions to research and practice, as detailed below.

7.2.1 Contributions to Research

There are two main contributions to research. First, to the best of knowledge, *Library Escape* is one of the few efforts to design DGBL by involving end-users, and structuring it on theoretical frameworks. Study I offered a coherent understanding of how multidisciplinary theoretical frameworks can be used to enable meaningful and engaging DGBL design. The iterative design process was guided by the PD approach. Kuhlthau's (2004) ISP Model was utilized to structure the IL educational content. Using the six stages of the ISP Model enabled the game to organize various IL topics systematically, which was received favorably by the participants in the game evaluation. The design process of *Library Escape* could guide practitioners to base their work on grounded pedagogical and game design principles rather than depending solely on intuition or individual experience. Furthermore, the game was also

analyzed based on instructional science and game design principles of the ARCS and GameFlow Models. Librarians can also use a similar approach to diagnose their IL games, and ascertain which aspects of the games are effective, and which are not.

Second, Study II undertook the first step in highlighting the positive influence of affects and affective EAs in an IL digital game. Previous IL games neglected the affective aspects of students' learning. Results from Study II confirmed the positive influence in affective EA, and extended it to the context of online IL education. The findings demonstrated that students paid attention to affective aspects in online IL game design. Moreover, instead of examining the affective EAs based on a single factor such as its gender, voice, or appearance, Study II utilized a holistic approach that included EA's affective instructions, facial expressions and body gestures, thus allowing researchers to get a more complete understanding of using affective EAs in DGBL (Prendinger & Ishizuka, 2013; Santos, 2016). Librarians should include affects, or affective EAs, as an essential construct in their design frameworks, to increase the effectiveness of IL games. More generally, the positive influence of affective EAs can be applied in other domains in human interaction with computers, such as improving customer satisfaction in online shopping, facilitating the searching process in digital libraries, and encouraging patients' cooperation in the healthcare information systems.

7.2.2 Contributions to Practice

The PhD research contributes to practice in three aspects. First, Study I shed light on how users can be actively involved in DGBL design. Many previous efforts to develop DGBL have failed because designers turned a deaf ear to inputs from potential users. Digital game-based learning differs from entertainment games in that it needs to fulfill both learning needs and gameplay enjoyment of players. Therefore, to improve the educational effectiveness and gameplay

enjoyment of DGBL, input from potential users need to be understood and incorporated. In Study I, feedback from end-users were elicited using focus groups and user interviews under the PD approach, increasing the likelihood for success for the IL game. The game design process and design insights can inform and stimulate the further implementation of DGBL in libraries and schools, and improve students' learning motivation and enjoyment. Specifically, the active involvement of end-users through focus group discussion and user interviews demonstrated how the PD approach could be used in IL game design projects. Synergizing pedagogical principles with game design heuristics in DGBL design can be challenging, as the two sometimes contradict each other. Three design guidelines were shared at the end of Study I, offering practical tips for researchers. They were called to pay attention to issues such as being accommodating yet pragmatic towards user input, and being guided yet flexible when using the PD approach, as well as balancing the game design and pedagogical principles. A better understanding of the PD process can also inform ways of conducting collaborative projects and facilitate sharing in IL game design.

Second, the game prototype and design insights drawn from *Library Escape* can be used by librarians, educators, and faculty members as a starting point for the use of DGBL in IL education. The IL game has the advantage of being usable in any academic library, as it is one of the first attempts to teach a general model (i.e., the ISP Model), rather than library-specific knowledge. The topics were covered in depth, and ordered using Bloom's taxonomy. One impediment for implementing DGBL is the huge effort needed for their development. Hence a reusable game prototype with general IL knowledge increases its usefulness to students in other institutions, especially to those libraries or institutions that are keen to use DGBL but lack the financial or human resources for doing so. They can adopt *Library Escape* to tackle the low interest in IL learning, and use it to obtain evidence-based results, which in turn will promote the uptake of DGBL.

Last but not least, for EAs to be effective, affect should be incorporated in their design. Study II showed that EAs with appropriate affective feedback were perceived to be more engaging, credible and human-like. It also offered evidence-based findings on the benefits of incorporating new technologies in traditional learning to engage students, in terms of motivation, enjoyment, perceived usefulness and behavioral intention. Such affective feedback from EAs is especially important to alleviate students' potential negative feelings such as anxiety, uncertainty, frustration or boredom in online learning. Incorporating affective feedback in EAs is a starting point for librarians, educators, and designers to optimize the positive impact of affects and EAs on learning. For example, the ISP Model suggests that information seekers often feel uncertain and apprehensive at the initial stages when they first receive the searching tasks. Gradually, uncertainty and apprehension will be replaced by confidence as a clearer focus emerges. Hence, the EAs can mirror this by showing more encouraging and supportive behaviors in the initial phases of IL learning programs, but allow users to feel more independent as their competence increases.

7.3 Limitations

Although the PhD research makes several contributions to research and practice, the findings should be interpreted against the backdrop of three limitations.

First, in Study I, the participants in the focus group and user interviews only included tertiary students, and students who played games. These students were not experts in IL education, and their IL knowledge was limited. Their lack of IL knowledge may have consequently affected the design of the IL game. However, the actual stakeholders of the IL game also include students who do not play games, as well as librarians and faculty members, whose understanding of pedagogical principles and professional experience may have equipped them with some best practices on how to teach IL. Their feedback and opinions could

increase the game's success. This issue was alleviated by involving one experienced IL expert who pointed out several useful aspects of the IL knowledge content that was incorporated into the game before the user interviews were conducted. Further, the use of PD approach in Study I enabled a deeper understanding of end-users. However, it is challenging to follow all their suggestions. Therefore, the researcher adopted a pragmatic attitude to balance different views in the design process.

Second, convenience sampling was used to recruit participants in both studies, reducing the generalizability of the findings. Nonetheless, some controls were put place to mitigate its effect. For example, the participants were undergraduate and graduate students from various disciplines from two major universities, to ensure that the sample was more representative of the population. Study II employed random assignment to minimize between-group difference. Hence, the findings can be used as the first step to investigate tertiary students' attitudes towards using DGBL in IL education.

Third, students' subjective feedback from Study II indicated several avenues for further improvement in the game. Players could not proceed to the next level without answering quiz questions correctly, hence disrupting their flow experience in the gameplay. Despite its pedagogical considerations, insisting students to answer all quiz questions correctly may have irritated them and caused low rating in the post-test questionnaire. Based on participants' feedback, the IL knowledge content in this game could be reduced, and sequel games that are discipline specific could be designed to provide contextualized learning. Additionally, there is a lack of audio cues from the librarian, which may have resulted in the unsatisfactory learning outcome. These issues will be addressed in the future game revisions.

7.4 Future Work

The findings of Study I and Study II revealed three possible avenues for future work: revising the IL game, knowledge improvement, and comparison of DGBL with other approaches.

First, as mentioned in the third limitation above, the high-fidelity prototype from Study I should be revised and improved before it can be used for further research, as multiple rounds of revision are needed as the best guarantee for success. The subjective feedback from participants in Study II revealed several design issues with the game, such as the lack of save/quit function, binary story outcomes of either completing or failing the game, a lack of audio cues from the EA, and so on. Besides adopting students' feedback, professionals such as librarians and educators should be consulted to improve the educational aspects in *Library Escape*. Further, expert-based heuristic evaluation method can be used as an additional source of input for the game revision. Four to eight game design experts can be invited to play *Library Escape* and compare the game against educational game evaluation heuristics. The experts can identify the design decisions that violate these heuristics, and recommend areas of improvement. The results will provide useful information on how to revise the game design.

Second, knowledge improvement was not found in the game evaluation in Study II. Hence future research should investigate how to optimize learning performance through the use of affective EAs. For example, the amount of IL knowledge was heavy and many participants felt overloaded in *Library Escape*. Participants suggested that both visual and audio cues of EAs should be provided to cater to different learning styles and maximize the EAs' positive influence. Relatedly, because different learners may experience negative feelings at different stages, it is critical for EAs to detect learners' behaviors, and provide timely customized affective feedback. Hence, another possibility is to investigate ways for EAs to detect learners' reactions and computationally model their affective feedback. This will enable

the affective feedback from EAs be coordinated in response to individual learners' progress in real time, increasing their usefulness.

Third, Study II compared the influence of using affective EAs with three conditions in DGBL. However, it did not examine whether DGBL was effective as a learning medium when compared with traditional face-to-face IL instruction. Further, another approach to using games in learning is gamification, which refers to the application of typical game elements, such as points, badges, leaderboards and achievement, in non-gaming contexts (Brigham, 2015). Studies have found gamification an effective tool to increase motivation in different contexts (Ibanez, Di-Serio, & Delgado-Kloos, 2014; Zuckerman & Gal-Oz, 2014). Its application in IL instruction and empirical evidence of student learning improvement are lacking. Therefore, future research can implement a gamified IL instructional website, and compare it with *Library Escape*, to examine which elements are more effective in promoting learning. Relatedly, while some researchers have argued that simple board or puzzle games might work better to attract students, the game *Library Escape* used in this study is more complex with different 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.

7.5 Concluding Remarks

Library instruction programs that impart IL knowledge are essential to students' academic success. Using affective EAs in DGBL is a promising approach to engage students and increase their interest in IL learning. Despite the increasingly sophisticated gaming devices and game mechanisms, the potential of affective EAs and games is still not fully exploited by libraries. Of course, it is not easy to take something pedagogically sound and to turn it into an immersive

game while retaining useful learning content. The game elements and learning content need to be well integrated so that students are motivated and intrigued to understand the concepts and theories in the games. To combine these traditionally separate research fields to produce good educational games will involve librarians, game designers, and faculty members to work together with students, and understand their needs, while paying attention to the affective aspects of IL education.

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APPENDICES

Appendix A-1 Focus Group Protocol in Study I

Section 1: General Instructions

Good morning/afternoon. My name is ____ from WKWSCI. Thank you for coming. As stated in the email, this study is divided into two interview sessions. So in today's interview, you will play some information literacy games, and after that I will ask you about your likes and dislikes about the game, and the reasons. The purpose is to get your perceptions of the game experience. There are no right or wrong or desirable or undesirable answers. I would like you to feel comfortable with saying what you really think and how you really feel.

Section 2: Video Recorder Instructions:

If it is okay with you, our conversation is video-recorded. The purpose of this is so that I can get all the details but at the same time be able to carry on an attentive conversation with you. I assure you that all your comments will remain confidential. I will be compiling a report which will contain all participants' comments without any reference to individuals.

Section 3: Consent Form Instructions:

Before we get started, please take a few minutes to read and sign this consent form. (After consent form is returned, turn video recorder on.)

Section 4: Interview Instructions:

1. Introducing the concept of information literacy games

Information literacy is a broad term, it refers to people's skill to determine the nature and extend of the information needed, to access needed information effectively and efficiently, to evaluate information and its sources critically and incorporates selected information into their knowledge base and value system, to uses information effectively to accomplish a specific purpose, to understands many of the economic, legal, and social issues surrounding the use of information and accesses and uses information ethically and legally.

Normally university would conduct a two-hour information literacy tutorial for freshmen, but students' feedback is not very positive. So we want to design a game that could help people improve these skills, as games tend to be more engaging and interacting.

So are you clear about the information literacy game concept?

2. Invite participants to play the three games

3. Questions

1. What do you like about the games? Why?
2. What don't you like about the games? Why?
3. How do you think the games can be improved to make it more fun/engaging/entertaining?

4. Introducing the influence of emotion in gaming perceptions

Emotions are one of the major factors in the user experience of gaming. People play games to elicit emotions. New forms of human computer interaction have been developed to cater the user's emotional needs. Naturally, users should be able to fall back on familiar mechanisms and modalities when interacting with computational systems. It has been demonstrated that emotions influence people's attitude they play an essential role in rational decision making, perception, learning, and other cognitive functions, such as information seeking behaviour. By creating emotional interfaces, developers try to find a way for human computer interaction that is similar to the human-human interaction. The more the interaction between human and machine becomes similar to the communication between humans the easier it gets to use.

Emotions in games could be expressed through icons, narratives, character expressions, story lines, etc. Here are some examples.

5. Introducing Kuhlthau's Information Seeking Process Model

Stages	Task Initiation	Topic Selection	Prefocus Exploration	Focus Formulation	Information Collection	Search Closure	Starting Writing
Feelings	uncertainty	optimism	confusion, frustration, doubt	clarity	sense of direction/ confidence	relief	satisfaction or dissatisfaction
Thoughts		ambiguity	— — — — —	— — — — —	→ specificity		
				— — — — —	→		
				Increase interest			
Actions		seeking relevant information	— — — — —	— — — — —	→ seeking pertinent information		

Figure 38.1 Kuhlthau's Information Search Process.

Note: From *Seeking meaning: A process approach to library and information services*, 2nd edition (p. 82), by C. C. Kuhlthau, 2004, Westport, CT: Libraries Unlimited. Copyright by Carol Collier Kuhlthau. Adapted with permission.

Her model depicts a series of cognitive and affective stages through which people are thought to move as they find and evaluate information.

At the extreme left is the stage of **initiation**, in which a person becomes aware of uncertainty or lack of knowledge about something. This is the birth of an information need, as the person identifies what is missing in their knowledge.

The stage that follows is **selection**, in which we select the topic we are pursuing and how to approach it. At this point one assesses one's own degree of interest, necessary tasks, and available resources (time, relevant information), and tend to be optimistic about the process and outcome.

In the third stage, **exploration**, feelings of doubt and confusion may arise, as sources are explored and the information search becomes difficult to frame or express to information systems or other persons. At this point some seekers may abandon their effort to expand their understanding.

The fourth stage is **formulation**, a time when focus is sharpened and clarity of purpose may be achieved. At this point the search may narrow and confidence in the outcome tends to return.

State five is **collection**, when effort is focused on gathering, digesting, and recording the most relevant information on the topic.

At the sixth stage, **presentation**, one is able to use the retrieved information to answer the initial question or complete the task. Any further searching at this stage is likely to turn up redundant information.

Finally, a seventh stage may be **assessment** of what one is accomplished, leading to improved self-awareness and esteem.

6. Question

- Divide the team.
- As we need your help to design an information seeking game with emotion components, what genre do you think it should be and why? Such as action game, adventure game, racing games, role-playing game, simulation game, strategy game, puzzle game, shooter game, sports game, or others?
- You are given 15 min to decide on the genre, and come out with a suitable game design for information literary game with emotional elements. This covers the following aspects.
 - ✧ **The game's genre and key features.** For example, a design treatment for Doom might have read: a shooting game, with a first-person perspective based on a 3D ray-casting engine.
 - ✧ **A short description of the experience you want to give to the player.** Is the game a comedy? An adrenaline thriller? A puzzle? Will it be a technology showcase, a graphic wonder or a story? Linear or not? Is it single-player or multi-player? Playable over a LAN or the internet? What are the key elements of gameplay and of the interface?
 - ✧ **What kind of look-and-feel do you want:** A realistic 3D style? Cartoons? Isometric? Lots of intricate move combinations and secret rooms, or straightforward gameplay suitable for children?
 - ✧ **How will you structure the game:** levels? Missions? Episodes? How many? How long will each be? How will you provide replay value?
 - ✧ **Who are your major characters/units/game pieces?**

- Now you have 40 min to discuss game design with your teammates, and each group will present your ideas after that. You need to cover aspects such as genre, key features, description of game experience, look and feel of the game, structure of the game, and major characters and game pieces.
- 2 presentations (each around 10 min) followed by Q&A.
- Please modify your game design and summarize the final version to our facilitators.
- Interviewers could also ask questions.

Section 5: Interviewer Reflection

After the respondent leaves the room, please take a couple of minutes to indicate your reactions and observations about the interview.

Interviewer's name	
Respondent Name	
Date of Interview	
Please describe the respondent's attitude toward you and the interview	
Please describe any unusual circumstances and/ or events that had any bearing on the interview such as interruptions, language difficulty, etc.	
Please describe anything else that happened during the interview that has any bearings on the study's objectives	
Additional comments	

***** 10-minute Tea Break *****

Preparation: Please bring markers, pencils, erasers, A3 paper to allow participants to design the game.

Section 1: General Instructions:

Good morning/afternoon. Thank you for coming and nice to see you again. As discussed in last interview session, today you will present your team's ideas, comment on the other team's presentation, and provide feedback. I am here to facilitate your discussions. So let's get started.

Again, there are many ways to design games, there are no right or wrong or desirable or undesirable answers. I would like you to feel comfortable with saying what you really think and how you really feel.

Section 2: Video Recorder Instructions:

If it is okay with you, our conversation is video-recorded. The purpose of this is so that I can get all the details but at the same time be able to carry on an attentive conversation with you. I assure you that all your comments will remain confidential. I will be compiling a report which will contain all participants' comments without any reference to individuals.

Now I will turn on the video-recorder.

Section 3: Presentation and Feedback

1. Now you have 40 min to discuss game design with your teammates, and each group will present your ideas after that. You need to cover aspects such as genre, key features, description of game experience, look and feel of the game, structure of the game, and major characters and game pieces.
2. 2 presentations (each around 10 min) followed by Q&A.
3. Please modify your game design and summarise the final version to our facilitators.
4. Interviewers could also ask questions.

Section 4: Wrap-up

Do you have any other points to add? (If not) Thank you very much for participation.

We might contact you in future should some clarifications needed. You could also email W120030@e.ntu.edu.sg or call 94527949 if you have further thoughts.

Background knowledge

Explanations of Different Game Genre

Game genre describes the way the story is told. A genre is a narrative style that effects the structure of the story, the depth of character, and other storytelling elements.

Action Games: Games that offer intensity of action as the primary attraction.

Adventure Games: Adventure games involve exploration of, and interaction with, the environment as a main facet of gameplay.

Puzzle Games: Puzzle games are short but addictive graphical games that usually require the player to solve a puzzle such as a maze, logical problem or positioning different pieces together.

Racing Games: Racing games involve the player competing in races.

Role Playing Games: Games that offer the player an opportunity to immerse themselves in the player character's situation.

Shooters: Shoot em' Up o Shooter games involve shooting or destroying multiple objects and opponents.

Strategy Games: Strategy games require the player to take on a leadership role and oversee every detail of the provided scenario(s). Gameplay focuses on strategies and careful planning and resource management in order to win.

Simulations: Simulation games attempt to realistically mimic conditions of a particular environment or activity.

Sports Games: Sports Games emulate traditional physical sports such as basketball and golf.

Research Support Office

Reg. No. 200604393R

IRB-2013-11-011

15 January 2014

Associate Professor Goh Hoe Lian, Dion
Wee Kim Wee School of Communication and Information

NTU INSTITUTIONAL REVIEW BOARD APPROVAL

Project Title: Designing an affective information literacy game

(Amount Approved: SGD\$3,000; to be funded by WKWSC 3K Grant for Research Students)

I refer to your application for ethics approval with respect to the above project.

The Board has deliberated on your application and noted from your application that your research involves collecting behavioral data from participants through interviews.

You have also confirmed that informed consent will be obtained from the participants and you have guaranteed the confidentiality of your participants' biodata obtained from them.

The documents reviewed are:

- a) NTU IRB application form dated **25 November 2013**
- b) Participant information sheet and consent form: version 1 dated **25 November 2013**
- c) Data collection form: version 1 dated **25 November 2013**

The Board is therefore satisfied with the bioethical consideration for the project and approves the ethics application under **Expedited** review. The approval period is from **15 January 2014** to **14 January 2015**. The NTU IRB reference number for this study is **IRB-2013-11-011**. Please use this reference number for all future correspondence.

The following protocol and compliances are to be observed upon NTU IRB approval

1. All research involving procedures greater than minimal risk on minors (individuals who are less than the legal age of 21 years old) requires IRB approved written Parental Consent and assent from the participant to be obtained before any research protocols can be administered. Minimal risk refers to an anticipated level of harm and discomfort that is no greater than that ordinarily encountered in daily life, or during the performance of routine educational, physical, or psychological examination.
2. Only the approved Participants Information Sheet and Consent Form should be used. It must be signed by each subject prior to initiation of any protocol procedures. In addition, each subject should be given a copy of the signed consent form.

Research Support Office

3. No deviation from, or changes of, the protocol should be initiated without prior written NTU IRB approval of an appropriate amendment.
4. The Principal Investigator should report promptly to NTU IRB regarding:
 - a. Deviation from, or changes to the protocol.
 - b. Changes increasing the risk to the subjects and/or affecting significantly the conduct of the trial
 - c. All serious adverse events (SAEs) which are both serious and unexpected.
 - d. New information that may affect adversely the safety of the subjects of the conduct of the trial.
 - e. Completion of the study.
5. Continuing Review Request/ Notice of Study completion form should be submitted to NTU IRB for the following:
 - a. Annual review: Status of the study should be reported to the NTU IRB at least annually using the Continuing Review Request/ Notice of Study completion form.
 - b. Study completion or termination: Continuing Review Request/ Notice of Study completion form is to be submitted within 4 to 6 weeks of study completion or termination.

A handwritten signature in black ink, appearing to read "Lee Sing Kong", is positioned above the typed name.

Professor Lee Sing Kong,
Chair, NTU Institutional Review Board
encl.

cc Chair, Wee Kim Wee School of Communication and Information
Members, NTU Institutional Review Board

Appendix A-3 User Interview Protocol in Study I

General Instructions:

Good morning/afternoon. My name is Yanru from WKWSCI. Thank you for coming. As stated in the email, in this interview, you will be presented with an information literacy game prototype and its design ideas. After that I will ask you about your likes and dislikes about the game and how to improve it. The purpose is to get your perceptions of how such a game should be designed. There are no right or wrong or desirable or undesirable answers. I would like you to feel comfortable with saying what you really think and how you really feel.

During our interview, I will take notes to capture your ideas. Before we get started, please take a few minutes to read and sign this consent form.

Introducing the concept of information literacy games

Information literacy refers to people's skill to determine the nature and extend of the information needed, to access needed information effectively and efficiently, to evaluate information and its sources critically and incorporates selected information into their knowledge base and value system, to uses information effectively to accomplish a specific purpose, to understands many of the economic, legal, and social issues surrounding the use of information and accesses and uses information ethically and legally. So are you clear about the information literacy game concept?

Overview of game missions

Missions: Venues ISP Stages	Topic	Quests (objects hidden in)
Mission 1: Closed Stacks Task initiation	General Introduction	1. Definitions of IL (book shelf) 2. The importance of IL to students (ceiling bulb) 3. Three modes of IL education delivery (whiteboard) 4. Five ACRL information tasks (stools)
Mission 2: Reference Desk Topic Selection	Affect in Information Behavior	1. Basis for topic selection (telephone) 2. Mellon (1986) library anxiety (clock pendulum) 3. Bates (2007) uncertainty (notebook) 4. Bostic (1992) five factors contributing to library anxiety (computer)
Mission 3: Open Shelves Prefocus Exploration	Information Seeking Behavior	1. What is information seeking (poster) 2. Wilson et al. (2010) First Model (book) 3. Johnson Model (shelf) 4. Ellis Everyday Information seeking Model (magazines)
Mission 4: Virtual Library Focus Formulation	Kuhlthau's ISP Model	1. What is unique about ISP Model (ebooks) 2. Constructivist perspective (backward chaining) (ejournals) 3. Different stages of ISP, iterative process (databases) 4. Focus on students' feelings (searching bar)

Mission 5: Café Information Collection	Use of ISP Model	1. The development of the ISP model (coffee machine)
		2. Other works on ISP model (forward chaining) (ice machine)
		3. How the ISP model helps librarians (piano)
		4. How the ISP model helps students (plants)
Mission 6: Exhibition Area Search Closure	Integrative session	1. When to stop looking for information? (screen)
		2. Can information be “objective”? (sculpture)
		3. Do people really “need” information? (painting)
		4. “There is much more about IL than what is presented here!” as an exhortation to explore IL further (librarian)

Questions

- What do you like about it? Why?
- What don't you like about it? Why?
- How do you think the game can be improved to make it more fun/engaging/entertaining?
- How do you think the game can be improved to make it more pedagogically-sound?

Background knowledge

Explanations of Different Game Genre

Game genre describes the way the story is told. A genre is a narrative style that effects the structure of the story, the depth of character, and other storytelling elements.

Action Games: Games that offer intensity of action as the primary attraction.

Adventure Games: Adventure games involve exploration of, and interaction with, the environment as a main facet of gameplay.

Puzzle Games: Puzzle games are short but addictive graphical games that usually require the player to solve a puzzle such as a maze, logical problem or positioning different pieces together.

Racing Games: Racing games involve the player competing in races.

Role Playing Games: Games that offer the player an opportunity to immerse themselves in the player character's situation.

Shooters: Shoot em' Up o Shooter games involve shooting or destroying multiple objects and opponents.

Strategy Games: Strategy games require the player to take on a leadership role and oversee every detail of the provided scenario(s). Gameplay focuses on strategies and careful planning and resource management in order to win.

Simulations: Simulation games attempt to realistically mimic conditions of a particular environment or activity.

Sports Games: Sports Games emulate traditional physical sports such as basketball and golf.

Kuhlthau's ISP Model

Task	Thoughts	Feelings
Task initiation		
To prepare for the decision of selecting a topic	Contemplating assignment, comprehending task, relating prior experience and learning, considering possible topics	Apprehension at work ahead, uncertainty
Topic selection		
To decide on topic for the research	Weighing topics against criteria of personal interest, project requirements, information available, and time allotted; predicting outcome of possible choices; choosing topic with potential success	Confusion, sometimes anxiety, brief elation after selection, anticipation of prospective task
Prefocus exploration		
To investigate information with the intent of finding a focus	Becoming informed about general topic, seeking focus on information on general topic, identifying several possible focuses, inability to express precise information need	Confusion, doubt, sometimes threat, uncertainty
Focus formulation		
To formulate a focus from the information encountered	Predicting outcome of possible foci using criteria of personal interest, requirements of assignment, availability of materials and time allotted, identifying ideas in information from which to formulate focus, sometimes characterized by a sudden moment of insight	Optimism, confidence in ability to complete task
Information collection		
To gather information that defines, extends, and supports the focus	Seeking information to support focus, defining and extending focus through information, gathering pertinent information, organizing information in notes	Realization of extensive work to be done, confidence in ability to complete task, increased interest
Search closure		
To conclude search for information	Identifying need for any additional information, considering time limit, diminishing relevance, increasing redundancy, exhausting resources	Sense of relief, sometimes satisfaction, sometimes disappointment

Basic emotions

fear, anger, pride, sadness, joy, excitement

Information Literacy Competency Standards for Higher Education by ACRL and ALA

- The information literate student determines the nature and extent of the information needed.
- The information literate student accesses needed information effectively and efficiently.
- The information literate student evaluates information and its sources critically and incorporates selected information into his or her knowledge base and value system.
- The information literate student, individually or as a member of a group, uses information effectively to accomplish a specific purpose.
- The information literate student understands many of the economic, legal, and social issues surrounding the use of information and accesses and uses information ethically and legally.

Research Support Office

Reg. No. 20140013809

IRB-2014-11-008

20 January 2015

Associate Professor Guli Hue Lian, Dion
Wee Kim Wee School of Communication and Information

NTU INSTITUTIONAL REVIEW BOARD APPROVAL

Project Title: Evaluating an affective information literacy game prototype

I refer to your application for ethics approval with respect to the above project.

The Board has deliberated on your application and noted from your application that your research involves collecting behavioral data from participants through interviews.

You have also confirmed that informed consent will be obtained from the participants and you have guaranteed the confidentiality of your participants' biodata obtained from them.

The documents reviewed are:

- a) NTU IRB application form dated **11 November 2014**
- b) Participant information sheet and consent form: version 1 dated **11 November 2014**
- c) Data collection form: version 1 dated **11 November 2014**

The Board is therefore satisfied with the bioethical consideration for the project and approves the ethics application under **Expedited** review. The approval period is from **20 January 2015 to 19 January 2016**. The NTU IRB reference number for this study is **IRB-2014-11-008**. Please use this reference number for all future correspondence.

The following protocol and compliances are to be observed upon NTU IRB approval

1. All research involving procedures greater than minimal risk on minors (Individuals who are less than the legal age of 21 years old) requires IRB approved written Parental Consent and assent from the participant to be obtained before any research protocols can be administered. Minimal risk refers to an anticipated level of harm and discomfort that is no greater than that ordinarily encountered in daily life, or during the performance of routine educational, physical, or psychological examination.
2. Only the approved Participants Information Sheet and Consent Form should be used. It must be signed by each subject prior to initiation of any protocol procedures. In addition, each subject should be given a copy of the signed consent form.

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Appendix B-1 NTU IRB Approval for Experiment and Interviews in Study II

Research Support Office

Reg. No. 200604803R

IRB-2015-10-003

04 November 2015

Associate Professor Goh Hoe Lian, Dion
Wee Kim Wee School of Communication and Information

NTU INSTITUTIONAL REVIEW BOARD APPROVAL

Project Title: Evaluating the Influence of Affective Embodied Agents in an Information Literacy Game

I refer to your application for ethics approval with respect to the above project.

The Board has deliberated on your application and noted from your application that your research involves collecting behavioral data from participants using surveys and focus group discussion.

You have also confirmed that informed consent will be obtained from the participants and you have guaranteed the confidentiality of your participants' biodata obtained from them.

The documents reviewed are:

- a) NTU IRB application form dated **01 October 2015**
- b) Participant information sheet and consent form: version 1 dated **01 October 2015**
- c) Data collection form: version 1 dated **01 October 2015**

The Board is therefore satisfied with the bioethical consideration for the project and approves the ethics application under **Expedited** review. The approval period is from **04 November 2015** to **03 November 2016**. The NTU IRB reference number for this study is **IRB-2015-10-003**. Please use this reference number for all future correspondence.

The following protocol and compliances are to be observed upon NTU IRB approval

1. All research involving procedures greater than minimal risk on minors (individuals who are less than the legal age of 21 years old) requires IRB approved written Parental Consent and assent from the participant to be obtained before any research protocols can be administered. Minimal risk refers to an anticipated level of harm and discomfort that is no greater than that ordinarily encountered in daily life, or during the performance of routine educational, physical, or psychological examination.
2. Only the approved Participants Information Sheet and Consent Form should be used. It must be signed by each subject prior to initiation of any protocol procedures. In addition, each subject should be given a copy of the signed consent form.

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Research Support Office

3. Consent forms are important documents therefore they should be stored in the strictest arrangement. Loss of consent form would result in disciplinary action.
4. No deviation from, or changes of, the protocol should be initiated without prior written NTU IRB approval of an appropriate amendment.
5. The Principal Investigator should report promptly to NTU IRB regarding:
 - a. Deviation from, or changes to the protocol.
 - b. Changes increasing the risk to the subjects and/or affecting significantly the conduct of the trial
 - c. All serious adverse events (SAEs) which are both serious and unexpected.
 - d. New information that may affect adversely the safety of the subjects of the conduct of the trial.
 - e. Completion of the study.
6. Continuing Review Request/ Notice of Study completion form should be submitted to NTU IRB for the following:
 - a. Annual review: Status of the study should be reported to the NTU IRB at least annually using the Continuing Review Request/ Notice of Study completion form.
 - b. Study completion or termination: Continuing Review Request/ Notice of Study completion form is to be submitted within 4 to 6 weeks of study completion or termination.
7. All Principal Investigators should comply with existing legislation that would have an impact on the domain of their research.

Professor Lee Sing Kong,
Chair, NTU Institutional Review Board
encl.

cc Chair, Wee Kim Wee School of Communication and Information
Members, NTU Institutional Review Board

1. Pretest**Q1. (Topic: Keyword Searching)**

Select the set of search terms that best represent the main concepts in the following query:

What are the health risks associated with the use of drug therapy for hyperactive students?

- a. Drug therapy, health risks, hyperactivity
- b. Drug therapy, health risks, students
- c. Drug therapy, hyperactivity, students
- d. Drugs, hyperactivity, therapy
- e. I don't know

Q2. (Topic: Boolean Operator)

While researching a paper on character education, you find that it is also sometimes called *values education* or *moral education*. Which of the following is the best case to use in searching when you have fairly synonymous terms and it does not matter which of the terms is found in the record?

- a. Character education and values education and moral education
- b. Character education or values education or moral education
- c. Character, values and moral education
- d. Character, values or moral education
- e. I don't know

Q3. (Topic: Copyright)

In your paper, you want to use some data from an article by another author. How do you proceed according to ethical principles and the protection of author's rights?

- a. I am allowed to make reasonable use of the data as long as I cite the source article
- b. I can only use the data if I quote the source text word-for-word and cite the source article

- c. I can only use the data if I obtain written permission from the author
- d. Under no circumstances can I use the data
- e. I don't know

Q4. (Topic: Publication Cycle)

Research studies are generally first communicated through:

- a. Books
- b. Encyclopedia entries
- c. Professional conferences
- d. Journal articles
- e. I don't know

Q5. (Topic: Information Evaluation)

Which of the following is the best criterion to evaluate the credibility of an Internet site?

- a. The date of publication is provided
- b. The author is well-respected in the field
- c. Responsibility for the site is clearly indicated
- d. The site is rapidly accessible
- e. I don't know

Q6. (Topic: Source Selection)

For a history class on the 20th century, you need to find an interview of someone's firsthand account of a fire that happened in 1961 in Bukit Ho Swee. Which of the following would provide the most relevant results?

- a. A newspaper database
- b. A scientific journal
- c. Social media
- d. Magazine database

- e. I don't know

Q7. (Topic: Beginning Information Search)

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?

- a. A book
- b. A database
- c. A journal article
- d. A subject encyclopedia
- e. I don't know

Q8. (Topic: Using OPAC)

To find all the documents about *Margaret Atwood* in the library catalog, you would do a search:

- a. By title
- b. By publisher
- c. By subject
- d. By author
- e. I don't know

Q9. (Topic: Information Search Strategies)

You are searching for information on the spread of influenza in the Middle Ages. Which of the following sets of keywords would retrieve the largest number of relevant results in a search engine like Google?

- a. influenza
- b. influenza, Middle Ages
- c. influenza, flu, epidemic, Middle Ages, medieval
- d. influenza, disease, illness, information, research, medieval, Middle ages, statistics
- e. I don't know

Q10. (Topic: Journal Evaluation)

Which of the following indicates that an article is an outcome of scholarly research?

- a. It is made available in an academic library
- b. It is indexed by databases
- c. It is reviewed by experts for academic publication
- d. It is written by university faculty
- e. I don't know

2. Posttest

2.1. Manipulation check (1 item)

The librarian avatar in the program:

- 1. Expresses different emotions
- 2. Doesn't express emotions
- 3. Not applicable

2.2. Learning outcome

Q1. (Topic: Keyword Searching)

Select the set of search terms that best represent the main concepts in the following query:

What are the effects of family relations on the academic results of primary school students?

- a. family relations
- b. family relations, academic results
- c. family relations, academic results, primary school
- d. family relations, parents, academic results, children, primary school, class performance
- e. I don't know

Q2. (Topic: Boolean Operator)

While researching a paper on social media, you find that it is also sometimes called *social*

networking sites or *online social network*. Which of the following is the best example to use in searching when you have fairly synonymous terms and it does not matter which of the terms is found in the record?

- a. Social media and social networking sites and online social network
- b. Social media or social networking sites or online social network**
- c. Social media, social networking sites or online social network
- d. Social media, social networking sites and online social network
- e. I don't know

Q3. (Topic: Copyright)

You bought some old documents in a second-hand bookshop. Which of the documents can I scan and publish on my Webpage without authorization?

- a. Anonymous photo published in a women's magazine
- b. Article from a daily newspaper
- c. Original manuscript by William Shakespeare**
- d. Translation of a poem written by a living poet and published by a British publisher
- e. I don't know

Q4. (Topic: Publication Cycle)

To find the most recent information about drug abuse, you should consult:

- a. A book
- b. A journal article**
- c. Encyclopaedia Britannica
- d. A subject dictionary
- e. I don't know

Q5. (Topic: Information Evaluation)

For your biology class, you must research a recently discovered species of plant. A place you'd expect to find relevant and reliable information would be:

- a. A peer-reviewed journal
- b. Social media
- c. A magazine
- d. A newspaper database
- e. I don't know

Q6. (Topic: Source Selection)

For a 20th-century history class, you need to find an interview of someone's firsthand account of a riot that happened 20 years ago in Chicago. Which of the following would provide the most relevant results?

- a. A peer-reviewed journal
- b. Social media
- c. A magazine
- d. A newspaper database
- e. I don't know

Q7. (Topic: Beginning Information Search)

In order to find a brief history and summary about a subject about which you know very little, you should first consult:

- a. A journal
- b. An encyclopedia
- c. A database
- d. A book
- e. I don't know

Q8. (Topic: Using OPAC)

You have a class assignment to investigate how group work impacts student learning. A keyword search in the library catalog on "group work" has returned over 2,000 items, too many to sieve through. To narrow your search, which of the following steps would you next

perform?

- a. Add “impacts” as a keyword
- b. Add “student learning” as a keyword
- c. Limit search results by date
- d. Limit search results by publication type
- e. I don’t know

Q9. (Topic: Information Search Strategies)

If you are researching the 1918 influenza outbreak and need to find primary source materials, which of the following set of keywords would produce results that are the most relevant?

- a. Influenza, 1918
- b. Influenza, 1918 epidemic
- c. Influenza, 1918, diary
- d. Influenza flu statistics
- e. I don’t know

Q10. (Topic: Journal Evaluation)

Which of the following does NOT describe articles published in a scholarly journal?

- a. They are written for the layperson
- b. The articles typically include a list of references
- c. The research method used is described
- d. The articles have been evaluated by several independent referees before publication
- e. I don’t know

2.3. Motivational support (17 items)

Think back over your entire experience with the game.

Item	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
When I first played the game, I had the impression that it would be easy for me.					
There was something interesting at the beginning of the game that got my attention.					
The game was more difficult to understand than I would like for it to be.					
After reading the introductory information, I felt confident that I knew what I was supposed to learn from the game.					
Completing the game gave me a satisfying feeling of accomplishment.					
It is clear to me how the content of the game is related to things I already know.					
The game had so much information that it was hard to pick out and remember the important points.					
The interface design of the instructional program is eye-catching.					
There were examples that showed me how the game could be important to some people in the learning setting.					
Completing the game was important to me.					
The quality of the writing in the game helped to hold my attention.					
The content of the instructional program is so abstract that it was hard to keep my attention on it.					
As I played the game, I was confident that I could learn the content.					
I enjoyed the game so much that I would like to know more about this topic.					
The design of the game looks dry and unappealing.					
The content of the game is relevant to my interests.					
The way the information is arranged in the instructional program helped keep my attention.					
There are explanations or examples of how people use the knowledge in the game.					
The activities in the game were too difficult.					
The game has things that stimulated my curiosity.					
I really enjoyed learning with the game.					

Item	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The amount of repetition in the game caused me to get bored sometimes.					
The content and style of writing in the game convey the impression that its content is worth knowing.					
I learned some things that were surprising or unexpected with the game.					
After playing the game for a while, I was confident that I would be able to pass a test on the content.					
The game was not relevant to my needs because I already knew most of it.					
The wording of feedback, or of other comments in the instructional program, helped me feel rewarded for my effort.					
The variety of reading passages, activities, illustrations, etc., helped keep my attention in the game.					
The style of writing in the game is boring.					
I could relate the content of the game to things I have seen, done or thought about in my own life.					
There are so many words on each game screen that it is irritating.					
If felt good to successfully complete the game.					
The content in the instructional program will be useful to me.					
I could not really understand quite a bit of the material in the game.					
The good organization of the content in the game helped me be confident that I would learn this material.					
It was a pleasure to play such a well-designed game.					

2.4. Enjoyment (12 items)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I felt attracted to this game.					
I felt emotionally attached to the game.					
I felt emotionally affected while playing this game.					
I felt emotionally involved in the game.					
I was less worried about my life during the game.					

I became less aware of my surroundings because I was engrossed in the game.					
I lost track of time during the game.					
I was less self-aware during the game.					
I think this game is an effective way of learning IL skills.					
I think this game is a good way of learning IL skills.					
I think it is worthwhile to use the game.					
I think this game is an interesting way of learning IL skills.					

2.5*. Agent Persona Instrument (ONLY applicable to affective-EA condition)

The librarian	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
... led me to think more deeply about the presentation.					
... made the instruction interesting.					
... encouraged me to reflect what I was learning.					
... kept my attention.					
... presented the material effectively.					
... helped me to concentrate on the presentation.					
... focused me on the relevant information.					
... improved my knowledge of the content.					
... was interesting.					
... was enjoyable.					
... was knowledgeable.					
... was intelligent.					
... was useful.					
... was helpful.					
... was instructor-like.					
... has a personality.					
...’s emotion was natural.					
... was human-like.					
...’s movement was natural.					
... showed emotion.					
... was expressive.					
... was enthusiastic.					
... was entertaining.					

... was motivating.					
... was friendly.					

2.5. Usefulness (3 items)

Playing this game would improve my IL skills.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Playing this game would make it easier to learn IL knowledge.					
I would find the game useful in my studies.					

2.6. Intention to Use (9 items)

Assuming that I have access to this game, I intend to play it.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Given that I have access to this game, I predict that I would play it.					
When presented with this game, I am willing to use it.					
The game made me want to learn more about IL.					
Based on my experience today, I will consider learning more about IL.					
At the next available opportunity, I intend to learn more about IL.					
I would recommend this game to others (e.g., friends, classmates).					
If my friends were looking for educational games to improve their IL knowledge, I would tell them to try this game.					
I would spread positive word of mouth recommendations about this IL game.					

2.7. Subjective feedback (4 questions)

- (a) Reflect on what you have learnt on IL.
- (b) What do you like most about the program?
- (c) What do you like least about the program?
- (d) Do you have other suggestions and feedback?

2.9 Demographics

(1). Valid Email Address (for follow-up study only, will be kept strictly confidential):

(2). Gender:

Male _____ Female _____

(3). Country of Origin:

Singapore _____ Malaysia _____ Indian _____ China _____

Indonesia _____ Thailand _____ Myanmar _____ Vietnam _____

_____ Others (please indicate) _____

(4). Degree Pursuing:

Bachelor _____ Masters _____ PhD _____ Others (please indicate) _____

(5). Year of Study:

1 _____ 2 _____ 3 _____ 4+ _____

(6). Program of Study, School:

_____, _____

(7). Computer game experience:

None _____ Less than 1 year _____ 1 to 2 years _____ 2 to 3 years _____ More than 3 years _____

(8). How often do you play the following types of video games?

Types of Games	Almost every day	At least once a week	At least once a month	Seldom	Never
Stand alone PC games					
Massive multiplayer online games					
Arcade games					
Mobile games					
Console games (e.g., Xbox, Play Station)					
Portable handheld device games (e.g. Gameboy, PSP)					

(9). Age (dropdown list): Below 18, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32,

33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, above 50

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