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Story Decorated Context-Awareness Role Playing Learning Activity Generation

BY

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Abstract

In this research, a context-aware mobile role playing game is developed to provide users with a series of story decorated quests and allows them to interact with specific real and virtual objects in the real world. The game is designed based on multi-agent architecture, which allows reusable and modular agents and makes the game much more flexible and scalable. The usefulness of the CAM-RPG is evaluated with a comprehensive experiment. The interesting findings are: (1) generated story in CAM-RPG positively influences users' attitude toward game use and increases users' perceived game usefulness; (2) users' game-playing confidence, degree of liking computer games, and attitude toward computer games significantly influence attitudes toward CAM-RPG; and (3) there is no gender difference for users' game acceptance, but users' computer game attitude, time spent playing computer games, and voluntariness of use do significantly influence users' acceptance.

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List of Abbreviation

The following table lists all abbreviation words used in this thesis

A	ANOVA	Analysis of variance
C	CGAS	Computer game attitude scale
	Ac	Attitude toward computer
	Acg	Attitude toward computer game
	An	Anxiety
	Att	Attitude
	Bh	Behavior
	Cf	Confidence
	Lk	Like
	Lr	Learning
	Ls	Leisure
	Com	Comfortable
	CAM-RPG	Context-aware mobile role-playing game
	CG	Computer game
D	DB	Database
E	ELC	Edmonton Learning Centre
G	GBL	Game-based learning
	GPS	Global positioning system
H	HCI	Human/computer Interaction
I	IM	Information Management
K	KS	Knowledge structure
L	LBS	Location-based services
M	M-learning	Mobile learning
	MAA	Multi-agent architecture
	MIS	Management Information System
N	NKFUST	National Kaohsiung First University of Science and Technology
	NPCs	Non-player controlled characters
O	OWL	Web ontology language
	AO	Accommodation ontology
	DCO	Destination ontology
P	PDA	Personal digital assistants
Q	QR code	Quick Response two-dimension barcode
R	RFID	Radio-frequency identification
	RMS	Records management system
T	TAM	Technology acceptance model
	PEoU	Perceived ease of use
	PU	Perceived usefulness
	CA	Context-awareness of the game's characteristic
	ST	Storyline of the game's characteristic
	ATT	Attitude toward using the CAM-RPG
	IT	Intention of using the CAM-RPG
U	UI	User interface
V	VoU	Voluntariness of use
	VIF	Variance inflation factor

Chapter I – INTRODUCTION

This research focuses on story decorated learning activity generation in a context-aware mobile role-playing game (CAM-RPG). In this chapter, I will explain the motivation for this research, describe the goals and possible contributions of this research, and explain the structure of this thesis.

1.1 Motivation

According to 2010 statistics, vendors and manufacturers can produce and sell more than three hundred millions smartphones and have 72 % increasing from 2009 to 2010, moreover, smartphones occupied 19 % of total mobile communications device sales in 2010 (Pettey & Goasduff, 2011). The statistics data show a rapidly growing smartphone market and indicate changes in the ways mobile phones are used. For instance, more and more smartphone applications are being developed for business assistance, entertainment, education, useful utilities, and so forth. In the foreseeable future, most people in workplace will have at least one smartphone.

With the rapid growth of mobile technologies, positioning technologies (e.g. GPS) and location-based services (LBS) have been widely used in many industries, such as insurance and logistics. For instance, an insurance company uses a GPS-enabled mobile phone-like gadget to detect a car's position changes, and the gadget automatically calls the owner when it finds the car is moving after the owner has locked the car and started the anti-theft function. The owner and the insurance company can trace the car using a LBS system (Vaughan-Nichols, 2009). The technologies and applications specify that LBS are an important part of the future of mobile computing.

Many researchers use mobile devices to make students feel that they are living in an era or place in which they can obtain knowledge; e.g., users can learn about rainforest plants and ecology in the Amazon River zone of a botanical garden. This is called mobile/ubiquitous learning (Chang & Chang, 2006; Chen, Kao, Yu, & Sheu, 2004; Kurti, Milrad, & Spikol, 2007; Wu, Yang, Hwang, & Chu, 2008). Some other researchers have developed mobile games for educational purposes; these games not only allow learners to undertake learning activities in specific environments, such as museums and historical sites, but also get them more motivated than the abovementioned mobile learning (m-learning) systems (Chang, Wu, Chang, & Heh, 2008; Wu, Chang, Chang, Yen, & Heh, 2010).

However, most existing research on ubiquitous learning and game-based learning (GBL) focuses on specific disciplines in educational settings (i.e., school campus, museum or historical site) only. The learning systems proposed in these educational settings usually deliver knowledge related to natural science, art, and history. On the other hand, knowledge and skills also exist in our daily lives and working environments, for instance, understanding the purchasing procedure and using the photocopy machine. Thus, people need to learn before they are required to complete specific tasks.

Mobile phones have limited computing power and resources compared to desktop and laptop computers, so mobile applications are usually small and simplified. Tan and Kinshuk (2009) propose five design principles for developing applications on mobile devices: multiplatform adaptation, low resource usage, little human/device interaction, small data communication bandwidth use, and no additional hardware. These design principles take the limited computing power and resources that mobile devices such as smartphones have into consideration. The software architecture design then becomes an important research issue for reducing computing power consumed by m-learning systems.

1.2 Goal and Contribution

In order to provide users with an approach to learning from the objects in an authentic learning environment, and design an architecture for developing a complex system on a limited device such as mobile phone a context-aware mobile role playing game is designed and developed. This research has the following goals: (1) applying a mechanism and relevant techniques to store and represent all physical objects' attributes, existing knowledge, and concept relations in an authentic learning environment (by playing the mobile educational game, users are able to interact with the physical objects and learn some specific knowledge from the objects); (2) generating learning activities automatically and forming a storyline according to the users' location and the surrounding contexts, so they can play the role of one of the actors in the story and interact with objects that may represent specific knowledge/concepts and get familiar with the environment; (3) designing and implementing a multi-agent-based mobile game. With the design of multi-agent system architecture (MAA), different agents take responsibility for different services and tasks. In such circumstances, It is possible to better resolve the application development issues mobile devices have (i.e., limited resources and wireless connection ability) due to the multi-agent system's advantages (Balaji & Srinivasan, 2010).

Furthermore, my research has four contributions. First the proposed game has a context-aware knowledge structure (i.e., ubiquitous knowledge structure and narrative knowledge structure) that can represent all learning objects and characteristics associated with the environment. A Context-awareness knowledge structure can be applied to multiple learning domains and can be used not only to create personalized learning activities but also to generate immersive stories. Moreover, it can be built by the general public (e.g., teachers or administrators) easily. With the context-awareness knowledge structure's help, administrators are able to build and manage learning objects for the chosen environments of particular learning topics. The analysis and design of such a context-awareness knowledge structure will be introduced in Chapter III. Second, the game can generate different learning activities and form learning activity chains automatically according to the user's location, chosen role and theme, and surrounding learning objects, rather than using pre-built learning activities so all users see the same learning activities no matter what they are learning or where they are. Third, the game can create a corresponding storyline to enhance the generated learning activity chain. The generated stories give the simple learning activities the backgrounds and make the activities immersive. The story generation also enriches the game-play and makes users empathetic, rather than asking them to do monotonous activities for no reasons. Finally, the game's multi-agent architecture makes it easy to maintain and extend. By developing the system with multiple agents, the game can have benefits such as consuming less computing power and resources, having the flexibility to deal with a lost Internet connection and missing required hardware, and expandability and updatability through adding and exchanging agents. These aspects may contribute and have potential benefits to different users, including researchers, developers, employee, and employers in the future.

For academic researchers, this research explores the presentation of different knowledge structures and the constructions of knowledge/concepts. One of the system's contributions is to store all learning materials/concepts embedded within the learning objects in an authentic environment. The proposed context-awareness knowledge structure can benefit future researchers because the proposed knowledge structure can be applied to different learning environments (e.g., workplaces, universities, museums, zoos, botanical gardens, and national parks) and can be used to store a variety of domain knowledge easily and systematically. The proposed knowledge structure can store as many learning objects as desired as well as the relevant characteristics associated with the authentic environment.

Another contribution is that the proposed game provides users the opportunity to interact with learning objects and learn the associated knowledge through learning activities. The game can generate the right learning activities for the user according to where the user is located. For instance, the game can generate a "do me a favor for meeting day" activity for users when they are in the office and generate a "looking for the lost painting" activity when they are in the art gallery. Anyone can play the game at any time and anywhere because the proposed knowledge structure covers knowledge of various domains in many places around the world. The generated activities may benefit users engaging in self-learning in the authentic environment with real world objects. In addition, future researchers will be able to explore the user behaviors, reflections, and learning performance from the interaction happened between users and learning objects.

For mobile application developers, the multi-agent-based design approach provides reusable and modular agents. The architecture can be used when developers want to establish a large system on mobile devices that have limited resources and computing power. With the advantages of multi-agent architecture design, agents in the game can be replaced or expanded to fit different demands. In addition, mobile application developers can refer to the method of collaboration and communication among agents implemented in this research, which makes developing mobile applications more efficient.

For administrators, the proposed research provides a way to convert the real world into an authentic learning environment. Administrator can build concepts and concept relations with the proposed knowledge structure for any learning domain and any authentic environment. For instance, the game may present employees with daily events for on-the-job training purposes and the administrator could build the knowledge structure of their daily working environment; the game can also present visitors with treasure-hunting quests for museum learning and the administrator can build the knowledge structure of artifacts and exhibitions in the museum.

For users, the proposed game can bring new learning experiences and allow them to have fun while learning. Users can play a character in the game, do the quests, and interact with the learning objects in the authentic environment. I expect to see this "learning by playing" style may have a positive impact on the user's learning performance.

1.3 Objectives and Research Issues

In this section, I describe four research objectives of this thesis work. In order to achieve the objectives, several issues are needed to be solved. Each objective may have one or more issues.

Objective #1: Design a knowledge structure that can store learning objects' attributes and represent the concept relations among learning objects.

First of all, most m-learning researchers develop applications for specific disciplines such as history, botany, language, and so on. These applications may lack flexibility in porting to different disciplines; therefore, in this thesis work, I design a knowledge structure that can store and present multidisciplinary knowledge in different learning environments.

To achieve this objective, several issues need to be resolved:

Issue #1: What kind of structures can be used to store real objects and their related material?

Many knowledge structures can be used to present the knowledge of learning materials in different domains. Some structures can store conceptual relations, some structures can store virtual objects such as images and files, and some structures can store real objects in the real world. I need to analyze these knowledge structures' features (e.g., concept map, ontology, knowledge map, and so forth) and design an appropriate knowledge structure either by modifying existing structures or by combing two or more structures. The details of the proposed knowledge structure can be found in Section 3.1.1.

Objective #2: Comply with the design principles of mobile application development.

Many m-learning researchers consider the limited computing power and resources that mobile devices have and develop small mobile applications. The five mobile application development design principles proposed by Tan and Kinshuk (2009) are important and need to be taken into consideration when designing the mobile educational game.

To achieve this objective, the following issues need to be resolved:

Issue #2: Multiplatform adaptation issue.

There are many different mobile phone manufacturers, e.g., Nokia, HTC, Apple, Motorola, and so on. These manufacturers' mobile phones use different operating systems, such as SymbianOS, Windows Mobile, and iOS. These various platforms make it hard for mobile application developers to develop a system that can run on every mobile phone. An ideal architecture needs to be designed in order to provide a flexible way to develop a mobile educational game running on different platform easier.

Issue #3: Limited-resource issue.

The mobile phone limited-resource issue is the constraint of mobile application development in much of the research (Satyanarayanan, 2001; Mascolo, Capra, & Emmerich, 2002; Biegel & Cahill, 2004). One possible direction for solving this issue is for mobile application to be designed to use the computing power of the phone as little as possible. Correspondingly, computation must take place on the server side as much as possible. This solution tends to convert mobile applications into distributed computing systems. However, this distributed computing solution leads to a data communication cost issue (i.e., Issue #4). I would like to find a better way to solve these two issues in this research.

Issue #4: Data communication cost issue.

Unlike for applications on desktop computers with a fixed network infrastructure, mobile phone users usually need to spend extra money to access the Internet via wireless networks and cellular networks. For instance, you may need to purchase a data plan to allow your mobile phone to send and receive emails. In addition, mobile phones may encounter sudden disconnection problems, for example, the mobile phones may lose its signal when driving through a tunnel. This research needs to consider minimizing bandwidth use as much as possible.

Issue #5: Human/device interaction issue.

This is a human/computer interaction (HCI) issue. Due to the small screen and keypad, mobile phones, in many cases, offer human/device interactions that are inconvenient and even difficult for users. To address this issue, I need to consider which interactions are really necessary to users and minimize interactions as much as possible.

Issue #6: Additional hardware issue.

This issue is similar to the multiplatform adaption issue. Mobile application developers need to consider what built-in functions users' mobile phones really have. For instance, GPS receivers may only exist in high-level smartphones and an RFID reader is usually additional hardware that users may need to purchase themselves. If a mobile application requires additional hardware, the application may have less opportunity to be accepted by the public in practice. I need to design a way to allow my system (i.e., the game) to run on mobile phones in which some necessary functions are missing, for example, my game can still locate where the user is located on a mobile phone without a built-in GPS receiver.

Multi-agent-based architecture will be applied to my system design to comply with Issues 2-6. The details are discussed in Section 4.1.3.

Objective #3: Generate a series of learning activities.

There are many mobile educational games in the world, and many games use location-based service to present users with more attractive and context-aware game-play experiences with built-in/pre-defined learning activities. Little of the research talks about automatically generated learning activities according to user needs and the surrounding context; this research is going to generate personalized context-awareness learning activities automatically for the users.

To achieve this objective, several issues need to be resolved:

Issue #7: How to retrieve suitable learning objects that users need from the knowledge structure?

Since the knowledge structure stores all learning objects and their attributes and embedded concepts, as well as object relationships, an approach to retrieving relevant learning objects according to the user context, e.g., the chosen theme, location, learning experiences, must be developed so the retrieved learning objects can make users feel that the objects are what they want to see/know. The retrieval method will be designed in Section 3.1.1.

Issue # 8: How to generate learning activities?

The resolution of Issue #7 requires many learning objects associated with users' needs and location. How to choose some of them and put them together to form a learning activity is an issue. For this issue, I deploy a simple method to generate learning activity candidates and eliminate similar ones immediately. The method will be explained in Sections 3.1.2 and 3.2.3

Issue #9: How to sort the learning activities and create a learning activity chain?

As mentioned, learning activities may involve more than one learning objects, so a user may need to spend more time to find all the required learning objects that a learning activity asks for. Even if two learning activities involve the same amount of learning objects, some learning objects might not be easy to find (or access). Therefore, the game needs to have a mechanism to sort the learning activities from simple to complex. Users may solve their first learning activity with no difficulty and may need to seek multiple learning objects in later activities. The simple activity is like a training quest and the complex activities are like the challenges. Since the order of learning activities may be an important factor from both learning and playing viewpoints, I will design an approach to sort these generated learning activities and put them into a chain. The details will be discussed in Sections 3.1.3 and 3.2.3.

Objective #4: All users to have a joyful game-play experience.

Even if this research can generate a series of learning activities for users, the game will be boring if it just asks users to do the activities one by one. Little of the research talks about how to design the contents of mobile educational games and make users feel interested and want to play the game continuously. For this objective, I will design an educational role-playing game in order to make users feel that they are living in the game world. Users play an actor, explore the game world, complete the quests, and learn something.

For this objective, I consider applying the narrative theory to the game design in order to enhance the learning activity chain and transform it into an interesting storyline. Two issues need to be considered to achieve this objective.

Issue #10: How to decorate the learning activity chain with narrative elements?

According to the literature review, I can identify core narrative elements for this game and then design a structure to store all necessary narrative element data for creating a story. I need to find a simple method to pick up element data from the structure to decorate learning activities. The pick-up method needs to maintain the consistency and sequence in-between learning activities in the storyline, for instances, I won't have the car today if I sold it yesterday.

Issue #11: Does the proposed CAM-RPG help users learn as well as increase their positive attitudes and intentions for using the game?

After I develop and implement the mobile educational game to help users engage in self-learning, I need to know the users' perceptions of the game. Although most research results argue that game-based learning does have a positive impact on user's intention of using and facilitate user's learning performance, some research findings indicate that there is no significant relationship between user's learning motivation and educational games. I conduct an experiment to see if the proposed CAM-RPG can improve user attitude and intention toward using the game.

1.4 Thesis Organization

Chapter II discusses the relevant works that many researchers have done in the domain of m-learning, game-based learning, multi-agent systems, knowledge structure, and theories this research needs to design an activity-generation mechanism and scalable mobile educational game. Chapter III describes the process of context-awareness learning activity generation. In order to make the learning activities more fun for users, this chapter also uncovers a way of using narrative elements to generate a story to enhance the learning activities in the game. Chapter IV focuses on multi-agent-based mobile educational game design including how to solve the five design issues of mobile application development, system architecture, and collaboration among agents. The gameplay from the user's viewpoint is also discussed in this chapter. In Chapter V, I raise the research questions I want to verify in the experiment, list corresponding hypotheses, design the experiment and related questionnaires to collect qualitative and quantitative data, analyze the collected data both quantitatively and qualitatively, evaluate the effectiveness of the game and discuss the important findings. Chapter VI summarizes this research and talks about possible future work.

Chapter II – RELEVANT RESEARCH

In this chapter, some relevant research are reviewed. These researches offer strong support of my research both theoretically and technically. The researches come from various domains include mobile learning, game-based learning, multi-agent systems and knowledge structure.

2.1 Terms Definition

In this section, some specific terms and theories are defined from previous research in order to present clear ideas in the following sections.

- *Context*: "Any information that can be used to characterize the situation of an entity. An entity can be a person, place, or physical or computational object that is considered relevant to the interaction between a user and an application, including the user and applications themselves (Dey & Abowd, 1999)."
- *Context-aware application*: "A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task (Dey & Abowd, 1999)."
- *Agent*: Agents are independent computer programs operating within software environments such as operating systems, databases, or computer networks. These agents help users with routine computer tasks, while still accommodating individual habits. (Roesler & Hawkins, 1994)" For example, an agent could help users compare vehicles' prices online.
- *Multi-agent system*: A multi-agent system is a software environment in which many agents live. These agents are responsible for their

own tasks, have goals, and collaborate with other agents whose responsibilities belong to the pre- and post-requisite tasks.

- *Narrative:* "Narrative is a structure which should consist of all narrative texts and only those texts which are narrative; narrative is a story with a constructive format that describes a sequence of fictional or non-fictional events. (Mieke, 1985)"
- *Information theory*: Information theory is a mathematical methodology proposed by Claude E. Shannon in 1948 to find the fundamental limits on signal processing operations such as compressingand storing data reliably on data communication. Information theory has been widely applied in many areas such as natural language processing and statistical inference.
- *Rough set*: Rough set was proposed by Zdzislaw I. Pawlak in 1982. It can be seen as a mathematical approach to express vagueness, certainty, and negative region cases for a set of objects according to their relevant information/knowledge.

2.2 Mobile Learning

E-learning has been widely accepted as a mature methodology that can be used when teachers and students are separated into different places, so they can interact with each other via a variety of synchronous or asynchronous tools such as web-cam, video, audio, teleconference systems, online forums, and email. However, these tools, which required an Internet connection, also become a restriction of e-learning. Learners have to stay in areas with an available wired/wireless Internet environment (Chang & Chang, 2006).

With mobile platform features such as portability, multi-media capacity, wireless Internet access, sensor technologies and location-aware potential (Kim & Schliesser, 2007; Gil-Rodríguez & Rebaque-Rivas, 2010), mobile applications are widely used and bring opportunities to various application domains in our daily lives, including education, transportation, healthcare, tourism, and training.

In the last decade, many researchers have seen mobile learning (m-learning) as the further evolution of e-learning (Georgiev, Georgieva, & Smrikarov, 2004; Keegan, 2005; Laouris & Eteokleous, 2005; Vogel, Spikol, Kurti, & Milrad, 2010). Unlike computer-based learning (learning at a specific place with desktop computers), m-learning delivers education and training materials to a variety of lightweight devices such as personal digital assistants (PDAs), tablet PCs, smartphones, and mobile phones, which users can comfortably carry and use for learning anywhere, at any time (Keegan, 2005). Beyond the learning devices, some researchers also think the context of pedagogy differs between e-learning and m-learning. While e-learning pedagogy is mainly compatible with the classroom paradigm, m-learning has made learning occur in the field (Laouris & Eteokleous, 2005). Especially for environmental sciences, m-learning brings potential benefits for learners' self-learning by realizing real-time and location-based learning materials (Vogel, Spikol, Kurti, & Milrad, 2010).

Brown and colleagues (1989) argue that students can learn specific knowledge more efficiently by interacting with a situated environment (Brown, Collins, & Duguid, 1989). With the help of mobile devices and relevant technologies, the learning style has changed from indoor learning to an outdoor learning mode. Learners can observe or touch the learning objects and can interact with the m-learning system immediately. This kind of learning mode combines virtual and real worlds and make learning more interesting. For instance, Wu and colleagues (2010) developed a mobile educational game on historical sites to guide and teach students about specific point in history and culture. These systems integrate contents (i.e., domain knowledge), independent learning (i.e., learner's self-leaning), and m-learning techniques (i.e., portable device and wireless transmission) to achieve the form of situated learning.

Chang and colleagues (2008) proposed a mobile adventure game that allows learners to choose their preferred topics to learn in the museum. In the adventure game, learners receive quests on mobile phones according to their preferences and look for the quest-required artifacts.

Kurti and colleagues (2007) developed a collaborative game in the museum that provides different missions for two groups of children (i.e., an outdoor group with mobile phones and an indoor group with laptops) learning collaboratively. A series of paired missions is offered to the two groups in order to allow children to collaborate with others (in different groups). For instances, the outdoor- group children may ask the indoor-group children to search the Internet for desired information such as a building's history or a person's name. Correspondingly, the indoor-group children may ask the outdoor-group children to take photos of particular buildings or landmarks that their task requires.

The concept of adaptive learning has also been considered in m-learning research to offer learners suitable and appropriate learning materials. In Di

Bitonto's research, a mobile application installed on the user's mobile device can accompany the user around the museum, give him/her some options to choose the art works s/he likes, and provide suitable contents in different forms (e.g., text, video, audio, and image) according to the user's preference, interaction pattern with the application, and cognition (e.g., how the user thinks, perceives, and remembers) of the received contents (Di Bitonto, Roselli, Rossano, Monacis, & Sinatra, 2010). Some researchers use learning styles to model learners systematically from their preferences, learning reflections, and learning experiences, in order to provide them with adaptive learning contents through the use of mobile technology (Al-Hmouz, Shen, Yan, & Al-Hmouz, 2010).

Location-based services (LBS) are some of the most common services in mobile applications because LBS can provide users with the right information at the right place and the right time. LBS allow the mobile applications not only to be aware of the user's location, but also to deliver relevant information as personalized services. Canadi, Höpken, & Fuchs (2010) describe the scenarios in the museum (i.e., souvenir shop, event activity promotion, tourist information, and mobile ticketing) that combine LBS and mobile tagging (i.e., QR codes) to present a vision of the future of mobile computing. For instance, a visitor a visitor can get an introduction to the automobile industry's history after s/he takes a photo of the QR code attached to the old automobile in the exhibition hall; a visitor can get promotion information or be redirected to an online shopping website after taking a picture of the QR code attached to the door of a souvenir shop.

Positioning techniques (i.e., GPS and triangulation of cellular networks) also are widely used. With the support of GPS-enabled devices, users have access to location-based services such as driving guidance, vehicle/mobile locks and trace services for getting back lost property, and social networks for finding nearby friends (Vaughan-Nichols, 2009).

Considering the abovementioned research and techniques, one of my research purposes is to make user interact with the surrounding learning objects and engage in self-learning anywhere, at any time. My research takes situated learning, context-aware m-learning and location-based services into considerations to design and develop the system.

2.3 Game-based Learning

Garris et al. (2002) applied an instructional model to instructional games that uses game-feature-relevant instructional contents as inputs and makes the game-play a cycle, as shown in Figure 1. In this model, the repeatable judgment-behavior-feedback activity is a game cycle. First, the user encounters some circumstances (i.e., challenges, puzzles, and choices) in the game. S/he may decide which action s/he wants to take within the circumstances, i.e., his//her judgment. After s/he chose the action, s/he acts and these actions are his/her behaviors. The game generates corresponding results (i.e., rewards, failure/complement, and next quest) as feedback for him/her. These repeated activities can increase the user's motivation and enjoyment of playing the game, make users play the game continuously, and increase users' confidence in the gameplay (Garris, Ahlers, & Driskell, 2002).

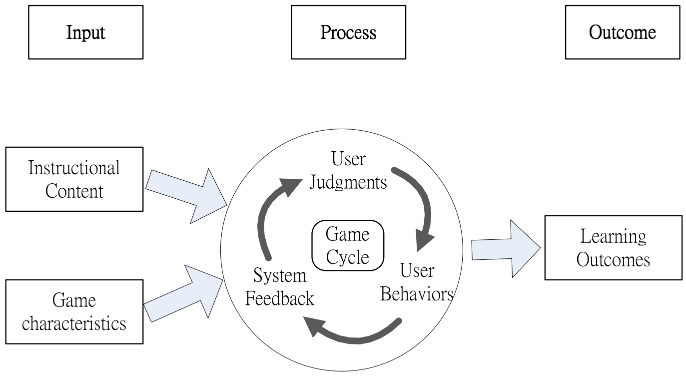


Figure 1. Game-based instructional model (according to Garris, Ahlers, & Driskell, 2002)

Mattheiss and colleagues (2009) propose an advanced motivation model based on Garris's instructional model. They add s "personal" characteristic to the "Input" layer and divide the outcomes into "cognitive" and "affective motivational" as shown in Figure 2.

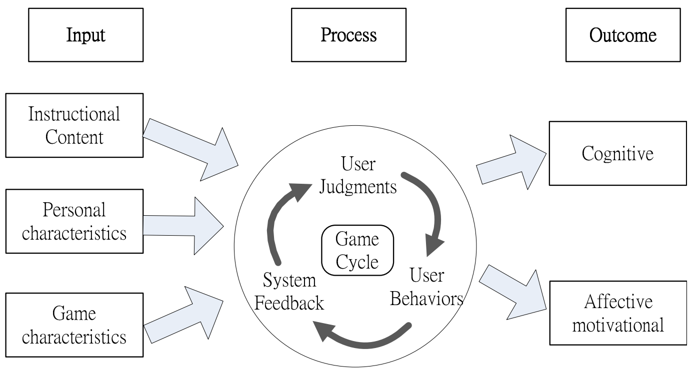


Figure 2. Advanced motivation model (according to Mattheiss, Kickmeier-Rust, Steiner, & Albert, 2009)

Mattheiss and colleagues (2009) propose that each part of the model can be considered incentive factors to enhance motivation. Personal characteristics such as gender and age could potentially influence the preference for playing a specific game; thus, personal characteristics should be considered while designing an educational game. The game-based instructional model and the advanced motivation model provide some perspectives for designing successful educational games.

Game-based learning (GBL) has been a hot topic in the training and education field. The combination of digital games and learning materials provides a new form of knowledge presentation and a transference process of the learning experience (Pivec, 2003; Chen & Shan, 2010; Wu, Chang, Chang, Yen, & Heh, 2010). For instance, learners may be engaged in the challenges of the game and construct their own knowledge with the use of trial-and-error to conquer the challenges. In addition, the characteristics of games such as fantasy, curiosity, and challenge, attract players to be continuously involved in a game (Malone, 1981).

Furthermore, motivation in game-based learning is still a topic about which researchers have different thoughts. Whitton (2007) has done a quantitative and qualitative study analyzing the use of computer game-based learning in higher education. He has concluded that there is no significant evidence of the relationship between motivation and using a game for learning. However, this does not mean that games should not be used in teaching. He proposes that game-based learning research should create experiential, immersive, and engaging, problem-based learning experiences that appropriately map the curriculum.

There are many different game genres (ACMI, 2011), and two of them seem to be rather suitable for educational purposes: adventure games and role-playing game (Frazer, Argles, & Wills, 2008; Lu, Lou, Papa, & Chung, 2010). During the adventure journey of the gameplay in these games, players may encounter missions, tasks, and puzzles. The implicit knowledge or solutions for these quests require players' judgments and reactions. The challenges that a game gives to the players and the pleasure experiences that players gain from achievements in the game also motivate them to play the game continuously and foster their comprehensive understanding of domain knowledge.

Correspondingly, to create a joyful game and gameplay experiences, it is important to think of using drama, storylines, humor, and characters. Dickey (2006) presents an overview of game genres and analyzes how important narrative in educational game design. Some researchers also propose that the use of narrative design in the game gives players empathy toward the characters (i.e., have pity toward the victim character or feel responsibility like a hero). The generated fun and empathy of games attract players to be involved constantly (Aylett et al., 2006).

Narrative elements such as storyline, character, and interaction have been analyzed and used in the game-based learning design (Ying, Wu, Chang, & Heh, 2009). Conle (2003) also summarizes that narrative involves a temporal sequence, a plot, characters, context, and the sense of an ending. In the GBL environment, narrative elements provide users with contextual information and connect to users' own understanding to stimulate their reflection, evaluation, illustration, exemplification, and inquiry (Conle, 2003).

Another important game element is the quest. Quests are the easiest way to design and present the narrative elements in a game (Tosca, 2003). In general, quests have several properties, such as the objective, the task, and success or failure conditions. Ashmore and Nitsche (2007) have summarized three types of quests in the game, leveling up quests which include start/finish conditions and tasks, are common in role-playing games and massive multiplayer online games (e.g., Dungeons & Dragons and World of Warcraft); mission-based quests, which have the same elements as leveling-up quests, except that the leveling issues are usually applied in shooting games and stage-based games (e.g., Counter-Strike and Super Mario Bros); and exploring quests, which present various obstacles and keys in the game to motivate players to explore the game world (e.g., Spore). Finally, they conclude that quests should consider four elements: the space, the challenges, the goal, and the dramatic setting.

2.4 Multi-Agent System

Agents are independent computer programs, capable of acting autonomously and continuously to meet the design objectives (Baylor, 1999). An agent-based system usually involves a number of relatively small computing systems/modules (i.e., agents) and allows them to communicate and collaborate with each other to solve a bigger problem. Agent definitions vary among researchers in different domains. In Artificial Intelligence, an intelligent agent is viewed as a smart computing component which can collaborate with others, and even learn from the interaction autonomously to complete its tasks/objectives. In software engineering, a software agent is generally defined as,

"a component of software and/or hardware which is capable of acting exactingly in order to accomplish tasks on behalf of its user." (Nwana, 1996), but is not limited to this definition.

Nwana (1996) has proposed an agent typology including four types of agents (i.e., collaborative agents, collaborative learning agents, interface agents, and truly smart agents) according to the three main characteristics; autonomous, learning, and cooperation. The categories are not definitive but provide a general view for agents.

A multi-agent system is a software environment in which many agents live. These agents are responsible for their own tasks and collaborate with other agents whose responsibilities belong to the pre- and post-requisite tasks. Multi-agent architecture is useful for developing mobile applications because it can divide a complex task into several small tasks and assign these tasks to different agents. Moreover, these agents can work either in the same place (e.g., a mobile phone) or in different machines/platforms as a distributed system.

Jih and colleagues (2006) proposed a multi-agent-based healthcare application for a smart home. In their architecture, four groups of agents were developed (i.e., context manager, context event broker, inference agent, and device agents). The research purpose was to divide complex problems (e.g., personalized response generation and services delivery in a smart home) into small sub-problems and use different agents as handlers. These agents could generate appropriate responses like text messages for the user and send the messages to mobile devices.

Balaji and Srinivasan (2010) implemented a multi-agent system to operate complex controls in an urban traffic network management system. This research applied multiple agents in traffic stations (e.g., traffic lights in the intersections) with different agents working out a signal control policy together in order to make traffic flow smoothly. The results show that MAA can be seen as a helpful solution to complex computation problems such as optimizing the traffic signal timings. Balaji and Srinivasan (2010)summarize the benefits of multi-agent systems as: (1) increased speed and efficiency because agents are working in parallel and asynchronously; (2) increased reliability and robustness since it is unlikely that all agents will fail at the same time; (3) increased scalability and flexibility since agents can be added at any time when needed; (4) reduced computational and communication costs due to the non-centralized architecture; and (5) high reusability because agents can be easily replaced or upgraded.

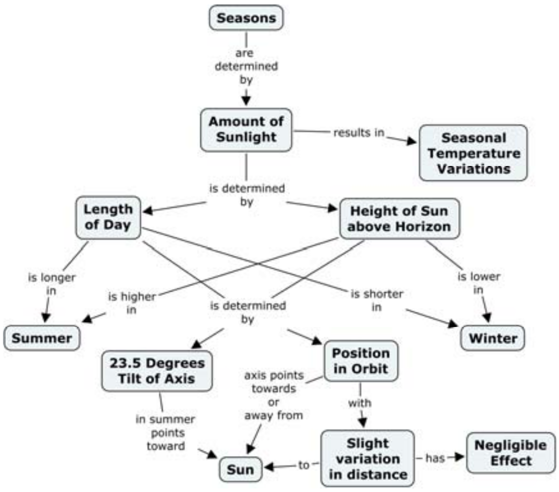
In educational mobile applications, some researchers propose multi-agent-based architecture to provide users with location-aware service and support users learning in the ubiquitous environment (Chang, Tan, Liu & Lin, 2008). They design and develop different agents with specific abilities and allow the agents to communicate and to collaborate with each other. The agents work on different tasks, such as positioning and grouping learners, leaning path planning, and learning material delivering. Many other researchers have also applied the multi-agent concept to learning management and mobile educational system design, and have reported good results in system scalability (Zhang & Lin, 2007; Dutchuk, Muhammadi, & Lin, 2009).

In summary, multi-agent-based architecture offers system analysts a reusable and modular design principle, allows developers to build a flexible and scalable system, and helps followers upgrade/update the system. For instance, the functionalities of agents are independent, and an agent can be upgraded or replaced easily without altering the whole system. In addition, the agent-based architecture can cope with the mobile development issues, especially the resource usage and data communication costs because the agents work collaboratively and autonomously.

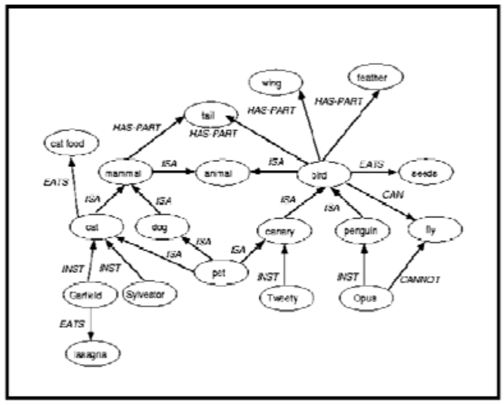
2.5 Knowledge Structure

In order to provide users' with personalized/customized learning services, first, we need to know what the users want to learn and what they already know. Knowledge structure is a good way to store and present the concept relations that learning materials may have.

Knowledge structure can be traced back to the memory model proposed by Quillian in 1967. After that, several knowledge structures are proposed to visualize concepts via graphs. Novak and Gowin (1984) have proposed a structure called concept map, which uses graphs to organize and represent knowledge. The concept map uses circles or boxes to represent concepts, and connects two concepts with an undirected line to represent the concept relation. Concept maps can be used not only as learning tools but also evaluation tools (Novak & Cañas, 2006). Ogata and Yano (2005) proposed a knowledge awareness map, which can visualize the relations between the sharing knowledge and the learner interactions. Another well-known theoretical structure, called the semantic network, was proposed by Sowa in 1983. A semantic network is a systematic means for researchers to model an individual's mental schema of declarative knowledge (Sowa, 1983, 1991). Figure 3 shows the two knowledge structures.



Concept Map for presenting seasons (Novak & Cañas, 2008)



Semantic Networks for presenting birds (Sowa, 1991)

Figure 3. Knowledge structures

Another methodology for presenting knowledge is ontology which has evolved from the philosophy domain to the computer science and artificial intelligence fields. Ontology has been applied in the text analysis area and has been used widely, e.g., WordNet and Web Ontology Language (OWL), to analyze the semantic lexicon of words (Mathieu, 2005). Researchers use ontology to define vocabulary that presents the knowledge of a particular domain in order to provide a platform for effective communication and knowledge sharing among users and systems.

Daramola and colleagues (2009) present an ontology-based architecture framework that constructs tourism-related OWL for developing a tourism recommendation system. In the research, they define two ontologies destination context ontology (DCO) and accommodation ontology (AO) with respective social attributes (i.e., weather temperature, scenery, volume of traffic, crime rate, and city type). The tourism recommendation system first takes a user's preference list as an input and retrieves and sorts the correlated destinations as initial recommendations. The system then uses DCO to filter and revise the initial recommendations based on the user's preferred social attributes. Finally, the system uses AO to filter and generate a list of accommodation suggestions.

Wu and colleagues (2008) proposed the ubiquitous knowledge structure for museum learning and elementary-level botanic learning (Wu, Chang, Chang, Liu, & Heh, 2008). It has been proven to be a good way to store the knowledge that learning objects (in the real world) and materials (in the textbook) offer. Its hierarchical structure is easy to understand and manage for general administrators (e.g., school teachers and system managers) and there is no specific rule for building a knowledge structure. In addition, it can be applied to multiple domains/disciplines.

Three layers of the ubiquitous knowledge structure are adopted in this research to build the context-awareness knowledge structure according to the learning environment in which the mobile game takes place. Figure 4 shows the altered context-awareness knowledge structure: the domain layer defines subjects and topics as well as themes. In addition, different domains may cover the same objects and characteristics. The characteristic layer is a hierarchical structure, may be associated with many domains, and has root characteristics and child characteristics. The object layer stores all learning objects in the real world, e.g., workplaces, equipment, devices, forms, and flyers.

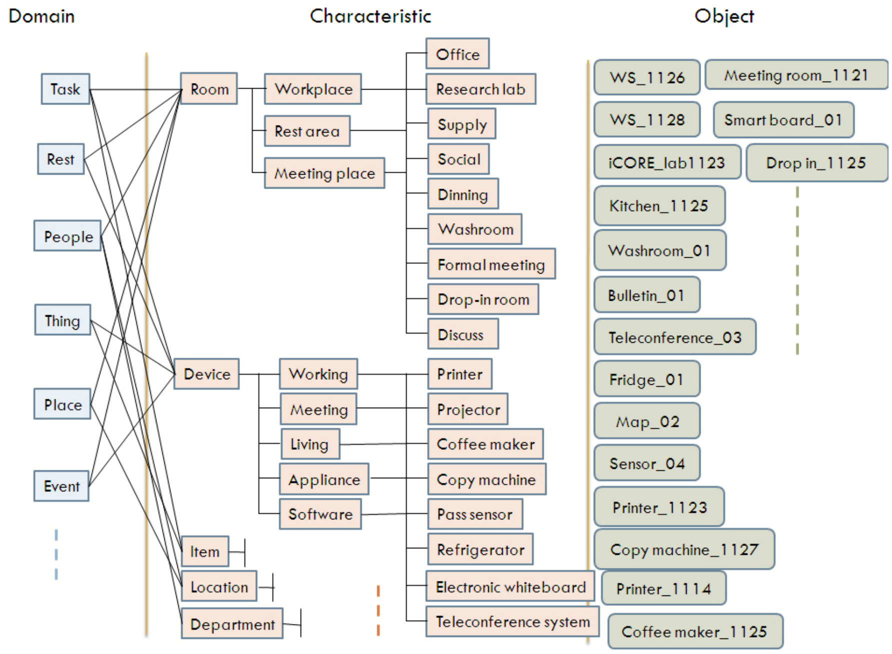


Figure 4. Partial ubiquitous knowledge structure for the 11th floor of ELC.

In summary, a variety of knowledge structures that exist in the real world have been shown. By analyzing and modifying the existing knowledge structures, the ubiquitous knowledge structure is used as a solution to store and present the knowledge for the CAM-RPG.

2.6 Information Theory and Rough Set

In order to measure a learning object and learning characteristic's degree of commonality/rareness, information theory and rough set are taken into consideration in this research.

Information theory uses logarithmic base and probability to calculate the value of a learning object/characteristic in the environment by comparing it with others. Information theory was developed by Shannon in 1948. Information theory is a theoretical method of applied mathematics and electrical engineering to quantify information or signals. Some researchers use it to measure the importance of information involved in learning objects in the real world (Liu, Kuo, Chang, & Heh, 2008). In this research, a learning object's information value is:

$$I(LO_i) = \log_2\left(\frac{1}{P_{LOi}}\right),$$

where P_{LOi} is the characteristic probability of the learning object LO_i, and I(LO_i) is the information value of the learning object LO_i.

The rough set is an approach to determining whether the user is interested in the learning objects. the rough set was developed by Pawlak and his colleagues in the 1970s (Pawlak, 1973) and has been widely used in various domains: data analysis, knowledge discovery, decision analysis, pattern recognition, and intelligent systems. The rough set has three regions that can be used to classify things into three categories (Chang, Wu, Chang, & Heh, 2008; Düntsch, & Gediga, 1998; Pawlak & Skowron, 2007):

- Positive set/certainly: All elements within the positive set fit the success criteria that the researchers made.
- Boundary set/possibly: No elements within the boundary set can be easily classified into either the positive or negative set due to uncertainty or partial fit in the success/failed criteria.
- Negative set/certainly not: All elements within the negative set fit the failed criteria that the researchers made.

This research uses the rough set to define and filter the irrelevant items in the knowledge structure and uses information theory to calculate the items' information value.

2.7 Theoretical Model of Experiment

To assess the proposed game, the extended technology-acceptance model, computer game attitude scale, and usability analysis are applied to explore user's perception, attitude, and intention toward using the proposed game as well as examine the system's usability.

The technology acceptance model (TAM) was proposed by Fred D. Davis in 1986 and became the most common theory used to explain the user's behavioral intention of using an innovative technology. It is one of the most used models in information system research because of its simplicity and ease of implementation. The original TAM has four constructs: the perceived ease of use, the perceived usefulness, the attitude toward using the innovative technology, and the behavioral intention of using the innovative technology. Some researchers have revised TAM by adding their own variables to the original model to explore the influences of different external variables (Bourgonjon, Valcke, Soetaert, & Schellens, 2010; Ibrahim, 2011).

Usability is a general term used in human/computer interaction (HCI) research, and can be widely explained as how easy to use the user interface is and how effectively and efficiently the product can help users achieve particular goals. Nielsen (1993) explains that usability is a quality attribute measured up by five components to test a system's overall acceptability. A usable system should be "easy to learn", "efficient to use", "easy to remember", "have few errors", and "be subjectively pleasing". The five components proposed by Nielsen are generally accepted as essential of any software project (Fetaji, Dika, & Fetaji, 2008; Holzinger, 2005; Nielsen, 1993, 2010; Seong, 2006):

- Learnability (easy to learn): Users can rapidly do some works with the system.
- Efficiency (efficient to use): Users can not only learn how to use the system quickly, but also have high productivity using the system.
- Memorability (easy to remember): After a period of not having used the system, users still remember how to use the system without having to learn the instructions again.
- Error tolerant (few errors): Users make few errors when using the system and the errors can be easily addressed.
- Satisfaction (subjectively pleasing): Users are satisfied with the system.

Chapter III – CONTEXT-AWARENESS LEARNING ACTIVITY GENERATION

Chapter III mainly focuses on the context-awareness learning activity generation, and how to combine narrative elements to produce a story decorated learning activity chain. Section 3.1 introduces the generation flow and its steps. Section 3.2 describes the development of story decorated context in the game. Section 3.3 presents a complete example to demonstrate the circumstances of the story decorated learning activity (or says quest) generation process.

3.1 Learning Activity Generation

The section describes a conceptual view for CAM-RPG. The game uses knowledge structure to store environment information and its learning objects, furthermore, uses the activity generating engine to generate a series of learning activities according to the user's situation and context surrounding by him/her. Figure 5 shows the learning activity generation flow. This flow has five steps:

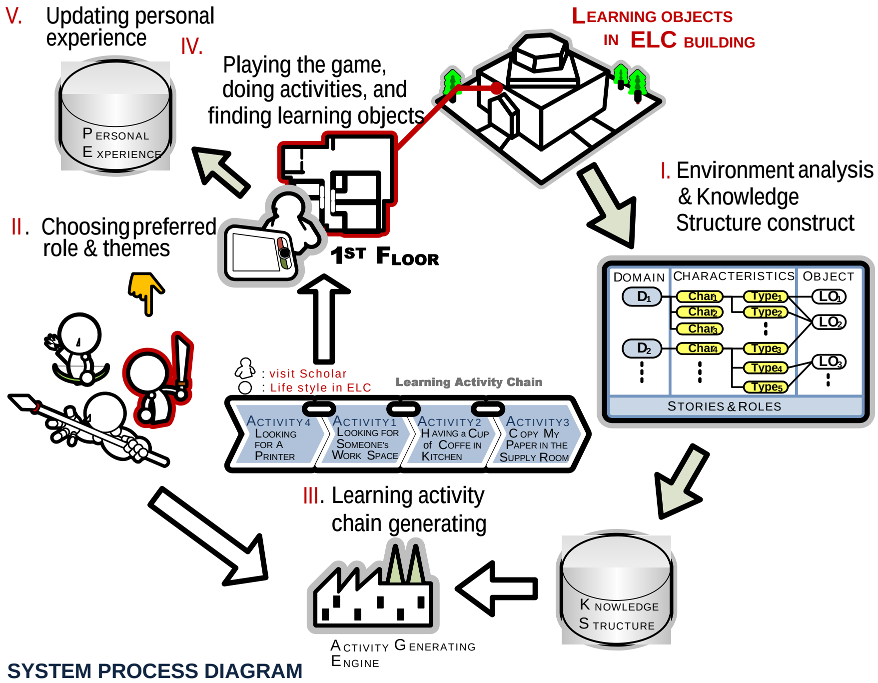


Figure 5. Learning activity generation flow

I. **Analysis:** The first step is to list the learning domains and corresponding objects which users can learn in the authentic environment; then to identify all characteristics and to figure the associated learning objects out. The analysis results are stored into the ubiquitous knowledge structure. After that, roles and corresponding themes in the game are designed for covering one or more learning domains.

II. **Role & theme:** At this step, the user can choose one of the two roles that I designed at Step 1 and choose the theme s/he wants to play.

III. **Learning activity chain generation:** The game puts the chosen role and theme that the user made at Step 2 into the activity generating engine to generate activities. The activity generating engine retrieve suitable learning objects from the ubiquitous knowledge structure and then generate a list of learning activities for the user doing. At the end, the engine sorts the learning activities according their difficulty/complexity and offers the user the learning activity in the chain one by one.

IV. **Learn by playing:** The user can follow the instructions and look for the designated learning objects to do the learning activities one by one, at meanwhile, s/he can get familiar with the environment.

V. **Personal experience update:** The learning objects and related knowledge s/he has learnt will be stored in database in order to record his/her learning status (e.g. what learning activities s/he has solved and what learning objects s/he has learnt) and performance (e.g. how well s/he did in doing the learning activities and how many learning activities s/he has done)

A short example is presented here to describe the abovementioned five steps more clearly.

Example:

In the authentic environment - Edmonton Learning Centre (ELC), Athabasca University, there are a lot of rooms such as workspaces, meeting rooms, drop-in rooms, kitchens, and so on. There are also many facilities including hardware and software in these places, such as printers, projectors, teleconference systems, coffee makers, and so forth. In addition, some policies and working procedures are existed and important for staffs to learn and to be aware of. The administrator first analyzes the learning objects and constructs the ubiquitous knowledge structure in the CAM-RPG as well as designs roles and themes for potential users.

For people who work or visit ELC, they may download and install the CAM-RPG at their first day here. They may choose a role and relevant theme which they consider the most important lesson to them for being at ELC. Next, the game will generate a series of story decorated learning activities according to their chosen role and theme, their current location at ELC, the surrounding learning objects, and their CAM-RPG playing experience.

The users then can start to play the game and look for the learning objects which the game's learning activities ask for in the authentic environment. They can take a picture of the QR codes attached on the learning objects and get important information they need to know about the learning objects, for instances, how to setup a teleconference system and how to apply for vacation leave. In the meanwhile, the activities they have done are stored in the game as their personal learning experience (i.e., the abovementioned CAM-RPG playing experience). □

The detailed process of generating activities and making a learning activity chain is explained in the following subsections.

3.1.1 Learning Objects Retrieval

In Figure 5, I have illustrated the overall idea and flow of the CAM-RPG. In the sub-section, I am going to explain the detailed design of the activity generating engine. The generating process (i.e., Step III in Figure 5) includes five tasks:

Task 1: Retrieving characteristics and learning objects according to the chosen theme

In the game design, several pre-defined themes have already been created in the database. Each theme is associated with a domain and multiple themes can have relations with the same domain. For example, when user chooses the theme - "Life Style in ELC", the theme actually associates with the domain, "Event", which covers the frequently happened events in daily works. The engine retrieves all domain relevant learning objects and its characteristics from the knowledge structure.

Task 2: Using rough set to filter the irrelevant learning objects and characteristics to the chosen theme

The engine uses rough set to discover the necessary root characteristics toward to the chosen theme, and then analyzes the relations among learning objects and relevant characteristics. Once again, take the "Life style in ELC" theme as example (as Figure 6 shows), the relevant characteristics (i.e. positive and boundary characteristics) are "Room" and "Device" and the irrelevant characteristic (i.e. negative characteristics) is "Item".

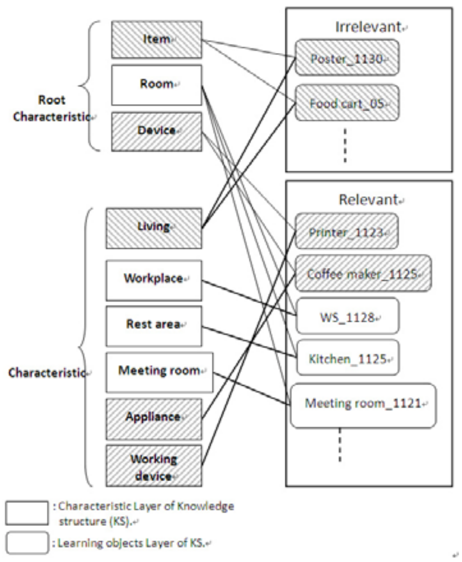


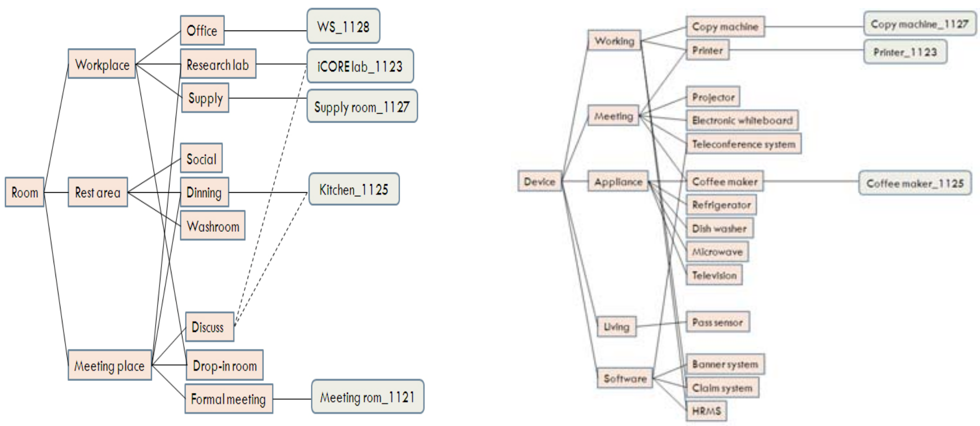
Figure 6. Relations analysis for "Life style in ELC" theme

3.1.2 Learning Activity Generation

After the first two tasks, the game can receive a numbers of learning objects which are associated with the selected theme, "Lift Style in ELC". The generating engine then uses information theory to give every learning object a weight in order to generate a series of learning activities.

Task 3: Using information theory to weight all learning objects

The engine uses information theory to weight learning objects according to how many theme relevant characteristics the learning objects have. For example as Figure 7(a) shows, the root characteristic – "Room" has three characteristics, "Workplace", "Rest area", and "Meeting place"; each characteristic has three child characteristics. Meanwhile, some child characteristics such as research lab, dinning, and drop-in room may have more than one parent characteristic, because their implicit characteristics.



(a) Room Characteristic (b) Device Characteristic

Figure 7. Example of hierarchical characteristics

In order to weight the learning objects, the engine has to calculate the information value of all characteristics. The probability of a characteristic depends on which level the characteristic is at and how many siblings the characteristic has, for examples:

$P(Characteristic_{Workplace}) = 1/3$,

$P(Characteristic_{Meeting\_Place}) = 1/3$,

$P(Characteristic_{Rest\_Area}) = 1/3$,

$P(Characteristic_{Office}) = P(Characteristic_{Workplace}) * 1/4$

$= 1/3 * 1/4 = 1/12$ (1)

$P(Characteristic_{Discuss}) = P(Characteristic_{Meeting\_Place}) * 1/5$

$= 1/3 * 1/5 = 1/15$ (2)

$P(Characteristic_{Dinning}) = [P(Characteristic_{Rest\_Area}) * 1/3] + [P(Characteristic_{Meeting\_Place}) * 1/5]$

$= [1/3 * 1/3] + [1/3 * 1/5]$

$= [1/9] + [1/15] = 8/45$

$I(Characteristic_{Office}) = \log2 (1/P(Characteristic_{Office}))$

$= \log2(1 / (1/12)) = 3.5850$

$I(Characteristic_{Discuss}) = \log2 (1/P(Characteristic_{Discuss}))$

$= \log2(1 / (1/15)) = 3.9069$

$I(Characteristic_{Dinning}) = \log2 (1/P(Characteristic_{Dinning}))$

$= \log2(1 / (8/45)) = 2.4919$ □

Thus, the information value of the learning objects, $Object_{WS\_1128}$ and $Object_{Kitchen\_1125}$ will be:

$I(Object_{WS\_1128}) = I(Characteristic_{Office}) = 3.5850$

$I(Object_{Kitchen\_1125}) = I(Characteristic_{Dinning}) + I(Characteristic_{Discuss})$

$= 2.4919 + 3.9069 = 6.3988$. □

A learning object may have one or more characteristics. If a learning object has only one characteristic, the learning object can be seen as an object with specific function (i.e. $Object_{WS\_1128}$). On the contrary, the learning object may be considered as a multi-function object if it has two or more characteristics (i.e. $Object_{Kitchen\_1125}$). In addition, a characteristic may have one or more child characteristics as Figure 7 shows. A learning object can be considered as a simplified object if it has characteristic which belongs to a smaller child characteristic set. Under this situation, the learning object will have smaller information value due to its characteristic has a larger probability. For examples, the probability of $Characteristic_{Office}$ is 1/12 as Eq.(1) shows. Similarly, a learning object can be considered as a diversified object if it has characteristic which belongs to a larger child characteristic set. Under such situation, the learning object will have larger information value. For examples, the probability of $Characteristic_{Discuss}$ is 1/15 as Eq.(2) shows. In this research, I assume that it is better for people doing On-the-Job training with simplified objects at the beginning. Furthermore, I propose that the learning object with lower information amount (larger probability) is easier to find out in the environment. Since the learning object with higher information amount (smaller probability) may hide in many similar characteristics or it comes from multiple characteristic of information.

3.1.3 Learning Activity Chain Construction

After finished task 3, the game weights all learning objects that are filtered and retrieved from the context-awareness knowledge structure, the game starts to generate theme relevant learning activities and selects learning objects for activities.

Task 4: Finding learning objects for pre-defined learning activity templates and generating activities.

In the engine, we have a set of pre-defined learning activity templates stored in the database. The templates are associated with one or more learning objects and characteristics, for examples, "looking for a [printer]" template may associate with "$Characteristic_{Printer}$" and "having a [cup of coffee] in the [kitchen]" template may associate with "$Object_{Coffee\_Maker\_1125}$" and "$Object_{Kitchen\_1125}$".

The engine uses the characteristics and objects which retrieved by Task 2 to decide whether a template could be used or not. If a template requires specific characteristic(s), the engine will generate learning activities by picking up suitable learning objects which have the required characteristics. Otherwise, the engine simply generates the activity by filling the template up with the specific learning object(s) directly. At last, the engine summarizes the information values of the learning objects associated with the learning activity, which means, each learning activity has its own information value.

Task 5: Generating learning activity chain based on the information values the activities have

The engine can then sort the learning activities generated from Task 4 based on how many learning objects the activity contains and what information value the activity has. In this research, the learning activities in the chain are sorted by learning object amounts and activity information values.

The engine currently generates sequential activity chain based on two rules, (1) the activity involves less learning object(s) has higher priority, (2) if activities involve same amount of learning objects, the activity with lower information value has higher priority. The system's multi-agent-based architecture (which is introduced in Chapter IV) allows additional rules of sorting learning activities as well as new methods of information calculation to be added into the system, by adding new functions to existing agents or by designing new agents to replace the old ones. In either case, the system's activity generation process can be enhanced as request.

3.2 Story decorated Context in the Game

Storytelling is a critical part in designing an interesting and engaging game. Most of popular games have its background story no matter the story is a simple linear story (i.e., saving the princess) or a complex drama (i.e., the war between Alliance and Horde). Good storytelling in the game design makes the game realistic and immersive as well as users involve constantly. Therefore, it is important for designers to understand classic story structure. Generally, a story usually begins with a basic concept or an idea. The basic idea is to place some characters, in some situations, in some settings in the game. (Rabin, 2010)

3.2.1 Narrative Elements Design

By combining the idea of ubiquitous knowledge structure and the four defined narrative elements, a four-layer narrative knowledge structure is designed to help the game generate stories for different chosen theme and learning activity chain's length.

Time layer stores all time relevant elements that can be applied to the story. The elements in Time layer can have two kinds of relations including hierarchical and sequential relation. Place layer stores the place relevant elements to present virtual space, spots, and the relations between each others in the story. Character layer stores non-player controlled characters (NPCs) that can be used to deliver the story as well as interact with the users. Characters have optional properties such as its actions and emotions. These properties are stored as its schema to make the story generation engine vividness. At last, Item layer store all virtual items which may be used by NPCs and/or put at specific places in virtual space/spots.

By expanding the narrative knowledge structure, the composition of the narrative elements will be more diverse and richness. In addition, both context-awareness knowledge structure and narrative knowledge structure are easy to understand for general public (e.g., teachers and staffs in historical and cultural sites) and easy to build for different discipline. Figure 8 shows the narrative knowledge structure for storing narrative elements which can be used in the story generation process later.

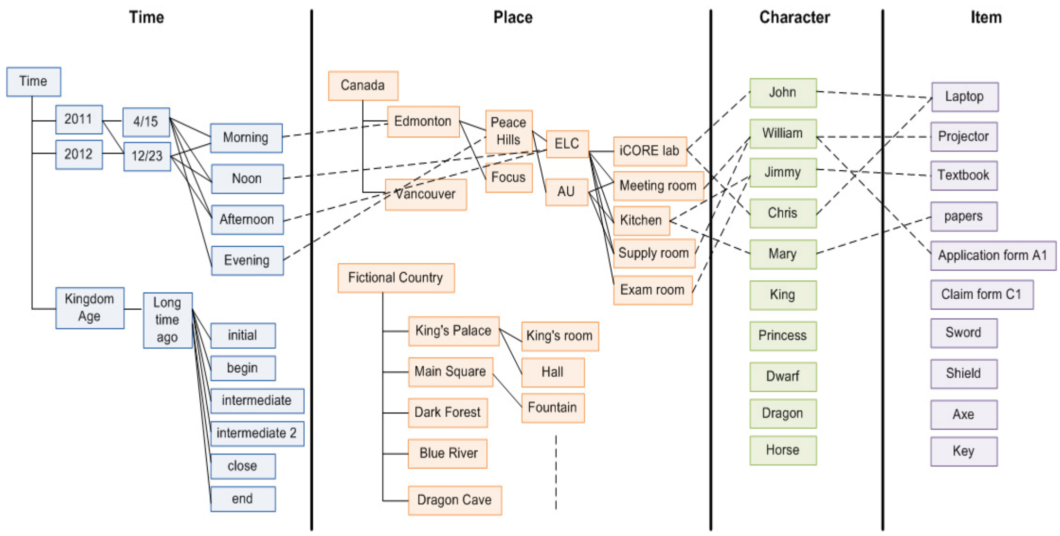


Figure 8. Narrative knowledge structure

In the narrative knowledge structure, each layer can have more than one level. The relation between elements is created optionally. The elements built in the narrative knowledge structure can be mixed of truth and fiction as Figure 8 shows. Different schema is designed to store the properties of narrative elements in each layer. The schema of narrative elements can be seen as the settings of the storyline and used in generating story. Figure 9 presents the schema of "Noon" element in time layer and "William" element in character layer.

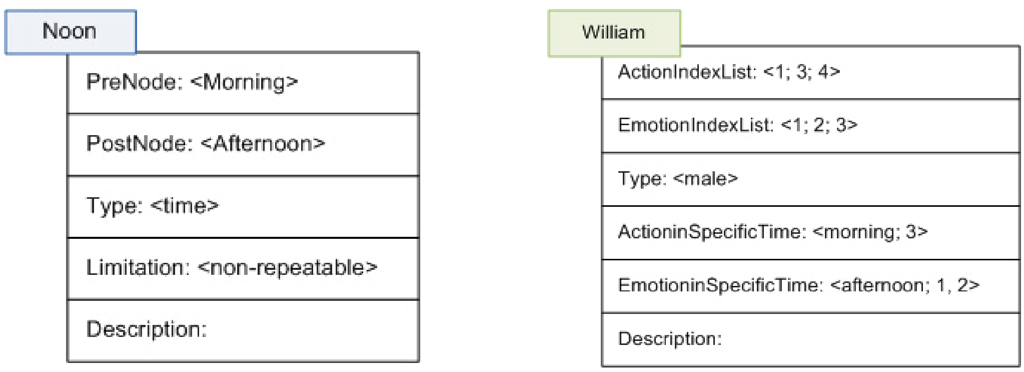


Figure 9. Narrative element schema examples

The abovementioned narrative knowledge structure and narrative element schema present a clear concept for the game's administrator (e.g., teachers) to build. The story generation engine then can generate a series of stories (i.e., a storyline) with the narrative structure according to the chosen theme and amount of learning activities.

3.2.2 Storytelling - Generating a Story

In this section, the story generation process and the learning activity chain decoration with the generated stories are talked. Unlike the learning activity generation engine which uses rough set and information theory to filter irrelevant learning objects and weight the information values, the story generation engine has four filters which are associated to the four layers of the narrative knowledge structure. In addition, a set of story template also pre-defined in the database. Story templates represent the concept of "plot" and the story generation engine can pick-up one or more templates to form a plot and connects several plots to form a storyline.

The first step of generation process is to retrieve a set of narrative elements from the narrative knowledge structure. Similar to the learning activity generation, each theme is associated to one or several root nodes in Time layer. For example, "Life style in ELC" is associated to the time element, "2011". The story generation engine first finds the root node, and then pulls out a series of child nodes and relevant nodes of its very next layer, i.e., the root nodes of Place layer. These narrative elements will be put into the candidate list as Figure 10 shows.

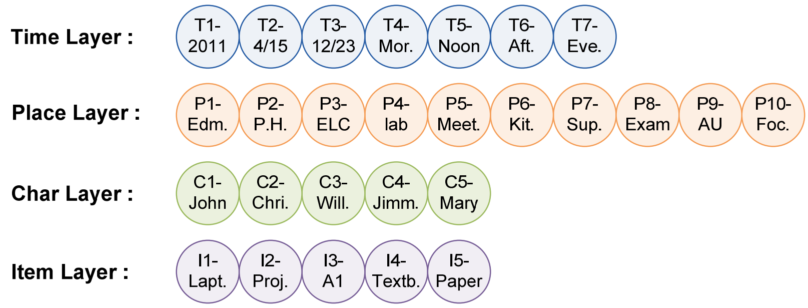


Figure 10. The candidate list of narrative elements

Once the story generation engine had the candidate list of narrative elements, the engine starts working on the plot generation from the story templates according to the amount of learning activities in the generated learning activity chain. Each plot may be formed with one single template (i.e., a whole story) or composition of several templates. For example, the learning activity generation engine produces four learning activities for "Life style in ELC" as Figure 6 shows, which means the story generation engine should have at least four correspondent plots for decorating the chain with stories. Figure 11 shows the four plots the engine works out.

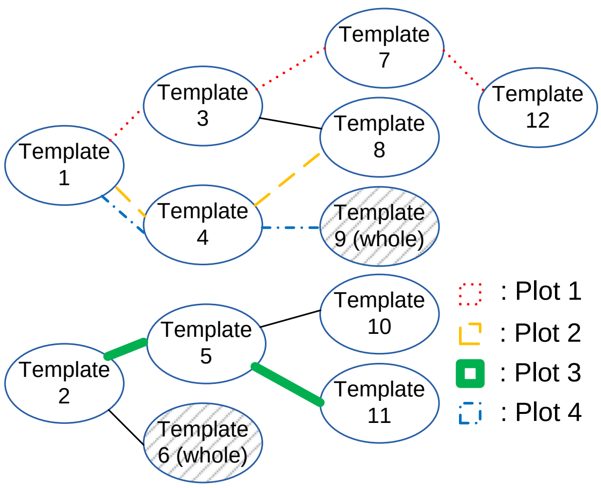


Figure 11. Story template tree and the four plots that the engine worked out

By expending of the story template tree, the generated plots have diversified results. Furthermore, each story template has five properties include

"Story Pattern", "Relevant Template", "Non-Repeatable Element", "Whole Story", and "Content". Story pattern property lists the required narrative elements of the story template; Relevant Template property states a list of template IDs which are the parent of the story template; Non-repeatable element property indicates which element(s) included in the story pattern can be used only once; Whole story property tells whether the story template is a well-structured and self-contained story; and, Content property is the story context. Table 1 lists Template #7's property values as an example.

Table 1. Template #7's properties

Template ID	7
Story Pattern	[Room][Male]
Relevant Template	<3>
Non-repeatable Element	[Room]
Whole Story	False
Content	In the [P1], [C1] is talking with [C2]. [C2] sees you come in and invites you to join the talk.

After the story generation engine worked out the plots, the next step that the engine needs to do is to fill up the chosen templates with the pre-selected narrative elements in the candidate list for decorating the learning activities and transforming the chain to a storyline. The step is called the filling and forming process.

In the beginning of the filling and forming process, the story generation engine calculates the amount of required narrative elements and summarizes the story patterns for each plot. For instance, Plot 1 in Figure 11 covers four templates: Template #1, #3, #7, and #12. Each template has its own properties like Table 1 lists. Therefore, the engine can get the total amount of required narrative elements as well as the story patterns for filling up. Table 2 illustrates the calculation results for Plot 1.

Table 2. Calculation results for Plot 1

Template #1	Template #3	Template #7	Template #12
[Time][Building]	[Floor]	[Room][Male]	[Male][Item]
T=1; P=1; C=0; I=0	T=0; P=1; C=0; I=0	T=0; P=1; C=2; I=0	T=0; P=0; C=1; I=1
Plot Generation →	Plot 1		
Story Pattern	[Time][Building][Floor][Room][Male][Item]		
Amount of Elements	T=1; P=3; C=3; I=1		
Non-repeatable Element	[Room]		

(T: Time elements; P: Place elements; C: Character elements; I: Item elements.)

As abovementioned, four filters are used by story generation engine to filter out the plot irrelevant or non-sense narrative elements in the candidate list. For instance, in Table 2, the generated Plot 1 asks the pattern of time narrative elements as "time" , which means the engine will not need the elements such as "year - 2011", "date - 4/15", and "date - 12/23" when it fills up in the plot and corresponding templates. Similarly, the engine also doesn't need the elements such as "city - Edmonton" and "female - Mary" for Plot 1 either. The modified candidate list of narrative elements is shown by Figure 12.

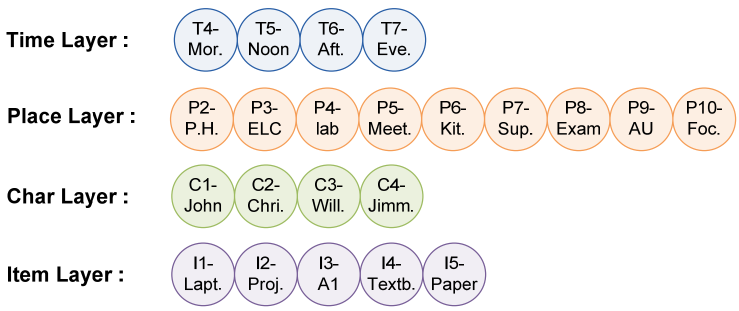


Figure 12. The modified candidate list of narrative elements

Next, the story generation engine starts using the narrative elements in the candidate list to fill up the plots. For instance, the four templates in Plot 1 compose a short story template as follows:

> "Monday's [T1], [P1] is busy as usual. Today is my first time to [P2]. It would be great if I can make some friends there. [C1] told me that I should find [C2] in [P3] first. At that place, [C2] is

using his [I1] and looks like he needs someone's help. He sees me coming in and says, 'Good to see you, I just need a hand to complete my task.'"

This plot asks for one time narrative elements, three place narrative elements, two characters, and one item from the narrative knowledge structure. The four filters are used to check the amount of required elements. If the target plot only asks one element, then the engine just randomly picks up from the modified candidate list, on the other hand, the engine will consider (1) the sequence between elements (i.e., morning goes before noon; 2011 goes before 2012, etc.); (2) the limitation of repeatable elements (i.e., if the dragon was killed, it would not be used by the followed plots), and (3) specific schema in the layer (i.e., actions and emotions in a character's schema) respectively. At the end, all plots are filled up with the modified candidate list of narrative elements and several short stories came out for decorating the learning activity chain as well as the game. Taking Plot 1's short story template as an example here to see what the engine has done and what an output story looks like:

"Monday's *afternoon*, *Peace Hills* is busy as usual. Today is my first time to *ELC*. It would be great if I can make some friends there. *John* told me that I should find *Will* in *meeting room* first. At that place, *Will* is using his *laptop* and looks like he needs someone's help. He sees me coming in and says, 'Good to see you, I just need a hand to complete my task.'"

Once the story generation engine filled up all plots, the engine decorates the learning activities with these short stories and forms a storyline. Due to both learning activity generation and story generation are based on the user's chosen theme (for example, life style in ELC), the game can provide a meaningful storyline for the user.

3.3 Complete Example

In this section, I will demonstrate the whole generation process with a complete example. The story decorated context will be used to decorate the learning activity chain which is generated by the game. Eventually, a meaningful and interesting storyline will be generated automatically according to user's preferences.

3.3.1 Scenario

Chris is a visiting scholar who comes to the Edmonton Learning Centre of Athabasca University first time. In the learning centre, there are a lot of rooms for different purposes (e.g. working, meeting, drop-in, and dinning) as well as many hardware and software (e.g. printers, projectors, teleconference systems, coffee makers, banner system, and expense claim system). In order to make himself get familiar with the new research environment and everything related to what he needs for doing research in the University, he downloads and installs the Context-Aware Mobile Role Playing Game (CAM-RPG) in his smartphone with built-in camera and Wi-Fi.

The game provides two roles for users, i.e. visiting scholar and new employee. Thus, Chris chooses to play as a visiting scholar which fits what he is right now in Athabasca University. After he chose the role, he finds that several themes which he may want to know more. Chris then chooses a theme named “Life Style in ELC” because he wants to know how to survive in this new environment before starting his research life here.

The game then generates a series of learning activities related to the chosen theme and role. These activities are not only sequential but also location-based. Each activity involves one or more learning objects including rooms, equipment (hardware and software), and items. Hence, he can get familiar with the environment and the facilities surround him by playing the game and doing the sequential learning activities one by one.

Based on the game design in Section 3.2, the system will automatically generate series of quests related to the theme, e.g. “Life Style in ELC” theme will involve many daily event relevant quests such like “bring a cup of coffee from the kitchen”, "need someone printing these papers for the upcoming meeting", “I need a washroom before starting the long meeting”, “how to operate the teleconference system?”, and so forth. The quests are not only in sequence but also are linked by a situated background story. The story is attractive and connects to the life Chris has right now. The story and the quests make Chris feel that he is the actor of the story and those things the actor has encountered are what he may encounter in very near future. Because the quests are chained, Chris has to solve the quests one by one.

3.3.2 Generation Process

In this section, the Chris scenario is used to present the whole process and possible results. After Chris decided to play as a "Visiting Scholar" and chose "Life Style in ELC" theme, the game retrieves several pre-defined learning activity templates according to the chosen role and theme and relevant learning objects and characteristics in the environment. These templates are "looking for someone's work space", "having a cup of coffee in the kitchen", "photocopy my paper in the supply room", "looking for a printer", and "looking for the meeting room".

The engine calculates the learning objects' information values:

Room: (based on Figure 7(a))

$I(Object_{WS\_1128}) = 3.5850$

$I(Object_{Kitchen\_1125}) = 6.3988$

$I(Object_{Meeting\ room\_1121}) = \log_2(1 / (1/3 * 1/5)) = 3.9069$

$I(Object_{Supply\ room\_1126}) = \log_2(1 / (1/3 * 1/4)) = 3.5850$

Device: (based on Figure 7(b))

$P(Characteristic_{Copy\_Machine}) = 1/5 * 1/4 = 1/20$

$P(Characteristic_{Coffee\_maker}) = [1/5 * 1/5]+[1/5 * 1/5] = 2/25$

$P(Characteristic_{Printer}) = [1/5 * 1/4]+[1/5 * 1/5] = 9/100$

$I(Object_{Copy\ machine\_1127}) = \log_2(1 / (1/20)) = 4.3219$

$I(Object_{Coffee\ maker\_1125}) = \log_2(1 / (2/25)) = 3.6439$

$I(Object_{Printer\_1123}) = \log_2(1 / (9/100)) = 3.4739$

Item:

belongs to irrelevant set as Figure 6 shows.

The engine then starts to generate activities (we list partial activities below):

$Activity_1$: Looking for $Characteristic_{Office}$ → Looking for $Object_{WS\_1128}$

Activity$_2$: Having a cup of Object$_{Coffee_maker_1125}$ in Object$_{Kitchen_1125}$

Activity$_3$: Object$_{Copy\ machine_1127}$ my paper in the Object$_{Supply\ room_1126}$

Activity$_4$: Looking for a Characteristic$_{Printer}$ → Looking for Object$_{Printer_1123}$

Activity$_5$: Looking for the Characteristic$_{Meeting_room}$ → Not Available

The engine generates sequential activity chain based on two rules, (1) the activity involves less learning object(s) has higher priority, (2) if activities involve same amount of learning objects, the activity with lower information value has higher priority. Based on the two rules, Figure 13 shows the learning activity chain for “Life Style in ELC” theme below.

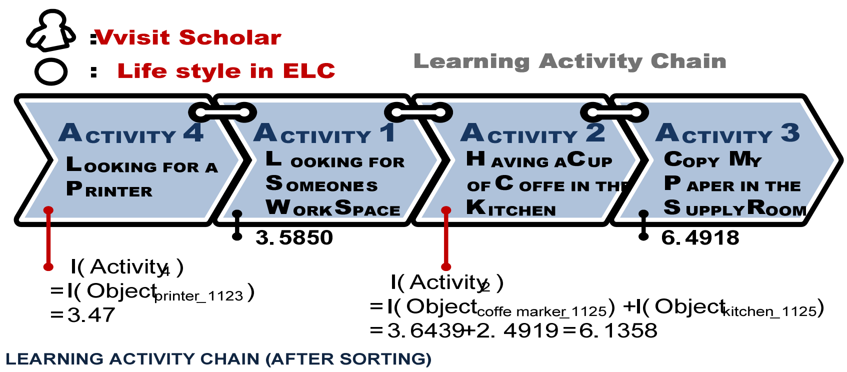


Figure 13. Learning activity chain for "Life Style in ELC"

3.3.3 Story decorated Quest Chain

With the learning activity generation engine and story generation engine's help, the game then provides Chris several learning activities as Figure 13 shown and uses some stories to decorate the simple learning activities and to form a quest chain. Chris first sees a short story on his mobile's screen and then accepts the request from the story (e.g., a character asks Chris to do him/her a favor). To solve the quest he received from the game, he has to walk around at

ELC and look for the learning object(s) that the quest asks for. After he finishes a learning activity, he receives the next story decorated quest and continually plays the game.

Both the learning activities (i.e., the quests) and the stories are generated according to the user's chosen role and theme, which means that the stories are consistent with the quests and make Chris aware of he is playing the "visiting scholar" role in the authentic environment. In such case, Chris will not receive a fiction story or be told in a forest while doing learning activities associated with "Life style in ELC" theme.

Nevertheless, the current system tends to generate the same amount of stories to decorate the quests. The game still needs a complete and well pre-defined story template tree. The game may generate repeated stories if the story template tree is not rich enough. The background story and the template tree require game designer or administrator's efforts in order to make the story decorated quests perfect.

Chapter IV – MULTI-AGENT BASED MOBILE GAME DESIGN

In this chapter, I describe the multi-agent based system design used in my research. Section 4.1 introduces the system architecture and all agents in the system. In addition, I discuss how the multi-agent system design makes the game comply with the five design principles. Section 4.2 mainly describes the agent collaborations. I explain the agent collaborations separately based on five stages in order to present that different agents are awake for specific tasks asynchronously. Section 4.3 demonstrates the game play from the user's viewpoint and describes the interactions between the user and the agents.

4.1 System Architecture

To develop a lightweight, flexible, and scalable mobile educational game, this research takes multi-agent architecture (MAA) into consideration. MAA not only makes different agents have different responsibilities, but also provides an expandable way to develop further functions.

In the following sections, I will describe the MAA design in the CAM-RPG and how these agents work together to complete the tasks.

4.1.1 Conceptual Model

The multi-agent architecture was designed in order to develop a lightweight, flexible, and scalable mobile game. This architecture not only enables different agents to work on different tasks, but also provides a method for easy improvements and maintenance of the game. For instance, we can put new agents into the game for special purpose and replace old agents with new and more functional ones. Figure 14 shows the MAA of the proposed mobile educational game.

Two groups of agents reside on the user's mobile phone: three agents form a group to serve and interact with the user, namely, Player Agent, Translator, and Learning Activity Item Collector; and six agents form a group to work out context-awareness and the location-based learning activity chain, namely, Learning Activity Generator, Calculator, Map Holder, Database (DB) Access Agent, Storyteller, and Position Locator.

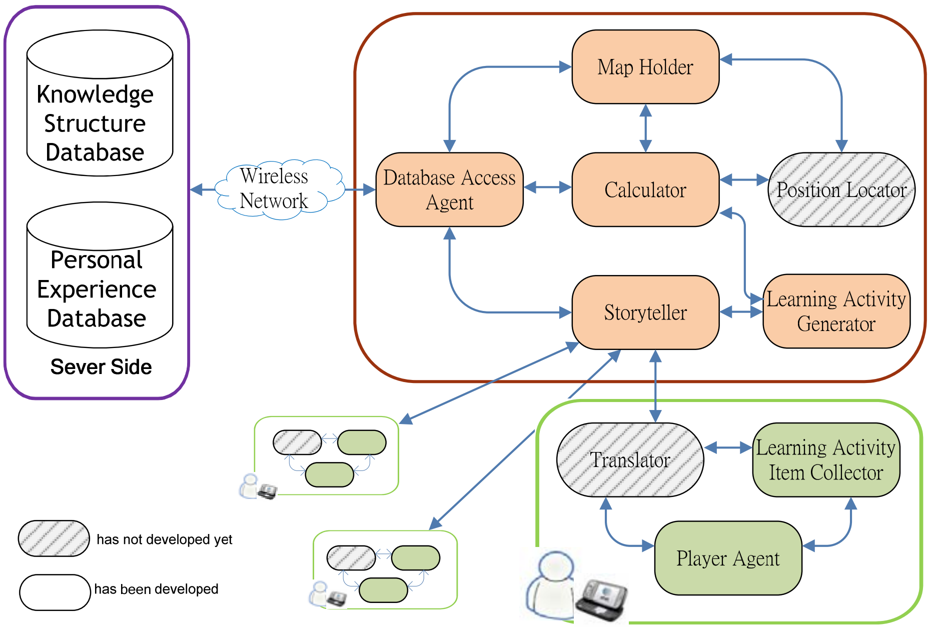


Figure 14. Multi-Agent architecture of the proposed mobile educational game

The conceptual model illustrates the relationships among agents from the system's point of view. Each agent has its goal, task, demands, and communicated targets. The multi-agent-based system is sufficient, with the benefits of MAA systems that Balaji and Srinivasan (2010) summaried.

4.1.2 Agents

In this section, I describe the different responsibilities and tasks of agents in the CAM-RPG:

- **Player Agent:** Player Agent is a bridge between the user and other agents. It receives the decisions the user makes and acquires data from other agents such as the translator and learning activity generator.
- **Learning Activity Item Collector:** Learning Activity Item Collector helps the user scan the QR codes with the built-in camera, and decrypts and interprets the QR codes. The QR codes store both positioning data and the knowledge and instructions that the corresponding objects may have.
- **Translator:** Translator can identify different language inputs and encode/decode the inputs with the appropriate character set. Translator is very useful in non-English-speaking countries (e.g. China, India, and Japan) as well as in bilingual environments (e.g., English-French and Dutch-English).
- **Calculator:** Calculator and Learning Activity Generator accomplish the tasks of context-awareness learning activity generation. Calculator is responsible for measuring learning objects' information values according to the chosen role, theme, and context surrounding the user.
- **Learning Activity Generator:** Learning Activity Generator is responsible for generating activities based on the characteristics and corresponding learning objects filtered by Calculator and re-sorting those activities into a chain.

- **Position Locator:** Position Locator is responsible for detecting the user's location. The GPS-enabled Position Locator gathers GPS data packets from the GPS receiver and extracts the longitudes and latitudes from the packets. The camera-enabled collector gets the encoded data by scanning the two-dimensional barcode and decoding the data it stores.
- **Map Holder:** Map Holder always keeps a copy of the map where the user is to serve other agents when the network connection is no longer available and DB Access Agent is not able to connect to the database. The map in the proposed game is a context-awareness knowledge structure, namely ubiquitous knowledge structure (Wu et al., 2008).
- **DB Access Agent:** DB Access Agent uses the appropriate data manipulation language (i.e., SQL commands) to access data from the database for other agents. If a network connection is not available, the agent will tell the other agents to look for Map Holder's help, but will keep those jobs requiring database updates. DB Access Agent will do batch updates when the network connection is recovered.
- **Storyteller:** Storyteller uses a narrative knowledge structure and story templates to generate several short stories to decorate the correspondent learning activities produced by the learning activity generator.

4.1.3 Mobile Application Development Issues

Using the multi-agent concept in developing the mobile educational game, allows me to comply with the five design principles of mobile application development proposed by Tan and Kinshuk (2010).

Regarding the **"multiplatform adaption"** design principle, the proposed game uses Java Micro Edition (Java ME) as the programming language to implement most of the agents and uses native programming languages to implement those agents that access low-level mobile phone features and functions, e.g., built-in cameras. In addition to the programming language, we use QR codes to store positioning data in order to make sure that users can play the game with mobile phones that do not have built-in GPS receivers. This design allows the game to work well on different mobile platforms as long as they support Java applications.

Regarding the **"little resource usage"** design principle, the multi-agent based educational game I developed for mobile phones consumes relatively fewer resources since not all agents need to be started at the very beginning.

Regarding the **"little human/device interaction"** design principle, in the proposed game, Player Agent only talks to users to ask them to pick the role and theme at the beginning. After that, Player Agent gives the users a learning activity to solve and only interacts with them again after they have asked Learning Activity Item Collector to scan a QR codes.

Regarding the **"small data communication bandwidth use"** design principle, DB Access Agent and Map Holder are designed in such a way that the mobile educational game does not require network bandwidth all the time. Specifically, Map Holder will do a one-time backup from the server's database to the mobile device's local records management system (RMS) at the start of the game, which means the game then can work without an Internet connection.

Once the Internet is recovered, the game will do a batch update function to achieve data synchronization. Moreover, I use QR codes to store the knowledge and instructions that the corresponding objects may have and to reduce the system's need to access the learning contents on the Internet.

Regarding the **"no additional hardware"** design principle, similar to "multiplatform adaption", users are not required to have either mobile phones with built-in GPS receivers or RFID readers to get the longitudes and latitudes for where they are or the learning contents associated with specific learning objects.

4.2 Collaboration among Agents

In this section, the details of the collaboration among agents are discussed. Figure 15 illustrates the relationships among the agents and database. Agents communicate with each other by sending requests and receiving responses. An agent is initiated only when other agents need that agent's help. With such a flexible collaboration mechanism, it is possible to extend and enhance the game anytime very easily by adding new agents or replacing old ones without changing the main program.

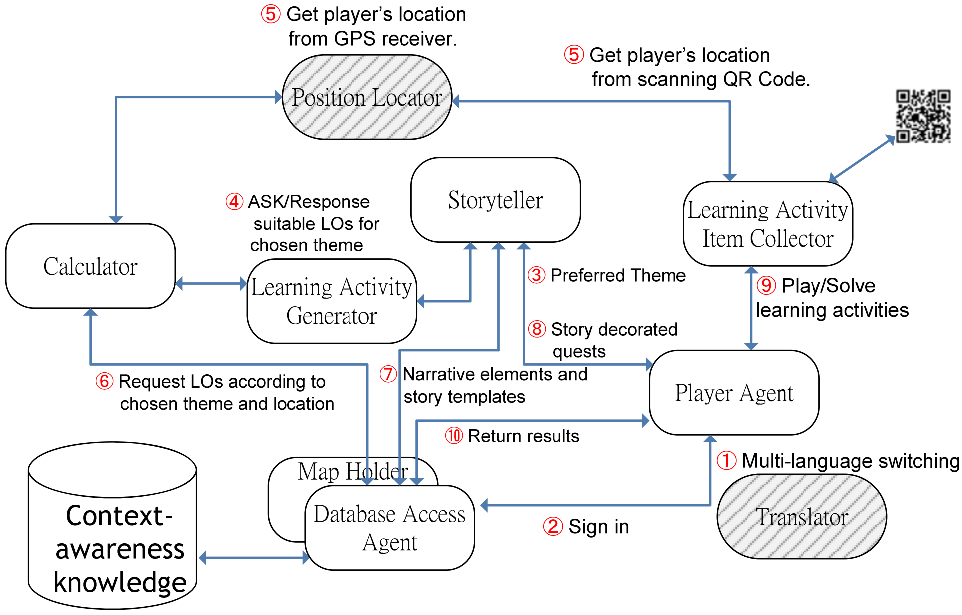


Figure 15. Working flow and collaborations among agents

The following sections describe the stage-by-stage details of the collaborations among agents.

4.2.1 Sign on/Sign in

In Step 1 and Step 2 in Figure 15, four agents are involved: Player Agent, Translator, DB Access Agent, and Map Holder. Player Agent first gets the username and password from the user and sends these data to Translator to check the language used for these data. Player Agent then sends the username and password to DB Access Agent for verification. DB Access Agent checks if the username already exists in either the game database or other system databases (e.g. Moodle database). If the username does not exist, DB Access Agent informs Player Agent. Player Agent then asks the user to create an account to play the game. Map Holder is a backup for DB Access Agent; it helps other agents retrieve required data in the offline mode (i.e., when no wireless connection is available). Figure 16 shows the whole process and communication among agents at this stage.

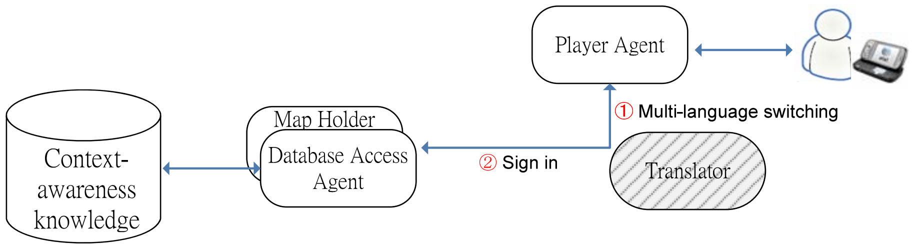


Figure 16. The agent collaborations at Stage 1

4.2.2 Learning Activity/Story Generation

At Step 3 in Figure 15, two agents are involved: Player Agent and Storyteller. After the user has signed in or registered a new account successfully, Player Agent offers the user two roles to play, namely, new employee and visiting scholar. Each role has some pre-defined themes for the user to choose. The chosen role and theme are then sent to Storyteller. Figure 17 shows the whole process and communication among agents at this stage.

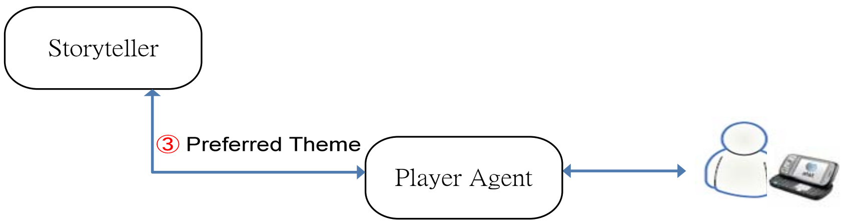


Figure 17. The agent collaborations at Stage 2

Once Storyteller receives the user's theme choice, the game starts Stage 4. At this stage, five agents are involved: Calculator, Learning Activity Generator, Storyteller, DB Access Agent and Map Holder. Once the user chooses his/her preferred role and theme, Learning Activity Generator sends the chosen role and theme to Calculator and asks Calculator to return those learning objects and their corresponding characteristics. Meanwhile, Storyteller sends the chosen role and theme to DB Access Agent to get a narrative element candidate list for generating stories.

Calculator first asks DB Access Agent to provide qualified learning activity templates, learning objects, and corresponding characteristics for the chosen role and theme. Next, Calculator eliminates those irrelevant learning objects and characteristics based on the location data it got from Position Locator at Step 5 in Figure 15, for instance, those learning objects outside the city where the user is currently located. Finally, Calculator measures the information values of the remaining learning objects and corresponding characteristics according to the algorithm described in Section 3.1.2 and sends the identified learning activity templates, learning objects and corresponding characteristics with information values back to Learning Activity Generator.

After Learning Activity Generator gets the data back from Calculator, Learning Activity Generator tries every possible learning activity instance by putting the learning objects and characteristics into the learning activity templates. Eventually, the selected activities are sorted based on the method described in Section 3.1.3. After Learning Activity Generator generates activities, it sends the results to Storyteller in order to let Storyteller generate the same amount of stories from the candidate narrative elements and story template tree.

Again, Map Holder here acts as an offline version of DB Access Agent and serves the other agents, such as DB Access Agent. Figure 18 shows the whole process and communication among agents at this stage.

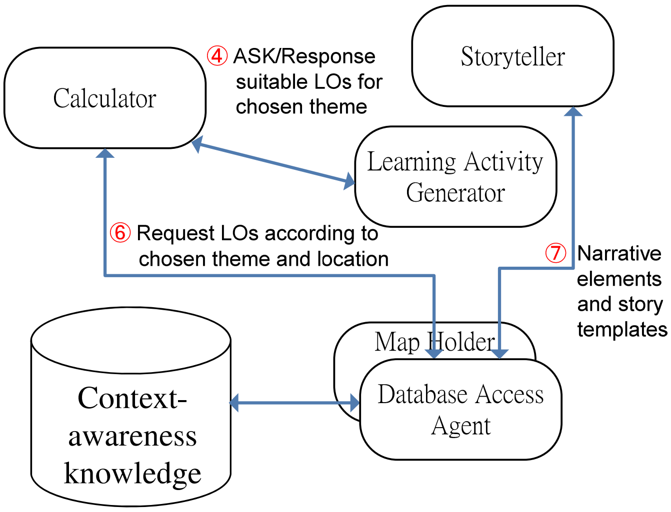


Figure 18. The agent collaborations at Stage 4

4.2.3 Activity Item Collection

In Step 8 to 10 in Figure 15, five agents are involved: Storyteller, Player Agent, Learning Activity Item Collector, DB Access Agent, and Map Holder. At the beginning, Storyteller gives Player Agent the story decorated quest chain. The user then receives the quests one by one from Player Agent. Each quest asks the user to find specific learning object(s) and to collect the learning objects by scanning QR codes. Therefore, Player Agent helps the user to wake Learning Activity Item Collector up when the user wants to collect the learning activity item. Learning Activity Item Collector can start the built-in camera in order for the user to take photos of QR code and decode the QR codes for the user. Player Agent then checks whether the learning object collected by the user is what the learning activity asks for. Finally, the user's experiences are saved back to the database, as shown in Figure 19.

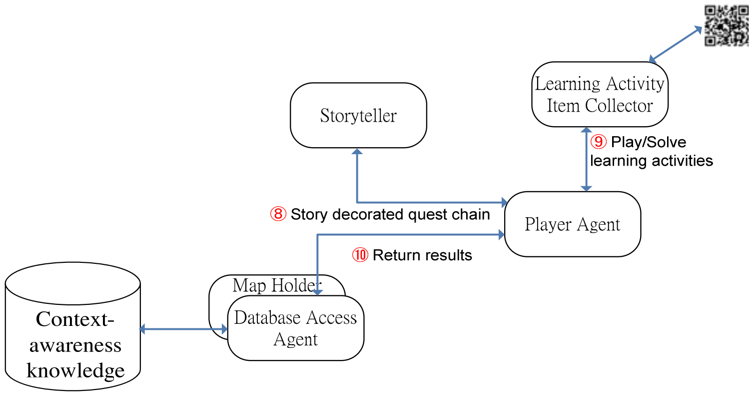


Figure 19. The agents collaborations at Stage 5

4.2.4 Positioning

For location-based service (Step 5 in Figure 15), three agents are involved: Learning Activity Item collector, Calculator, and Position Locator. Before Calculator can start to filter learning objects and corresponding characteristics for Learning Activity Generator to generate the learning activity chain, Calculator needs to know where the user is located. Calculator asks for Position Locator's help in getting the longitudes and latitudes of the user's position from the GPS data packet. Some users' mobile phones may not have built-in GPS receivers. In such cases, Position Locator can still get location data by working with Learning Activity Item Collector. Learning Activity Item Collector can scan QR codes and extract the location data stored in them. Once Learning Activity Item Collector has the location data, it passes the data back to Position Locator, and Position Locator sends the data back to Calculator, as shown in Figure 20.

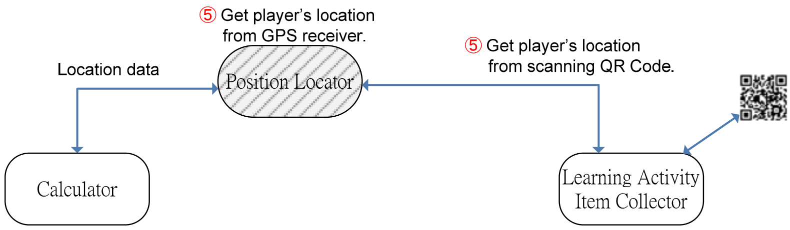


Figure 20. The agent collaborations at Stage 3 !

4.2.5 Backup and Recovery

Map Holder is an important agent for achieving the "small data communication bandwidth use" design principle described in Section 4.1.3. Map Holder will be started as a thread at the very beginning. It copies whole database from the server to the mobile device and stores them in the local Record Management System (RMS). It then waits and listens to the different agents asking DB Access Agent for Internet access and data. These requests include Steps 2, 6, and 10 in Figure 15. If the Internet connection is available while an agent is sending the request, DB Access Agent will take action and access the DB directly. However, if the Internet connection is unavailable or the user turns the Wi-Fi service off, Map Holder will take responsibility for handling the request and respond by finding the acquired data that has been backed up in the local RMS.

Another critical function of Map Holder is recovery. Once again, Map Holder starts at the very beginning. It will check whether or not the local RMS has data; in other words, Map Holder check whether the user has ever played the game on the current device before. If there is no data in the local RMS, Map Holder will retrieve the player profile, including player account, last access date/time, and player experience (i.e. completed activities) from the server. With the player profile, the user can pick up the game from wherever s/he left off last time and the game can provide the user with a better playing/learning experience.

4.3 The Gameplay

In this section, I demonstrate the gameplay with screenshots. During gameplay, Player Agent is the only agent that interacts with the user and enables data exchange between the user and other agents. Correspondingly, DB Access Agent is the only agent designed to access the database to reduce the complexity of system development. The following subsections describe five phases of gameplay, during which a variety of agents will participate in different phases to help, train, and challenge the user to complete the required activities. Figure 21 shows screenshots of the completed gameplay.

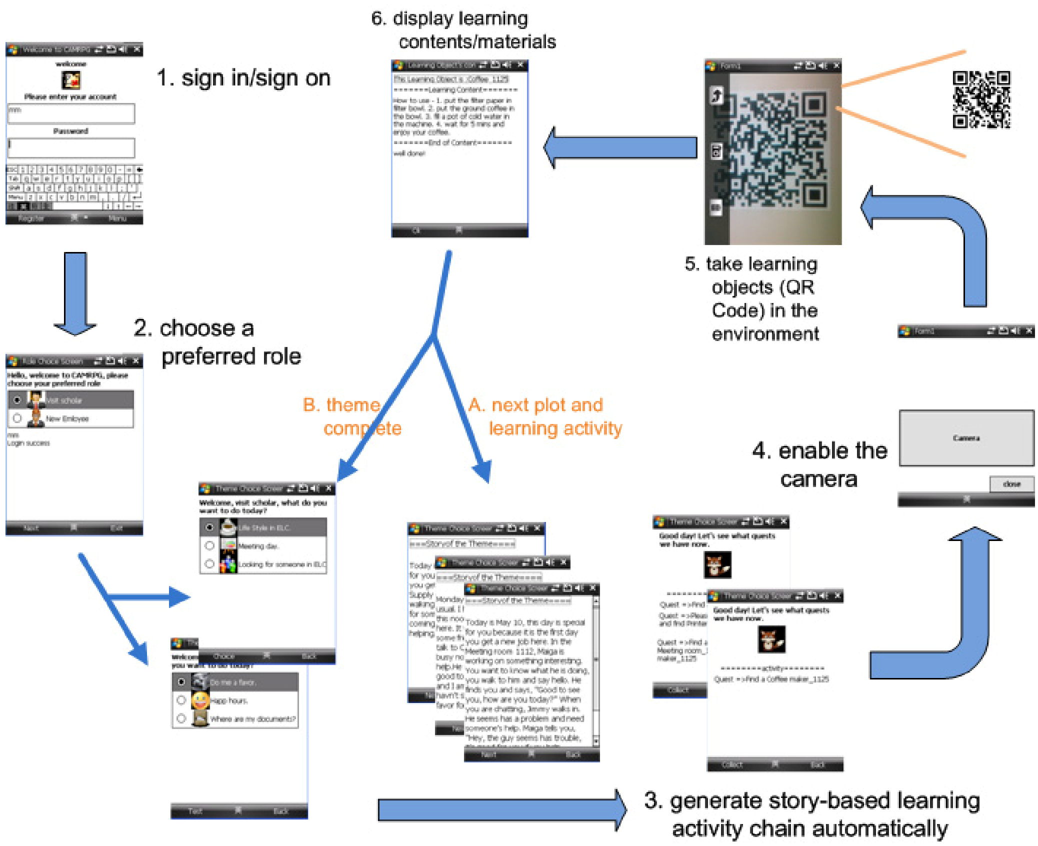


Figure 21. Screenshots of the game-play

4.3.1 Teleport

In this phase, the user enters the game world. Player Agent, Map Holder, and DB Access Agent are awake to handle the user's log in/register request.

The teleport process is necessary in order to let the user feel s/he is entering a virtual, imagined, fantasy world. The relevant agents' work was described in Section 4.2.1. Figure 22 and the following descriptions show the interactions between the user and the agents as well as agent behaviors.

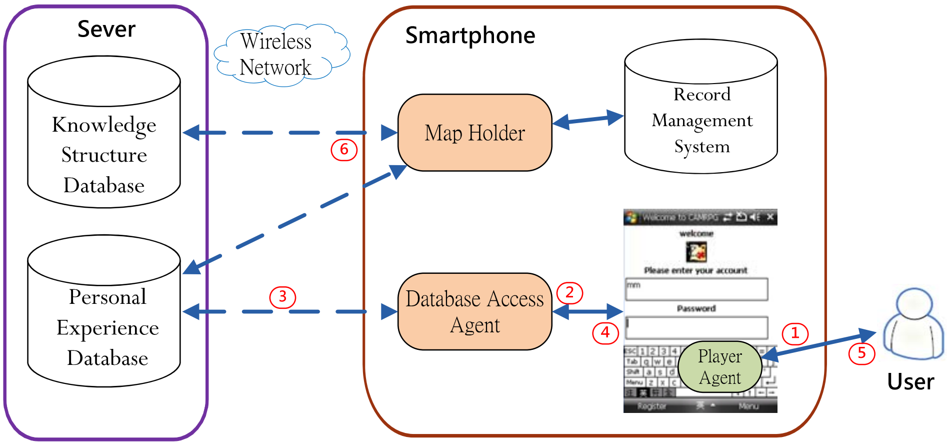


Figure 22. Interactions among the user and agents in Teleport phase

Agents' actions:

(1) Player Agent gets the user's account/password.

(2) Player Agent sends the account/password to DB Access Agent.

(3) DB Access Agent accesses the user's profile.

(4) If the account exists, DB Access Agent sends the result to Player Agent.

(5) If the account does not exist, Player Agent asks the user to register an account.

(6) Map Holder downloads the whole database to the mobile device's RMS at the very beginning.

4.3.2 Transfer

In this phase, the user is asked to choose a role and the theme s/he wants to play. Player Agent and Learning Activity Generator are awake to deal with the user's choices. The transfer phase is used to give the user an idea of the roles and themes in the game. Correspondingly, the user can gain a better idea understanding of what the game offers via his/her chosen role and theme. The relevant agent work was described in Stage 3 of Section 4.2.2. Figure 23 and the following descriptions show the interactions between the user and the agents as well as agent behaviors.

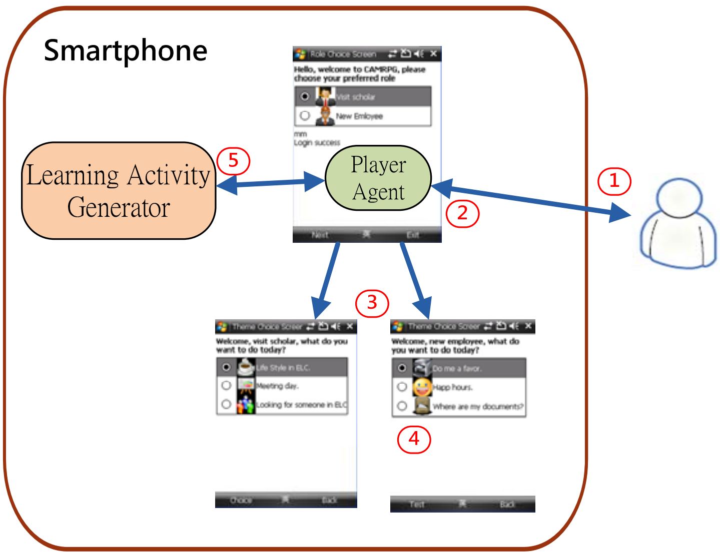


Figure 23. Interactions among user and agents in Transfer phase

Agents' actions:

(1) Player Agent offers two roles as choices for the user.

(2) The user chooses a role.

(3) Player Agent shows the user different themes as options according to the user's chosen role.

(4) The user chooses a theme.

(5) Player Agent sends the chosen theme to Learning Activity Generator.

4.3.3 Training

In this phase, Player Agent displays a progress bar and asks the user to wait for a few seconds. In the background, Learning Activity Generator, Calculator, Storyteller, DB Access Agent, and Map Holder start collaborating to generate a series of story decorated quests for the user. The training phase focuses on agent collaborations involving retrieving, weighting, and sorting the learning objects and learning activities based on the user's chosen theme. Player Agent then receives several story decorated quests. The relevant agent work was described in the Stages 5 and 6 of Section 4.2.2. Figure 24 and the following descriptions show the interactions among agents as well as agent behaviors.

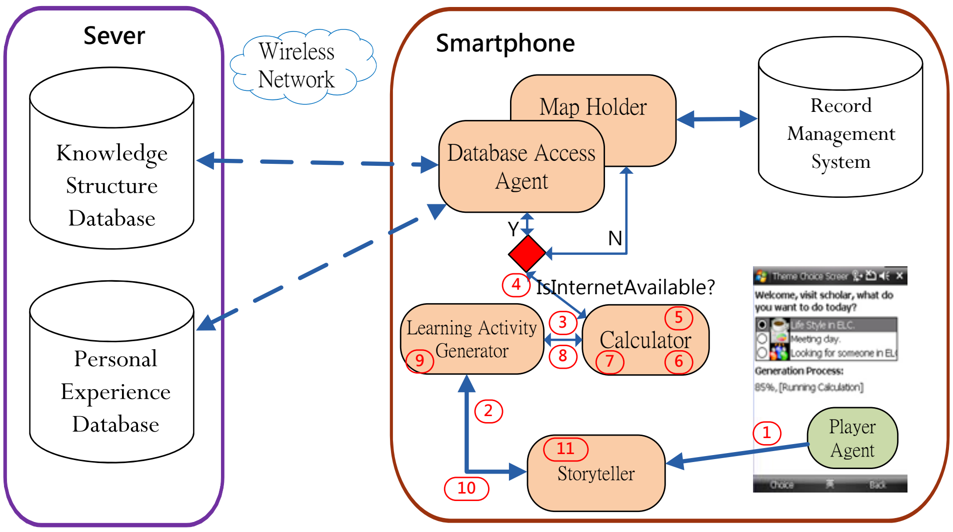


Figure 24. Interactions among agents in Training phase

Agents' actions:

(1) Player Agent asks Storyteller to provide story decorated quests for the chosen theme.

(2) Storyteller sends the request to Learning Activity Generator.

(3) Learning Activity Generator asks Calculator to provide learning activities for the chosen theme.

(4) Calculator retrieves the matched domain, characteristics, and learning objects via DB Access Agent/Map Holder.

(5) Calculator calculates the information value of each learning object according to the probability.

(6) Calculator fills the activity templates with learning objects and characteristics and generates the activity candidates.

(7) Calculator calculates information values for each activity candidate.

(8) Calculator sends the results back to Learning Activity Generator.

(9) Learning Activity Generator eliminates similar learning activity candidates and sorts the learning activities according to their information values.

(10) Learning Activity Generator sends the generated learning activity chain back to Storyteller.

(11) Storyteller uses the narrative element candidate list filtered from the narrative knowledge structure and the selected story template tree to generate stories for the learning activity chain.

4.3.4 Challenge

In this phase, Player Agent receives a series of learning activities from Learning Activity Generator. The challenge phase provides the user learning activities as quests in the game. The user will start doing the quests one by one. The relevant agent work was described in Stages 5 and 6 of Section 4.2.2. Figure 25 and the following descriptions show the interactions between the user and the agents as well as agent behaviors.

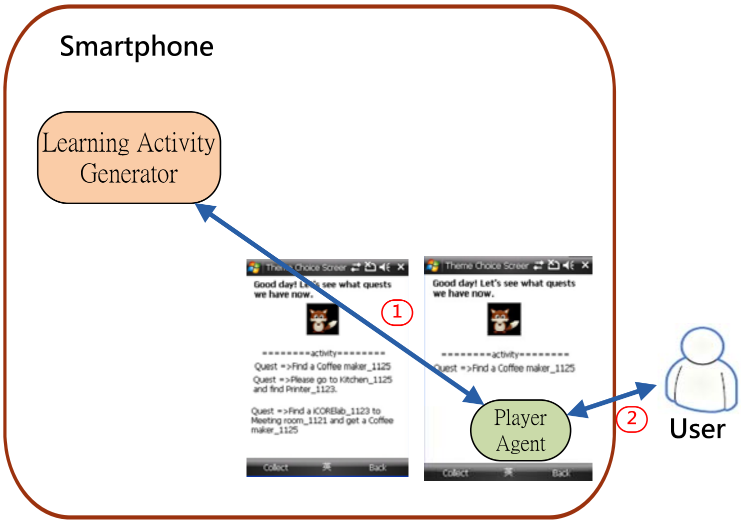


Figure 25. Interactions among the user and agents in Challenge phase

Agents' actions:

(1) Learning Activity Generator sends the learning activity chain (or quest chain) to Player Agent.

(2) Player Agent shows learning activities to the user one by one.

4.3.5 Adventure

In this phase, the user starts doing the activities one by one. S/he looks for the activity-relevant items (activity items for short), for example, the coffee maker, "*Object*$_{Coffee\ Maker\ 1125}$," and the workspace, "*Object*$_{WS\_1128}$." Player Agent, Learning Activity Item Collector, Map Holder, and DB Access Agent are awake to support the user. The activity items are learning objects in the real environment and have two-dimensional barcodes attached. The user needs to explore the environment and look for the activity items required for his/her quest.

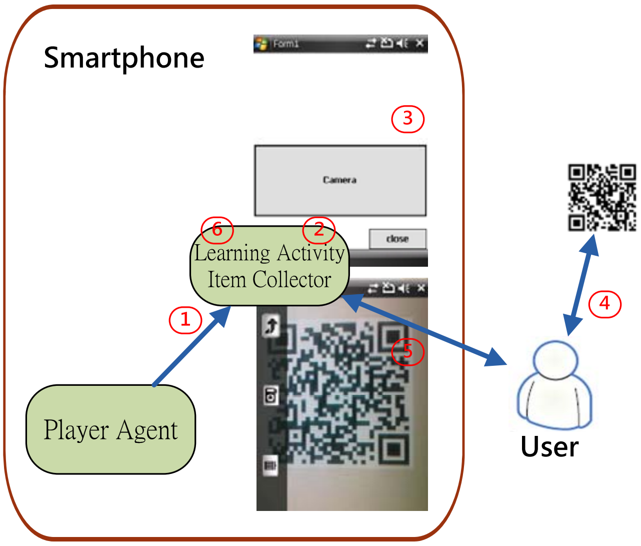


Figure 26. Interactions among the user and agents in Adventure phase - item collecting

The adventure phase lets the user walk around in the real world, look for specific activity items, take pictures on the two-dimensional barcodes, and receive the relevant instructions/tutorial for the learning objects. The relevant agent work was described in the Stages 5 and 6 of Section 4.2.3. Figure 26 and the following descriptions show the interactions between the users and the agents as well as agent behaviors when the user seeks and collects learning activity items.

Agents' actions:

(1) Player Agent wakes Activity Item Collector up when the user wants to start collecting activity items.

(2) Activity Item Collector checks which platform and operating system the user's mobile phone is running.

(3) Activity Item Collector enables the built-in camera.

(4) The user starts looking for the activity items (QR codes) in the real environment.

(5) The user takes a picture of the QR code attached to an activity item.

(6) Activity Item Collector decodes the QR code.

Figure 27 and the following descriptions show the interactions between the user and the agents as well as agent behaviors after the user collects an activity item.

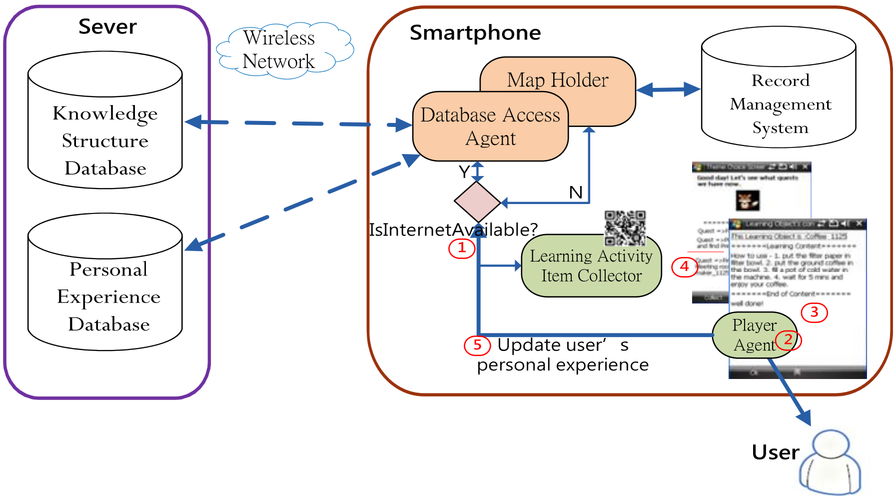


Figure 27. Interaction among user and agents in Adventure phase - presenting

Agents' actions:

(1) Activity Item Collector sends the decoded QR code string to DB Access Agent/Map Holder.

(2) DB Access Agent/Map Holder retrieves and delivers the learning contents/materials to Player Agent.

(3) Player Agent displays the learning contents/materials to the user.

(4) Player Agent shows next learning activity to the user.

(5) In the background, Player Agent updates the player profile via DB Access Agent/Map Holder.

(6) After the user finishes all learning activities, Player Agent goes back to the transfer phase.

Chapter V – EXPERIMENT AND DISCUSSION

In the previous chapters, the proposed research features, including learning activity chain generation, storyline generation, MAA, and the gameplay, have been demonstrated. This chapter focuses on an experiment to discover users' attitudes and perceptions toward the proposed mobile educational game and the generated activities and stories, and to evaluate whether such a context-aware game does create better learning performance and voluntariness of use. This chapter starts with the research model and hypotheses summarized from the literature review and assumptions. Section 5.2 talks about the experiment design, including participants and learning topic, questionnaires, and procedure. The validity and reliability of questionnaires are examined in Section 5.3. Section 5.4 presents the data analysis results, including decretive statistic, quantitative analysis, and qualitative analysis. At the end of this chapter, some findings and discussions are discussed.

5.1 Research Model and Hypotheses

This section describes the research questions I would like to test and verify based on other similar research in the past. The research questions are mainly about users' technology acceptance of and attitude toward computer games, and the systems' usability. I take several moderators (e.g., gender, gaming experience, smartphone use experience, and voluntariness of use) into consideration for designing the research model and making hypotheses. This research will explore the user perceptions of using the proposed game with theoretical models and instruments such as TAM and usability, rather than psychology states, because the research of cognition psychology usually requires tracking and observing users' actions and behavior which using a system for a longer period of time. In the experiment section, I would like to know if the proposed techniques and the innovative learning approach do attract users to use the game and increase their intention of using it.

5.1.1 Research Model and Questions

This experiment will be used to answer the following questions:

(1) Do any of the proposed CAM-RPG characteristics attract users?

(2) Does the user's computer game attitude influence his/her attitude toward using the CAM-RPG?

(3) Does the system's usability influence the user's acceptance of the CAM-RPG?

(4) Is there any gender difference in users' attitudes toward and behavioral intention of using the CAM-RPG?

(5) Does the user's gaming experience influence his/her attitude toward and behavioral intention of using the CAM-RPG?

(6) Does the user's smartphone use experience influence his/her attitude toward and behavioral intention of using the CAM-RPG?

(7) Does the user's voluntariness of using the CAM-RPG influence his/her attitude toward and behavioral intention of using the CAM-RPG?

The abovementioned research questions involve several theories and scales, including Technology Acceptance Model (TAM), a system usability assessment, and user computer game attitude scales. First of all, user technology acceptance is a growing research field in information systems (IS) research. As mentioned in Section 2.7, researchers used different external variables to build the extended TAM for their research. In my experiment, two external variables (i.e., the game's contexts) are proposed for inclusion in the original TAM.

The second theory I apply in the research model is an assessment of the system's usability. Usability in the mobile environment is considered an important system design and development goal. Hussain and Ferneley (2008) reviewed the existing measurement models for usability and proposed a set of usability guidelines for mobile application development. Seong (2006) also proposed a framework, including three categories (i.e., user analysis, interaction, and interface design) and ten guidelines for usability of m-learning portals.

The proposed educational game is quite different from the context of information technology, so TAM may not fully reflect the influences between the educational game's context and the users' acceptance. A user's attitude toward playing computer games may also be a factor that impacts his/her attitude toward using the CAM-RPG. Hence, the third theory I apply in the research model is the computer game attitude scales (CGAS). CGAS is a questionnaire proposed and examined by Chappell and Taylor in 1997. I took the items from both the original CGAS questionnaire proposed in 1997 (hereafter CGAS 1997) and more recent CGAS research (Chen, 2007; Chen, 2010) into consideration for the questionnaire design to collect complete enough data to measure a user's attitude toward playing computer games. A compact but high-validity and strong-reliability questionnaire, CGAS 2011, is the result. It will be summarized and its design explained after the collected data is comprehensively analyzed. I use CGAS 2011 to do further quantitative analysis later in Section 5.3.1.

Figures 28 and 29 show the macro view (i.e., all considered theories) and micro view (i.e., the detailed constructs) of the proposed research model, respectively.

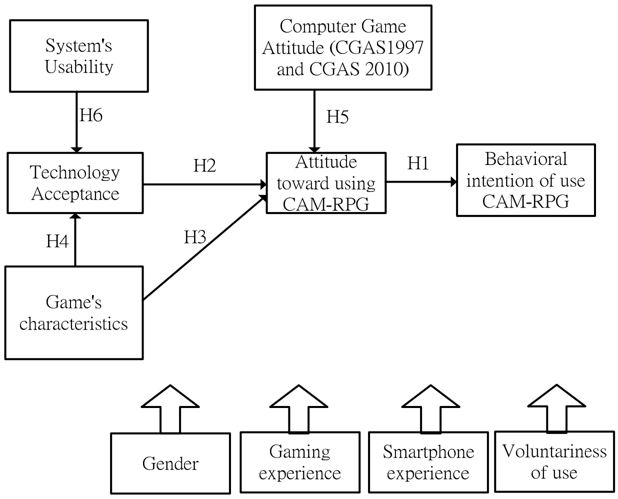


Figure 28. Macro view of the proposed research model

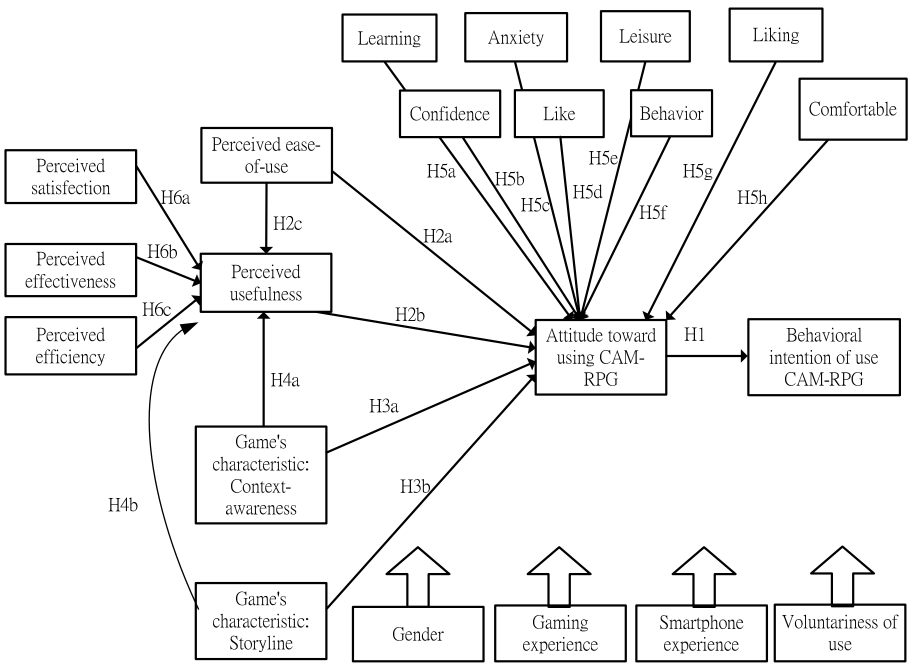


Figure 29. Micro view of the proposed research model

Some researchers have examined the acceptance factors for educational games or entertainment games. Bourgonjon and colleagues incorporated gender, gaming experience, and learning opportunities into TAM to figure out students' perceptions of using video games in the classroom (Bourgonjon, Valcke, Soetaert, & Schellens, 2010). Ibrahim proposed an educational games acceptance model combining the constructs of TAM and the unified theory of acceptance and use of technology (UTAUT) together (Ibrahim, 2011). These studies enhance TAM by bringing other models/theories into it. These revised TAMs (known as extended TAM) are used not only to investigate the external variables, but also to decide on factors and moderators.In this research, I add four moderators—gender, gaming experience, smartphone use experience, and voluntariness of use—from the relevant researches to investigate their impacts on user acceptance of using the game. This research wants to know the answers for the research questions mentioned at the beginning of this section by analyzing the collected data from the experiment.

The next section describes the details of all hypotheses extracted from the relationships among variables in the research model.

5.1.2 Hypotheses

In this section, the hypotheses needed to be verified in the research model are discussed. I use the constructs described in Figure 29 to make hypotheses listed in Tables 3, 4, and 5.

Table 3. Hypotheses of the Extended Technology Acceptance Model

Model	Macro View	Micro View
Extended –TAM	H1	H1: Attitude has a positive effect on behavioral intention.
	H2	H2a: Perceived ease-of-use has a positive effect on

		attitude toward using CAM-RPG.
		H2b: Perceived usefulness has a positive effect on attitude toward using CAM-RPG.
		H2c: Perceived ease-of-use has a positive effect on perceived usefulness.
	H3	H3a: Context-awareness of the game has a positive effect on attitude toward using CAM-RPG.
		H3b: Storyline of the game has a positive effect on attitude toward using CAM-RPG.
	H4	H4a: Context-awareness of the game has a positive effect on perceived usefulness.
		H4b: Storyline of the game has positive effect on perceived usefulness.

The abovementioned hypotheses list the assumed relationship for the extended TAM. Several constructs, such as usability (e.g., effectiveness, efficiency, and satisfaction) and computer game attitude (e.g., learning, confidence, anxiety, leisure, behavior, liking, and comfort) are examined further. I integrate the concepts from CGAS 1997 proposed by Chappell and Taylor in 1997, and a CGAS proposed by Wu and his colleagues in 2010 (CGAS 2010) together to develop a suitable CGAS questionnaire (i.e., CGAS 2011) to discover the relationships between users' computer game attitudes and perceptions of the CAM-RPG. These hypotheses are listed in Table 4:

Table 4. Hypotheses of CGAS and Usability

Model	Macro View	Micro View
Computer Game Attitude Scale	H5	H5a: Computer game learning has a positive effect on attitude toward using CAM-RPG.
		H5b: Computer game confidence has a positive effect on attitude toward using CAM-RPG.
		H5c: Computer game anxiety has a negative effect on attitude toward using CAM-RPG.
		H5d: Computer game liking has a positive effect on attitude toward using CAM-RPG.
		H5e: Computer game leisure has a positive effect on attitude toward using CAM-RPG.
		H5f: Computer game behavior has a positive effect on attitude toward using CAM-RPG.
		H5g: computer game liking has a positive effect on

		user's attitude toward using CAM-RPG.
		H5h: Computer game comfortable has a positive effect on user's attitude toward using CAM-RPG.
Usability	H6	H6a: Perceived effectiveness of the system has a positive effect on perceived usefulness.
		H6b: Perceived efficiency of the system has a positive effect on perceived usefulness.
		H6c: Perceived satisfaction of the system has a positive effect on perceived usefulness.

For the moderators proposed in the research model (as shown in Figures 28 and 29), I also make five hypotheses:

Table 5. Hypotheses of Moderators

Model	Micro View
Moderators	H7: There is gender difference on user's acceptance toward using the CAM-RPG.
	H8: Experience of using Smartphones does have positive effect on user's acceptance toward using the CAM-RPG.
	H9: Gaming experience does have positive effect on user's acceptance toward using the CAM-RPG.
	H10: The voluntariness of use CAMRPG does have positive effect on user's acceptance toward CAM-RPG.
	H11: There is gender difference on user's computer game attitude.
	H12: Gaming experience does have positive effect on user's computer game attitude.

5.2 Experiment Design

5.2.1 Participants and Procedure

The participants in this experiment were 70 undergraduate students (age range 21-22 years old), including 37 males and 33 females, from the Department of Information Management (IM), National Kaohsiung First University of Science and Technology (NKFUST), Taiwan. The experiment took place in three laboratories in the fifth floor of NKFUST teaching building E.

To start, I introduced the proposed game and presented a scenario in the class. I also emphasized to the students that there was no compensation, reward, or recognition for participating in this experiment, and nothing will happen to the students who do not want to join the study.

Because the experiment was held in the middle of the semester, and all students who voluntarily participated in the experiment were waking an undergraduate-level manage information systems (MIS) course, I used MIS course contents and unit concepts to construct the knowledge structure, learning objects, and story template tree to create an authentic learning environment (i.e., the fifth floor of teaching building E) for the students. All voluntary students were grouped into 23 teams with three to four students per team and were asked to make appointments with me to play the CAM-RPG. The reason for grouping is the limited number of devices (i.e., the smartphones for the experiment) and the students' available time. Before the teams came to meet me in the authentic learning environment, they were asked to fill out part I of the questionnaire (I divided the questionnaire into two parts to reduce the time that the students would need to fill it out).

All students had 20 minutes to play the game with the smartphones I had prepared for them in the authentic learning environment. After they played the game, they were asked to fill out part II of the questionnaire to provide the necessary data for analyzing and verifying my hypotheses. All presentations, documents, gameplay contents, and questionnaires were designed and developed in Chinese to ensure that the students fully understood and to reduce possible negative effects and anxiety caused by a foreign language.

5.2.2 Questionnaire Design

The research questionnaire was divided into two parts in order to reduce the time spent by students in filling it out. Part I was delivered to students after they teamed up and before they came to see me. Part I used three sections to collect the essential information of the respondents, including demographics, computer/video gaming experience, and computer game attitudes. In the demographics and computer/video gaming experience sections, the questionnaire asked about students' demographic information, experience using smartphones, and experience playing a variety of games.

In this experiment, I adopted CGAS 2010 questionnaire by Wu and his colleagues. CGAS 2010 has 31 five-point Likert-scale items (5 for "strongly agree" to 1 for "strongly disagree"), and these 31 items are categorized into three subscales composed of six factors: computer cognitive subscale ("learning" and "confidence" factor); computer affective subscale ("anxiety" and "like" factor); and computer behavior subscale ("leisure" and "behavior" factor).

Part II of the questionnaire was delivered to students after they played the game in the authentic learning environment. This part used 40 five-point Likert-scale items (5 for "strongly agree" to 1 for "strongly disagree") to address four main constructs of Technology Acceptance Model (i.e., perceived ease of use, perceived usefulness, attitude toward using, and behavioral intention of using), two examined constructs (i.e., context-awareness and storyline), and three constructs of usability (i.e., the system's effectiveness, the system's efficiency, and the user's satisfaction). In addition, five items were developed to evaluate the influence of "voluntariness of use" and one optional open-ended question was developed to determine students' expectation for game features and functions. The full questionnaire can be found in Appendix A.

5.2.3 Data Collection

I spent two weeks to do the experiment with the volunteer students and to collect data due to the limited number of smartphones and students' available time. As mentioned in Section 5.2.1, all students were asked to fill out part I of the questionnaire before playing the game. When they came to see me, I lent each student a smartphone and briefly introduced the gameplay procedure and game functions. The students then started to play the game. They received story-enhanced learning activities and looked for the required learning objects in the real world. The learning objects were associated with MIS topics/concepts and were presented in different formats, like video clips, presentation slides, case studies, and real systems. In the gameplay, students acted as IT experts and received quests from their boss (i.e., a non-player-controlled character). The quests asked them to visit the science park (i.e., the authentic learning environment) and collect some important information for their company. While students were playing, they would learn about these learning objects actively through presentations and demonstrations instead of sitting passively in the classroom and receiving lectures from the course instructor.

After the students played for 20 minutes and solved several learning activities, they were asked to come back and fill out part II of the questionnaire. I also had brief interviews with the students to understand the students' perceptions of the game and what the shortcomings of the game might be.

5.3 Validity and Reliability Analysis

The questionnaire was adopted from previous research results and its validity and reliability have been proven by other researchers. In this research, however, I analyzed it further before using the collected data to examine/verify my hypotheses. Two teams that did not show up to complete part II of the questionnaire. Therefore, I had to remove the correspondent responses to part I of the questionnaire. In addition, two responses were removed because they had extreme values for all questions and had conflicting answers for the flip-flop items. The final valid sample includes 62 students, 34 male and 28 female. I analyze the reliability and validity of the responses part by part (CGAS, TAM, and usability) below.

5.3.1 Reliability and Validity Analysis for CGAS Questionnaire

For the 31 CGAS items in part I of the questionnaire, I tried to examine the validity and reliability according to the factors categorized by both of CGAS 1997 and CGAS 2010. I did this because I would like to determine the most important and representative items and factors to create CGAS 2011 for future use. After all, CGAS 1997 is more than 10 years old and computer/video gaming now is quite different, and CGAS 2010 mainly targets elementary school students rather than adolescent students.

The results show that all factors have a good measure of reliability except the behavior factor in CGAS 2010. I reviewed the three items of the behavior factor and believe that they may not fully explain the factor in this research because of the different subjective situations. These three items do not have any correlation with the other factors, either. Therefore, I decided to remove the behavior factor in this research. Table 6 shows the reliability analysis of all factors for the CGAS questionnaire.

Table 6. Reliability analysis of CGAS 2010 and 1997 questionnaire

Concept of CGAS	Factor	Description	Items	Cronbach's Alpha if Item Deleted	Overall Cronbach's alpha
Cognition of CGAS 2010	Learning (Lr)	User's attitude of learning from playing computer games.	Lr01 - Q24 Lr02 - Q25 Lr03 - Q27 Lr04 - Q28 Lr05 - Q29 Lr06 - Q30	.767 .798 .784 .765 .754 .784	**.810**
	Confidence (Cf)	User's confidence in playing computer games.	Cf01 - Q20 Cf02 - Q21 Cf03 - Q22 Cf04 - Q23	.942 .945 .934 .940	**.955**
Affection of CGAS 2010	Anxiety (An)	User's perception anxiety toward playing computer games.	An01 - Q02 An02 - Q03 An03 - Q04	.777 .774 .796	**.847**
	Like (Lk)	User's computer games liking.	Lk01 - Q06 Lk02 - Q07 Lk03 - Q08	.767 .674 .715	**.800**
Behavior of CGAS 2010	Leisure (Ls)	User's attitude of taking computer games as leisure	Ls01 - Q14 Ls02 - Q15 Ls03 - Q16 Ls04 - Q17 Ls05 - Q18 Ls06 - Q19	.854 .849 .822 .816 .831 .838	**.860**
	Behavior (Bh)	User's behavior in computer using	Bh01 - Q10 Bh02 - Q12 Bh03 - Q13	.388 .198 .420	<u>**.438**</u>
CGAS 1997	Liking (Lk)	User's feeling of liking computer games.	Lk01 - Q06 Lk02 - Q07 Lk03 - Q08 Lk04 - Q16 Lk05 - Q17 Lk06 - Q18 Lk07 - Q19	.829 .841 .846 .831 .835 .814 .834	**.856**
	Comfortable (Com)	User's feeling of comfortable with playing computer games.	Com01 - Q02 Com02 - Q03 Com03 - Q04 Com04 - Q14 Com05 - Q15 Com06 - Q20 Com07 - Q21 Com08 - Q22 Com09 - Q23	.882 .886 .888 .889 .881 .866 .865 .873 .869	**.888**
Attitude (Att)		User's perception of computer attitude	Att01 - Q01 Att02 - Q05 Att03 - Q09 Att04 - Q11 Att05 - Q26 Att06 - Q31	.762 .781 .777 .767 .789 .806	**.812**

Bold: Cronbach's alpha value is higher than 0.75
Bold and underline: Cronbach's alpha value is lower than 0.75

I further examined the CGAS questionnaire's validity with principal analysis. Table 7 shows the factor loading in each subscale based on 2010's research categories.

Table 7. Validity analysis of the CGAS questionnaire (based on 2010's categories)

	Component					
	1 (Cf)	2 (An)	3 (Lk)	4 (Att)	5 (Ls)	6 (Bh)
An1_Q02	.240	**.707**	.265	-.015	.156	-.055
An2_Q03	.181	**.813**	.226	.003	-.054	-.096
An3_Q04	.029	**.776**	.211	.163	.128	.081
Ls1_Q14	.339	.530	.008	.264	**.058**	.206
Ls2_Q15	.410	.499	.119	.198	**.127**	-.172
Ls3_Q16	.417	***.641***	-.020	.015	**.327**	.193
Ls4_Q17	.268	***.718***	-.076	.117	**.426**	.001
Ls5_Q18	.377	.332	.298	.136	**.638**	-.022
Ls6_Q19	.153	.337	.102	.404	**.669**	-.072
Cf1_Q20	**.877**	.137	.230	-.009	.123	.082
Cf2_Q21	**.801**	.204	.195	.004	.271	.025
Cf3_Q22	**.866**	-.036	.334	.076	.143	-.045
Cf4_Q23	**.873**	.079	.188	.011	.118	-.060
Lk1_Q06	.447	.372	**.432**	.067	.237	.177
Lk2_Q07	.270	.085	**.676**	.042	.248	.123
Lk3_Q08	.241	.150	**.797**	.206	.175	-.018
Att1_Q01	-.020	.644	.141	**.308**	-.028	.500
Att2_Q05	.195	.343	-.182	**.546**	.093	.210
Att3_Q09	.079	.550	.136	**.490**	.135	-.008
Att4_Q11	-.190	.483	.173	**.491**	.043	.434
Att5_Q26	.031	.117	.161	**.823**	.191	-.036
Att6_Q31	.667	.309	-.004	**.312**	-.181	.266
Bh1_Q10	.139	.018	-.032	.176	-.040	**.710**
Bh2_Q12	.012	-.057	.242	-.362	-.007	**.709**
Bh3_Q13	.342	.286	.308	.013	.141	**.224**
Lr1_Q24	***.664***	.436	-.059	-.067	.120	.202
Lr2_Q25	.211	.309	.347	-.449	.287	.254
Lr3_Q27	.196	.219	***.747***	-.149	-.271	.056
Lr4_Q28	.563	.204	.459	.056	-.408	.138
Lr5_Q29	***.620***	.473	.254	-.247	-.151	-.093
Lr6_Q30	.457	.488	.112	.224	-.137	.150

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 8 iterations.

	Component					
	1 (Cf)	2 (An)	3 (Lk)	4 (Att)	5 (Ls)	6 (Bh)
An1_Q02	.240	**.707**	.265	-.015	.156	-.055
An2_Q03	.181	**.813**	.226	.003	-.054	-.096
An3_Q04	.029	**.776**	.211	.163	.128	.081
Ls1_Q14	.339	.530	.008	.264	**.058**	.206
Ls2_Q15	.410	.499	.119	.198	**.127**	-.172
Ls3_Q16	.417	***.641***	-.020	.015	**.327**	.193
Ls4_Q17	.268	***.718***	-.076	.117	**.426**	.001
Ls5_Q18	.377	.332	.298	.136	**.638**	-.022
Ls6_Q19	.153	.337	.102	.404	**.669**	-.072
Cf1_Q20	**.877**	.137	.230	-.009	.123	.082
Cf2_Q21	**.801**	.204	.195	.004	.271	.025
Cf3_Q22	**.866**	-.036	.334	.076	.143	-.045
Cf4_Q23	**.873**	.079	.188	.011	.118	-.060
Lk1_Q06	.447	.372	**.432**	.067	.237	.177
Lk2_Q07	.270	.085	**.676**	.042	.248	.123
Lk3_Q08	.241	.150	**.797**	.206	.175	-.018
Att1_Q01	-.020	.644	.141	**.308**	-.028	.500
Att2_Q05	.195	.343	-.182	**.546**	.093	.210
Att3_Q09	.079	.550	.136	**.490**	.135	-.008
Att4_Q11	-.190	.483	.173	**.491**	.043	.434
Att5_Q26	.031	.117	.161	**.823**	.191	-.036
Att6_Q31	.667	.309	-.004	**.312**	-.181	.266
Bh1_Q10	.139	.018	-.032	.176	-.040	**.710**
Bh2_Q12	.012	-.057	.242	-.362	-.007	**.709**
Bh3_Q13	.342	.286	.308	.013	.141	**.224**
Lr1_Q24	***.664***	.436	-.059	-.067	.120	.202
Lr2_Q25	.211	.309	.347	-.449	.287	.254
Lr3_Q27	.196	.219	***.747***	-.149	-.271	.056
Lr4_Q28	.563	.204	.459	.056	-.408	.138
Lr5_Q29	***.620***	.473	.254	-.247	-.151	-.093
Lr6_Q30	.457	.488	.112	.224	-.137	.150

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 8 iterations.

Bold: item's factor loading is over 0.6 for the pre-defined component
Bold and underline: item's factor loading for the pre-defined component is less than 0.6
Bold and italic: item's factor loading is over 0.6 for component other than pre-defined one

The validity analysis in Table 7 shows that some items may not be good measures (i.e., values in bold underline and bold italic) for the factor to which they belong. I also found that the items for anxiety and leisure were close to the items for comfortable in CGAS 1997. Next, I removed the items with lower factor loading and re-ran the exploring factor analysis for the rest as shown in Table 8.

Table 8. Validity analysis of CGAS questionnaire

	Component					
	1 (An+Ls)	2 (Cf)	3 (Lk)	4 (Att)	5 (Lr)	6 (Bh)
An1_Q02	**.695**	.193	.204	.099	.249	-.070
An2_Q03	**.745**	.096	.168	.135	.324	-.103
An3_Q04	**.767**	-.022	.246	.209	.073	.077
Ls1_Q14	**.589**	.266	.106	.210	-.127	.253
Ls2_Q15	**.603**	.376	.287	.041	-.277	-.045
Ls3_Q16	**.731**	.379	-.017	.091	.045	.176
Ls4_Q17	**.770**	.236	-.119	.278	.098	-.045
Cf1_Q20	.206	**.884**	.176	.036	.131	.086
Cf2_Q21	.309	**.829**	.174	.047	.045	.050
Cf3_Q22	.031	**.904**	.283	.105	.085	-.014
Cf4_Q23	.146	**.895**	.141	.049	.056	-.030
Lk1_Q06	.493	.440	**<u>.515</u>**	.000	-.057	.257
Lk2_Q07	.149	.275	**.677**	-.002	.183	.097
Lk3_Q08	.180	.249	**.815**	.151	.119	-.022
Att2_Q05	.298	.173	-.185	**.655**	-.049	.140
Att3_Q09	.502	.036	.137	**<u>.590</u>**	.055	-.034
Att4_Q11	.426	-.208	.243	**<u>.507</u>**	-.024	.424
Att5_Q26	.064	.038	.177	**.879**	-.097	-.089
Bh1_Q10	.058	.090	.022	.105	-.037	**.823**
Bh2_Q12	-.089	.005	.063	-.206	.480	**.635**
Lr1_Q24	.452	***.598***	-.161	.073	.319	.104
Lr2_Q25	.293	.223	.098	-.161	**.628**	.090
Lr3_Q27	.049	.180	.533	.045	**.678**	-.048
Lr4_Q28	.094	.504	.362	.123	.395	.152
Lr5_Q29	.478	.544	.218	-.215	.283	-.128
Lr6_Q30	.412	.371	.042	.361	.338	.088

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 10 iterations.

Bold: item's factor loading is over 0.6 for the pre-defined component.
<u>Bold and underline:</u> item's factor loading for the pre-defined component is less than 0.6
Bold and italic: item's factor loading is over 0.6 for component other than the pre-defined one

Table 8 shows that the learning factor and its items in CGAS 2010 research may not represent the meaning very well in this research. Thus, I reviewed the questionnaire items and reorganized the factors and items as shown in Table 9.

Table 9. Subscales and reliability analysis for CGAS 2011

Factor	Item	Overall Cronbach's alpha
Attitude toward computer	Q1, Q5, Q9, Q11, Q26, Q31	**0.812**
Attitude toward computer game	(Q6), Q15, Q19, Q27, Q28, Q29, Q30	**0.784**
Comfortable	Q2, Q3, Q4, Q16, Q17, (Q24)	**0.877**
Liking	(Q6), Q7, Q8, (Q19), Q13, Q14	**<u>0.708</u>**
Behavior	Q10, Q12, Q18	**<u>0.285</u>**
Confidence	Q20, Q21, Q22, Q23,(Q24), Q25	**0.896**

Bold: Cronbach's alpha value is higher than 0.75
<u>Bold and underline:</u> Cronbach's alpha value is lower than 0.75

To determine the new subscales for CGAS 2011, I divided the attitude factor into "attitude toward computer" and "attitude toward computer games". I also merge the anxiety factor and leisure factor together to create a new "comfortable" factor, just as Chappell and Taylor had in 1997. In addition, the behavior factor does not present good results in reliability analysis, which means these three items cannot represent the behavior factor in this experiment. The detailed reliability analysis of CGAS 2011 is presented in Table 10.

Table 10. Reliability Analysis of CGAS 2011 questionnaire

Concept of CGAS 2011	Original factor (in CGAS2010)	Items	Cronbach's Alpha if Item Deleted	Overall Cronbach's alpha
Attitude toward computer (Ac)	Attitude Attitude Attitude Attitude Attitude Attitude	AC_Q01 AC_Q05 AC_Q09 AC_Q11 AC_Q26 AC_Q31	.762 .781 .777 .767 .789 .806	**0.812**
Attitude toward computer games (Acg)	Liking Leisure Leisure Learning Learning Learning Learning	ACG_Q06 ACG_Q15 ACG_Q19 ACG_Q27 ACG_Q28 ACG_Q29 ACG_Q30	.728 .742 .799 .770 .740 .728 .742	**0.784**
Comfortable (Com)	Anxiety Anxiety Anxiety Leisure Leisure Learning	COM_Q02 COM_Q03 COM_Q04 COM_Q16 COM_Q17 COM_Q24	.849 .851 .860 .851 .842 .875	**0.877**
Liking (Lk)	Liking Liking Behavior Leisure	LK_Q07 LK_Q08 LK_Q13 LK_Q14	.630 .575 .651 .708	**<u>0.708</u>**

Confidence (Cf)	Confidence Confidence Confidence Confidence Learning	CF_Q20 CF_Q21 CF_Q22 CF_Q23 CF_Q25	.851 .855 .852 .855 .955	**0.896**
Behavior (Bh)	Behavior Behavior Leisure	BH_Q10 BH_Q12 BH_Q18	.003 .149 .420	**<u>0.285</u>**

Bold: Cronbach's alpha value is higher than 0.75
<u>Bold and underline:</u> Cronbach's alpha value is lower than 0.75

Next, I examined the items' validity within their new subscales. The results of all items are listed in Table 11 and show that some items are not good enough for presenting the new subscales of CGAS 2011. I removed the items with lower factor loading and listed the rest in Table 12.

Table 11. Validity analysis of CGAS 2011 questionnaire (all items)

	Component				
	1 (Com)	2 (Cf)	3 (Lk)	4(Ac)	5(Acg)
Attitude to Computer_Q01	.586	-.145	.196	**<u>.479</u>**	.246
Attitude to Computer _Q05	.244	.133	-.194	**.664**	.251
Attitude to Computer _Q09	.460	.052	.112	**<u>.553</u>**	.130
Attitude to Computer _Q11	.475	-.186	.203	**.618**	-.040
Attitude to Computer _Q26	.005	.089	.107	**.854**	.019
Attitude to Computer _Q31	.165	.364	.064	**<u>.318</u>**	***.730***
Attitude to CG_Q06	.492	.527	.427	.137	**<u>-.039</u>**
Attitude to CG _Q15	.576	.457	.104	.113	**<u>-.025</u>**
Attitude to CG _Q27	.105	.032	***.776***	-.107	**<u>.349</u>**
Attitude to CG _Q28	.081	.289	.533	-.001	**<u>.577</u>**
Attitude to CG _Q29	.427	.430	.298	-.269	**<u>.471</u>**
Attitude to CG _Q30	.360	.215	.159	.249	**<u>.573</u>**
Comfortable_Q02	**.712**	.173	.265	.012	.205
Comfortable _Q03	**.755**	.058	.233	.015	.278
Comfortable _Q04	**.770**	.020	.203	.268	.057
Comfortable _Q16	**.695**	.391	-.025	.152	.207
Comfortable _Q17	**.734**	.281	-.124	.250	.146
Comfortable _Q24	**<u>.374</u>**	.461	-.049	.044	***.600***
Linking_Q07	.152	.316	**.674**	.082	.018
Linking _Q08	.177	.334	**.759**	.233	-.073
Linking _Q13	.247	.263	**<u>.296</u>**	.163	.317
Linking _Q14	.515	.250	**<u>.031</u>**	.324	.267
Confidence_Q20	.173	**.826**	.216	.017	.332
Confidence _Q21	.282	**.839**	.160	.056	.168
Confidence _Q22	.000	**.868**	.306	.056	.230
Confidence _Q23	.109	**.847**	.162	-.001	.272

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 8 iterations.

Bold: item's factor loading is over 0.6 for the pre-defined component
<u>Bold and underline:</u> item's factor loading for the pre-defined component is less than 0.6
Bold and italic: item's factor loading is over 0.6 for the component other than the pre-defined one

Table 12. Validity analysis of CGAS 2011 questionnaire (achieved items)

	Component				
	1 (Cf)	2 (Com)	3 (Ac)	4 (Lk)	5 (Acg)
Confidence_Q20	**.842**	.172	.021	.233	.280
Confidence _Q21	**.856**	.287	.082	.176	.107
Confidence _Q22	**.876**	.008	.043	.322	.188
Confidence _Q23	**.869**	.120	.001	.182	.200
Comfortable_Q02	.221	**.771**	.019	.264	.123
Comfortable _Q03	.067	**.754**	.052	.231	.297
Comfortable _Q04	.043	**.759**	.306	.224	-.008
Comfortable _Q16	.400	**.680**	.180	-.037	.192
Comfortable _Q17	.326	**.753**	.293	-.122	.065
Attitude to Computer_Q01	-.145	.548	**<u>.500</u>**	.183	.314
Attitude to Computer _Q05	.210	.257	**.681**	-.187	.114
Attitude to Computer_ Q09	.024	.420	**<u>.552</u>**	.101	.236
Attitude to Computer _Q11	-.214	.429	**.653**	.187	.067
Attitude to Computer _Q26	.085	-.026	**.844**	.099	.041
Liking_Q07	.309	.157	.097	**.665**	.013
Liking_Q08	.309	.133	.290	**.769**	-.102
L iking_Q27	.082	.163	-.111	**.780**	.264
Attitude to CG _Q24	.498	.376	.037	-.051	**<u>.595</u>**
Attitude to CG _Q28	.309	.076	-.041	.558	**<u>.570</u>**
Attitude to CG _Q30	.241	.351	.248	.160	**.620**
Attitude to CG_Q31	.397	.122	.320	.062	**.732**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations.

Bold: item's factor loading is over 0.6 for the pre-defined component
<u>Bold and underline:</u> item's factor loading for the pre-defined component is less than 0.6
Bold and italic: item's factor loading is over 0.6 for the component other than the pre-defined one

Finally, a valid and reliable revised CGAS questionnaire (i.e., CGAS 2011) with five subscales and 21 items was determined and confirmed. This revised CGAS and the collected data will be analyzed further using quantitative methods in the next section.

5.3.2 Reliability and Validity Analysis for TAM Questionnaire

For the 40 items of part II questionnaire, I first examined validity and reliability. Table 13 lists the reliability analysis results. The Cronbach's alpha for the overall questionnaire is 0.826, indicating that the questionnaire (and its items) can be seen as reliable because its internal consistency is good enough (i.e., exceeds 0.75) (Hair, Anderson, Tatham, & Black, 1998).

Table 13. Reliability Analysis of part-II questionnaire

Constructs	Description	Type	Items	Cronbach's Alpha if Item Deleted	Cronbach's alpha
Perceived ease of use (PEoU)	User's perceived ease of using CAM-RPG	Independent/Dependent	PEoU01 – Q01 PEoU02 – Q02 PEoU03 – Q04 PEoU04 – Q30 PEoU05 – Q31 PEoU06 – Q32 PEoU07 – Q35	.670 .652 ***.758*** ***.774*** .663 .660 .712	**<u>0.743</u>**
Perceived usefulness (PU)	User's perceived usefulness toward CAM-RPG	Independent/Dependent	PU01 – Q03 PU02 – Q33 PU03 – Q34 PU04 – Q36 PU05 – Q37	.755 .746 .752 .746 .768	**0.793**
Context-awareness of the game (CA)	User's feeling about CAM-RPG's characteristic: Context-Awareness	Independent	CA01 – Q12 CA02 – Q13 CA03 – Q14 CA04 – Q15 CA05 – Q16 CA06 – Q17	.671 ***.807*** .661 .632 .681 .664	**0.752**
Storyline of the game (SL)	User's feeling about CAM-RPG 's characteristic: Storyline	Independent	SL01 – Q08 SL02 – Q09 SL03 – Q10 SL04 – Q11	.811 .781 .791 .767	**0.832**
Attitude toward using the CAM-RPG (ATT)	User's attitude toward using CAM-RPG	Independent/Dependent	ATT01 – Q05 ATT02 – Q06 ATT03 – Q07 ATT04 – Q23	.756 .763 .698 .805	**0.807**
Intention of using the CAM-RPG (IT)	User's behavioral intention of using CAM-RPG	Dependent	IT01 – Q24 IT02 – Q25 IT03 – Q26 IT04 – Q27 IT05 – Q28	.862 .857 .878 .856 .897	**0.894**
Voluntariness of use (VoU)	User's voluntariness of using CAM-RPG	Moderators	VoU01 – Q18 VoU02 – Q19 VoU03 – Q20 VoU04 – Q21 VoU05 – Q22	.313 .261 .453 .526 .472	**<u>0.679</u>**

*Complete questionnaire and item description can be found in Appendix A.
Bold: Cronbach's alpha value is higher than 0.75

<u>Bold and underline:</u> Cronbach's alpha value is lower than 0.75
Bold and italic: Cronbach's alpha value for the factor will be higher if the item is deleted

Next, the items' internal commonality for each construct in the research model was examined using principal component analysis, and the items with lower factor loading were removed. Three items were excluded due to the relatively low factor loading, and the rest of the items show good results in factor analysis, which means these items can be used to represent the constructs respectively. Lower loading items, they may have occurred due to unclear questions or misunderstanding. They need to be revised to fit the presented constructs for future study and experiments. Table 14 shows all constructs' results in principle component analysis.

Table 14. Validity analysis for TAM questionnaire

	Component 1
PEoU01 – Q01	.759
PEoU02 – Q02	.850
<u>PEoU03 – Q04</u>	**<u>.295</u>**
<u>PEoU04 – Q30</u>	**<u>.165</u>**
PEoU05 – Q31	.817
PEoU06 – Q32	.799
PEoU07 – Q35	.580

	Component 1
PU01 – Q03	.733
PU02 – Q33	.758
PU03 – Q34	.741
PU04 – Q36	.762
PU05 – Q37	.703

	Component 1
CA01 – Q12	.755
<u>CA02 – Q13</u>	**<u>.150</u>**
CA03 – Q14	.761
CA04 – Q15	.844
CA05 – Q16	.717
CA06 – Q17	.701

	Component 1
SL01 – Q08	.775
SL02 – Q09	.826
SL03 – Q10	.813
SL04 – Q11	.847

	Component 1
Att01 – Q05	.805
Att02 – Q06	.795
Att03 – Q07	.875
Att04 – Q23	.710

	Component 1
I01 – Q24	.863
I02 – Q25	.885
I03 – Q26	.819
I04 – Q27	.885
I05 – Q28	.745

Extraction Method: Principal Component Analysis.
<u>Bold and underline:</u> item's factor loading for the pre-defined component is less than 0.6

5.3.3 Reliability and Validity Analysis for Usability Questionnaire

Because some items in the usability assessment were similar to TAM items (e.g., effectiveness is partially involved in ease of use), part II of the questionnaire had 11 usability items. Reliability and validity analysis were tested for those 11 items in the usability assessment. Table 15 lists the reliability analysis results. The Cronbach's alpha for the overall questionnaire is 0.873, indicating that the questionnaire (and its items) can be seen as reliable because its internal consistency is good enough (i.e., exceeds 0.75). Although the Cronbach's alpha value would be up to 0.758 if I removed item #32 from the effectiveness factor, it seems item #32 was miscategorized (or the wording of item #32 made respondents feel that it was asking them for their feelings about the efficiency of the CAM-RPG) according to Table 16. Therefore, I might need to move item #32 to the proper factor instead of removing it directly.

Table 15. Reliability for Usability questionnaire

Concept	Description	Items	Cronbach's alpha if item deleted	Cronbach's alpha
Effectiveness	User's feeling about effectiveness of CAM-RPG	Effectiveness01 – Q30 Effectiveness02 – Q31 Effectiveness03 – Q32	.521 .507 ***.758***	<u>**0.699**</u>
Efficiency	User's feeling about efficiency of CAM-RPG	Efficiency01 – Q33 Efficiency02 – Q34 Efficiency03 – Q35 Efficiency04 – Q36 Efficiency05 – Q37	.730 .755 .721 .721 .726	**0.777**
Satisfaction	User's satisfaction of using CAM-RPG	Satisfaction01 – Q38 Satisfaction02 – Q39 Satisfaction03 – Q40	***.902*** .728 .677	**0.840**

Bold: Cronbach's alpha value is higher than 0.75
<u>**Bold and underline:**</u> Cronbach's alpha value is lower than 0.75
Bold and italic: Cronbach's alpha value for the correspondent factor will be higher if the item is deleted

Next, the items' internal commonality for each construct in the research model was examined using principal component analysis. The results show that item #32 in the effectiveness factor and items #35, #36, and #37 need to be reviewed and the rest of the items present a good measure of factor loading, indicating these items can be used to stand for their respective constructs. Table

16 shows each construct's results for principal component analysis.

Table 16. Validity analysis for Usability questionnaire

	Component		
	1 (Satisfaction)	2(Efficiency)	3(Effectiveness)
Effectiveness01 – Q30	.070	.344	**.764**
Effectiveness02 – Q31	.168	.152	**.834**
Effectiveness03 – Q32	.143	***.736***	.229
Efficiency01 – Q33	.221	**.792**	.208
Efficiency02 – Q34	.154	**.789**	.088
Efficiency03 – Q35	.379	**<u>.460</u>**	.172
Efficiency04 – Q36	.536	**<u>.176</u>**	.507
Efficiency05 – Q37	***.628***	.093	.518
Satisfaction01 – Q38	**.700**	.113	.332
Satisfaction02 – Q39	**.854**	.251	-.030
Satisfaction03 – Q40	**.832**	.303	.083

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations.

Bold: item's factor loading is over 0.6 for the pre-defined component
<u>Bold and underline:</u> item's factor loading for the pre-defined component is less than 0.6
Bold and italic: item's factor loading is over 0.6 for the component other than the pre-defined one

After I reviewed the wordings of items #32, #35, #36, and #37 as well as the results of the reliability analysis, I decided to move item #32 to the efficiency factor and not consider items #35, #36, and #37 for further analysis due to their factor loading values being too low. These three items need to be revised or replaced by other items that can correctly represent the efficiency factor. The adjusted reliability and validity analyses are listed in Tables 17 and Table 18.

Table 17. Adjusted reliability analysis for Usability questionnaire

Concept	Items	Cronbach's alpha if item deleted	Cronbach's alpha
Effectiveness	Effectiveness01 – Q30 Effectiveness02 – Q31	.[a] .[a]	**0.758**
Efficiency	Efficiency01 – Q32 Efficiency02 – Q33 Efficiency03 – Q34	.661 .609 .751	**0.763**
Satisfaction	Satisfaction01 – Q38 Satisfaction02 – Q39 Satisfaction03 – Q40	***.902*** .728 .677	**0.840**

[a] The value is negative due to a negative average covariance among items.
Bold: Cronbach's alpha value is higher than 0.75
Bold and italic: Cronbach's alpha value for the factor will be higher if the item is deleted

Table 18. Adjusted validity analysis for Usability questionnaire

	Component		
	1 (Satisfaction)	2 (Efficiency)	3(Effectiveness)
Effectiveness01 – Q30	.118	.320	**.814**
Effectiveness02 – Q31	.201	.104	**.885**
Efficiency01 – Q32	.178	**.758**	.223
Efficiency02 – Q33	.240	**.799**	.202
Efficiency03 – Q34	.145	**.789**	.078
Satisfaction01 – Q38	**.707**	.132	.313
Satisfaction02 – Q39	**.898**	.204	.025
Satisfaction03 – Q40	**.887**	.250	.146

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 5 iteration

Bold: item's factor loading is over 0.6 for the pre-defined component.

From Table 18, there are only two items representing the effectiveness factor; this needs to be improved by examining more items in the future. Nevertheless, I will use this revised usability assessment and the collected data to do further quantitative analysis in Section 5.4.2.

5.4 Data Analysis

This section describes how I analyzed the collected data with statistical methods, including descriptive statistics, quantitative analysis, and qualitative analysis of the collected data as well as reports on the results of the experiment. Descriptive statistics show a summary of the responses, and I used it to group the responses while doing quantitative data analysis. In quantitative analysis, I used t-test and multi-regressions to analyze the relationships among constructs and to explore the answers to the research questions. For the qualitative analysis, I interviewed every group after they completed part II of the questionnaire. I wanted to know how students felt about the game and what they expected the game to have. Charts and tables are used to highlight trends and findings that have significant meanings in statistics.

5.4.1 Descriptive Statistics

The questionnaire collected students' demographic information, gaming experiences, attitudes toward computer games, attitudes toward using the CAM-RPG, and behavioral intention of using CAM-RPG. I first used descriptive statistics to summarize the collected data and compare the constructs' mean and standard deviation values for different groups (e.g., genders, smartphone using, player types, and voluntariness of using the CAM-RPG). Table 19 shows the basic information for the 62 effective participants.

Table 19. Demographic information of students

Gender	N	Smartphone(s) using experience	Playing Video Games	Playing Handheld Video Games	Playing Computer Games
Male	34	10 (29.4%)	30 (88.2%)	29(85.2%)	34(100%)
Female	28	9 (32.1%)	21 (75%)	22(78.5%)	27(96.4%)
Total	62	19(30.6%)	51(82.2%)	51(82.2%)	61(98.3%)

From Table 19, I found that most undergraduate students have rich experiences playing games, especially computer games. Video and computer games are both major entertainment activities for them. In addition, only 30.6% of undergraduate students have experiences of using smartphones. Table 20 further summarizes how much time the students usually spend (hours per week) playing video games, handheld video games, and computer games.

Table 20. Comparison table of game playing time

	Gender	N	Mean (hours per week)	Stand deviation	t value
Video Game play time	Male	34	4.2353	7.26577	0.271

	Female	28	4.8393	10.24790	
Handheld Video Game play time	Male	34	4.4853	7.27020	-1.540
	Female	28	2.2500	3.93112	
Computer Game play time	Male	34	22.3529	16.38714	**-2.823****
	Female	28	12.7500	10.13839	

*: p < 0.05 **: p < 0.01 ***: p < 0.001

From Table 20, I found that there is a significant difference between male and female students in playing computer games. I further observed and distinguished the groups by comparing the time they spend playing games. I define the top 25% of students for time spent playing computer games as hardcore players. On the other hand, the bottom 25% of students for time spent playing computer games are defined as casual players. The rest of students are defined as regular players. The new sample sizes of the comparable variables are listed in Table 21 in order to be used for the quantitative analysis (i.e., independent t-test) in the next section.

Table 21. Sample sizes of gender, time spent on playing computer games, experience of using smarphones, and voluntariness of use CAM-RPG

Grouped by	Groups	N	Mean
Gender	Male	34	-
	Female	28	-
Time spend on playing Computer Games	Hard-core player	18	36.77 (hrs/week)
	Regular player	25	15.52 (hrs/week)
	Casual player	19	3.52 (hrs/week)
Gender and time spend on playing Computer Games	Hard-core male player	14	38.64 (hrs/week)
	Hard-core female player	4	30.25 (hrs/week)
	Regular male player	13	15 (hrs/week)
	Regular female player	12	16.08 (hrs/week)
	Casual male player	7	3.43 (hrs/week)
	Casual female player	12	3.58 (hrs/week)
Have experience of using smartphones	Yes	19	-
	No	43	-
Voluntariness of using CAM-RPG	High	17	3.74 (of 5 point)
	Low	19	1.95 (of 5 point)

Finally, the descriptive statistical data of the constructs for the proposed research model are listed in Table 22. The overall mean score for the six constructs is four on the five-point scale. In the next section, I will examine whether the constructs have differences between the comparable groups of Table 21. I will also analyze the coefficients between constructs to examine the proposed research model.

Table 22. Descriptive statistical data of six constructs

Constructs	N	Mean	Std. error	Std. Deviation
Perceived ease of use	62	4.1968	.08499	.66922
Perceived usefulness	62	4.1290	.07994	.62944
Context-awareness	62	3.9935	.05799	.45660
Storyline	62	4.0121	.07349	.57870
Attitude toward using CAM-RPG	62	4.1371	.07792	.61350
Intention of use CAM-RPG	62	3.8548	.08420	.66300

5.4.2 Quantitative Analysis

Independent T-test for CGAS

In this section, I first use the independent t-test to explore whether there are significant differences in computer game attitudes for different groups of students (e.g., genders, time spent playing computer games, experience using smartphones, and voluntariness of using the CAM-RPG, as listed in Table 16). Tables 23 and 24 show the independent t-test results.

Table 23. Gender difference on factors of CGAS

	Gender	N	Mean	Standard deviation	t value
Confidence	Female	28	2.9911	1.01032	**-2.935****
	Male	34	3.6985	.88715	
Comfortable	Female	28	4.0357	.64877	-.473
	Male	34	4.1235	.78627	
Attitude toward computer	Female	28	4.1000	.47297	1.730
	Male	34	3.8000	.81054	
Liking	Female	28	2.9286	.88591	**-2.885****
	Male	34	3.5000	.67295	
Attitude toward computer games	Female	28	3.7768	.64671	-1.119
	Male	34	3.9706	.70379	

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

The statistical analysis data in Table 23 shows that there are significant differences between male and female students' perceptions of confidence, comfortable and Liking of gaming. Male players show higher confidence and comfortable feelings and enjoy playing computer games more than female players. **Hypothesis 11** has been confirmed and will be discussed in Section 5.5.

Two comparable variables, smartphones using experience and voluntariness of using the CAM-RPG, are not tested here because part I of the questionnaire mainly focuses on users' attitudes toward computer games and is not about using smartphones and the CAM-RPG.

For time spent playing computer games, Table 24 is the result of one-way analysis of variance (one-way ANOVA). There are significant differences among three groups on the subscales of confidence [$F(2,59) = 6.065$, $p < 0.005$], comfortable [$F(2,59) = 7.318$, $p < 0.005$], and attitude toward computer games [$F(2,59) = 5.315$, $p < 0.05$].

Table 24. Game playing time difference on subscales of CGAS (One-way ANOVA)

		Sum of Squares	df	Mean Square	F	Sig.
Confidence	Between Groups	10.439	2	5.220	6.065	**.004****
	Within Groups	50.779	59	0.861		
	Total	61.218	61			
Comfortable	Between Groups	6.337	2	3.168	7.318	**.001****
	Within Groups	25.547	59	0.433		
	Total	31.884	61			
Attitude toward computer	Between Groups	0.408	2	0.204	.419	.660
	Within Groups	28.694	59	0.486		
	Total	29.102	61			
Liking	Between Groups	3.434	2	1.717	2.686	.077
	Within Groups	37.715	59	0.639		
	Total	41.149	61			
Attitude toward computer games	Between Groups	4.308	2	2.154	5.315	**.008***
	Within Groups	23.907	59	0.405		
	Total	28.215	61			

***: p < 0.001, **: p < 0.01, *: p < 0.05

Table 25 shows the results of post hoc with Scheffe's method. The results indicate that hardcore players (i.e., those who play games more than 35 hours per week) show more positive responses for confidence, comfortable, and attitude toward computer games than regular and casual players. **Hypothesis 12** has thus been confirmed and will be discussed in Section 5.5.

Table 25. Post Hoc (Scheffe) for the subscales of CGAS 2011 (three groups, only list significant results)

Dependent Variable	(I) player_type	(J) player_type	Mean Difference (I-J)	Std. Error	Sig.
Confidence	Casual player	Regular player	-0.56789	.28235	.141
		Hard-core player	**-1.06067****	**.30514**	**.004**
	Regular player	Casual player	0.56789	.28235	.141
		Hard-core player	-0.49278	.28678	.237
	Hard-core player	Casual player	**1.06067****	**.30514**	**.004**
		Regular player	0.49278	.28678	.237
Comfortable	Casual player	Regular player	-0.29768	.20027	.338
		Hard-core player	**-.81813****	**.21644**	**.002**
	Regular player	Casual player	0.29768	.20027	.338
		Hard-core player	**-0.52044***	**.20341**	**.045**
	Hard-core player	Casual player	**0.81813****	**.21644**	**.002**
		Regular player	**0.52044***	**.20341**	**.045**
Attitude toward computer games	Casual player	Regular player	-0.18158	.19374	.647
		Hard-core player	**-0.65936***	**.20938**	**.010**
	Regular player	Casual player	0.18158	.19374	.647
		Hard-core player	-0.47778	.19677	.060
	Hard-core player	Casual player	**0.65936***	**.20938**	**.010**
		Regular player	0.47778	.19677	.060

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

Furthermore, I use gender to categorize player types further and create six player types to see if any specific difference exists. The results of one-way ANOVA indicate that there are significant differences among three groups on the subscales of confidence [$F(5,56) = 3.838$, $p < 0.005$], comfortable [$F(5,56) = 3.569$, $p < 0.05$], and liking [$F(5,56) = 2.413$, $p < 0.05$]. In Table 26, post hoc results show that significant differences exist between hardcore male players and casual female players on the subscales of confidence and comfortable.

Table 26. Post Hoc (Scheffe) for the subscales of CGAS 2011 (six, groups, only list significant results)

Dependent Variable	(I) player_type	(J) player_type	Mean Difference (I-J)	Std. Error	Sig.
Confidence	Casual female	Casual male	-0.92857	.42914	.465
		Regular female	-0.66667	.36837	.659
		Regular male	-1.13462	.36122	.097
		Hard-core female	-1.43750	.52095	.197
		Hard-core male	**-1.39286***	**.35497**	**.016**
	Hard-core male	Casual female	**1.39286***	**.35497**	**.016**
		Casual male	0.46429	.41769	.940
		Regular female	0.72619	.35497	.529
		Regular male	0.25824	.34754	.990
		Hard-core female	-0.04464	.51157	1.000
Comfortable	Casual female	Casual male	-0.20714	.31250	.994
		Regular female	-0.60000	.26825	.426
		Regular male	-0.16538	.26304	.995
		Hard-core female	-0.90000	.37937	.358
		Hard-core male	**-0.89286***	**.25849**	**.049**
	Hard-core male	Casual female	**0.89286***	**.25849**	**.049**
		Casual male	0.68571	.30417	.417
		Regular female	0.29286	.25849	.935
		Regular male	0.72747	.25308	.161
		Hard-core female	-0.00714	.37253	1.000

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

Independent T-test for TAM

Next, I use an independent t-test to explore whether there are significant differences in technology acceptance between different groups of students (e.g., genders, time spent playing computer games, experiences of using smartphones, and voluntariness of using the CAM-RPG listed in Table 21). The statistical data analysis in Table 27 shows two meaningful results: (1) female students have more positive feedback than male students for all constructs, and (2) there is no obvious difference between male and female students for six constructs, which means I may need to examine the connections in-between gender and computer game attitude further.

Table 27. Gander difference on six constructs of TAM

	Gender	Quantity	Mean	Standard deviation	t value
Perceived ease of use	Female	28	4.3429	.40682	1.579
	Male	34	4.0765	.81205	
Perceived usefulness	Female	28	4.3000	.37515	1.987
	Male	34	3.9882	.75629	
Context-awareness	Female	28	4.0000	.29313	0.106
	Male	34	3.9882	.56126	
Storyline	Female	28	4.0982	.51523	1.065
	Male	34	3.9412	.62480	
Attitude toward using the CAM-RPG	Female	28	4.2589	.36945	1.519
	Male	34	4.0368	.74907	
Intention of using the CAM-RPG	Female	28	3.9857	.60106	1.422
	Male	34	3.7471	.70032	

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

From Table 27, we can see that although both groups' mean values are quite high (positive) for all constructs, male students have relatively higher standard deviation. This circumstance shows that male students may have extreme high or low responses for these constructs. Hence, I further take the user attitude toward computer games (i.e., the subscale of CGAS 2011) into consideration to see whether this attitude is the reason why no significant differences are. I separate male students into two subgroups: higher computer game (CG) attitude (male high) and lower CG attitude (male low) (i.e., male students with a more positive attitude toward computer games and male students with a less positive attitude) accordingly. The new results are listed in Table 28.

Table 28. Re-examine Gander issue on six constructs of TAM

	Group	Quantity	Mean	Standard deviation	T value
Perceived ease of use	Female	28	4.3429	.40682	
	Male Low	19	3.9789	.86896	-1.933

	Male High	15	4.2000	.74450	-0.818
Perceived usefulness	Female	28	4.3000	.37515	
	Male Low	19	3.8842	.77550	**-2.454***
	Male High	15	4.1200	.73601	-1.068
Context-awareness	Female	28	4.0000	.29313	
	Male Low	19	3.7579	.45499	**-2.222***
	Male High	15	4.2800	.55959	1.809
Storyline	Female	28	4.0982	.51523	
	Male Low	19	3.8553	.64719	-1.430
	Male High	15	4.0500	.59911	-0.276
Attitude toward using the CAM-RPG	Female	28	4.2589	.36945	
	Male Low	19	3.9211	.79080	-1.738
	Male High	15	4.1833	.69093	-0.470
Intention of using the CAM-RPG	Female	28	3.9857	.60106	
	Male Low	19	3.600	.60369	**-2.155***
	Male High	15	39333	.78801	-0.244

***: p < 0.001, **: p < 0.01, *: p < 0.05

Table 28 shows the comparison results for female students and male students with higher CG attitude as well as female students and male students with lower CG attitude. The results indicate that both female students and higher CG attitude male students had relatively high (positive) responses to the six constructs compared to lower CG attitude male students. In addition, male students who had a lower attitude toward computer games showed relatively lower responses than female students. There are significant differences for the constructs of perceived usefulness (PU), context-awareness (CA), and intention of using the CAM-RPG (IT). **Hypothesis 7** has thus been confirmed. Section 5.5 will discuss the results and hypotheses in detail.

Next, I explore the other comparable groups of Table 21 (i.e., time spent playing computer games, voluntariness of using the CAM-RPG, and smartphone use experience) to see whether differences exist. Table 29 lists the t-test between the comparable groups on the constructs that show significant statistical analysis results. The detailed statistical data of the independent t-test for these groups can be found in Appendix B (i.e., Tables #2 and #4). However, the statistical analysis for experience of using smartphones (i.e., Table #5 in Appendix B) shows there is no obvious difference between smartphone users and traditional mobile phone users. **Hypothesis 8** therefore is rejected.

Table 29. Comparable Groups for Constructs (only list important constructs)

	Constructs	Group	Quantity	Mean	Standard deviation	t value
Time spend on playing Computer Games	Attitude toward using the CAM-RPG	Hardcore	18	**4.3750**	.33486	**2.476***
		Casual	19	3.9605	.63060	
Voluntariness of Using CAM-RPG	Storyline	High	15	**4.3500**	.63246	**2.107***
		Low	17	3.9118	.54444	
	Intention of using the CAM-RPG	High	15	**4.2267**	.57504	**2.454***
		Low	17	3.6000	.82765	

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

Grouped by time spent playing computer games, the statistical analysis results show that there are significant differences between hardcore and casual players for attitude toward using the CAM-RPG (P = 0.018). **Hypothesis 9** has thus been confirmed. For voluntariness of using the CAM-RPG, the results show significant differences between the high-score group and the low-score group for the storyline construct (P = 0.044) and the intention of using the CAM-RPG construct (P = 0.02). **Hypothesis 10** has thus been confirmed. The analysis results and hypotheses will be discussed in Section 5.5.

Independent T-test for Usability

To verify whether there is any gender difference in the perceptions of usability of the proposed game, I examined the concepts by checking the statistics data and the independent t-test results listed in Tables 30 and 31. For this part of the data analysis, the qualified sample size is 55 (including 24 female and 31 male participants). Some participants were removed from the analysis because they either had extreme values for all items or had conflicting answers for the flip-flop items. These invalid responses might have been caused by the long experiment and the usability items being in the last part of the questionnaire.

Nevertheless, from the statistics point of view, all participants have quite good perceptions (i.e., mean values on average are over 4 out of 5 points) toward the CAM-RPG they played, as listed in Table 30. It seems that female participants perceived the effectiveness and the efficiency of the proposed game to be a little bit higher than did the male participants.

Table 30. Statistics data of perceived usability of CAM-RPG for male and female students

Usability	Gender	N	Mean	Std. Deviation	Std. Error
Effectiveness	Female	24	**4.4167**	.54507	.11126
	Male	31	4.0968	.55407	.09951
Efficiency	Female	24	**4.1042**	.53627	.10947
	Male	31	4.0242	.54143	.09724
Satisfaction	Female	24	3.9667	.43606	.08901
	Male	31	**3.9935**	.55253	.09924

The t-test results in Table 31 indicate that there is significantly different perceived effectiveness (t-value = 2.138, $p < 0.05$) toward the proposed game between male and female participants. Although the gender issue for usability of the game is not included in my hypotheses, this finding is interesting to the research and needs to be discussed in the next section.

Table 31. Independent T-test to examine gender issue on three concepts of Usability

Usability of CAM-RPG		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Effectiveness	Equal variances assumed	.012	.913	**2.138**	53	**.037***[*]	.31989	.14959
Efficiency	Equal variances assumed	.172	.680	.336	53	.738	.05780	.17196
Satisfaction	Equal variances assumed	.806	.373	-.022	53	.982	-.00291	.13047

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

Next, the rest of the moderators (i.e., time spent playing computer games, experience using smartphones, and voluntariness of using the CAM-RPG) are analyzed with independent t-tests and one-way ANOVA to see if there is any difference in usability assessment between different groups of students. The sample size for voluntariness of using the CAM-RPG is slightly different than for others. I classify the top 25% of students who are more positive about their voluntariness of using the CAM-RPG into the high-score group. On the other hand, the bottom 25% of students, who are less positive on these items, are put into the low-score group. The two groups' mean values are 3.89 and 2.65 (out of 5 points), respectively.

Table 32. Sample sizes of gender, time spent on playing computer games, experience of using smarphones, and voluntariness of use CAM-RPG

Grouped by	Groups	N	Mean
Gender	Male	31	-
	Female	24	-
Time spend on playing Computer Games	Hard-core player	14	40.21 (hrs/week)
	Regular player	26	17.19(hrs/week)
	Casual player	15	3.67 (hrs/week)
Have experience of using smartphones	Yes	17	-
	No	38	-
Voluntariness of using CAM-RPG	High	17	3.89 (of 5 point)
	Low	14	2.65 (of 5 point)

For time spent playing computer games, the analysis result indicates that there is no significant difference among the three types of players. The descriptive statistics data listed in Table 33 show that although no significant difference exists, casual players have more positive perceptions for all factors of usability assessment than regular and hardcore players.

Table 33. Descriptive statistics data of three player types on Usability assessment

		N	Mean	Std. Deviation	Std. Error
Effectiveness	Casual player	15	**4.4000**	.54116	.13973
	Regular player	26	4.2500	.53385	.10470
	Hard-core player	14	4.0357	.63441	.16955
	Average	55	4.2364	.56809	.07660
Efficiency	Casual player	15	**4.1111**	.68622	.17718
	Regular player	26	3.9615	.56825	.11144
	Hard-core player	14	3.8571	.55028	.14707
	Average	55	3.9758	.59440	.08015
Satisfaction	Casual player	15	**4.0222**	.63579	.16416
	Regular player	26	4.0513	.46849	.09188
	Hard-core player	14	3.8810	.56398	.15073
	Average	55	4.0000	.53672	.07237

For the students' voluntariness of using the CAM-RPG and having experience using smartphones, the statistics data show that there is no obvious difference between the comparable groups (i.e., high-score group and low-score group; smartphone users and traditional mobile phone users; hardcore players, regular players, and casual players). The statistical analysis results can be found in Tables #6, #7, and #8 in Appendix B.

Because there is significant difference between male and female students on the effectiveness factor of usability, as shown in Table 31, I also combined the gender issue with computer game attitude to examine technology acceptance as listed in Table 28. It is interesting to examine whether any significant difference exists in TAM if the gender issue and usability are combined. To verify this additional question, I categorized four groups according to their gender and responses for usability assessment (i.e., average mean value over 4 as high usability and average mean value less than 4 as low usability) and used one-way ANOVA to see whether there is positive correlation and significant difference among different groups.

The statistical analysis results listed in Table 34 show that there is no significant difference among the groups for the six constructs of TAM. The result indicates that usability does not influence the technology acceptance in this research due to the participants' present relatively high positive responses (i.e., mean values on average are over 4 out of 5 points) for all usability items. Usability will not be considered a moderator in this experiment.

Table 34. Combination of gender and usability on the six constructs of TAM (one-way ANOVA)

		Sum of Squares	DF	Mean Square	F	Sig.
Perceived ease of use	Between Groups	0.687	3	0.229	0.456	0.715
	Within Groups	25.637	51	0.503		
	Total	26.324	54			
Perceived usefulness	Between Groups	1.773	3	0.591	1.378	0.260
	Within Groups	21.867	51	0.429		
	Total	23.639	54			
Context-awareness	Between Groups	0.890	3	0.297	1.352	0.268
	Within Groups	11.187	51	0.219		
	Total	12.077	54			
Storyline	Between Groups	2.416	3	0.805	2.606	0.062
	Within Groups	15.761	51	0.309		
	Total	18.177	54			
Attitude toward using the CAM-RPG	Between Groups	0.745	3	0.248	0.591	0.624
	Within Groups	21.455	51	0.421		
	Total	22.200	54			
Intention of using the CAM-RPG	Between Groups	2.403	3	0.801	1.809	0.157
	Within Groups	22.575	51	0.443		
	Total	24.977	54			

Multiple Regressions

Multiple regression analysis is used to examine and predicate the linear relationship between one dependent variable and one or more independent variable(s). In this research, I use a simple linear regression (e.g., use attitude toward using the CAM-RPG to determine intention of using the CAM-RPG) and several multiple linear regressions (e.g., perceived ease of use, perceived usefulness, context-awareness, and storyline determine attitude toward using the CAM-RPG; perceived ease of use, context-awareness, and storyline determine perceived usefulness) to explore the cause-effect relationships in the research model.

First, the independent constructs were analyzed before entering the regression model in order to know whether there is a collinear problem in the statistics. A collinear problem is a statistical situation in which two or more predictors (independent constructs) in a multiple regressions are highly correlated. This situation causes an abnormally high R-square (i.e., explanatory power) in the regression model because the variances, standard error, and parameter estimates of predictors are probably inflated. It may also cause insignificant or incorrect coefficients (e.g., positive to negative) between predictors and affected variables.

The results show that there is no serious collinearity issue between the independent constructs in Table 35, in which tolerance > 0.1 and VIF < 10, and Table 29, in which no two variables' variances > 0.8 at the same line (Hair, Anderson, Tatham, & Black, 1998).

Table 35. Coefficients of Perceived ease of use, Perceived usefulness, Context-awareness, and Storyline

	Unstandarized Coefficients		Standardized coefficient	T	Sig.	Colinearity statistic	
	B	Std. Error	Beta			Tolerance	VIF

(constant)	.441	.423		1.044	.301		
Perceived ease of use	.296	.137	***.323***	2.162	**.035***	.260	3.849
Perceived usefulness	.338	.146	***.346***	2.311	**.024***	.259	3.865
Context-awareness	.015	.156	.012	.099	.921	.430	2.323
Storyline	.248	.111	***.234***	2.235	**.029***	.529	1.889

[a] Dependent Variable：Attitude toward using CAM-RPG
***: p < 0.001, **: p < 0.01, *: p < 0.05

Table 35 shows the coefficients of four independent constructs toward the dependent construct attitude toward using the CAM-RPG. Three constructs (i.e., perceived ease of use, perceived usefulness, and storyline) present significant coefficient measures (ß = 0.323, 0.346, and 0.234, $p < 0.05$). We can also determine whether linear dependence existed in the independent constructs by observing the collinearity statistic fields in Table 35. A collinearity statistic indicates that the constructs may have a serious overlap (i.e., a collinearity problem, which means there is high correlation between the independent constructs) if the variance inflation factor (VIF) is over 10 and tolerance tends to zero.

Table 36. Colinearity diagnostics

Model	Dimension	Eigenvalue	Condition index	Variance proportions				
				(constant)	PEOU[b]	PU[b]	CA[b]	SL[b]
1	1	4.968	1.000	.00	.00	.00	.00	.00
	2	.015	18.274	.41	.12	.07	.01	.01
	3	.009	23.118	.21	.06	.00	.00	.84
	4	.005	32.640	.30	.03	.32	.71	.01
	5	.003	38.685	.09	.79	.61	.28	.13

[a] Dependent Variable: Attitude toward using the CAM-RPG
[b] PEOU: Perceived ease of use; PU: Perceived usefulness; CA: Cintext-awareness; SL:Storyline

Table 36 also shows the collinearity diagnostics by using SPSS 17. The rest of the collinearity diagnostics are in Appendix C, including the concepts of CGAS and usability.

Path Analysis for the Multiple Regressions Model

Figure 30 shows the path diagram of the proposed research model. The result of path analysis shows attitude toward using the CAM-RPG (ATT) has strong effects on intention to use the CAMRPG as 0.455 ($p < 0.001$) of path coefficient. The effects of perceived ease of use (PEOU), perceived usefulness (PU), context-awareness (CA) and storyline (SL) quality explain 74% of ATT, while PEOU, PU, and SL have significant effects (ß = 0.331, 0.437, and 0.234, $p < 0.05$) on ATT, but CA does not (ß = 0.012). For the cause-effect relationship between the independent variables, the effects of PEOU, CA, and SL quality explain 75% of PU, while PEOU (ß = 0.678, $p < 0.001$) and SL (ß = 0.206, $p < 0.05$) have significant effects on PU, but CA does not (ß = 0.066).

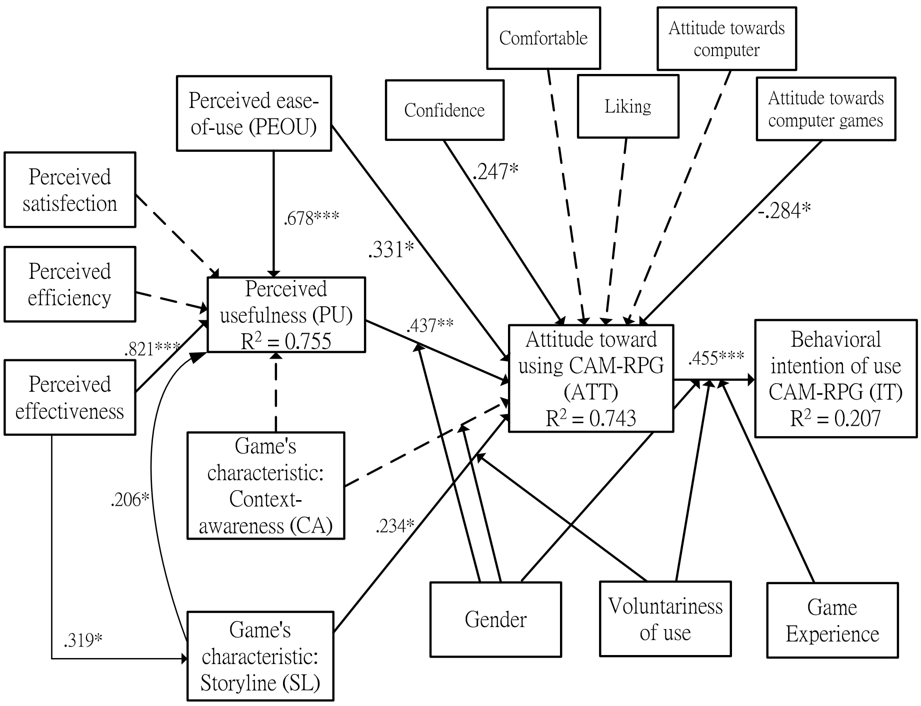


Figure 30. Path analysis diagram

For the external factors' effects, the confidence and attitude toward computer games subscales of the computer game attitude scale have significant effects on attitude toward using the CAM-RPG (ß = 0.247 and -0.284, $p < 0.05$) but the subscales of comfortable, liking, and attitude toward computer do not achieve significance (ß =-0.19, -0.174, and 0.091).

Sequentially, the effects of usability factors on PU were analyzed, and the result shows that only perceived effectiveness has a strong effect on PU (ß = 0.821, $p < 0.001$). In addition, I analyzed the path coefficient between three factors of usability and the constructs of TAM to see if I could find some special relations between the two theoretical models. The path analysis results indicate that only the coefficient between perceived effectiveness and storyline is significant (ß = 0.319, $p < 0.05$). Relations between the three factors of usability and perceived ease of use, context-awareness, attitude toward using the CAM-RPG, and intention of using the CAM-RPG do not exist. The path analysis results are listed in the tables (i.e., Tables #3–#8) in Appendix C.

Furthermore, I examined whether there is correlation and a cause-effect relationship between the factors of two external theories (i.e., usability and computer game attitude scale). In other words, I wanted to verify whether the factors of usability had a significant impact on the factors of the new computer game attitude scale (i.e., CGAS 2011), and vice versa. The results shows there is no significance in any path coefficient between the factors of the two theories, which means the two theories can be considered independently as the external variables of TAM. The path analysis results are listed in the tables (i.e., Tables #9 - #11; Tables #12 - #16) in Appendix C.

Next, gender, gaming experience, and voluntariness of use are considered as moderators according to the quantitative analysis results described earlier in this section. However, the smartphone experience variable has been removed because there is no significant difference. As mentioned in the earlier analysis, the gender moderator has no significant effect, but gender with computer gaming attitude affects perceived usefulness, context-awareness, and intention of using the CAM-RPG (as Table 28 shows); the game experience moderator affects intention of using the CAM-RPG; and voluntariness of use affects on storyline and intention (as Table 29 shows). The analysis results and findings will be discussed in Section 5.5.

5.4.3 Qualitative Analysis

All students were grouped into 23 teams and had an appointment with me as described in Section 5.2.1. During the appointment, the students not only experienced the game and filled out the questionnaire, but also had short interviews with me. Correspondingly, I observed all students' gameplay situations and recorded them for qualitative analysis.

First, the responses from both male and female students were highly appreciative of the proposed CAM-RPG in every way. Most of the students were interested in solving the story decorated quests in the game, and they wanted to see what they would get after finding the next learning object as well as what the upcoming story would be. Some students who presented high interest also responded with lots of feedback in the questionnaire and discussed it with me. Table 37 presents a summary of the students' comments and expectations for the proposed CAM-RPG. These comments also indicate the issues that the current version of the system needs to improve.

Table 37. Participants' comments and expectations for CAM-RPG

Users' expected Function in future upgrade.	**Description**	**Comments from**	**Proportion (of 21 teams)**

Pictures and Graphical User Interface (UI)	Add more pictures (i.e., the picture of the target objects) and design graphical UI in the game.	Team 1, Team 2, Team 5, Team 8, Team 19.	24%
Animation	Add some animation or videos in the game would be more engaging than the current pure-text version.	Team 1, Team 12, Team 17, Team 19	19%
Hints	Add the function of hints in the game. The hints are associated to the quests, location and direction, and game guide.	Team 9, Team 12, Team 17, Team 19	19%
Leveling mechanism	Design a mechanism that Character can level up and has more capabilities or functions.	Team 6, Team 7, Team 20	16%
Multi-language	Design multi-language version for the game.	Team 5, Team 16	10%
Music and sound effects	Add background music and sound effects in the game.	Team 3, Team 12	10%
Interaction with other players	Upgrade the game to multi-player version.	Team 3, Team 19	10%
Reward mechanism	Design rewards (i.e., gold and experiences) for the quests in the game.	Team 3	5%
Score Ranking Board	Design a score board and marking mechanism in the game.	Team 9	5%
Combination of objects	Design a mechanism that different objects can be combined like character's items or equipments.	Team 18	5%

The abovementioned comments are valuable for the game's future improvement. Because the participants are all undergraduate students and most of them have played various types of game for years, it is important to know that the participants are still interested in the proposed game and give feedback without any additional request. However, the participants would prefer to see more pictures and even animations in the game rather than the pure-text version of the current game. They also want the game to have a help function and provide hints in the gameplay in order to save time when looking for objects.

5.5 Findings and Discussion

From the data analysis, there are several findings that can help us understand users' attitudes toward and acceptance of the proposed mobile educational game as well as exploring the research questions proposed in Section 5.1.1. I categorize these findings into common findings (i.e., those that have been proven in other research), important findings (i.e., those that are supported by this research), and unexpected findings (i.e., those that did not support my assumptions in this research).

Common Findings

Findings for H1 and H2: Cause-effect relationship of constructs in TAM.

For common findings, the original technology acceptance model present good results in cause-effect relationship of all constructs (e.g., IT, ATT, PEOU, and PU). Especially for the path coefficients between perceived ease of use and perceived usefulness in particular, the results tell us that ease of use is an important factor in educational game design as well as other technology acceptance issues. Users appreciate a simple and easy-to-use interface, and a user friendly interface directly impacts perceived usefulness. In addition, attitude toward using the CAM-RPG and intention of using the CAM-RPG also present strong significant coefficients in our research model. These findings have been proven in many studies on information systems' acceptance.

Findings for H10: The voluntariness of using the CAM-RPG has a positive effect on user's acceptance of the CAM-RPG.

For users' voluntariness of using the CAM-RPG, the statistical analysis results show that there are significant differences between the more voluntary group and the less voluntary group for intention of using the CAM-RPG, and storyline of the game. From the experiment, we can find that the participants have different perceptions of voluntariness of using the CAM-RPG because some of them thought the course's instructor asked them to use it. Hence, the less voluntary group shows relatively lower measures for intention construct and may not be interested in the game's characteristics. This result is similar to Venkatesh and Davis' research in 2000, they proposed that voluntariness is one of the factors in the social influence processes. The social influence processes impact intention of use in technology acceptance model directly (Venkatesh & Davis, 2000).

Important Findings

First of all, the descriptive statistical data (i.e., Table 22) shows the responses from both males and females were positive in terms of appreciation of the proposed CAM-RPG. In addition, female participants' responses to all constructs were relatively higher than those of male participants in the experiment. According to the participants' basic information, the results show that male participants spend almost double the hours playing computer games that females do on average. We believe that because male students play more games on average, they have a higher standard against which to evaluate the proposed game than female students.

Findings for H11: There is a gender difference for computer game attitude.

I used gender and time spent playing computer games as the comparable variables in the CGAS test, and the results show that there are significant differences between female and male participants for the confidence and like factors. Male participants presented more positive confidence and preferences for playing computer game than female participants.

Findings for H12: Gaming experience has a positive effect on computer game attitude.

Another finding from the CGAS test with game playing time is that the hardcore players' responses are relatively more positive than those of the casual players for almost of all factors. There are significant differences for all factors except attitude. We believe that the hardcore players have more positive perceptions of playing computer games and take computer games as their main leisure activity, unlike casual players. Nevertheless, students in both groups had similar perceptions on the subscale of attitude toward computers, which means they both appreciate computers and regard computers as essential tools in the modern world.

Findings for H7: There is gender difference for acceptance of using the CAM-RPG.

I explored the effect that gender may have using TAM. The results show that female participants are relatively more positive than male participants for all constructs. I further took male students' attitude toward computer games into consideration to see the changes. The results show that there is a significant difference between female students and male students with less positive attitude toward computer games. However, female students have similar responses to male students who have a more positive attitude toward computer games. This result is similar to very recent studies on game-based learning (Fengfeng, 2008; Papastergious, 2009), which proposed that games can be equally effective and motivating for both male and female students. The impact of gender on acceptance tends to disappear during the implementation phase. Correspondingly, experience of smartphone use did not present any impact on users' acceptance model.

Findings for H5: CGAS has a positive effect on attitude toward using the CAM-RPG.

The next findings involve the external factors that may affect technology acceptance. This research examined both the computer game attitude scale in 1997's research (CGAS 1997) and 2010's research (CGAS 2010) in the experiment. I examined both of CGASs using exploring factor analysis (EFA) to determine whether new subscales and relevant items can be used. The results of factor analysis identified five subscales:confidence, comfortable, liking, attitude toward computer, and attitude toward computer games. However, the behavior factor in CGAS 2010 may need to be analyzed further in order to design effective behavior factors for mobile educational games in the future.

Findings for H9: Gaming experience has a positive effect on acceptance of using CAM-RPG.

Furthermore, the student responses reflect the significant differences between two groups divided by time spent playing computer games (i.e., hardcore players and casual players) on the constructs of attitude toward using the CAM-RPM. The result is consistent with the CGAS test. In other words, the participants who spend more time playing computer games have a more positive attitude than the casual players toward the proposed CAM-RPG as well as computer games in general.

Findings for H8: Experience using smartphones has a positive effect on acceptance of using CAM-RPG.

The result did not show any significant differences between students who have experience using smartphones and those who only have experience using traditional mobile phones. The reason may be that the participants in this experiment were undergraduate students and they were all familiar with mobile phones and games. Therefore, experience using smartphones does not affect acceptance of innovative technology.

Additional finding: Significant difference exists between male and female participants' perceived effectiveness of the CAM-RPG.

One interesting finding comes from the usability assessment of the proposed game: Female participants have more positive perceived effectiveness and efficiency of the CAM-RPG than male participants. For the effectiveness factor, in particular, a significant difference exists between female and male participants. Female participants believe that they can learn object-relevant knowledge effectively in the authentic environment. This result is similar to the pilot study I did in 2010 (Lu, Chang, Kinshuk, Huang, & Chen, 2011). In addition, the mean values for the effectiveness and satisfaction factors in this research increased from the 2010 study. This finding encouraged me, and I could do more research about gender difference in potential learning performance improvement in the future.

I tried to explore whether there are any relations between usability and technology acceptance. The statistics data shows that perceived effectiveness has a positive influence on storyline, which means users who thought the proposed CAM-RPG helped them learn effectively had a positive perception of the storyline, and which further impacted their perceived ease of use. This finding of the new relations is interesting because it tells us that story may be an important enhancement factor for perceived effectiveness and perceived ease of use in mobile game-based learning.

Unexpected Findings

Findings for H3 and H4: Game's characteristics have positive effects on perceived usefulness.

For the path analysis results, I found that most of the proposed constructs qualified to explain the dependent variables, except the context-awareness construct. This could be because the experiment environment design may not fully represent the concept of context-awareness well enough to make students aware of the game's characteristics. For instance, the student may receive learning activities from the CAM-RPG while s/he is in teaching building E and have different learning activities while s/he is in the library; in other words, the game will not ask the user to find a learning object which is far away from his/her current location.

However, in this experiment, the learning environment did not cover different buildings or long time periods (i.e., a student finishing some quests and re-logging in to get new, different quests). These shortcomings caused the context-awareness construct to present relatively lower measures and an insufficient cause-effect relationship on the path coefficient.

In summary, Table 38 shows all the results we found from data analysis to explain the proposed research hypotheses.

Table 38. Hypotheses and analysis results

	No.	Hypothesis	Result	Page
H1	H1	Attitude has a positive effect on behavioral intention.	**Supported**	105
H2	H2a	Perceived ease of use has a positive effect on attitude toward using CAM-RPG.	**Supported**	105
	H2b	Perceived usefulness has a positive effect on attitude toward using CAM-RPG.	**Supported**	105
	H2c	Perceived ease-of-use has a positive effect on perceived usefulness.	**Supported**	105
H3	H3a	Context-awareness of the game has a positive effect on attitude toward using CAM-RPG.	Not supported	105
	H3b	Storyline of the game has a positive effect on attitude toward using CAM-RPG.	**Supported**	105
H4	H4a	Context-awareness of the game has a positive effect on perceived usefulness.	Not supported	105
	H4b	Storyline of the game has positive effect on perceived usefulness.	**Supported**	105
H5	H5a	Computer game learning has a positive effect on attitude toward using CAM-RPG.	Not support	106
	H5b	Computer game confidence has a positive effect on attitude toward using CAM-RPG.	**Supported**	106
	H5c	Computer game anxiety has a negative effect on attitude toward using CAM-RPG.	**Supported**	106
	H5d	Computer game liking has a positive effect on attitude toward using CAM-RPG.	**Supported**	106
	H5e	Computer game leisure has a positive effect on attitude toward using CAM-RPG.	**Supported**	106
	H5f	Computer game behavior has a positive effect on attitude toward using CAM-RPG.	Not Supported	106
	H5g	Computer game liking has a positive effect on user's attitude toward using CAM-RPG.	Not Supported	106
	H5h	Computer game comfortable has a positive effect on user's attitude toward using CAM-RPG.	Not Supported	106
H6	H6a	Perceived effectiveness of the system has a positive effect on perceived usefulness.	**Supported**	106
	H6b	Perceived efficiency of the system has a positive effect on perceived usefulness.	Not supported	106
	H6c	Perceived satisfaction of the system has a positive effect on perceived usefulness.	Not supported	106
	H7	There is gender difference on user's acceptance toward using the CAM-RPG.	**Conditional Supported on PU, CA, and IT.**	98
	H8	Experience of using smartphones does have positive effect on user's acceptance toward using the CAM-RPG.	Not supported	98

	H9	Gaming experience does have positive effect on user's acceptance toward using the CAM-RPG.	**Supported (Attitude)**	99
	H10	The voluntariness of use CAM-RPG does have positive effect on user's acceptance toward CAM-RPG.	**Supported (Storyline and Intention)**	99
	H11	There is gender difference on user's computer game attitude.	**Supported (Confidence and Like)**	94
	H12	Gaming experience does have positive effect on user's computer game attitude.	**Supported**	95

Chapter VI – CONCLUSIONS

6.1 Summary

This research presents a context-aware mobile role playing game in which the kernel, learning activity generation engine and story generation engine, can generate a series of story decorated learning activities automatically. This game can help users learn by role-playing in the authentic learning environment. The storyline makes up the learning activity chain and makes the learning process more interesting and immersive.

The game generates story decorated learning activity chains automatically according to the learning objects in the environment and the user's preferences and learning experience. The proposed game has several advantages and benefits to users. First, the knowledge structure is fundamentally based on two engines and can be built up easily for any learning domain in any authentic environment easily by general public. Second, the story decorated learning activities give users story backgrounds consistent with the learning activities they are going to do. The stories can make users feel that they are living in the virtual world and that they have responsibility to help the NPCs finish some tasks.

This research includes the completed system development and a comprehensive experiment to verify the usability of the game and to discover the user perceptions of the game. I expect to see that the proposed game can not only comply with the five principles of mobile application design (Tan and Kinshuk, 2009), but also has significant impacts on user's motivation and acceptance of using the game.

This research has several findings from the experiment: (1) the storyline of the proposed CAM-RPG has a positive effect on users' attitude toward using the game and increases users' perceived usefulness; (2) users' confidence in playing games, degree of liking computer games, and attitude toward computer games significantly influence their attitude toward using the CAM-RPG; (3) the system's usability is important to the design of educational games because the effectiveness directly impacts users' perceived usefulness of the game; and (4) although there is no gender difference in users' acceptance of the game, users' computer game attitude, time spent playing computer games, and voluntariness of use attitude do significantly influence users' acceptance of the game. I also have findings common to others' research and a few unexpected findings, as mentioned in Section 5.5.

The findings also indicate that although the proposed game and its ubiquitous knowledge structure can be applied in multiple disciplines and subjects for learning, students in the experiment felt that the context-awareness characteristic of the game was less important for gameplay and did not affect their attitude toward using the game. To make users aware of the advantages of a context-aware mobile educational game, subject selection (e.g., learning environment, selected learning topic, and learning materials) will be an issue. The current game might work well for outdoor teaching/learning as well as treasure hunting learning at particular sites (e.g., museums, botanical gardens, and historical sites). It might be also suitable to replace orientation/training courses for freshmen and new students of the graduate program.

However, it might be a worst practice to apply the game in an environment in which learning objects have no strong connections to either the learning topic or the environment (e.g., trying to learn a business intelligent system from a desktop computer in a laboratory). The learning environment and learning topic selection will be taken into consideration while designing experiments in the future.

6.2 Future Work

Four more research issues need to be further considered: reward, multimedia learning contents, path planning, and interactivity. First of all, rewards are very important to motivate people, e.g., students who study in schools and employees who do their jobs in workplaces. Rewards can be real or virtual; many researchers argue that virtual rewards are better. In the proposed game, I do have rewards for every learning activity. However, the rewards currently have no significant meaning to the users. In the next stage, I may need to make the rewards more valuable to the users.

Second, the proposed CAM-RPG allows users to collect the learning activity items and presents the learning contents/material accordingly. The current content type for learning is pure textual instruction. In future research, I may develop multimedia contents. For example, after a user scans a two-dimensional barcode, animations, webpages, Flash, and streaming videos will be delivered to the user's mobile phone. In addition, I can investigate the user's learning style in order to know what kind of learning contents/materials s/he prefers.

Path planning is an emerging research issue in context-aware m- learning. In my research, the game can retrieve a suitable story-based learning activity chain for the user according to his/her profile, location, and surrounding context. In future research, I may add path-planning methodology to the generation process in order to give users a more efficient and effective learning route.

Finally, interactivity is also a research direction and can be planned in two ways. Currently, the experiment focuses on measuring user perceptions of the game with three theoretical models. The first way of dealing with the interactivity issue is examining user perceptions of their interactions with other players (human-to-human), the game itself (human-to-technology), learning objects in the authentic environment (human-to-the-world), and the learning contents (human-to-content). The second way is to explore and design a mechanism for providing users with the preferred and most appropriate interaction method automatically according to the user context (e.g., preference and learning style), contents (e.g., text, video, audio, and images), surrounding context (e.g., learning objects surround the user), and mobile device context (e.g., mobile device's features, operating system, and bandwidth). Furthermore, the user's perceived effectiveness of and satisfaction with such context-aware personalized and adaptive interaction mechanism should be evaluated.

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APPENDIX A – Full Questionnaire

Dear participant,

This questionnaire is being used to get your feelings toward the context-aware mobile educational game. Please answer the following questions based on your game playing experience and your opinions on the game. No personal data and confidential information is being collected. All raw data will be encoded with a special code and be transferred into excel spreadsheet as statistical data. There is no connection between you and the special code. The statistical data are anonymous for future analysis and are only accessed by the researcher and his supervisor. Your answers will be valuable and help this project get improved; again, we will carefully protect the data you have completed in the questionnaire. We appreciate your participation and completion of this questionnaire as volunteers. At the last, if you do have any question regarding the privacy issues, you can freely choose not to complete this questionnaire at any time.

Sincerely,

Dr. Echo Huang[a] and Dr. Maiga Chang[b]
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PART I

A. Basic Informaiton

1. **Group name:** ______________________
2. **Student ID:** _________________
   (note: Student ID is collected and used in our statistical analysis. Student ID is only used in this experiment, which means providing your ID will not impact to your final performance/mark in this course.)
3. Gender: ☐ Male ☐ Female
4. Are you using smartphone? ☐ Yes ☐ No
   (If No, please go forward to Q5.)

5. What brand of smartphone you are using?

☐ Apple ☐ Blackberry ☐ HTC ☐ Google Phone ☐ Motorola

☐ Nokia ☐ Other: _____________

6. What do you do for your free time?

☐ Read textbooks ☐ Read books (i.e., Comic、Novel, and so on)

☐ Outdoor exercises

☐ Indoor exercises

☐ Play games

☐ Watch television

☐ See movies

☐ Go to a concert

☐ Listen music

☐ Go to a theatre for performances

☐ Play video/computer games

☐ Practice individual interests

☐ Other: ____________

7. Have you ever played Video game? (e.g., PS2, PS3, Wii, Xbox, and so on.)

☐ Yes ☐ Totally Not (if No, please forward to Q9)

8. How many hours do you approximately play Video game everyday except Holidays and Summer/Winter vacations?

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
___hours	___hours	___hours	___hours	___hours	___hours	___hours

9. Have you ever played Arcade Game? (i.e., Coin-operated machines.)

☐ Yes ☐ Totally Not

10. How many hours do you approximately play Arcade game everyday except Holidays and Summer/Winter vacations?

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
___hours	___hours	___hours	___hours	___hours	___hours	___hours

11. Have you ever played Hand-held Video game? (i.e., PSP, NDS, and so on.)

☐ Yes ☐ Totally Not (if No, please forward to Q13)

12. How many hours do you approximately play Hand-held Video game everyday except Holidays and Summer/Winter vacations?

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
___hours	___hours	___hours	___hours	___hours	___hours	___hours

13. Have you ever played Computer game? (i.e., the games that can be played on computers.)

☐ Yes ☐ Totally Not (if No, please forward to Part - II)

14. How many hours do you approximately play Computer game everyday except Holidays and Summer/Winter vacations?

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
___hours	___hours	___hours	___hours	___hours	___hours	___hours

15. When did you start playing Computer games?

☐ Before elementary school ☐ In elementary school ☐ In junior high school ☐ In senior high school ☐ In university (when you are undergraduate student) ☐ In graduate program.

15. Where you play computer games usually?

☐ Home ☐ dormitory ☐ School ☐ Friends' place ☐ Internet bar

☐ Other: ___________

16. What kind of games is your favorite? (Please select the Game type and Game genres)

☐ Standalone Game	☐ Multi-player with less interaction	☐ Multi-player with rich interactions
Description: The game you can play alone on your own computer without either internet connection or other PC's connection.	Description: The game you can play with internet connection. In the game you see lots of players but you don't have to interact with them.	Description: The game you can play with internet connection. In the game you see lots of players and you may team up, chat, fight, and interact with them.

☐ Advergames. ☐ Adventure ☐ Arcade game ☐ Fighting

☐ First Person Shooters (FPS) ☐ First Person Sneaker

☐ MMORPG: 'Massively Multiplayer Online Role Playing Games'

☐ Platform (Ex: Super Mario Bros)

☐ Puzzle ☐ Racing Games ☐ RPG: 'Role Playing Games'

☐ Strategy Games ☐ RTS: 'Real Time Strategy'

☐ Serious Games (Serious games are games aimed at teaching, discussing or debating real-world concepts via game-play.)

☐ Simulations (EX: SimCity and Flight emulators)

☐ Sports Games ☐ TPS: 'Third Person Shooters'

☐ Other: _________________________________

B. The following questions are used to understand your computer and video game experiences. Please consider the following questions and select the best matched situations to your personal thoughts.

	Strongly agree <---------------> Strongly disagree				
1. I like to participate in computer courses.	☐	☐	☐	☐	☐
2. I don't feel annoyed when other people are discussing computer games.	☐	☐	☐	☐	☐
3. I agree with the instructor to use computer games as part of the course.	☐	☐	☐	☐	☐
4. I feel comfortable while playing computer games.	☐	☐	☐	☐	☐
5. I barely notice the news of the computer and information technology.	☐	☐	☐	☐	☐
6. I am very interested in solving quests/questions/missions in computer games.	☐	☐	☐	☐	☐
7. I keep the question in my mind if I have a pending quest/question/mission in the computer game.	☐	☐	☐	☐	☐
8. I keep finding the solution if I have a quest/question/mission which I cannot solve in the computer game.	☐	☐	☐	☐	☐
9. I believe that computers are essential tools in the modern world.	☐	☐	☐	☐	☐
10. I will join if my school has computer relevant club.	☐	☐	☐	☐	☐
11. I feel boring in participating in computer courses.	☐	☐	☐	☐	☐
12. I will attend if my school has summer/winter computer camps.	☐	☐	☐	☐	☐
13. I will take a look on computer game relevant stalls when I go to computer expo.	☐	☐	☐	☐	☐
14. I am in good mood while playing computer games.	☐	☐	☐	☐	☐
15. Playing computer games is part of my life.	☐	☐	☐	☐	☐

16. I usually play computer games after I finish a course exam.	☐	☐	☐	☐	☐
17. When I have free time, I play computer games.	☐	☐	☐	☐	☐
18. I discuss the computer games with my friends.	☐	☐	☐	☐	☐
19. I am not alone in the computer games due to I can make friends there.	☐	☐	☐	☐	☐
20. I am good in playing computer games.	☐	☐	☐	☐	☐
21. Playing computer games is easy to me.	☐	☐	☐	☐	☐
22. I am the guy who understands and plays computer games well.	☐	☐	☐	☐	☐
23. I am skilled computer game player.	☐	☐	☐	☐	☐
24. I can also install and setup other required software for specific computer game.	☐	☐	☐	☐	☐
25. I know how to get the instructions of installing computer games.	☐	☐	☐	☐	☐
26. I think there is no difference even we don't have computer in the modern world.	☐	☐	☐	☐	☐
27. I get more involved in the course after I play the educational game.	☐	☐	☐	☐	☐
28. Playing computer games makes me have better coordination on eyes and hands.	☐	☐	☐	☐	☐
29. Playing computer games enhances my imagination.	☐	☐	☐	☐	☐
30. Playing computer game improves my typing skill.	☐	☐	☐	☐	☐
31. I like to reveal the relevant information about computer and technology.	☐	☐	☐	☐	☐

PART II

C. The following questions are used to understand your feelings toward our mobile educational game after you have played for a while. Please consider the following questions and select the best matched situations to your personal thoughts.

	Strongly agree <---------> Strongly disagree				
I feel "CAM-RPG"					
01. User interfaces are easy to use	☐	☐	☐	☐	☐
02. It is easy to learn how to play	☐	☐	☐	☐	☐
03. Make me want to explore the game's world.	☐	☐	☐	☐	☐
04. I cannot find the functions that I am looking for.	☐	☐	☐	☐	☐
05. I would like to try its upgraded version.	☐	☐	☐	☐	☐
06. I would like to use the game much more if it has background music.	☐	☐	☐	☐	☐
07. I would like to use the game much more if I can team up with other players in the game.	☐	☐	☐	☐	☐
I feel the contents of "CAM-RPG"					
08. The storyline makes the game more interesting	☐	☐	☐	☐	☐
09. The stories give me some ideas of what I should do	☐	☐	☐	☐	☐
10. The integration of storyline and quests is perfect.	☐	☐	☐	☐	☐
11. I am engaged in the story and relevant quests.	☐	☐	☐	☐	☐
According to my experiences of playing the game…					
12. The learning objects (i.e, required quest items) can be found in the 5th floor of teaching building E.	☐	☐	☐	☐	☐
13. Some learning objects are not located in the 5th floor of teaching building E.	☐	☐	☐	☐	☐
14. If a quest required multiple learning objects, all of them can be found in the 5th floor of teaching building E.	☐	☐	☐	☐	☐
15. The learning objects are associated to my chosen theme.	☐	☐	☐	☐	☐
16. The quest difficulty is from simple to complex.	☐	☐	☐	☐	☐

17. The game will not generate exactly same quests for me when I sign in next time. (i.e., same quest's description as well as same required quest items.)	□	□	□	□	□
I play "CAM-RPG"					
18. The course's instructor/ teacher expected me to use.	□	□	□	□	□
19. The course's instructor/ teacher asked me to use.	□	□	□	□	□
20. I won't need to spend all the time in the classroom for the lectures.	□	□	□	□	□
21. Even after the school	□	□	□	□	□
22. Even the course's instructor/teacher doesn't ask me to use it any more.	□	□	□	□	□
Please provide your opinions to the following questions					
23. I hope the course's instructor/teacher to apply "CAM-RPG" into the course.	□	□	□	□	□
24. I will try to complete the tasks that the course's instructor/teacher ask me to do.	□	□	□	□	□
25. I will play "CAM-RPG" continuously in the future.	□	□	□	□	□
26. I will introduce "CAM-RPG" to other people in the future.	□	□	□	□	□
27. I would like to use other similar systems in the future.	□	□	□	□	□
28. I would play "CAM-RPG" if many of my friends are playing.	□	□	□	□	□
29. I hope that "CAM-RPG" could have following additional functions in its future upgrade. (optional question) ________________, ________________, ________________,________________, ________________, ________________					

D. Please assess and score our game, CAMRPG, from the high (5 points) to low (1 point).

		5 <------------------------------------->1				
30	The system flow is clear and simple to me.	☐	☐	☐	☐	☐
31	The terms and functions in the game are easy to understand.	☐	☐	☐	☐	☐
32	The human-computer interaction design of the game is good, I have no difficulty in using it.	☐	☐	☐	☐	☐
33	I can get needed information quickly within the game.	☐	☐	☐	☐	☐
34	The generated learning activities can save my time in learning.	☐	☐	☐	☐	☐
35	I can get familiar with the learning objects (i.e. devices, room places, items) quickly by playing the game.	☐	☐	☐	☐	☐
36	This game provides me enough information for what I want to know.	☐	☐	☐	☐	☐
37	This game provides me enough information for learning (i.e. learning objects and its knowledge).	☐	☐	☐	☐	☐
38	I can complete the learning activities that the game asks by traveling in the real world.	☐	☐	☐	☐	☐
39	The information provided by the game is correct.	☐	☐	☐	☐	☐
40	The information provided by the game can be trusted.	☐	☐	☐	☐	☐

You have done all of the questions. Thank you very much for your time!

APPENDIX B – Data Analysis by Comparing Means

Explanation:

Tables #1 - #5 use independent T-test for different groups on TAM's constructs. Table #1: gender; Table #2: player types; Table #3: CGAS score; Table #4: voluntariness of use; Table #5: smartphone using experience.

1. Independent T-test for Gender (Male and Female)

	Levene's Test for Equality of Variances		T-test for equality of means				
	F-test	significance	t	DF	Significance (two-tailed)	Mean Differences	Std. Error Differences
Perceived Ease of use	1.389	.243	1.579	60	.120	.26639	.16873
Perceived Usefulness	1.998	.163	1.987	60	.051	.31176	.15688
Context-awareness	5.889	.018	.106	51.567	.916	.01176	.11106
Storyline	1.090	.301	1.065	60	.291	.15704	.14752
Attitude	5.413	.023	1.519	50.038	.135	.22216	.14621
Intention	2.143	.148	1.422	60	.160	.23866	.16779

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

2. Independent T-test for Computer game playing time (Hardcore and Casual player)

	Levene's Test for Equality of Variances		T-test for equality of means				
	F-test	Significance	t	DF	Significance (two-tailed)	Mean Differences	Std. Error Differences
Perceived Ease of use	2.297	.139	1.412	35	.167	.26199	.18553
Perceived Usefulness	1.640	.209	1.160	35	.254	.20526	.17695
Context-awareness	1.695	.201	1.725	35	.093	.22573	.13088
Storyline	.500	.484	.357	35	.724	.06652	.18653
Attitude	1.719	.198	**2.476**	35	**.018***	.41447	.16739
Intention	.940	.339	1.270	35	.213	.30058	.23677

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

3. Independent T-test for CGAS score (High and Low)

	Levene's Test for Equality of Variances		T-test for equality of means				
	F-test	significance	T	DF	Significance (two-tailed)	Mean Differences	Std. Error Differences
Perceived Ease of use	.106	.747	1.555	33	.129	.29477	.18956

Perceived Usefulness	.247	.623	1.638	33	.111	.25359	.15483
Context-awareness	.010	.922	**3.172**	33	**.003***	.42222	.13310
Storyline	.025	.874	1.423	33	.164	.25327	.17794
Attitude	3.257	.080	1.929	33	.062	.31373	.16265
Intention	.017	.896	**2.382**	33	**.023***	.47843	.20084

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

4. Independent T-test for Voluntariness of Using CAM-RPG (high and low)

	Levene's Test for Equality of Variances		T-test for equality of means				
	F-test	significance	t	DF	Significance (two-tailed)	Mean Differences	Std. Error Differences
Perceived Ease of use	.620	.437	.413	30	.683	.08392	.20322
Perceived Usefulness	.905	.349	.164	30	.870	.03451	.20988
Context-awareness	.401	.532	1.248	30	.222	.22353	.17913
Storyline	.000	.984	**2.107**	30	**.044***	.43824	.20800
Attitude	.538	.469	.481	30	.634	.10000	.20807
Intention	3.155	.086	**2.454**	30	**.020***	.62667	.25536

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

5. Independent T-test for Smartphone using experience (yes and no)

	Levene's Test for Equality of Variances		T-test for equality of means				
	F-test	significance	t	DF	Significance (two-tailed)	Mean Differences	Std. Error Differences
Perceived Ease of use	1.504	.225	-1.319	59	.192	-.24755	.18772
Perceived Usefulness	2.879	.095	-.966	59	.338	-.17183	.17786
Context-awareness	.231	.633	-.435	59	.665	-.05659	.13013
Storyline	.001	.978	-.168	59	.867	-.02778	.16492
Attitude	1.045	.311	-.189	59	.851	-.03295	.17449
Intention	5.405	.024()	1.626	24.692	.117	.34057	.20942

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

Explanation:

Tables #6, #7, and #8 use independent T-test and one-way ANOVA for different groups on usability's factors. Table #6: voluntariness of use; Table #7: smartphone using experience. Table #8: player types (one-way ANOVA)

6. Independent T-test for Voluntariness of using CAM-RPG (high and low)

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F-test	significance	t	DF	Significance (two-tailed)	Mean Difference	Std. Error Difference
Effectiveness	.000	.998	-.560	29	.580	-.09664	.17246
Efficiency	1.293	.265	.366	29	.717	.07143	.19521
Satisfaction	.008	.929	1.454	29	.157	.23669	.16278
			1.457	28.100	.156	.23669	.16242

7. Independent T-test for Smartphone using experience (yes and no)

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F-test	significance	t	DF	significance (2-tailed)	Mean Difference	Std. Error Difference
Effectiveness	.004	.952	.758	53	.452	.12616	.16642
Efficiency	.924	.341	.363	53	.718	.06347	.17485
Satisfaction	.588	.446	.905	53	.370	.14190	.15687

8. ANOVA for time spend on playing computer games (player types)

		Sum of Squares	DF	Mean Square	F	Sig.
Effectiveness	Between Groups	.970	2	.485	1.533	.226
	Within Groups	16.457	52	.316		
	Total	17.427	54			
Efficiency	Between Groups	.477	2	.239	.667	.518
	Within Groups	18.602	52	.358		
	Total	19.079	54			
Satisfaction	Between Groups	.274	2	.137	.467	.630
	Within Groups	15.281	52	.294		
	Total	15.556	54			

APPENDIX C – Data Analysis by Regression

Explanation:

Table #1 lists the construct relations between CGAS factors and TAM.

1. Coefficients[a] of Computer Game Attitude Scale

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	Constant	5.087	.551		9.232	.000		
	Confidence	.277	.109	**.247**	2.102	**.036***	.502	1.991
	Comfortable	-.229	.177	-.190	-1.290	.203	.418	2.392
	Attitude toward computer	.158	.166	.091	0.857	.372	.477	2.095
	Liking	-.236	.116	-.174	-1.843	.071	.686	1.458
	Attitude toward computer games	-.309	.169	**-.284**	-2.338	**.024***	.441	2.268

[a] Dependent Variable: Attitude toward using the CAM-RPG

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions					
				Constant	CF[b]	COM[b]	AC[b]	LK[b]	ACG[b]
1	1	5.873	1.000	.00	.00	.00	.00	.00	.00
	2	.059	9.974	.03	.39	.02	.04	.04	.00
	3	.033	13.337	.00	.18	.00	.01	.94	.02
	4	.016	19.189	.84	.01	.13	.13	.00	.00
	5	.011	23.170	.12	.40	.02	.04	.00	.97
	6	.008	27.808	.01	.02	53	.79	.02	.00

[a] Dependent Variable: Attitude toward using CAM-RPG

[b] CF: Confidence; COM: Comfortable; AC: Attitude toward computer; LK: Liking; ACG: Attitude toward computer games

Explanation:

Table #2 lists the relations between CGAS and TAM.

2. Coefficients[a] of Perceived ease of use, Context-awareness, and Storyline

Model	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1 (Constant)	.125	.402		0.311	.757		
Perceived ease of use	.642	.098	**.678**	6.554	**.000*** **	.449	2.229
Context-awareness	.093	.150	.066	0.617	.540	.417	2.398
Storyline	.235	.106	**.206**	2.211	**.032***	.555	1.803

[a] Dependent Variable: Perceived usefulness

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions (Constant)	PEOU[b]	CA[b]	SL[b]
1	1	3.974	1.000	.00	.00	.00	.00
	2	.013	17.174	.51	.41	.00	.00
	3	.009	21.508	.16	.22	.01	.92
	4	.004	30.760	.34	.36	.99	.07

[a] Dependent Variable: Perceived usefulness
[b] PEOU: Perceived ease of use; CA: Context-awareness; SL:Storyline

Explanation:

Tables #3 - #8 list the relations between usability and TAM.

3. Coefficients[a] of Effectiveness, Efficiency, Satisfaction

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
1 (Constant)	.196	.659		.297	.768		
Satisfaction	.026	.141	.021	.182	.857	.637	1.569
Effectiveness	1.219	.148	**.821**	8.229	**.000*****	.833	1.201
Efficiency	-.302	.162	-.225	-1.866	.068	.570	1.753

[a] Dependent Variable: Perceived ease of use

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

Collinearity Diagnosticsa

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	Effectiveness	Efficiency	Satisfaction
1	1	3.970	1.000	.00	.00	.00	.00
	2	.011	18.585	.17	.15	.92	.01
	3	.010	19.478	.01	.53	.04	.66
	4	.008	22.232	.82	.32	.04	.34

[a] Dependent Variable: Perceived ease of use; Perceived usefulness; Context-awareness; Storyline; Attitude toward using CAM-RPG; Intention of using CAM-RPG

4. Coefficientsa of Effectiveness, Efficiency, and Satisfaction

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
1 (Constant)	3.916	.901		4.348	.000		
Effectiveness	.091	.197	.074	.461	.647	.756	1.323
Efficiency	.031	.196	.026	.159	.875	.702	1.424
Satisfaction	-.063	.211	-.048	-.296	.768	.741	1.350

[a] Dependent Variable: Perceived ease of use

5. Coefficientsa of Effectiveness, Efficiency, and Satisfaction

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
1 (Constant)	3.042	.595		5.117	.000		

	Effectiveness	.073	.130	.088	.563	.576	.756	1.323
	Efficiency	-.014	.129	-.017	-.107	.916	.702	1.424
	Satisfaction	.174	.139	.197	1.246	.218	.741	1.350

[a] Dependent Variable: Context-awareness

6. Coefficientsa of Effectiveness, Efficiency, and Satisfaction

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.580	.659		2.398	.020		
	Effectiveness	.326	.144	**.319**	2.257	**.028***	.756	1.323
	Efficiency	-.016	.143	-.016	-.110	.913	.702	1.424
	Satisfaction	.284	.154	.263	1.841	.071	.741	1.350

[a] Dependent Variable: Storyline

7. Coefficientsa of Effectiveness, Efficiency, and Satisfaction

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.865	.822		4.701	.000		
	Effectiveness	.136	.180	.121	.757	.453	.756	1.323
	Efficiency	-.134	.179	-.124	-.751	.456	.702	1.424
	Satisfaction	.060	.193	.050	.313	.756	.741	1.350

[a] Dependent Variable: Attitude toward using CAM-RPG

8. Coefficientsa of Effectiveness, Efficiency, Satisfaction

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.978	.864		3.448	.001		
	Effectiveness	.128	.189	.107	.678	.501	.756	1.323
	Efficiency	-.118	.188	-.103	-.630	.532	.702	1.424
	Satisfaction	.204	.202	.161	1.009	.318	.741	1.350

[a] Dependent Variable: Itention of using CAM-RPG

Explanation:

Tables #9 - #16 list the relations between usability and CGAS.

9. Coefficientsa : CGAS → Effectiveness

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.462	.544		6.359	.000		
	Confidence	.023	.108	.040	.210	.835	.502	1.991
	Comfortable	-.057	.175	-.069	-.328	.744	.418	2.392
	Attitude toward computer	.076	.164	.091	.461	.647	.477	2.095
	Liking	-.085	.114	-.122	-.739	.463	.686	1.458
	Attitude toward computer games	.233	.167	.288	1.396	.169	.441	2.268

a. Dependent Variable: Effectiveness

Collinearity Diagnosticsa

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions					
				(Constant)	CF[b]	COM[b]	AC[b]	LK[b]	ACG[b]
1	1	5.873	1.000	.00	.00	.00	.00	.00	.00
	2	.059	9.974	.03	.39	.02	.04	.04	.00
	3	.033	13.337	.00	.18	.00	.01	.94	.02
	4	.016	19.189	.84	.01	.13	.13	.00	.00
	5	.011	23.170	.12	.40	.02	.04	.00	.97
	6	.008	27.808	.01	.02	53	.79	.02	.00

[a] Dependent Variable: Effectiveness; Efficiency; Satisfaction

[b] CF: Confidence; COM: Comfortable; AC: Attitude toward computer; LK: Liking; ACG: Attitude toward computer games

10. Coefficientsa : CGAS → Efficiency

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.946	.566		5.209	.000		
	Confidence	-.106	.112	-.181	-.943	.350	.502	1.991
	Comfortable	-.058	.182	-.067	-.319	.751	.418	2.392
	Attitude toward computer	.223	.171	.257	1.309	.197	.477	2.095
	Liking	.103	.119	.142	.864	.392	.686	1.458
	Attitude toward computer games	.103	.174	.122	.594	.555	.441	2.268

a. Dependent Variable: Efficiency

11. Coefficientsa : CGAS → Satisfaction

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.069	.502		6.111	.000		
	Confidence	-.137	.099	-.260	-1.382	.173	.502	1.991
	Comfortable	.166	.161	.212	1.026	.310	.418	2.392
	Attitude toward computer	.039	.151	.050	.257	.798	.477	2.095
	Liking	.140	.106	.213	1.324	.192	.686	1.458
	Attitude toward computer games	.032	.154	.041	.205	.838	.441	2.268

a. Dependent Variable: Satisfaction

12. Coefficientsa : Usability → Confidence of CGAS

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.889	1.288		2.244	.029		
	Effectiveness	.415	.282	.232	1.470	.148	.756	1.323
	Efficiency	-.100	.280	-.059	-.358	.722	.702	1.424
	Satisfaction	-.207	.302	-.109	-.688	.495	.741	1.350

a. Dependent Variable: Confidence

Collinearity Diagnosticsa

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	Effectiveness	Efficiency	Satisfaction
1	1	3.970	1.000	.00	.00	.00	.00
	2	.011	18.585	.17	.15	.92	.01
	3	.010	19.478	.01	.53	.04	.66
	4	.008	22.232	.82	.32	.04	.34

a. Dependent Variable: Confidence; Comfortable; Attitude toward using computer; Liking; Attitude toward using computer games

13. Coefficientsa : Usability → Comfortable of CGAS

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.555	.855		2.989	.004		
	Effectiveness	-.015	.187	-.012	-.078	.938	.756	1.323
	Efficiency	.080	.186	.069	.430	.669	.702	1.424
	Satisfaction	.304	.200	.237	1.516	.136	.741	1.350

a. Dependent Variable: Comfortable

14. Coefficientsa : Usability → Attitude toward computer of CGAS

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.384	.849		2.810	.007		
	Effectiveness	-.001	.186	-.001	-.007	.994	.756	1.323
	Efficiency	.238	.184	.206	1.289	.203	.702	1.424
	Satisfaction	.165	.199	.130	.832	.409	.741	1.350

a. Dependent Variable: Attitude toward computer

15. Coefficientsa : Usability → Liking of CGAS

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.113	1.034		2.044	.046		
	Effectiveness	-.134	.227	-.093	-.591	.557	.756	1.323
	Efficiency	.140	.225	.102	.624	.535	.702	1.424
	Satisfaction	.291	.242	.190	1.201	.235	.741	1.350

a. Dependent Variable: Liking

16. Coefficientsa : Usability → Attitude toward computer games of CGAS

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.459	.874		2.812	.007		
	Effectiveness	.305	.192	.248	1.594	.117	.756	1.323
	Efficiency	.047	.190	.040	.247	.806	.702	1.424
	Satisfaction	-.018	.205	-.014	-.087	.931	.741	1.350

a. Dependent Variable: Attitude toward computer games