Lu, C., Chang, M., Kinshuk, Huang, E., & Chen, C.-W. (2014). Context-Aware Mobile Role Playing Game for Learning – A Case of Canada and Taiwan. *Educational Technology & Society, 17* (2), 101–114.

Context-Aware Mobile Role Playing Game for Learning – A Case of Canada and Taiwan

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ABSTRACT

The research presented in this paper is part of a 5-year renewable national research program in Canada, namely the NSERC/iCORE/Xerox/Markin research chair program that aims to explore possibilities of adaptive mobile learning and to provide learners with a learning environment which facilitates personalized learning at any time and any place. One of the sub-projects of this 5-year national research program is to design and develop context-aware mobile learning services. The research team of the sub-project applied narrative theory to design a location based Context-Aware Mobile Role Playing Game (CAM-RPG) in order to give students feeling of living in the game world and role playing, exploring the game world, completing the quests, and learning things. A pilot study was then conducted to see how the two game features – context-awareness and story generation – influence students' attitude towards the use of the mobile educational game. The research findings suggest that the story generated in CAM-RPG positively influences users' attitude towards game use and increases users' perceived game usefulness. With the research findings, other components and outcomes of sub-projects, such as natural language processing, location-awareness, multiple input forms, social networking, and student modeling, can then be put together as one piece to provide students effective and efficient mobile learning experiences.

Keywords

Context-awareness, Location-based, Narrative theory, Educational game, Mobile game, Role-playing game, Technology acceptance model

Introduction

The exponential growth of wireless technology in recent years, increasing availability of high bandwidth network infrastructures (e.g., the SuperNet in Alberta), advances in mobile technologies and the popularity of handheld devices have opened up new accessibility opportunities for education. This has given rise to a five-year research program, funded by Canadian federal government and Alberta Provincial government in collaboration with various industry partners. The program aims to explore and develop different applications and content delivery systems, extending our understanding of mobile learning to provide rich learning experiences in order to not only improve the existing educational environment but also to widen access to education for the disadvantaged, particularly those living in remote and rural communities, who generally do not have access to learning opportunities and the disabled, who need specialized devices and applications for learning.

The learning environment that is being developed under this research program consists of different servers and databases, and provides several services for students. The location-awareness service is aimed to help mobile students forming face-to-face-learning groups. Moreover, innovative social networking functions are integrated in the learning environment. An adaptive mechanism is also developed that is responsible for providing learners with learning materials that fit their individual learning styles. The context-awareness service identifies the personalized context-aware knowledge structure in an ubiquitous/pervasive learning environment and is aimed to direct individual learners to learn and move in the real world using automatically generated guidance messages. Furthermore, learners are supported by an intelligent and multimodal asynchronous questions & answers (Q&A) knowledge sharing platform.

The program has three stages. The first stage consists of Canadian research team designing and developing the game and Taiwanese team designing and conducting the pilot study to verify the usability of the game. The second stage involves Canadian team improving the game according to the feedback received in the first stage and conducting a pilot study in Canada for both the iterative development process and cultural difference investigation. The last stage of the program involves application of the well-designed final product in a formal class and a comparative experiment involving both Canadian and Taiwanese students. The program is currently at the end of first stage.

In 2010, the research team of context-aware sub-project developed a Context-Aware Mobile Educational Game (CAMEG) (Lu, Chang, Kinshuk, Huang, & Chen, 2010a, 2010b). The game generates a series of learning activities (i.e., a learning activity chain) to enable students to interact with specific real objects (e.g., projector, rest room, pine tree, etc.) and virtual objects (payroll system, business policy, E-Commerce course, etc.) in authentic environments. The series of learning activities is automatically generated for individual students according to their learning history and surrounding context (i.e., learning objects associated with the chosen role that the student wants to play, the chosen learning theme, student's location, etc.).

However, majority of the existing educational games, including mobile games, have not looked at such individual feelings. Focus has primarily been on how to teach specific discipline or curriculum in formal educational and on-the-job training settings (i.e., workplace, school campus, museum and historical site). These games become boring when students are simply asked to conduct certain activities one-by-one repeatedly. Few researchers have talked about how to design the contents of mobile educational games in order to make them attractive for the students. This paper focuses on this aspect with aim to improve effectiveness of the mobile educational games.

The rest of the paper is organized as follows. The next two sections introduce the research background by reviewing relevant literature on educational games. The research model and hypotheses used in this research are then described. This is followed by the description of the pilot design and the collected data. Statistical analysis methods are then used to find the answer to the research question. Finally, the implications of the findings are discussed and conclusions are drawn.

Background and motivation

In the last decade, many researchers have seen mobile learning (m-learning) as a further evolution of e-learning (Georgiev, Georgieva, & Smrikarov, 2004). 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 anytime (Keegan, 2005). Beyond the learning devices, some researchers also think that the context of pedagogy differs between e-learning and m-learning. Especially for environmental sciences, m-learning brings potential benefits for learners' self-learning by realizing real-time and location-based learning materials (Jones, Scanlon, & Clough, 2013; Vogel, Spikol, Kurti, & Milrad, 2010).

Brown and colleagues argue that students can learn specific knowledge more efficiently by interacting with a situated environment (Brown, Collins, & Duguid, 1989). Learners can observe or touch the learning objects and can interact with the m-learning system immediately. Hwang, Yang, Tsai, and Yang (2009) also point out that context-aware learning is an innovative approach for detecting student situations and providing students personalized services and adaptive support. Wu and colleagues argue that context-aware ubiquitous learning enables students to interact with learning objects in the real world with the supports from the digital world (Wu, Hwang, & Tsai, 2013). It is important for a mobile learning system to be context-aware; hence, the research team decided to create an interesting context-aware mobile game for students learning domain knowledge.

Garris, Ahlers and Driskell (2002) applied an instructional model in games that uses game-feature-relevant instructional contents as inputs and makes the game-play a cycle. In this model, the repeatable judgment-behavior-feedback activity is a game cycle. These repeated activities can increase the student's motivation and enjoyment of playing the game, enable students to play the game continuously, and increase students' confidence in the gameplay (Garris, Ahlers, & Driskell, 2002).

Researchers have also identified the importance of story in the games (Connors, 2013; Simon, 2012; Sanders, 2011). Connors (2013) argues that story is fundamental for players remembering their gaming experiences and a game might be less impactful without the story. Simon (2012) argues that players may perceive two games to be exactly same if the games have no story, which would have negative effect on learners' motivation to come back to play the games. Sanders (2011) argues that story can make players aware of the goal of the game and can keep them exploring the game.

In order to make the Context-Aware Mobile Role Playing Games (CAMEG) interesting for the users and to motivate them to play, narrative elements were taken into consideration in this research. Narrative theory covers the elements that a story needs (Conle, 2003); therefore, it was decided to design the story generation engine based on narrative theory. The narrative elements such as storyline, character, and interaction have been analyzed in the literature and used in the game-based learning system design (Ying, Wu, Chang, & Heh, 2009). Researchers have also integrated various narrative elements and designed different approaches for generating story (Akimoto & Ogata, 2011; Akimoto & Ogata, 2012). The research team therefore applied narrative theory to enhance CAMEG in order to give students feeling of living in the game world and role playing, exploring the game world, completing the quests, and learning things. At the end, the enhanced mobile educational game with stories - Context-Aware Mobile Role-Playing Game (CAMRPG) was developed in 2011 (Lu, Chang, Kinshuk, Huang, & Chen, 2011c).

The research team has subsequently been tackling the following research question: do the two game features – context-awareness and story generation – really influence students' attitudes towards using such educational mobile role-playing games? A pilot study has been conducted, where a questionnaire (and associated statistical analysis) was employed to gather students' attitudes toward the game.

Story decorated context-aware mobile role-playing game

To develop a lightweight, flexible, and scalable mobile educational game based on the research components designed by various sub-projects of the research chair program, a multi-agent architecture (MAA) has been used (Lu, et al., 2010b, 2011a). A multi-agent system is a software environment containing many agents who are responsible for their own tasks while collaborating with other agents whose responsibilities belong to the pre- and post-requisite tasks. Multi-agent architecture is particularly useful for developing mobile applications because it can divide a complex task into several smaller tasks and can assign these tasks to different agents. Moreover, these agents can work either within same device (e.g., a mobile phone) or on different machines/platforms as a distributed system (Balaji and Srinivasan, 2010).

Figure 1 shows the multi-agent architecture of the mobile educational game developed in this research. More details for the responsibilities of each agent and the collaboration among agents can be found in Lu, et al. (2011a)

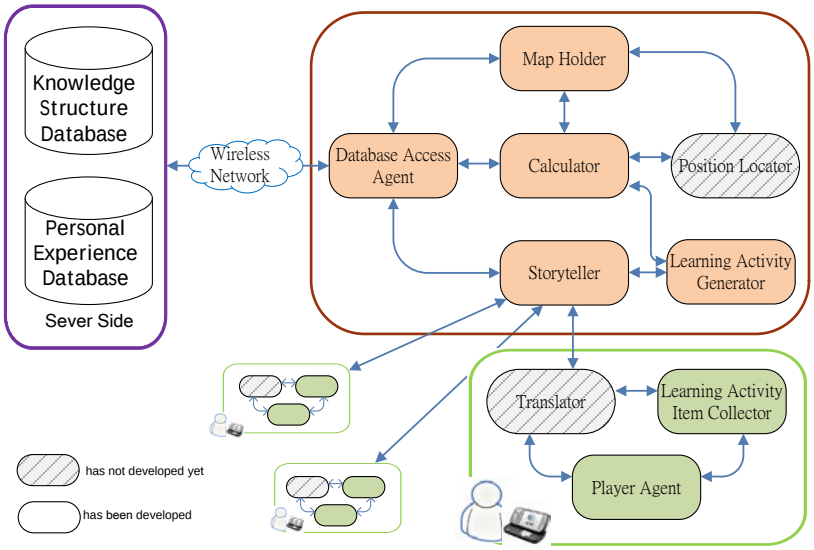

Figure 1. Multi-Agent architecture of the proposed mobile educational game

Figure 2 shows the screenshots of the game-play of CAMRPG. During the game-play, the Player Agent is the only agent that interacts with the user and enables data exchange between the user and other agents.

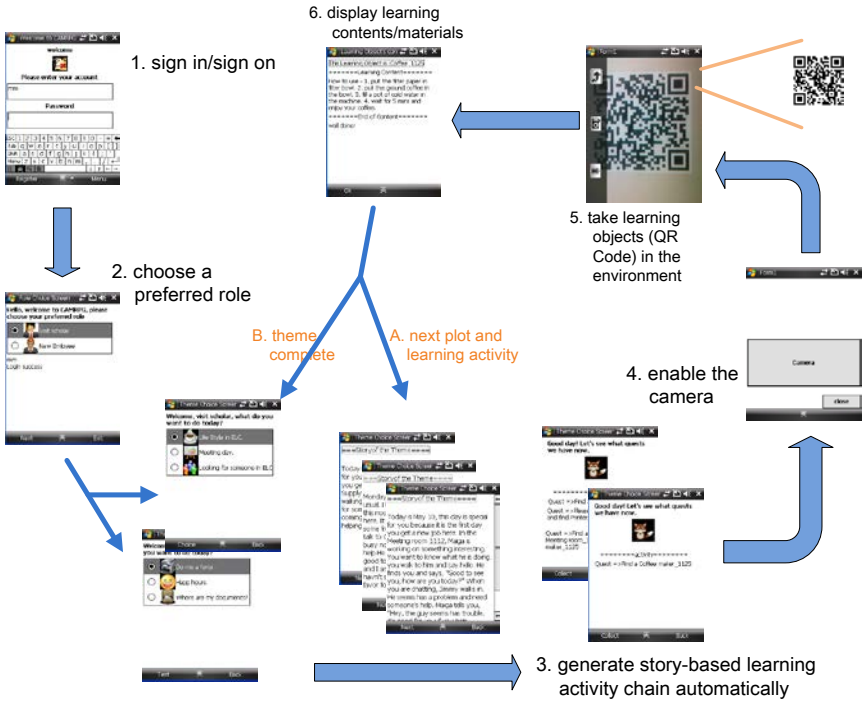

Figure 2. The game-play of CAMRPG

As shown in Figure 2, in the game, roles and corresponding pre-defined themes are designed for students to have opportunity to choose what learning direction and discipline they really need. For instance, a student who takes Introduction to Management Information System course may want to know more about what enterprise support system is and what benefits a business can gain from it. In such circumstances, the student can choose a particular role and theme s/he wants to play, for instance, a chief information officer (i.e., step 2).

The game then generates learning activities for the individual students according to the chosen role and theme. Before the students are asked to do the learning activities, the game makes stories up automatically and uses the stories to populate the generated learning activities for the individual students (i.e., step 3). After the students finish reading the story, the game shows them the learning activities (i.e., step 4). The students can use the built-in camera to collect the required learning object(s) by taking pictures of the objects' QR codes (i.e., step 5). Once the game has verified the correctness of the collected learning objects, it delivers each student a piece of text-based learning material about the corresponding learning object (i.e., step 6). In addition to text-based learning contents, the learning contents can also be HTML-based, binary-based image, URL of webpage, media stream and Flash animation.

At the end, the game checks if the students have completed all generated learning activities for the chosen role and theme. If there are other activities left, the game takes the individual students back to step 3 to read another story and asks them to finish another learning activity (as flow B on Figure 2 shows). If no activity is left, the game takes the students back to theme selection screen (as flow A on Figure 2 shows). The students can then either choose another theme or can even take another role.

Research model and hypotheses

The research team decided to explore the connection between student's perceived usefulness of the game and the two features (i.e., context-awareness and story generation) step by step, with the following research question "do the two game features – context-awareness and story generation – really influence students' attitudes towards using educational mobile role-playing games?"

A number of models have been proposed in the literature for analyzing user perceptions and acceptance towards technological systems. A well-established and tested model in the literature is the Technology Acceptance Model (TAM), proposed by Fred D. Davis in 1986. This model has become one of the most common instruments used to explain the users' behavioral intention of using an innovative technology. 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 also examined the acceptance factors for educational games or entertainment games by adding their own variables to the original model to explore the influences of different external variables, for instance, gender, gaming experience, learning opportunities and the unified theory of acceptance and use of technology (UTAUT) (Bourgonjon, Valcke, Soetaert, & Schellens, 2010; Ibrahim, 2011). In the pilot study of this research, two external variables (i.e., the two game features, namely context-awareness and story generation) are proposed for inclusion in the original TAM.

The proposed research model is adopted from the research done by Ibrahim (2011) and Bourgonjon et al. (2010). Different from previous models, this research has four moderators, namely gender, gaming experience, smartphone experience, and context-awareness feature as variables. The reason for taking smartphone experience into consideration is analyze whether or not the students who do not have experience in using smartphone encounter difficulty in using the game and perceive low ease of use than the students who have experience in using smartphone. Figures 3 and 4 show the macro view (i.e., all considered theories) and micro view (i.e., the detailed constructs) of the proposed research model respectively.

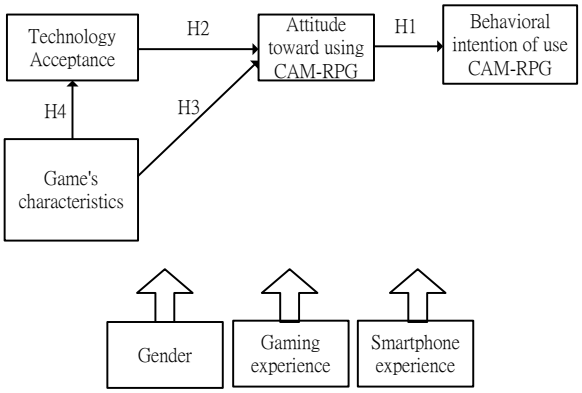

Figure 3. Macro view of the proposed research model

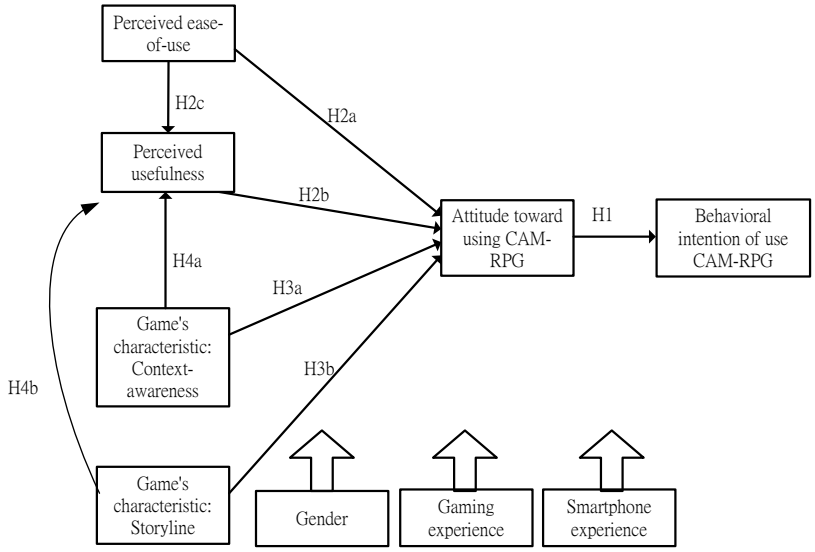

Figure 4. Micro view of the proposed research model

The hypotheses needed to be verified in the research model are listed in Table 1.

Table 1. Hypotheses of the extended technology acceptance model

Macro view	Micro view
H1	H1: Attitude has a positive effect on behavioral intention.
H2	H2a: Perceived ease-of-use has a positive effect on attitude toward using CAMRPG.
	H2b: Perceived usefulness has a positive effect on attitude toward using CAMRPG.
	H2c: Perceived ease-of-use has a positive effect on perceived usefulness.
H3	H3a: Context-awareness feature has a positive effect on attitude toward using CAMRPG.
	H3b: Story generation feature has a positive effect on attitude toward using CAMRPG.
H4	H4a: Context-awareness feature has a positive effect on perceived usefulness.
	H4b: Story generation feature has positive effect on perceived usefulness.

Pilot design and data collection

The purpose of the pilot study was to analyze whether a mobile learning system with the two features improves learners' willingness of using it. Initially, the researchers introduced the game and conducted a demonstration in a Management Information System (MIS) class at a national university in Taiwan. The researchers explicitly told the students that there was no compensation, reward, or recognition for anyone who participated in the study. It was also made clear that there were no consequences for not taking part in the study.

The experiment environment of the pilot study consisted of three laboratories located within one building of the university. Since all participants were taking undergraduate level MIS course at that moment (June, 2011), the MIS course contents and concepts were incorporated into the game and a virtual science park was built in that building. The park consisted of many famous IT businesses and companies that virtually resided in the park, and participants interacted with those organizations in the virtual park while playing the game.

The participants were asked to complete a demographic questionnaire before playing the game. All participants had 20 minutes to play the game in the authentic learning environment using the smartphones prepared by the researchers.

As the participants 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, such as video clips, presentation slides, case studies, and real systems. In the game-play, participants acted as information technology (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 they were playing, they would learn about these learning objects actively through presentations and demonstrations instead of sitting passively in a classroom and receiving lectures from the course instructor.

After the game-play, they were asked to fill out the technology acceptance model questionnaire. The questionnaire had thirty one five-point Likert-scale items (ranging from 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), and two examined constructs (i.e., context-awareness and story generation).

Reliability analysis

The questionnaire was adopted from previous research results, and its validity and reliability have been proven by Lu, Chang, Kinshuk, Huang, and Chen (2011b). The data collected in this research was analyzed before using it to examine/verify the hypotheses. Some participants did not show up at the scheduled time, hence, the corresponding

responses of the questionnaire were removed. In addition, responses of two more participants were removed because they had extreme values for all questions and had conflicting answers for the flip-flop items. The final valid sample therefore included 62 students, consisting of 34 male and 28 female students.

Table 2 lists the results of reliability analysis. 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).

The results showed that all constructs, except the behavior construct, had good measure of reliability. The three items of the behavior construct were reviewed and it was concluded that these items might not explain the construct well in this research because of the different subjective situations this research has. The three items had no correlation with the other constructs either. Therefore, the behavior construct was removed.

Table 2. Reliability analysis results of the technology acceptance model questionnaire

Construct	Item number	Overall Cronbach's alpha
Perceived ease of use (PEoU)	5	**0.743** (0.774 after PEoU03 and PEoU04' removal)
Perceived usefulness (PU)	5	0.793
Context-awareness feature (CA)	5	0.752 (0.807 after CA02's removal)
Story generation feature (SL)	4	0.832
Attitude toward using CAMRPG (ATT)	4	0.807
Intention of using CAMRPG (IT)	5	0.894

Note. Bold and underline = Cronbach's alpha value is lower than 0.75.

Validity analysis

Next, the internal commonality of items for each factor in the research model was examined using principal component analysis. Three items – PEoU03, PEoU04, and CA02 – were found to have factor loading less than 0.6 and therefore not good enough for presenting the construct. It was decided to remove these three items. The removal of PEoU03 and PEoU04 also improved the Cronbach's alpha value of "Perceived easy of use" construct by bringing it to 0.774, and the removal of CA02 improved the Cronbach's alpha value of "Context-awareness feature" construct to be 0.807. The remaining items could then be used to represent the factors respectively. Lower factor loading may have occurred due to unclear questions or misunderstanding. They need to be revised to fit the presented constructs in future studies and experiments. Table 3 lists results of all constructs in principle component analysis.

Table 3. Validity analysis results of the technology acceptance model questionnaire

	Factor					
Item	**1**	**2**	**3**	**4**	**5**	**6**
Factor 1: Perceived ease of use (PEoU) α = 0.743						
I_2: It is easy to learn how to play	.850					
I_{31}: The system flow is clear and simple to me	.817					
I_{32}: The terms and functions in the game are easy to understand	.799					
I_1: User interface are easy to use	.759					
I_{35}: I can get familiar with the learning objects quickly	.580					
Factor 2: Perceived usefulness (PU) α = 0.793						
I_{36}: It provides me enough information for what I want to know		.762				
I_{33}: I can get needed information quickly within the game		.758				
I_{34}: The learning activities can save my time in learning		.741				
I_3:This game makes me want to explore the game's world		.733				
I_{37}: This game provides me enough information for learning		.703				
Factor 3: Context-awareness feature (CA) α = 0.752						
I_{15}: The learning objects are associated to my chosen theme			.844			
I_{14}: If a quest required multiple learning objects, all of them can be found in the authentic learning environments			.761			

I_{12}: The objects can be found in the learning environments			.755			
I_{16}: The quest difficulty is from simple to complex			.717			
I_{17}: It doesn't generate exactly same quest for me			.701			
Factor 4: Story generation feature (SL) α = 0.832						
I_{11}: I am engaged in the story and relevant quests				.847		
I_{9}: The stories give me some ideas of what I should do				.826		
I_{10}: The integration of storyline and quests is perfect				.813		
I_{8}: The storyline makes the game more interesting				.775		
Factor 5: Attitude toward using CAMRPG (ATT) α = 0.807						
I_{7}: I would like to use the game much more if I can team up with other players in the game					.875	
I_{5}: I would like to try its upgraded version					.805	
I_{6}: I would like to use the game much more if it has background music					.795	
I_{23}:I hope the course's instructor to apply "CAM-RPG" into the course					.710	
Factor 6: Intention of using CAMRPG (IT) α = 0.679						
I_{25}: I will play "CAM-RPG" continuously in the future						.885
I_{27}: I would like to use other similar systems in the future						.885
I_{24}: I will try to complete the tasks that the course's instructor ask me to do						.863
I_{26}: I will introduce "CAM-RPG" to other people in the future						.819
I_{28}: I would play "CAM-RPG" if many of my friends are playing						.745
Eigenvalue	10.048	2.526	2.222	1.586	1.292	1.242
% of variance	35.88	9.02	7.94	5.66	4.61	4.43

Note. Overall α = 0.826, total variance explained is 67.54%

At the end, a valid and reliable technology acceptance model questionnaire for measuring participants' attitude towards mobile educational game with six constructs and twenty eight items was determined and confirmed. Quantitative statistical method was then used to get the answers for the research questions.

Data analysis and results

In order to answer the proposed research question, descriptive statistics was initially used to summarize the collected data and compare the constructs' mean and standard deviation values for different groups (e.g., gender smartphone use and player types). Independent t-test was then used to explore whether or not different groups of participants have different attitudes toward CAMRPG.

Descriptive statistics

The demographic questionnaire collected participant's gender information, experiences of playing games, time spent in playing games, and experiences with smartphones. Table 4 lists basic information for the final sample of 62 participants.

Table 4. Demographic information of the participants

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%)

Table 4 shows that most participants had rich experiences of playing games, especially computer games. Video and computer games are both found to be major entertainment activities for them. In addition, only 30.6% of participants had experiences of using smartphones.

Quantitative analysis

Independent t-test was used to explore whether there were significant differences in technology acceptance between different groups of participants (e.g., gender, time spent playing computer games, and experiences of using smartphones). The statistical data analysis in Table 5 shows two meaningful results: (1) female participants have more positive feedback than male participants for all constructs; and, (2) there is no obvious difference between male and female participants in their responses for six constructs. The results are in line with the findings of previous researchers (Gwee, Chee, & Tan, 2010; Law, 2010; Papastergiou, 2009).

Table 5. Gander difference on six constructs of technology acceptance model.

Construct	Gender	N	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 feature	Female	28	4.0000	.29313	0.106
	Male	34	3.9882	.56126	
Story generation feature	Female	28	4.0982	.51523	1.065
	Male	34	3.9412	.62480	
Attitude toward using CAMRPG	Female	28	4.2589	.36945	1.519
	Male	34	4.0368	.74907	
Intention of using CAMRPG	Female	28	3.9857	.60106	1.422
	Male	34	3.7471	.70032	

From Table 5, it can be seen that although the mean values of both groups are quite high (positive) for all constructs, male participants have relatively higher standard deviation. This circumstance shows that male participants may have extreme high or low responses for these constructs. It is notable that the statistical analysis for experience of using smartphones shows no obvious difference between smartphone users and traditional mobile phone users.

Multiple regression

To explore the cause-effect relationships in the research model, a simple linear regression (i.e., use of attitude towards using CAMRPG to determine the intention of using CAMRPG) and several multiple linear regressions (e.g., use of perceived ease of use, perceived usefulness, context-awareness feature, and story generation feature to determine attitude towards using CAMRPG; and, use of perceived ease of use, context-awareness feature, and story generation to determine perceived usefulness) have been used. Such multiple regression analysis is typically used to examine and predicate the linear relationship between one dependent construct and one or more independent construct(s).

First, the independent factors 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 existence of linear dependence in the independent constructs can be determined by observing the collinearity statistic fields in Table 6. A collinearity statistic indicates that the construct 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 (Hair, Anderson, Tatham, & Black, 1998). The results show that there is no serious collinearity issue between the independent constructs in Table 6, in which tolerance > 0.1, VIF < 10, and no two variables' variances > 0.8 at the same line.

Table 6. Coefficients of perceived ease of use, perceived usefulness, context-awareness and story generation feature

	Unstandardized coefficients		Standardized coefficient	t	Significance	Collinearity statistic	
	B	Std. Error	ß			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 feature	.015	.156	.012	.099	.921	.430	2.323
Story generation feature	.248	.111	.234	2.235	.029*	.529	1.889

Note. Dependent variable: Attitude toward using CAMRPG *: $p < 0.05$

Table 7. Collinearity diagnostics

Dimension	Eigenvalue	Condition index	Variance proportions				
			(constant)	PEoU	PU	CA	SL
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

Note. Dependent variable: Attitude toward using CAMRPG. PEoU = Perceived ease of use; PU = Perceived usefulness; CA = Context-awareness feature; SL = Story generation feature.

Table 8 lists the coefficients of four independent constructs towards the dependent construct – attitude towards using CAMRPG. Three constructs (i.e., perceived ease of use, perceived usefulness, and story generation feature) present significant coefficient measures (ß = 0.323, 0.346, and 0.234, $p < 0.05$).

Path analysis for the multiple regressions model

Figure 5 shows the path diagram of the research model. The result of path analysis shows that the attitude towards using CAMRPG (ATT) has strong effects on the intention of using CAMRPG as 0.455 ($p < 0.001$) of path coefficient. The effects of perceived ease of use (PEoU), perceived usefulness (PU), context-awareness feature (CA) and story generation feature (SL) explain 74% of the attitude towards using CAMRPG, while perceived ease of use (PEoU), perceived usefulness, and story generation feature have significant effects (ß = 0.331, 0.437, and 0.234, $p < 0.05$) on the attitude towards using CAMRPG, but context-awareness feature does not (ß = 0.012). For the cause-and-effect relationship between the independent variables, the effects of perceived ease of use, context-awareness feature, and story generation feature explain 75% of perceived usefulness, while perceived ease of use (ß = 0.678, $p < 0.001$) and story generation feature (ß = 0.206, $p < 0.05$) have significant effects on perceived usefulness, but context-awareness feature does not (ß = 0.066).

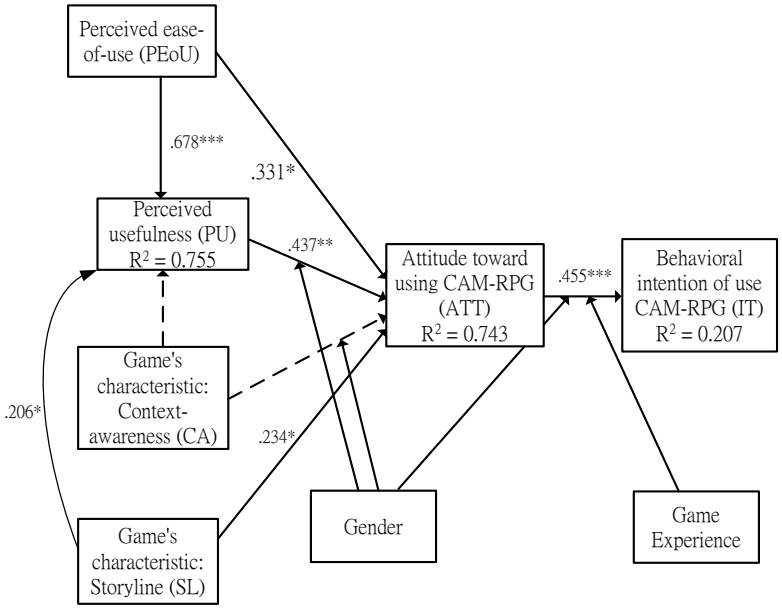

Figure 5. Path analysis diagram
$^{***}p < 0.001$. $^{**}p < 0.01$. $^{*}p < 0.05$.

Findings and discussions

Data analysis revealed several findings that can help in understanding users' attitudes towards and acceptance of the proposed mobile educational game as well as exploring the answer of the research question: do the two game features—context-awareness and story generation—really influence students' attitudes towards using educational mobile role-playing games?

These findings are categorized into three categories: 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 our assumptions in this research).

Common findings

Findings suggested that the original technology acceptance model presents good results in cause-and-effect relationship of all factors (e.g., PEoU, PU, ATT, and IT). In particular, for the path coefficients found between perceived ease of use and perceived usefulness, the results indicate that ease of use is an important factor in context-aware mobile 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 towards using CAMRPG and intention of using CAMRPG also present strong significant coefficients in our research model. These findings have been proven in many studies that have focused on the acceptance towards information systems.

Important findings

First of all, the descriptive statistical data (i.e., Table 6) shows that the responses from both males and females were positive in terms of appreciation of the proposed CAMRPG. In addition, responses of female participants to all factors were relatively higher than those of male participants in the pilot.

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

using smartphones did not affect acceptance of innovative technology. On the other hand, from the perspective of national research program, this result suggested that there is no need to worry about whether or not a user has used a smartphone while deploying such context-aware mobile role-playing game for learning.

Unexpected findings

From the path analysis results, it was found that most of the proposed factors qualified to explain the dependent variables, except the context-awareness feature factor. One reason perhaps is that the context-awareness feature is transparent to its users. For instance, a participant will receive from the game only those learning activities that involve learning objects in a library if the game detects that the participant is in library at that moment. So the participant would not feel what exactly the feature does for him or her. Another reason could be that the experiment environment in the pilot might not have represented the concept of context-awareness well enough to make participants aware of this game feature. For instance, the pilot was conducted using a virtual science park that was built in a university building used by the participants regularly for attending classes, which made it difficult for participants to have immersive feelings that they were in San Francisco or Helsinki. Finally, this pilot did not cover different buildings and did not continue over a longer time period. In such case, the participants could not experience scenarios like signing on to get quests at different places. These shortcomings might have caused the context-awareness feature factor to present relatively lower measures and an insufficient cause-and-effect relationship on the path coefficient.

Conclusions

This paper presented the outcome of the first stage of the context-aware sub-project, under the auspices of the 5-year national research chair program, namely the context-aware mobile role playing game, in which its kernel – learning activity generation engine and story generation engine – can automatically generate a series of story-based learning activities. This game can help users in learning by role-playing in authentic learning environments. The story makes up the learning activity chain resulting in more interesting and immersive learning process. Integrating story into a mobile educational game increases the perceived effectiveness and satisfaction toward the game, especially for the male students. On the other hand, the story reduces the perceived efficiency of using the system.

The findings indicate that participants in the pilot found the context-awareness feature of the game to be less important for the game-play and this factor did not affect their attitude towards using the game. The findings also identified the importance of authentic environment in mobile learning. The pilot study designed in this research clearly demonstrated that the context-awareness ability of the system was not even noticed by students, since they were asked to imagine a floor of a teaching building in school campus as a country in the world, hence there was a lack of an authentic environment. Such mismatch between the virtual and the real world has potential to reduce the perceived usefulness of the context-awareness functionality.

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) would be an important issue. The current game seems to work well for outdoor teaching/learning as well as learning based on treasure hunting paradigm at particular sites (e.g., museums, botanical gardens, and historical sites). It is also suitable for replacing orientation/training courses for freshmen and new students of the graduate programs. However, such game might not be suitable in environments 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 pilot study encompassed only a short-term intervention whose effect may not be carried for long run. The research results also provided a clear picture of what learning topics may be more appropriate for applying context-aware mobile role-playing games, what authentic environment and learning objects are the best for deploying context-aware mobile learning systems, and what features are important to students who use mobile role-playing games.

The next stage research will focus on continuing the architecture design and proof of concept of the services developed under the national research program. This includes the incremental improvement of various modules

based on proof of concept evaluations in Canada as well as continuing to integrate the developments within the overall system. As the research results show that the context-awareness feature is difficult to be noticed when the learning environment is a mix of mismatched virtual and real worlds, augmented reality may help in enhancing the perceived usefulness of context-awareness feature of the game. Also, in order to increase the effectiveness of the game, ordinary learning activities, such as field trips and remedial learning can be integrated into the game. Future plans of the context-aware sub-project include: (1) study and application of augmented reality concept within the interactive mobile learning systems in order to provide students the benefits of context-awareness; (2) develop Android version of CAMRPG and deploy it in rural areas for K-12 education and field trips; and, (3) integrate the outdoor remedial instructions and worksheet idea together to provide students an even more personalized ubiquitous learning experience according to their academic performances and the context surrounding them.

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