Chapter #

NATIONAL PALACE MUSEUM ADVENTURE – A MOBILE EDUCATIONAL ROLE PLAYING GAME FOR MUSEUM LEARNING

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1. INTRODUCTION

Most of the classroom learning is teacher-lead which students cannot observe and touch learning objects in real environments. Different from the traditional learning, the informal learning is student-lead and takes place outside of the traditional classroom. Students can choose learning objects which they are interested in at any time and in any sequence they want [1,2]. When students do informal learning, they must be so thoughtful in order to obtain some knowledge and skills [3]. Museum tour is informal learning, covers knowledge in variety of domains such as historic, cultural and art [4] and this research chooses museums to be the learning environment.

There are three issues needed to be taken into considerations on museum learning. First issue is mobility issue. Students in an informal learning environment like a museum always keep moving around and learn relevant knowledge. The learning devices that students use for museum learning need to be able to be carrying by the students and to be capable of providing students learning content for different learning objects from time to time. Both of personal digital assistant (PDA) and smartphone are ideal devices. The second issue is motivation issue. How can we make museum leaning interesting and get students motivated? Embedding game elements into museum learning seems a good solution because games are fun, enjoyable

and beneficial to learners [5]. This research tries to develop a game to give students immersion experience while playing the game and to make them learn knowledge implicitly during the game-play. The third issue is activity design issue. How can we design personalize activities for students according to the learning goal they choose? This research analyzes the relationships among the artifacts and its embedded knowledge in a museum and designs an activity generation method accordingly.

A mobile educational role playing game called National Palace Museum Adventure has been implemented and a pilot has been conducted to evaluate the effectiveness of doing informal learning in the museum via the game-playing. The results show that the game does engage students doing learning activities in the museum continuously and help students learn the knowledge embedded in the artifacts.

This chapter is organized as following. Section 2 first reveals the relevant literature of informal learning and mobile learning; then goes through the theories like rough set and information theory which can be used for finding the relations existed between artifacts and knowledge and storing learning contents; at the end, talks the procedures of activity generation. Section 3 explains the game design includes the roles the students can play as and the interactions happened between the student and the NPC in the game. Section 4 talks the game's architecture and the game-play. Section 5 starts with hypotheses and the pilot design, followed by the data analysis and findings discussion. Section 6 makes a summary of the research; discusses the pros and cons of the research according to the experiment results; and, finally plans the next steps for the research.

2. MAKING INFORMAL LEARNING AS GAME

2.1 Informal Learning and Museum Mobile Learning

Many researchers have found that it is very difficult to define informal learning due to the informal learning involves many conceptual and methodological challenges [6,7]. Eraut (2004) argues that the informal learning is different from formal learning and emphasizes that suggests greater freedom for learners [8]. Other researchers further argue that informal learning is being open-ended and free choice, intentional and interest-based, a self-directed and learner-centered, non-assessment-driven and non-qualification-oriented endeavour [7,9,10,11].

Informal learning may happen at anytime and anywhere, is a learner-lead pedagogy. For example, students in a museum can choose to take a look at

the artifacts which they would like to understand and know more [1]. Taking a course in traditional education setting as an example of formal learning, teachers must prepare materials and syllabus depending on their teaching styles. Hence, formal learning is a teacher-lead pedagogy [13]. Lelliott (2007) argues that formal learning is a structured educational system and students must get tested after learning. Moreover, students are asked to take identified courses even they do not have interests on the courses [1].

Wellington (1990) identifies the differences between informal and formal learning as Table 1 lists [14]. Students learn with formal learning will always write homework and/or take exams, teachers can assess the students' learning performances via mark their homework and exam papers. On the contrary, there is no homework and exam for the students who learn via informal learning, e.g. museum visits and informal discussions happened in lunch.

Table #-1. Difference between informal and formal learning

Informal learning	**Formal learning**
Voluntary	Compulsory
Intentional effort	Unintentional effort
Non-measured	Measured

Informal learning is different from formal learning because it takes place outside of the traditional classroom. Therefore, there are more social opportunities within informal learning [2]. There is no teacher to tell learners what to do. Students gain knowledge, skills and attitudes via reading newspapers, visiting exhibitions and chatting with friends [1]. Hence, Students may not be aware that they are learning.

Researchers usually categorize museums and wildlife centers into informal learning environments, as these places provide learners direct access to the natural world and scientific phenomena to help students practice and learn skills [15,16,17]. Scanlon et al. (2005) think informal learning in museums makes learning being causally and autonomously [18].

Museums are places which have plentiful opportunities for learning [4]. Museums provide a free-choice learning experience which learners can ignore contents that they are not interested in. However, if the learners do not interest with too many things, then they probably will feel bored or leave the museum shortly. Students will have sympathetic responses to the learning contents which are enjoyable and understandable to them [19]. Therefore, **motivating students is important.**

Regarding Museum Learning, there are two definitions which have been proposed [19]: (1) Abungu proposed in 1999 that "Museums in 21st century are the environments in which learning takes place while exploring exhibits.

The exhibits do not offer all answers, but motivate students to think and ask questions"; (2) Sheppard proposed in 2001 that "Museums enhance discovery. Students can learn visual thinking skills through the contents and context of the exhibits. Moreover, students can realize the variety of phases of the world by observing real learning objects." Hence, **designing museum learning through exploration** is a significant issue.

Mobile devices can support museum learning very well due to: (1) mobile devices can be context-awareness because it can sense the artifacts and ask relevant information from the server; (2) mobile learning processes and interactive contents are interesting to visitors and students [20]. Mobile applications already used in museums are (1) delivering information to the visitors and students, (2) providing tools that can support learning processes, and (3) presenting educational scenarios.

Many mobile applications have been developed to assist learners visiting and learning in museums. First, Kwak (2004) finds that sending information of the artifacts to students' handheld devices can make them have better experiences in the museum [21]. Yatani (2004) proposes the Musex system which was embedded into mobile devices [22]. The Musex asks children questions regarding museum exhibits and Children discover the exhibits and learn collaboratively in the museum. Feix and colleagues (2004) developed DinoHunter to construct a mobile edutainment activity in the museum via storytelling [23]. Klopfer et al. (2005) proposed Mystery at the Museum [24] with four features: (1) allowing participants to discover the exhibits they have never seen before; (2) enabling participants learn the knowledge of the exhibits while searching in the museum; (3) making participants understand the relations among exhibits; and, (4) making participants collaborate with each others.

2.2 Information Theory and Rough Set

Students can learn everything that they are interested in a museum. Hence, the critical problem of informal learning is how to design the programme in which people are interested. Information theory is a method regarding logarithmic base measurement. The base chooses '2' used to fit the computer basic unit such like a bit is 1 or 0 [25]. The importance of data depends on the probability, as the data which is commonly to be seen and found or an event which commonly happens may not so important to the users. In this research, the probability can be used for indicating how often and common a feature or a characteristic is to been found among artifacts, i.e., the probability is higher, the feature/characteristic is more common to be seen in the museum. The information value of a feature then can be noted as:

$$I(F_i) = \log_2(\frac{1}{P_{F_i}})$$

where P represents the probability of the feature F_i.

Rough set is an approach regarding ambiguity. Rough set is used in the knowledge discovery and pattern recognition. The advantage of the rough set is that researchers do not need to have additional information to analyze the relationships among data [26]. Three sets are involved in the rough set: positive, boundary, and negative sets. The definitions of these three sets are:

1. Positive set: All elements within positive set can be classified uniquely.
2. Boundary set: All elements within boundary set cannot be classified uniquely.
3. Negative set: All elements within negative set are not interesting to analyzer.

This research uses the three sets to distinguish if an artifact has all features that a learner needs. An artifact will be put into boundary set if it covers only part of necessary features and will be put into negative set and not be considered while generating activity for learners if it doesn't have any needed feature.

2.3 Activity Generator for Informal Learning

This section reveals how to designs the activity generator for informal learning. Museum learning is informal learning. Many scholars of informal learning consider that learning resources in museums are abundant, as.the resources in museum cover history, art, cultural and others. However the question is how to make those learning resources interesting and get students engaged to learn. Game is fun and enjoyable [5]. Hence, the research team tries to integrate museum learning with the game characteristics such as challenge and control. To do that, there are two things that must be considered.

First, the artifacts of a museum (i.e., National Palace Museum in our research) which are considered to be used for learning are needed to be preprocessed. Four features of artifacts are categorized and are used for the proposed museum learning game; they are "material", "dynasty", "purpose" and "shape". Second, a museum learning game with four learning activity chains which take different feature as its main feature is designed. The activities in the learning activity chains are called "main learning activities". The main learning activities are what users must complete. After the users accomplish a series of main learning activities, i.e., conquer a learning

activity chain, they would learn all of the knowledge related to the particular learning topic.

In this research, forty-six artifacts on the 2nd floor of National Palace Museum are chosen to be learning objects and ten feature relevant learning characteristics such as vase and bowl for the shape feature and bedding and decoration for the purpose feature are found. In order to know which artifacts can help the learning of particular topic, this research uses "Rough Set" to analysis the relationships among artifacts as Fig. 1 shows.

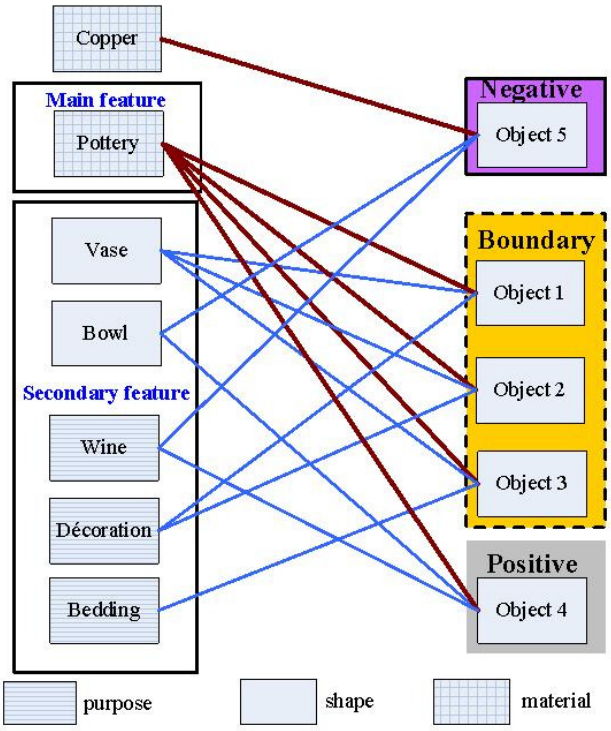


Figure #-1. Relation analysis by Rough Set

The artifacts are listed at the right hand side and the features are listed at the left side of Fig, 1. The feature of the learning activity chain the user chose, for instance, "material" feature in this case and other three features become secondary feature candidate while generating activities for the user. In the example shown in Fig. 1, the main feature is "material" and the secondary feature is "purpose". If we want to generate learning activity for learners to learn "pottery" artifacts which can be used for tasting wine, then the artifacts can be categorized into three different rough sets according to their connections to the main and the secondary features:

1. Boundary Sets: Although the artifacts in this set are pottery products, they are not mainly used for drinking or they are not used for tasting wine at all.
2. Positive Sets: The artifacts in this set are pottery and their purpose is for drinking.
3. Negative Sets: The artifacts in this area set are not even pottery products.

Due to the artifacts in both of the Positive and the Boundary sets are pottery products, they are selected to generate the activities for the learners. Each activity in the chosen activity chain has same main feature and secondary feature.

Once the artifacts have been selected and related activities have been generated, we use Information theories to decide the priority of each activity. The Information theory is used to measure the difficulty of activity in terms of finding an artifact which has the required features, as the information value represents how common a feature can be seen on the artifacts in the museum. More details of activity generation algorithm and mechanism can be found in [27].

3. GENERATING ROLE-PLAYING QUESTS FOR MUSEUM LEARNING

In this research, A mobile game – National Palace Museum Adventure (NPMA) – is designed and the activity generator is embedded into it. The game has game features such like "control", "curiosity", "fantasy" for learners by

1. allowing learners to choose different roles with different story, learning contents and goals;
2. automatically generating activities as game quests so learners may see different quests and can not predict what kind of quests they will see for next; and,
3. allowing learners to interact with the NPC in the game world.

3.1 Playing Roles

The game content influences what players would do and what they would complete and achieve [28]. This research designs the proposed game a role-playing game, as the role-playing game could make learners explore the world, gather required quest items and find answers by themselves via solving quests one by one. The characteristics of role-playing games fit our needs in developing a mobile game in National Palace Museum and our

intention in asking learners to find out the correct artifacts for particular quests by reading the description and explanation of the artifacts.

The game has two roles which learners can choose to be: "Cinema Property Handler" and "Artist" before they can start to play as Fig. 2 shows.

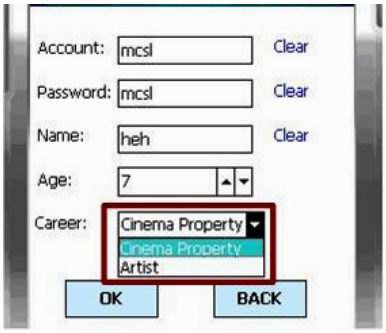


Figure #-2. Career Selection

Fig. 3 shows the four responsibilities that a cinema property handler and an artist has. There are four movies need the cinema property handler's help: "Journey to the west", "Dear and cauldron", "Condor hero" and "Heaven sword". Each movie is associated with a dynasty and needs the learners to find the movie director some artifacts with different features. On the other hand, the four responsibilities that an artist has are "Gorgeous aristocrat", "Populace art", "Religion art" and "Sculpture skill" and each responsibility is associated with a particular material. Similar to the movies, learners may need to help virtual client authenticate some artifacts with different features.



Figure #-3. Different roles' responsibilities

After learners select a responsibility, they would see the correspondent available quests of that particular responsibility. At the top-right hand side of the screen as Fig. 3 shows, an NPC introduces the background of the chosen

role for the learners. The background is used for giving learners an immersive experience and getting them motivated. After the learners choose a responsibility, they can enter into the game world and start to play the game.

3.2 Quest Design

The embedded activity generator introduced in Section 2.3 then generates responsibility relevant activities for the learners.

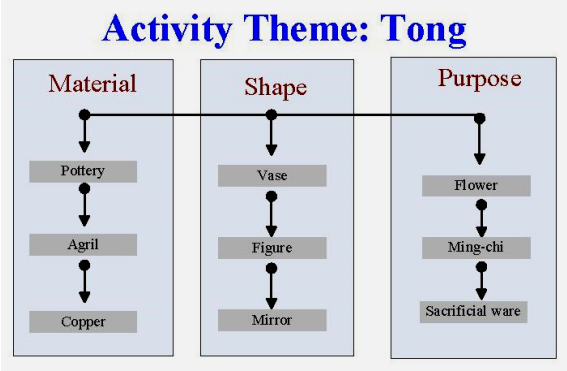


Figure #-4. A result of Activity Generator

As Fig. 4 shows, the main feature is dynasty when the learner chooses to be a cinema property handler and the other three features – material, shape, and purpose – become the secondary features. The research calculates and arranges the quest in a sequence and the learners need to complete the prerequisite quest before they can take the follow-up quest. For instance, the artifacts in Tong dynasty were made by three different materials – pottery, argil, and copper. The learners need to complete quests of pottery material then are allowed to take quests of argil material. The learners can see the available quests on the bulletin board in the association of adventurers in the game world. After learners choose to pick-up a quest, the quest principle provides them the quest's description includes the amount of artifacts they are required to find in the museum.

The quest description is consisted of three parts: principle models, nouns and verbs. This research designs the templates, listed in Table 2, for the three parts according to the careers.

Table #-2. Quest description templates for different careers

Career	Principle model	Noun	Verb

Career	Principle model	Noun	Verb
Archaeologist	You must [verb] the [noun] about [Main Feature] and [Secondary Feature] at this quest.	1. Antique 2. Ancient civilization	1. Find 2. Recognize 3. Discover
Cinema Property	To [verb] which [noun] are [Main Feature] and [Secondary Feature]	1. Antique 2. Ancient civilization	1. Find 2. Discover 3. Bring
Tomb Raider	To [verb] which [noun] are [Main Feature] and [Secondary Feature].	1. Artistic 2. Production antique	1. Steal 2. Find
Artist	You need to [verb] the [noun]s are [Main Feature] and [Secondary Feature] to learn new art skill.	1. Antique 2. Ancient civilization	1. Find 2. Ensure 3. Authenticate

3.3 Interaction and Feedback Mechanism

This section explains the interactions and feedback happened between the learners and the NPC in the game. First of all, the NPC introduces the role's background and the responsibilities for the learners after the learners chose a role to play in the game as Fig. 3 shows

After the learners choose a responsibility, they will interact with the NPC in the Association of Adventurers in the game worlds. The NPC will tell the learners that they can pick any quest listed on the bulletin board at the bottom-left hand side on the screen as Fig. 5 shows.



Figure #-5. The NPC in the association of adventurers

The learners can also interact with the NPC in the association of adventurers to report the solved quest, try another responsibility, try another role and stop playing the game. Fig. 6 shows the NPC's response when the learners want to try another responsibility by clicking the "Change Quest" button.



Figure #-6. The NPC's response toward the responsibility change request

When the learners want to try to play another role by clicking "Change Career" button. NPC will remind players of their current career. When the learners confirm their willing by clicking the "OK" button, the NPC will tell the learners what other roles they can play. Fig. 7 shows how the NPC doesn't want to see the learners leaving when they click "Exit Game" button – the NPC begs players to stay. With such interaction, the learners may stay and play more. As playing the game is the process of learning, longer the learners play this game much more they may learn via their game-play.



Figure #-7. The NPC begs the learners to stay and to keep playing

When the learners come to see the NPC to turn in the quest results, there are four situations could happen. The first situation is successful turning in the quest results, as the learners have found all necessary quest items as Fig. 8 shows. The second situation is that there is no further quest existed in the same secondary feature after the players turn in a quest successfully.

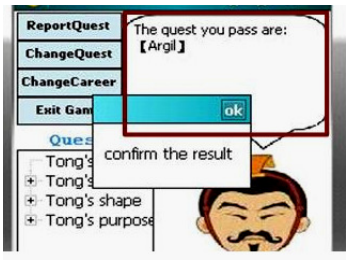


Figure #-8. Successfully turn in the result of a quest

The third situation is the NPC finds that the learners complete all quests generated for the chosen responsibility. Under such situation the NPC will congratulate their victory and ask them to try another responsibility that the chosen role has. The last situation is they players try to turn in the quest but without correct or have no all required quest items yet. Under such situation, the NPC will ask the learners not to cheat. Fig. 9 is the Petri net diagram of the possible interactions which could happen in-between the NPC and the learner. A node is an action that the learners may do in the game. A sentence aside of a node is the NPC's response.

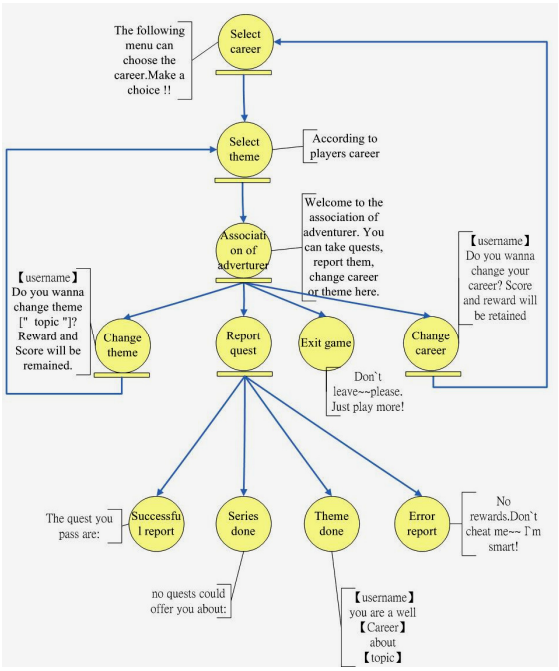


Figure #-9. The Petri net diagram of the NPC's responses

The proposed game uses reward as feedback. Four kinds of rewards are given to the learners when they solve the quests of particular features as Fig. 10 shows. When the learners complete a quest, the game gives the learners the correspondent reward and score as Fig. 11 shows.

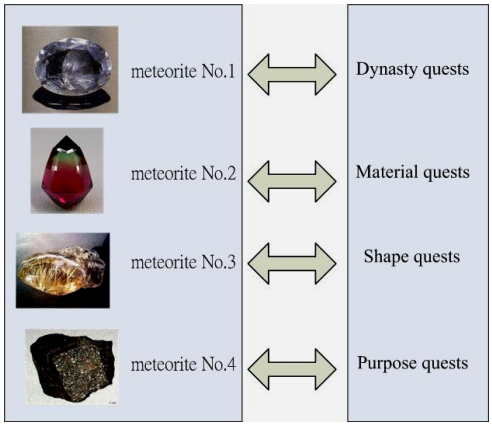


Figure #-10. The feature related rewards



Figure #-11. Reward and score that the learners receive for the completion of a quest

4. NATIONAL PALACE MUSEUM ADVENTURE – THE GAME

This section uses the experience of a mocked kid – Bruce – in National Palace Museum as case to explain how a student plays the game and learns in the museum.

One day, Bruce comes to National Palace Museum with a PDA pre-installed the National Palace Museum Adventure (NPMA) game. After he goes through the entrance, he starts the game and sees the main menu as Fig 12 shows.



Figure #-12. Main menu of the game

He has never played the game before so he clicks the "New Player" button to register an account and choose a role to play the game as Fig. 13 shows.



Figure #-13. Registering an account and choosing a role

He chooses to be an artist and the NPC tells him the responsibilities of being an artist. He wants to try the "Gorgeous aristocrat". The NPC asks him whether Enamel or Jade he want to try as Fig. 14 shows.

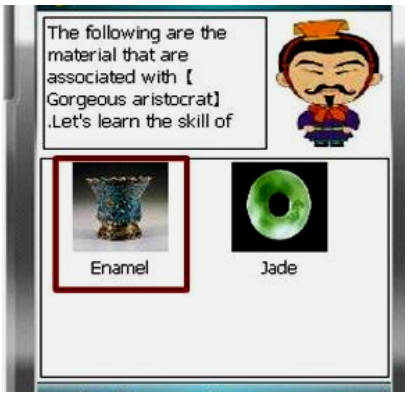


Figure #-14. Quest menu of gorgeous aristocrat

As Bruce chooses Enamel, the game then starts to generate Enamel related activities for him. Bruce finds himself is teleported to the association of adventurers in the game world and he has nothing in the bag at this moment because Bruce has never completed any quest yet. Bruce takes a look at the bulletin board and tell the NPC that he wants to take the Qing quest. When he takes the quest, the screen is switched to the Map page as Fig. 15 shows. Bruce can see the quest principle and the possible location clue for solving the quest.



Figure #-15. The quest principle and the map for location clues

According to the quest principle, Bruce understands what kind of artifacts he needs to find and the possible room he should go. He reads the descriptions of the artifacts to see which the quest is asking for. When he

finds one and believes the one is correct one, he opens the "antiques list" and chooses the one he believes is correct by entering the correspondent artifact serial number as Fig. 16 shows.



Figure #-16. Selecting an artifact candidate and entering the artifact serial number to confirm his decision

Bruce finds the right one; therefore, the game updates the numbers of remaining required artifacts as well as the antique list for him. When he finds out all required artifacts for the Qing quest, the game gives him a correspondent reward and score as Fig. 17 shows.

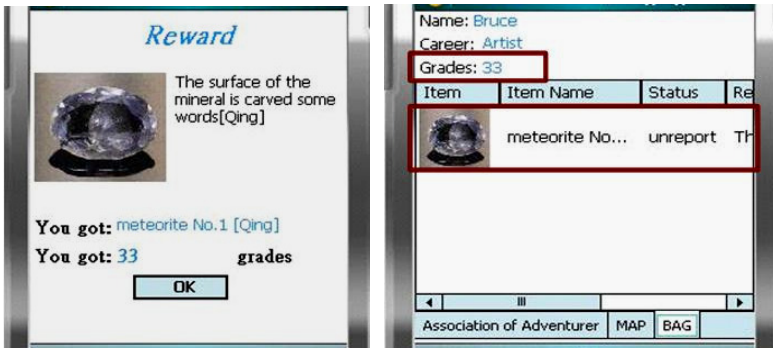


Figure #-17. Reward page and the updated bag

Bruce then comes back to the association of adventurers and reports to the NPC. After NPC verifies the turn-in quest results, the NPC updates the bulletin board and offers a new dynasty quest – Ming quest. Bruce can take this new quest or take any other quest listed on the bulletin board until all quests have been done. Once Bruce completes all quests, the NPC tells him

that he can try another topic of "Gorgeous aristocrat". Bruce returns to the "quest menu" and finds the "Enamel" is gone. He can choose another topic to conquer until no topic exists.

5. EVALUATION AND DISCUSSION

5.1 Hypotheses and Pilot Design

There are three hypotheses this research wants to prove:

- **Hypothesis 1**: learners can learn through playing the game in National Palace Museum
- **Hypothesis 2**: the proposed game makes learners spend more time in National Palace Museum
- **Hypothesis 3**: the knowledge learned through playing the game can be remembered longer

The pilot recruits nine subjects include four elementary school students and five high school students to form the experiment group. The experiment group students play the game in National Palace Museum. Also, the pilot recruits two subjects to visit National Palace Museum with pre-designed paper-based learning activities. Table 3 lists the details of experiment group students.

Table #-3. Details of experiment group students

Item	Description
Age	9 ~ 16 years old
Gender	1 girl, 8 boys
Educational level	4 elementary school (denoted by E1-E4), 2 junior high school (denoted by J1-J2), 3 senior high school (denoted by S1-S3)

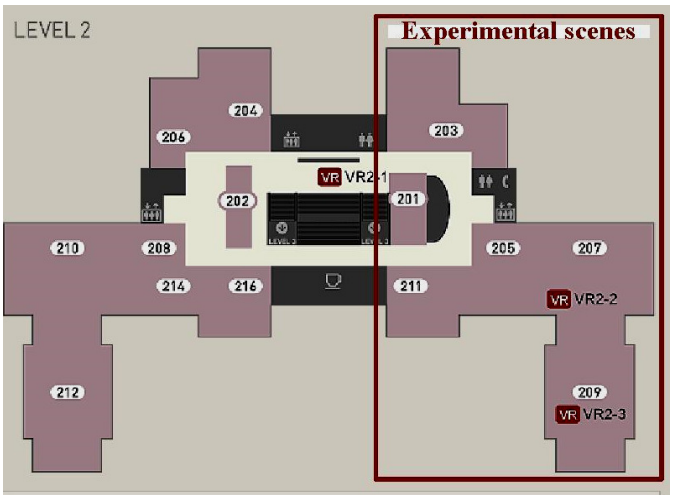


Figure #-18. The second floor plan of National Palace Museum

The chosen experiment site the east side of 2nd floor in National Palace Museum. The east side of 2nd floor has six rooms (i.e., 201, 203, 205, 207, 209 and 211). Fig. 18 shows the floor plan.

Forty-six artifacts in the six rooms are collected and four features – "dynasty", "shape", "material", "purpose" – that the artifacts have are chosen for activity generation. The activity generator which the game uses can generate one hundred twenty-one quests with these data. Table 4 lists the quest distribution.

Table #-4. Quest distribution

Theme	**Quest amount**	**Theme**	**Quest amount**
Tsin	3	Argil	3
Tong	9	Copper	8
Six	3	Lacquer	7
Jin	3	Stone	3
Sung	12	Bamboo	3
Ming	21	Ivory	6
Jade	7	Pottery	23
Enamel	10		

The experiment procedures are:

1. A research assistant explains the game for the subjects.
2. The subjects are allowed to try the game to get familiar with it before they start the museum visit.
3. The assistant show the subjects how to solve a quest.
4. The assistant double checks if the subjects really know everything about the game.

5. The subjects start the game play and solve quests around the east side of second floor. The assistant accompany the subjects to provide supports like room finding, quest principle explanation and technical problem shooting and solving.
6. The pilot only stops when the subjects decide to exit the game and to stop playing. Hence, each subject's time spent on playing the game in the museum is different from others.
7. The subjects are asked to fill a questionnaire and to take a post test when they decide to stop playing.
8. Two weeks later, the subjects are asked to do a delayed post-test which is identical with the post-test.

The questionnaire is designed and used for getting the subjects' perceptions toward the game. The questionnaire has ten five point likert scale questions, where 5 indicates the subjects strong agree with the question description and 1 indicates they strong disagree. The pilot has a post-test and a delayed post-test because the research team wants to see if the knowledge learned through playing the game can be remembered longer. The post-test and the delayed post-test are identical..

5.2 Data Analysis and Findings

The descriptive statistics results of the questionnaire responses are summarized in Table 5 and several findings can be told from it:

1. The subjects were engaged to learn in National Palace Museum (Q4 and Q10).
2. The subjects felt that they did learn knowledge in National Palace Museum through the game play(Q8); therefore, Hypothesis 1 is supported.
3. The subjects do find the hints and the location clues are useful for them to solve quests (Q3 and Q5).
4. The game does provide the subjects an immersive experience (Q7).

Table #-5. The descriptive statistics results of the questionnaire responses

	Question	**Mean**	**S.D.**
Q1	Does the game work well?	4.22	0.971825
Q2	Are quests too difficult to solve?	2.44	0.881917
Q3	Do you need hint for solving quests?	4.22	0.833333
Q4	Do rewards and score motivate you to keep playing?	4.00	1
Q5	Does the location clue help you solve quests?	4.22	1.20185
Q6	Do you feel the difficulty of the quests is getting higher?	3.33	1.224745
Q7	Do you feel you are the role you play in the game?	3.67	0.866025

	Question	Mean	S.D.
Q8	Do you learn knowledge while playing the game?	4.33	0.866025
Q9	Do you think the NPMA is a game?	3.89	0.927961
Q10	Can the game attract you to visit National Palace Museum?	4.11	0.927961

Table 6 lists the t-test result of the time-spent on the museum between the control and the experiment group. The result shows that the time-spent of experiment group students in the museum is significantly longer than control group students, which means, the game does engage students learning in the museum; therefore, Hypothesis 2 is supported.

Table #-6. t-test result of two groups' the time-spent on the museum

Experiment group		**Control group**			
Mean (hours)	S.D.	Mean (hours)	S.D.	Df	t
2.7	0.5	2	0	9	1.92*

*p = 0.04 < 0.05

Table 7 lists the t-test result of the score that the experiment group students received for the post-test and the delayed post-test. The result shows the delayed post-test score that experiment group students received is not significantly different from the post-test score, which means, the learning effect via playing the game in the museum can retain; therefore, Hypothesis 3 is supported.

Table #-7. t-test result of experiment group's post-test and delayed post-test score

Post test		**Delayed post-test**			
Mean	S.D.	Mean	S.D.	df	t
0.66	0.24	0.54	0.26	8	1.27

p = 0.12 > 0.05

5.3 Discussions

The research team expects that the learners will be enjoy their visit in National Palace Museum because of the game. Several observation and interview results do confirm our expectation.

(via observation)

E3: How many quests did you remain, brother (E4)?

After checking brother's progress

E3: I am better than you.

E3 then tried to help E4 complete quests. After E3 and E4 finished every quests that cinema property handler has, They seemed to be satisfied with their achievement.

(via interview)

E1: that the automatically generated quests are fun. I like the process of finding answer via quest solving.

E2: I felt that I was the role I played.

S1: Wow, time flies. We spent almost 3 hours to play. The game provided us goals which are more interesting than last time (without the game) (S1, S2 and S3)

The research team also believes the game can get learners motivated to learn in the museum. The interview results show that the game does have such potential.

(via interview)

E1: I like to visit a museum with the game instead of without it.

E2: I would like to play the game again. I want to finish the cinema property handler's quests which I haven't completed yet.

S3: I enjoy collaborating and competing with my friends in terms of playing the game in the museum. Yes, it is a game. Playing the game is better than teacher-lead learning in the museum. I know what I should find and read in the museum because the chosen topic is what I like.

J2: I agree that I can actively visit the museum with the game. The most attractive parts of the game are the reward and the role-playing.

NPMA is a game which the artifacts' knowledge is embedded into quests. Hence, the game can help learners learn while playing it. Several evidences can be proofs.

E1 and E2 try to conquer Tong's Ming-Chi quest. However, they did not understand what Ming-Chi is.

E1 & E2: assistant, what is Ming-Chi?

Assistant: Ming-Chi is a kind of mortuary objects. You can go to Room 201 and see which one can be used as mortuary object. Did you ever heard the story of Emperor Qin-Shihuang’s terracotta warriors and horses? The required artifacts are similar to that.

E2: (thought for a while) I got it.

She went to see the artifact – "Pottery figurine of a standing lady painted with colors Tang dynasty" and put the artifact's serial number into the game and she was right about that.

And then, E1 and E2 were capable of finding out all required artifacts in Room 201. They actually understood what Ming-Chi is.

In this research, the generated quests' priority in a chain is decided based on the information value of the artifacts involved. The research team expects

to see the later quests in a chain are more difficult for the learners. Some observation results show that it seems to be true.

(via observation)

When J2 saw a follow-up quest, he even wanted to change to another topic to play.

E1 and E2 had higher failure rate while solving later quests and the times they asked the assistant for help are also higher.

S1, S2 and S3 completed the beginning quests in the quest chain individually by themselves. However, for the later quests they solved through collaboration.

6. CONCLUSION

This chapter first reveals the design of mobile educational role-playing game for doing informal learning in museum and then explains the game-play with mocked user's experience so readers can have clear idea of how the things work. A pilot has been done for assessing the usefulness of the game and for verifying some hypotheses. Many interesting and important findings have been found. For instance, the game does make the learners spend more time in the museum. Moreover, the learners do learn the knowledge associate with the artifacts but still treat the game a game. With such finding, museums and exhibitions may consider to provide their visitors similar mobile role playing game apps to not only make visitors learn something while visiting the places but also make them come again and again – to make informal learning continue and become life-long.

In the future, the game can be enhanced by automatically generating collaborative activities for the learners. Learners in the museum can work on the quest together with their devices, for instance, a quest may involve artifacts located at different floors and rooms so individual learners in a group can have different tasks but all help the completion of the quest. On the other hand, the learners can see how others perform and such competition may get them engaged. The limitations of the current research include the small number of subjects and the unbalance numbers of subjects in different genders and groups. Also, the academic background and interests the subjects have are needed to be considered, as subjects have higher interest in history and arts may be more interested in the game-play and/or may perform better. The future pilot design should take these issues into consideration.

REFERENCE

1. Lelliott, A. D. (2007). Learning about Astronomy: a case study exploring how grade 7 and 8 students experience sites of informal learning in South Africa. Unpublished PhD Dissertation, University of the Witwatersrand, Johannesburg. Retrieve http://wiredspace.wits.ac.za/bitstream/handle/10539/4480/LellioTT.pdf
2. Tough, A. (2002). The Iceberg of Informal Adult Learning. The Research Network of New Approaches to Lifelong Learning, NALL Working Paper #49-2002. Retrieved from http://www.nall.ca/res/49AllenTough.pdf
3. Clough, G. , Jones, A. C., McAndrew, P., & Scanlon, E. (2008). Informal learning with PDAs and smartphones. Journal of Computer Assisted Learning, 24(5), 359-371.
4. Nikolaos, T., Loannna, P., Dimitrios, R., Nikoletta, Y., Vassilis, K., & Nikolaos, A., (2008). Design for mobile learning in museum. In J. Lumsden (Ed.), Handbook of Research on User Interface Design and Evaluation for Mobile Technology (253-269). IGI Global.
5. Ardito, C., Maria, F. C., Rosa, L., & Thomas, P. (2007). Making dead history come alive through mobile game-play. In Proceedings of ACM Computer/Human Interaction (CHI 2007), San Jose, California, USA, April 28-May 3, 2007, 2249-2254.
6. Lai, K.-W., Khaddage, F., & Knezek, G. (2013). Blending student technology experiences in formal and informal learning. Journal of Computer Assisted Learning, 29(5), 414-425.
7. Hofstein, A., & Rosenfeld, S. (1996). Bridging the Gap Between Formal and Informal Science Learning. Studies in Science Education, 28(1), 87-112.
8. Eraut, M. (2004). Informal learning in the workplace. Studies in Continuing Education, 26(2), 247-273.
9. Csikszentmihalyi, M., & Hermanson, K. (1999). Intrinsic Motivation in Museums: Why does one want to learn? In E. Hooper-Greenhill (Ed.), The Educational Role of the Museum (146-159). Routledge. Retrieved from http://www.ou.edu/cls/online/lstd5533/pdf/motivation.pdf
10. Eshach, H. (2007). Bridging In-School and Out-of-School Learning: Formal, Non-Formal, and Informal Education. Journal of Science Education and Technology, 16(2), 171-190.
11. Laurillard, D. (2009). The pedagogical challenges to collaborative technologies. International Journal of Computer-Supported Collaborative Learning, 4(1), 5–20.
12. Tran, Lynn Uyen. 2006. "Teaching Science in Museums: The Pedagogy and Goals of Museum Educators." Science Education 91 (2): 1-21. doi:10.1002/sce.20193.
13. Folkestad, G. (2006). Formal and informal learning situations or practices vs formal and informal ways of learning. British Journal of Music Education, 23(2), 135-145.
14. Wellington, J. (1990). Formal and informal learning in science: the role of the interactive science centres. Physics Education, 25, 247-252.
15. Martya, P. F., Alemannea, N., D., Mendenhallb, A., Mauryab, M., Southerlandb, S. A., Sampsonb, V., Douglasc, I., Kazmera, M. M., Clarkb, A., & Schellinger, J. (2013). Scientific inquiry, digital literacy, and mobile computing in informal learning environments. Learning, Media and Technology, 38(4), 407-428.
16. Holmes, J. A. (2011). Informal Learning: Student Achievement and Motivation in Science through Museum-Based Learning. Learning Environments Research, 14(3), 263-277.
17. Rivera Maulucci, M. S., & Brotman, J. S. (2010). Teaching Science in the City: Exploring Linkages between Teacher Learning and Student Learning across Formal and Informal Contexts. The New Educator, 6, 196-211.
18. Scanlon, E., Jones, A., & Waycott, J. (2005). Mobile Technologies: Prospects for Their Use in Learning in Informal Science Settings. Journal of Interactive Media in Education, 25, 1–17. Retrieve from http://jime.open.ac.uk/article/2005-25/

19. Hawkey, R. (2004). Learning with digital technologies in museums, science, centres and galleries. Futurelab. Retrieved from http://www2.futurelab.org.uk/resources/documents/lit_reviews/Museums_Galleries_Review.pdf.
20. Tsung, Y. L., Tan, H. T., & Yu, L. C., (2006). The Ubiquitous Museum Learning Environment: concept, design, implementation, and a case study. In Proceedings of IEEE International Conference on Advanced Learning Technologies (ICALT 2006), Kerkrade, The Netherlands, July 5-7, 2006, 989-991.
21. Kwak, S. Y. (2004). Designing a handheld interactive scavenger hunt game to enhance museum experience. Unpublished Master Thesis, Michigan State University, Michigan, USA.
22. Koji, Y., Masanori, S., & Fusako, K. (2004). Musex: A system for supporting childres`s collaborative learning in a museum with PDAs. In Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE 2004), Taoyuan, Taiwan, March 23-25, 2004, 23-25.
23. Feix, A., Gobel, S., & Zumack, R. (2004). DinoHunter: Platform for mobile edutainment application in museums. Lecture Notes in Computer Science, 3105, 264-269. Berlin: Springer.
24. Klopfer, E., Perry, J., Squire, K., Jan, M.-F., & Steinkuehler, C. (2005). Mystery at the museum: a collaborative game for museum education. In Proceeding of Conference on Computer Support for Collaborative Learning (CSCL 2005), Taipei, Taiwan, May 30-June 4, 2005, 316-320.
25. Düntsch, I., & Gediga, G. (1998). Uncertainty measures of rough set prediction. Artificial Intelligence, 106(1), 109-137.
26. Pawlak, Z., & Skowron, A. (2007). Rough sets: Some extensions.Information Science, 177(1), 28-40.
27. Chang, C., Wu, S., Chang, M., & Heh, J.-S. (2008). Activity Generator for Informal Learning in Museum. In Proceedings of the 7th WSEAS International Conference on E-ACTIVITIES (E-ACTIVITIES 2008), Cairo, Egypt, December 29-31, 2008, 189-194.
28. Adams, E, & Rollings, A. (2006). Fundamentals of Game Design. Prentice Hall.