Making the Real World as a Game World to Learners by Applying Game-Based Learning Scenes into Ubiquitous Learning Environment

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Abstract. A ubiquitous learning environment provides learners opportunities of observing and touching the learning objects around the learners according to their preferences and/or interests. Learners can solve problems, answer questions, and propose their own questions, in the ubiquitous learning environment. However, it is still a serious topic to learners and most of them only do learning when they really have to, because it is a learning task. Games have many features which make learners have higher motivation in learning and have willing in learning actively. Moreover, the 'stage' concept in the games is also a big factor which might attract learners doing continuous learning, because the learners feel they really accomplished something and want to challenge further. In this paper, we first use small stories and activities to figure out what the learners interests with, which means, make learners call; and, build the personalized knowledge structure for the learner according to his/her choices and interests. With the helps of the context-awareness knowledge structure, we designs and builds learning scenes to offer learners the personalized learning services based on the 'stage' concept in the game. Each learning scene may cover one or many learning spots, and each learning spot has different learning objects. We can construct a series of learning scenes dynamically for individual learner based on the learner's choices, preferences and interests. Furthermore, a learning path involves learning scene switching is also generated automatically for the learner. A scenario with several exhibition rooms and artifacts in a museum is used to demonstrate the idea and mechanism proposed by this research.

Keywords: game-based learning, scene, ubiquitous learning, pervasive learning.

1 Scenario

Stis and A-bin are good friends in the high school. One day, A-bin calls Stis and invites Stis to go to the Zoo with him. The reason that A-bin wants to go to the Zoo is because his teacher, Miss Claire, asked each student in the class to do a .biological report. A-bin chose the butterfly topic, hence, he needs to go to the Zoo to gather enough data, take some pictures, and even shooting some fantasy video-clips.

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When Stis and A-bin arrived at the Zoo, they take out their smartphones. The smartphones have been installed the individual ubiquitous learning service which provides the learners different game-based learning scenes automatically and dynamically according to the learners' requests and/or interests. Due to Miss Claire's project, A-bin makes his choice immediately in the butterfly topic. The individual ubiquitous learning service then comply his order and builds a series of learning scenes which cover different learning areas in the Zoo. The learning areas include the Amazon River, the Butterfly Exhibition Hall, and the Amazing Flower Hot-house.

In each learning area, there is at least one learning spot. For examples, the Amazon River has three major learning spots, The Woods, The People, and The Lifes; the Butterfly Exhibition Hall has a lot of exhibition rooms, each room has its own exhibition topic; and, the Amazing Flower Hot-house is also divided into different zones for showing different species. So, the learning scenes for A-bin's request will cover partial learning spots in the three learning area. Even that, the individual ubiquitous learning system will not ask A-bin to see all of the learning objects in the selected learning spots.

The individual ubiquitous learning system then guides A-bin moving in the Zoo with the learning path which is planned for the first learning scene. During A-bin moves in the Zoo according to the learning system's suggestion, he keeps observe learning objects and touch learning objects with his eyes, ears, and hands, at mean time, he keeps take pictures, shoot video-clips, and take notes, with his smartphone.

The ubiquitous learning system will keep tracing A-bin's completeness degree for the first learning scene and filter some redundant learning objects and learning spots out according to A-bin's progress. Once the learning system detects A-bin's completeness degree reaches the threshold, the system will see the learning missions in the first learning scene are accomplished, that is, 'stage clear' in game's term. At this moment, the system tells A-bin that he complete the first stage by pop-up messages followed by beeping and suggests A-bin to challenge the next stage.

Unlike A-bin, Stis does not have particular objective in the Zoo. The individual ubiquitous learning system installed in his smartphone first tells him several small stories and allows him to choose his favorite one(s). Also, the system will guide Stis to some learning spots which cover the Zoo's major topics. For examples, the system might tell Stis that, "you know? The chimpanzee's DNA is 99.99% similar to the human beings, but why they didn't evolve like us?"; and, the system might also ask Stis to see something first and do some small activities. If Stis expresses his interest in specific story, learning object(s), or activities, then the system builds the learning scenes and learning paths for him dynamically.

2 Introduction

In the traditional way of teaching, most of time is spent by lecturing and the learners are always just sitting there watching and listening. The learners work individually on assignments and do indoor learning. In 21st–century learners have different learning ways from earlier, for examples, doesn't like their teachers used to use papers and pens, learners now have used to use different information technologies; and, doesn't like their teachers used to do survey and self-learning in library, learners are familiar with using World Wide Web to do survey and self-learning [1].

In recent year, ubiquitous learning extends e-learning from indoor to outdoor, moreover, not like most of mobile learning applications which usually only provides

the knowledge of single domain in particular environment, the ubiquitous learning emphasizes to offer learners interdisciplinary knowledge domains in the real world [8]. Ubiquitous learning also provides the learning activities which allow learners to observe and touch the learning objects in the real world based on learners' choices and preferences [19]. If learners want, they still can do suchlike solving problems, answering questions, expressing and organizing questions, and even brainstorming, during their learning processes [7].

Active learning makes learners learning better because they are doing what they feel interesting and they feel that they are controlling everything. Games can encourage learners to learn after classes. Learners are usually 'actively' to play their favorite games. So, it might be work if we apply game concepts, scenes and scenes switching, to help learners 'active' learn and have fun in the ubiquitous learning environment.

Frankly speaking, playing games is really more interesting to users rather than learning things, no matter the learning activities are occurred in classroom, websites (e-learning), mobile devices (mobile learning), or real world (ubiquitous learning). However, all of the successful factors we see the games achieved are building on the free-will of players. The meaning of the free-will of players is leaving the players to decide what games they want to play with, which also means, the games allow the players make calls.

This paper uses two game concepts, "control" and "challenge", to develop a game-based ubiquitous learning environment in which learners (players) can make their own decisions in the learning topics and can challenge different learning scenes step by step.

Section 3 introduces the related works of ubiquitous learning environment, game-based learning, different knowledge structures, and different learning strategies. The relations and definitions between the elements of the learning scene are described in Section 4. Section 5 uses a way to construct learning scenes and introduces how to switch between the scenes. In Section 6, a real example of ubiquitous learning in the museum with learning scenes is built to demonstrate the effects of this research. Finally, Section 7 makes a conclusion and discusses the possible future works about individual scenes layout and switching.

3 Research Backgrounds

3.1 Ubiquitous Learning and Game-Based Learning

In traditional teaching way, the classroom is the major place in which the teachers and learners get face to face at the same time. The learners can only get the learning materials prepared in advance by the teacher. Hence, the learning activities are limited by what the teacher has arranged and the materials and courses are difficult to be modified immediately according to students' learning status. E-learning uses computer and internet technologies to allow teachers teaching and learners' learning [1]. E-learning provides a new learning method to allow learners doing learning activities with e-mail, web-camera, and web-based testing, even if the teacher and learners are not getting together. Mobile learning extends the learning from indoor to outdoor, gives learners opportunities to understand the learning materials via touching, observing, and feeling the learning objects in real environment [4][5][10].

Mobile learning provides both teachers and learners a new learning way in the e-learning field, however, there is still an unsolved research issue, which is the flexible learning issue. The learners' learning activities will be limited in the specific learning

environment and/or the specific domain knowledge arranged in advance. Ubiquitous learning not only extends e-learning from indoor to outdoor but also extends mobile learning from specific learning environment and specific knowledge domain to anyplace and multidiscipline [9].

Some researchers have thoughts that there are four characteristics of games could enhance learning effects: (1) challenges; (2) fantasy; (3) curiosity; and, (4) control [11]. Regarding the first characteristic, the challenges, Malone has offered the instructional activities which have a various difficulty levels to different learners according to learners' abilities [12][13]. The different learners then will face different challenges.

Many researches indicate that by using games in teaching can encourage learners to learn after school and increase learners learning motivation. This paper not only focuses on the first game characteristic, the challenges, but also makes learners "control" what they want to learn according to their interests in the ubiquitous learning environment.

3.2 Knowledge Structure

In order to make learners control the learning activities in the ubiquitous learning environment, first of all, the ubiquitous learning system has to know what the learners interest with and what the learners have already known. Usually, the knowledge structure is a good way to represent and store the information that a ubiquitous learning system may require.

Ogata and Yano have proposed a knowledge awareness map [16], which is a kind of knowledge structures, visualizes the relations between the sharing knowledge and learners' interactions. Computer-assisted learning system tries to find the useful things out for learners and pick the most appropriate one up to help the learners. However, the learners might have different demands, for examples, different learning preferences and different learning places. Therefore, the technology, such as Perkam [6] (PERsonalized Knowledge Awareness Map), which is used to support learning according to individual learner's preference is very important.

Morton and Bekerian have proposed two features about knowledge structure, which are Semantic Network and Schema Theory. Semantic network emphasizes the knowledge organization in human brains, which is also called the knowledge structure. Schema theory emphasizes the operational process of knowledge in human minds [14]. Furthermore, Novak and Gowin have also applied the knowledge structure in education, which is called Concept Map [15]. Learners can concrete the concepts and the knowledge they have learned from the courses by drawing their own concept maps, and the teacher can examine the individual learner's concept map to know the learner's learning status and learning effect.

3.3 Learning Path

Ubiquitous learning involves the real learning environment, therefore, a ubiquitous learning system has to take not only suitable learning objects but also distance into consideration when plans a personalized learning path for the learner.

Chang and his colleagues have provided a way to create learning path for learners [2][3]. After the learner takes a test, Chang and his colleagues use the concept map closeness for each learning object between the teacher's and the learner's to know what learning objects which a learner should learn first.

Although the learning path is useful to learners, in a ubiquitous learning environment, learners may not always familiar with the environment. Kuo et al. have developed a way to generate the guidance message by using information theory [10].

3.4 Learner Profiles

In order to apply the game features into the learning system, the learner profile have to add several game-based characteristics. In game-based learning system, learner profile should have the abilities or skills to describe the learner's individual information, for examples, "ID", "ability", "training level", and "major preference".

Because the most important game feature is "control", the game-based learning system should allow learners chose what they want to learn and/or what they interest with. Therefore, the major preference stored in the learner profile can be very useful. A learner's major preferences might be divided into several different parts (or says knowledge domains), take learning in a museum for example, the major preferences could be "Sung dynasty", "Ming dynasty", "wood", and "Bamboo".

This research uses context-awareness knowledge structure to store the domain knowledge and personalized preference. In a ubiquitous learning environment, the knowledge structure not only focuses on learning materials' characteristics but also the different knowledge domains which are covered by the learning objects around the learners. The different knowledge domains might be covered the same learning object set, for example, both of the free-falling theory in physics and architectural engineering are covered by the learning object, the Piazza del Duomo, in Italy.

4 Scene Analysis

4.1 Scene Definitions

For storing knowledge and learning object information, this research defines "learning scene" to record all learning locations and objects in the ubiquitous learning environment. Besides, the scene is also used to gather the information about what learning objects exist in different learning locations.

A scene will cover many learning areas; each learning area is a physical place, for example, an exhibition room in a museum. In each learning area, there is at least one or more learning spot. A learning spot may cover one or many learning objects. Take a museum for example, there are many exhibition rooms (the learning areas). Each room has at least one learning spots. When the visitor stands at each learning spot, he/she can see one or many artifacts (the learning objects).

There are two major elements in a scene as Fig. 1 shows: (1) Learning spot (spot), indicates a learning location which covered the learning objects in a personalized knowledge structure; (2) Learning object (object), denotes possible learning objects for the learning spot.

The context-awareness knowledge structure can be used to extract the personalized context-awareness knowledge structure in order to provide individual services according to the learner's preferences, for example, to decide which learning objects in the learning spots should be learned by the learner.

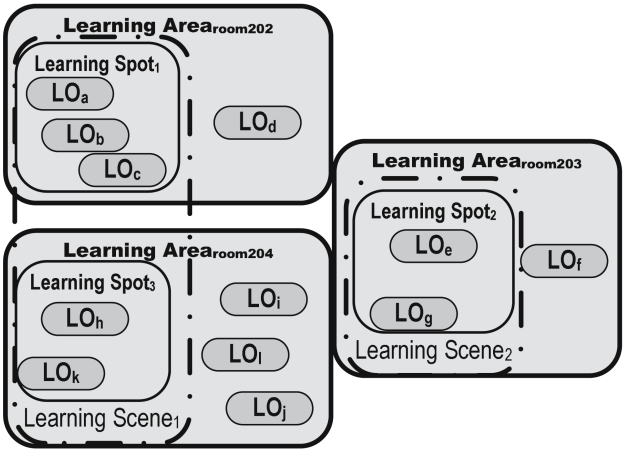


Fig. 1. Learning environment elements

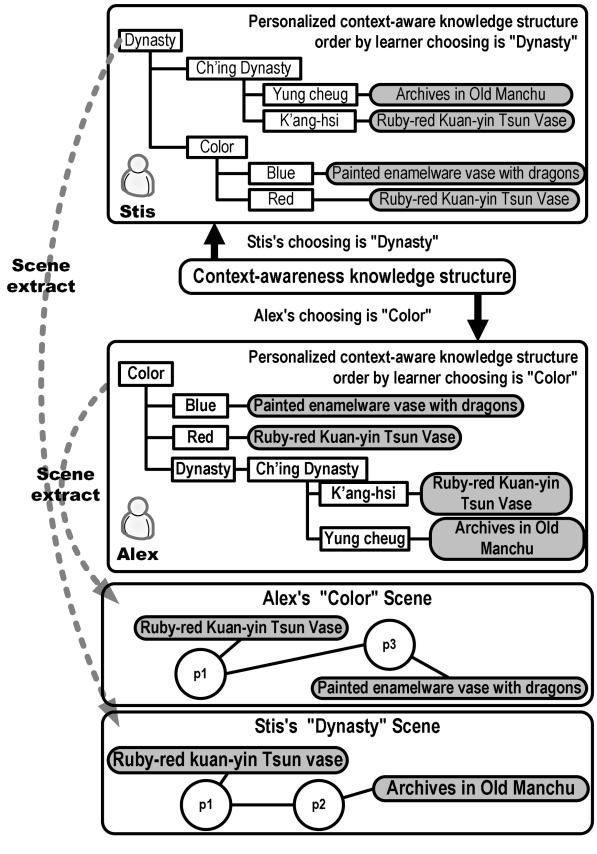


Fig. 2. Examples of two personalized context-awareness knowledge structures

4.2 Relations between Scenes and Personalized Context-Awareness Knowledge Structure

A personalized context-awareness knowledge structure can represent individual learner's preference in the ubiquitous learning environment. Furthermore, the ubiquitous learning system can provide different learners different learning objectives according to their personalized knowledge structure automatically.

The personalized context-awareness knowledge structure then can be used to build learning scenes for learners. Because different learners with different preference will feel differently even when they are looking the same learning objects in the real world, hence, the suitable learning scenes to the learner can be built once the ubiquitous learning system has the personalized knowledge structure. Moreover, different learning activities can be given to learners depends on their preferences and learning objects' characteristics.

In Fig. 2 there are two learners, Alex and Stis, have different viewpoints and/or preferences about the artifacts in the museum. The top part of Fig. 2 shows Stis' personalized context-awareness knowledge structure. Stis prefers the "Dynasty" characteristic rather than the "Color", hence, his personalized knowledge structure is constructed based on "Dynasty" characteristic. On the other hand, Alex has more interest in "Color", therefore his personalized knowledge structure root is constructed based on "Color" characteristic.

According to Wu's personalized knowledge structure [18], the major scene subject for Stis is "Dynasty". The bottom part of Fig. 2 shows how the ubiquitous learning system selects all learning objects related to the subject, "Dynasty", which Stis interests with to form a learning scene for Stis. Similarly, Alex's learning scene can be also constructed.

4.3 Game-Based Measurement with Learning Scenes

As the bottom part of Fig. 2 shows, there are many learning objects matched the preference of a learner. The next problem is what learning object should the ubiquitous learning system suggests the learner learning and observing first.

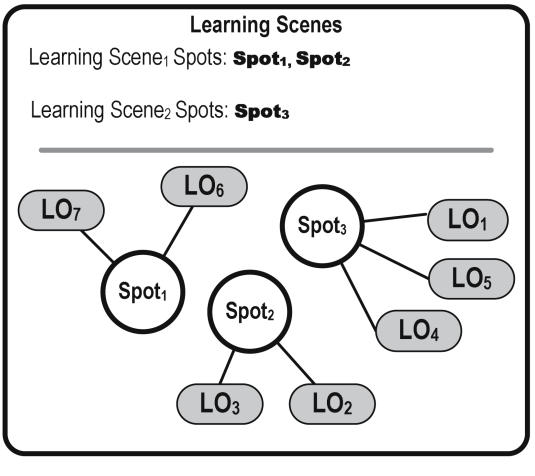


Fig. 3. Example of learning scene and objects

Fig. 3 shows an example of two learning scenes cover three learning spots and some learning objects. Assuming a learner stands at the learning $spot_2$. At learning $spot_2$, the learner can find two learning objects, $\{LO_2, LO_3\}$. Each learning object has its own characteristics about "Dynasty" subject. For example, the learning object LO_2 may have characteristic suchlike "Items of daily use were specially produced for the Ming imperial court". Moreover, the degree of realizing these story-like characteristics of learning objects can be seen as a quantitative measurement of learners' abilities and/or skill points based on the game-based learning theory.

This research defines the game-based measurement with the personalized learning scenes based on the probability theory. If a learner gets the idea from the questions, then the probability of specific characteristic will be raised and the probability represent the learner's degree of mastery in the specific characteristic. When the overall probability of a learning scene achieved a threshold, the ubiquitous learning system can say that the learner clears the stage or levels up, and ready to challenge another stage or level (another learning scene).

5 Scenes Construction and Switching

5.1 Scenes Construction

This research develops a way to extract scenes from the personalized knowledge structure. The whole scene construction flow involves 5 phases as Fig. 4 shows:

1. Phase I: Learning materials analysis, the learning objects in real environment have a lot of information (or also called characteristics), which might cover different domains or places. In this phase, we need to analyze the learning objects and its characteristics in the real world first. After this phase, the context-awareness knowledge structure can be built.
2. Phase II: Basic personalized context-awareness knowledge structure construction, because the personalized context-awareness knowledge structure should be created according to the learners' preferences and interests. The basic personalized context-awareness knowledge structure for individual learner can be constructed depends on which stories the learners interest with.
3. Phase III: Personalized context-awareness knowledge structure refinement, even if two learners choose the same story in phase II, their interests still might be a little different. In order to precisely refine the personalized context-awareness knowledge structure, the system asks the learner some advance questions about the characteristics of the learning objects which are involved in the story the learner has chosen. The personalized context knowledge structure is then refined according to the learner's feedback.
4. Phase IV: Personalized context-awareness knowledge structure generation, after repeating the phase II and III, the correspondent learning objects and characteristics the learner might need and/or interest with are clear to the system. The learner's personalized context-awareness knowledge structure is then can be generated in this phase.
5. Phase V: Learning scenes construction, the ubiquitous learning system can extract the learning objects that the learner may prefer according the personalized context-awareness knowledge structure. Because the personalized knowledge structure can represent different knowledge domain and the learning objects locate at different locations, the ubiquitous learning system then construct the game-based learning scenes based on the distinction features of the selected learning objects, such as "location" and "domain", as Fig. 4 shows.

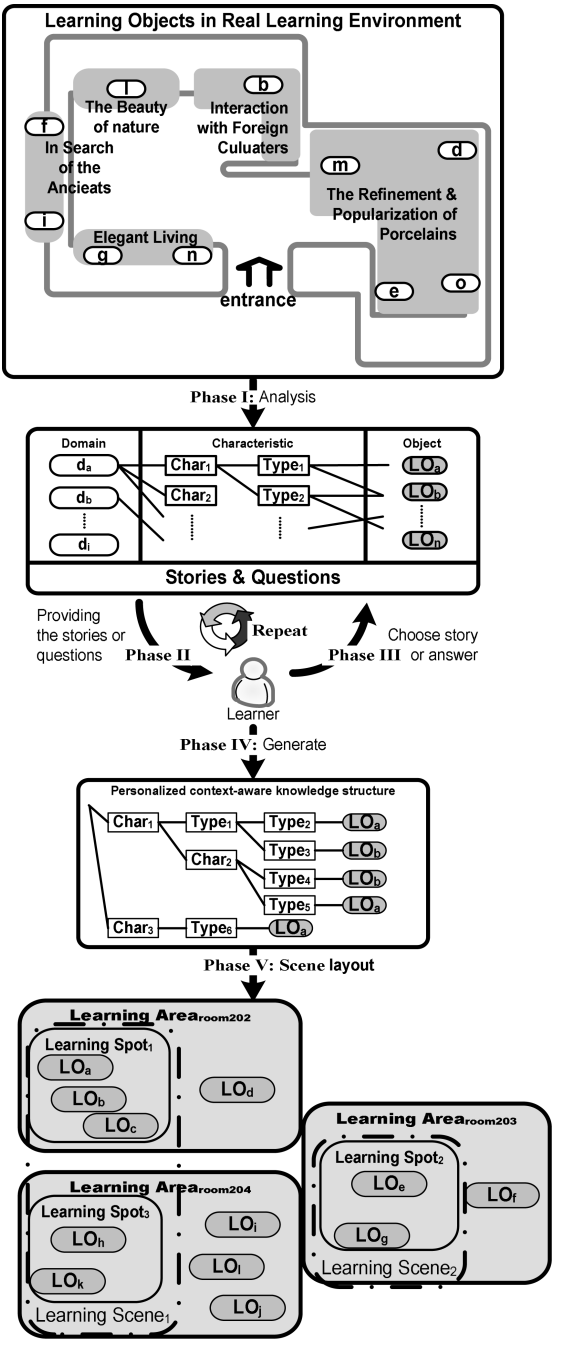


Fig. 4. The five phases to build individual scene

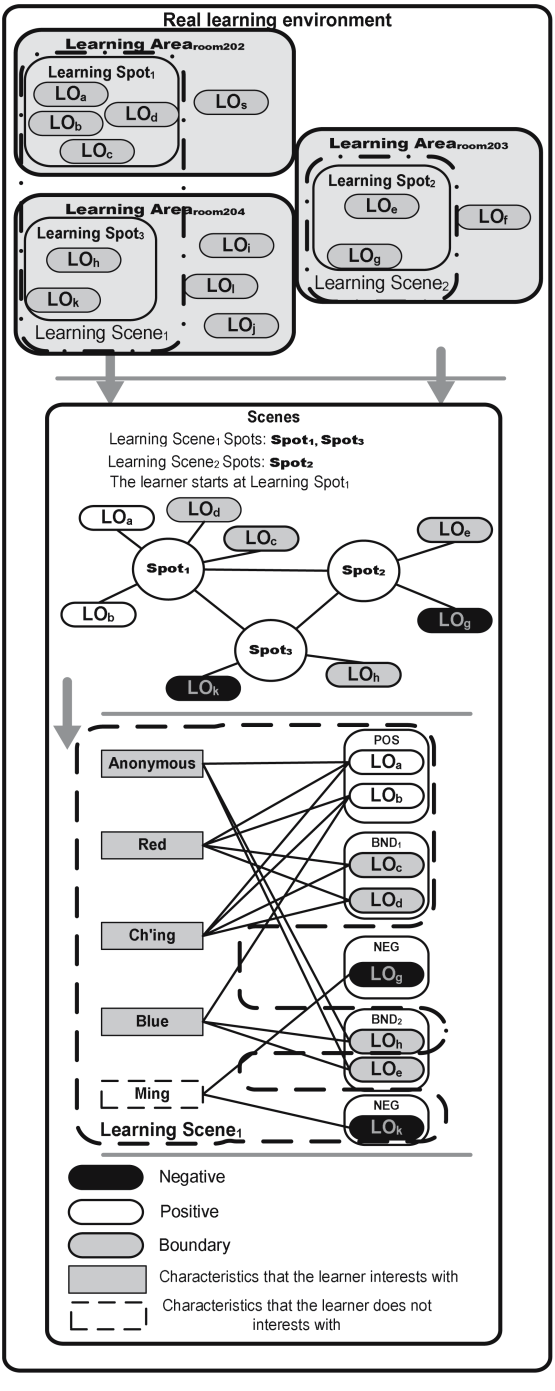


Fig. 5. The relation between characters and learning objects

5.2 Scenes Switching Principles

This research uses rough set theory [17] to develop scene switching methodology. In the rough set theory, data will be divided into three sets, including the Positive Set (POS), the Negative Set (NEG), and one or more Boundary Sets (BNDs). This research defines the positive set data as the learning objects which have more than one characteristic the learner is interesting with, the learner has to observe the learning objects in the positive set. On the contrary, the learning objects in the negative set don't have any characteristic that the learner interest with. Unlike the positive set and the negative set, there are many boundary sets in the learning scene. The learning objects in a boundary set also have the characteristics that the learner interests with. The difference between the positive set and the boundary set is that all of the learning objects in the same boundary set have the same characteristics, and the learner only needs to observe one of the learning objects for the same boundary set when he/she does learning activities in the ubiquitous learning environment.

Fig. 5 shows an example of using rough set to categorize learning objects involved in learning spots. At top part of Fig. 5, there are two learning scenes cover three learning areas. Each learning scene has one or more learning spots, and each learning spot contains one or more learning objects. In the middle part of Fig. 5, every learning object has many characteristics. The learning objects can be categorized into three sets. Table 1 lists a summary of the three sets and its learning objects.

Table 1. Three sets and its learning objects

POS	LO_a , LO_b
NEG	LO_g, LO_k
BND_1	LO_c, LO_d
BND_2	LO_e, LO_h

From Table 1 the ubiquitous learning system knows that the learner has to observe the learning object LOa. If the scene only includes four characteristics, including "Anonymous", "Red", "Ch'ing", and "Blue", then the ubiquitous learning system can do scene switching after the learner finished observing the LOa and LO_b.

6 Complete Example

6.1 Game-Based Learning in Museum

By using the game concept to help learner learning in the ubiquitous learning environment, the first thing is to define the learner profile suchlike "ID", "ability", and "major preference". The major preference includes the characteristics in the personalized context-awareness knowledge structure suchlike "dynasty", "color", "function", and "author", in Fig. 6. Ability is the learning object characteristics which learner has been observed. ID is the learner's name.

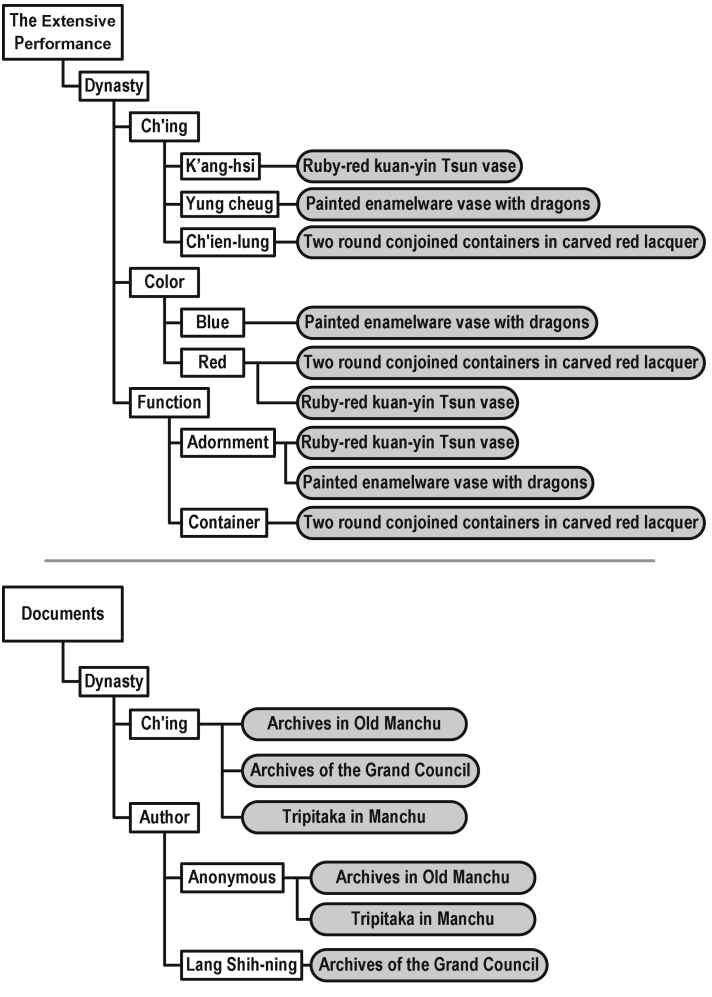


Fig. 6. The partial context-awareness knowledge structure in a museum

6.2 Scenario

This paper takes learning in a real museum for example. In a museum, there are many artifacts with different subjects and/or topics exhibiting in the different rooms. For example, the Room 203 in a museum as Fig. 7 shows, the "gray area" represents different subjects and/or topics (learning spots) suchlike "Elegant Living", "In Search of the Ancients", and "The Beauty of Nature"; "black circle" represents the artifacts (the learning objects) in the room; the number is the artifacts number. There are eleven learning objects in Room 203. This research considers a room as a learning area.

According the Phase I in Fig. 4, Fig. 6 shows the analysis results of learning objects. Fig. 6 represents how to use context-awareness knowledge structure to store a museum's learning objects and its characteristics.

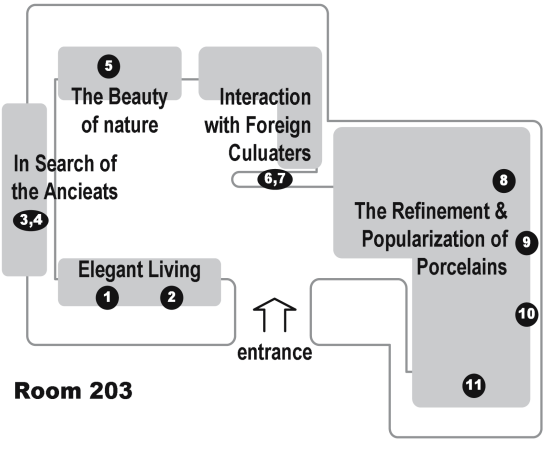


Fig. 7. Room 203 in a museum

The personalized context-awareness knowledge structures and game-based learning scenes are constructed based on with the learners' choices and their answers about the questions of artifacts' characteristics as Fig. 8 shows. The width or depth of personalize context-awareness knowledge structure depends on how much the learners' interest with and how exquisite they know.

Question

1. Items of daily use were specially produced for the Ming imperial court
2. The administration of porcelain production was very strict Following Cheng Hos maritime explorations in the early Ming
3. Diplomatic credentials are official documents sent by the head of state, as representative of his government, to the head of another country

Fig. 8. Example of the questions about "The Fashionable vs. the Antiquarian"

Fig. 9 shows the process of constructing the learning scenes after the learner answered the questions. After the learner answered the questions, the ubiquitous learning system can revise the personalized context-awareness knowledge structure and find the preference learning objects and interesting characteristics from the personalized context-awareness knowledge structure. Furthermore, the bottom part of Fig. 9 shows how to use the personalized knowledge structure to realize the learning preferred objects' locations, to define the learning spots, and to construct the learning scenes for individual learner.

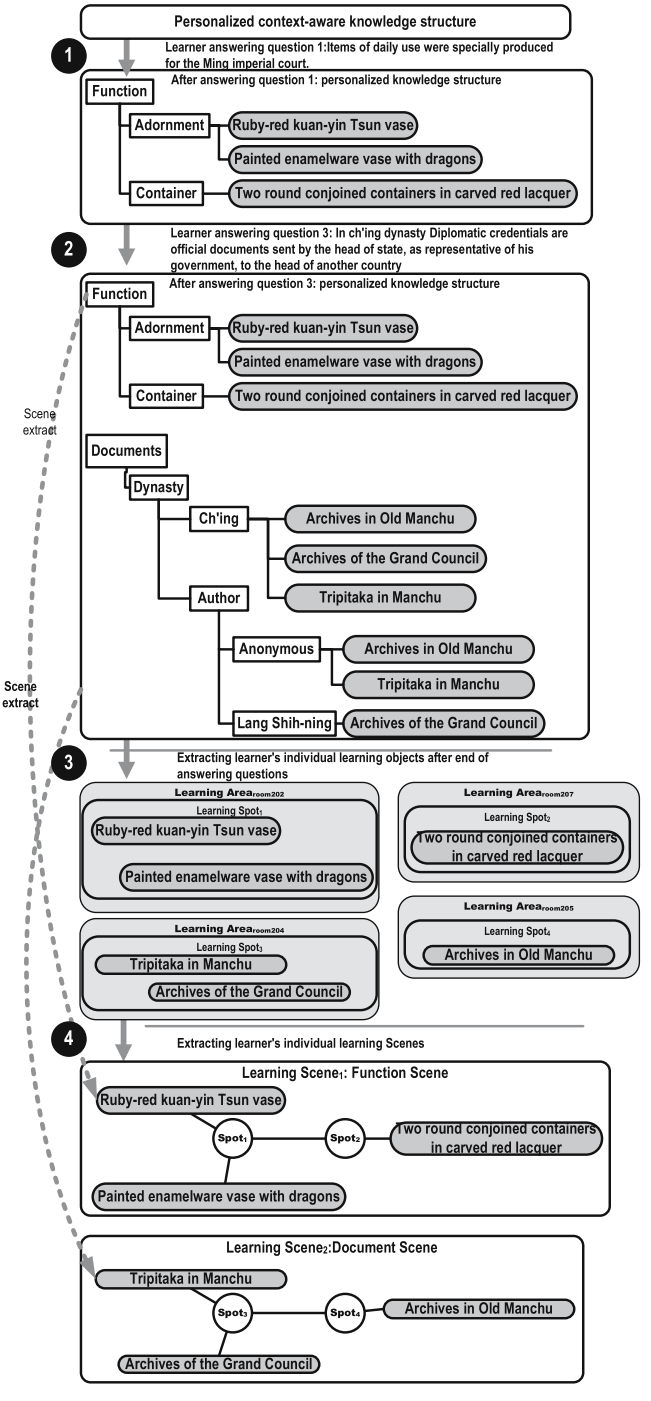


Fig. 9. Scenario constructing process

6.3 Individual Learning Path in Museum

With the learning scenes, this research uses the distances to plan the observation sequence for the learning objects in the positive set and boundary set that the learner may interest with.

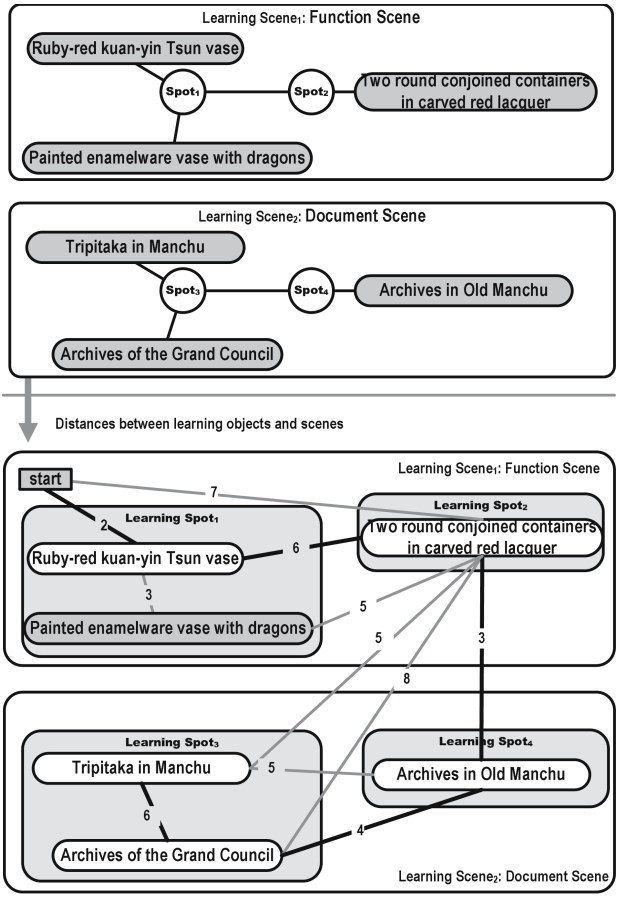


Fig. 10. Function scene and document scene relationship in scenario

The ubiquitous learning system then first picks the learning objects in the POS set, including "Ruby-red kuan-yin Tsun vase", "Two round conjoined containers in carved red lacquer", "Tripitaka in Manchu", "Archives of the Grand Council", and "Archives in Old Manchu". The learning path has to route every POS set learning objects.

Fig. 10 uses the "white ellipse" to represent the learning objects in the POS set, the must be observed learning objects. The scene can be switched from the Function Scene to the Document Scene after the learner has finished observing the white ellipse learning objects. According to the distance, the ubiquitous learning system generates

the learning guidance path: start → "Ruby-red kuan-yin Tsun vase" → "Two round conjoined containers in carved red lacquer" → "Archives in Old Manchu" → "Archives of the Grand Council" → "Tripitaka in Manchu".

7 Conclusions

There are two features of game-based learning theory are taking into this research, the control and the challenge. This research uses small stories and correspondent simple questions to let learners chose what they feel interesting and/or need. The learner "controls" what they will learn in the ubiquitous learning environment. The learners have to complete one learning scene before they can move to next one. They "challenge" the different stages one by one.

This paper proposes a way to construct game-based learning scenes and scene switching methodology according to learners' preferences and abilities. The research uses the personalized context-awareness knowledge structure to build the learning scenes for learners in ubiquitous learning environment. The ubiquitous learning system uses story and correspondent questions to realize the learner's preference and interests, refines the personalized context-awareness knowledge structure, constructs the learning scenes for individual learner, finds out the suitable learning objects, and plans the most appropriate learning path for the learner.

There are still some research issues could be discussed and done in order to improve the scene switching and learning path generation. For example, as we mentioned, the challenge issue. Currently, the game-based ubiquitous learning system uses probability as the measurement of learner (player) abilities. The next step is how to provide an automatically generated and non-interrupt adaptive test for such kind of ubiquitous learning environment. Regarding the learning path generation issue, the current research and system uses only distance between the learning objects. As we all know, it is just the simplest solving way, in the future research, other factors such-like learning scenes should be taken into consideration. Also, our next step should measure the cost effectiveness of the method proposed in this research. We are planning to do several different field experiments for biology course with the elementary schools.

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