A Methodology of Integrating Knowledge into Applied Game and Validation of Education and Entertainment Effects

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Abstract. Applied game aims to help player accumulate knowledge, improve skills, or enhance emotion quotient through game playing process. Although many applied games have been developed in education and training fields, the solution on issues of balance between education and entertainment is still open. This study proposes a methodology for integrating knowledge with applied game combining recreational functions and pedagogic effect. For the purpose, the unified representation based on ontology is employed for game elements, game challenge model and knowledge expression with which the relationship mapping mechanism from diverse categories of knowledge onto game atomic element, especially primary rule, is constructed. As a result, a practical design technique that facilitates to import knowledge into applied game is achieved. In order to verify the practicability, a case of applied game, Qbaby Picture Matching game is designed and developed based on the proposed method. It has been running online and applied in a kindergarten. Moreover, an experiment is performed to identify the effects of education and entertainment. The results imply that the game can definitely produce recreational functions and pedagogic effect. The fact indirectly verifies that the methodology may effectively integrate knowledge with game thereby providing a referable solution for issues of education and entertainment balance.

Keywords: Applied game · Knowledge · Event ontology · Game challenge

1 Introduction

Applied game, might be called educational game or serious game, is defined as a digital game integrating cognitive process with game challenge which helps learners accumulate knowledge, improve skills, or enhance emotion quotient. For it educative objective, one of the key points of designing applied game is investigating balance mechanism between entertainment and education aspects which gives instructions for designing a game with pedagogic function and recreational feature. According to the

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characteristics of learning software and game [1], it is essential to analysis the relationship between cognitive procedures and game playing sessions and to give a methodology for integrating two activities. As a new element to be imported, knowledge plays a very important role in applied game. Study on a model of unified representation shared by knowledge and other game elements game may provide a basis to analyze their relationships and thus propose an alternative reference to solve the balance issues mentioned above.

2 Related Work

For the purpose er model and learner model identifying his or her behaviors and knowledge states respectively, is applied in an educational game to implement personalization and adaption [3]. It facilitates to track the player's knowledge state according to which apof education and entertainment in designing applied game, many researchers propose several models or methodology. EFM is a model which connects motivation of learning, flow experience, effective learning environment with educational game [2]. It gives guideline and ideas for designing educational game such as to set up goals according knowledge and skill, process and method, attitude and values objective, etc. NGLOB (Narrative Game-based Learning Objects) method, which combines play propriate game structure is adapted in personalized and adaptive manner. But, as it states, NGLOB-based method is mainly aimed on personalization and adaption. The performance of combining knowledge with game is not addressed. Besides these studies, some researchers propose idea of knowledge-centered and try to make knowledge structurized in games. Bruno et al. [4] created a cognitive model based on analysis of knowledge natures, knowledge classification and pedagogical objectives specification, implementing the connection between knowledge and game. The model applies "object-oriented modeling" technique and refers to meta-knowledge model which describes learning activities and leaner's mental processes. The approach helps to give a reference when design a game with the objective of combining cognitive processes and game playing sessions. Another method using knowledge modeling is given by Minović et al. [5]. The model constructs pieces of knowledge resources based on learning objects to establish the balance between knowledge and its reusability. In his presented methodology an educational game metamodel and knowledge metamodel are designed using UML and XML. The approach is aimed to step towards a unified framework for development of educational games.

The methodologies and models above contribute to design and develop applied games with functions of entertainment and education. However, works on relationship and mapping mechanism between game elements and knowledge are not enough to support a framework which specifies the details of knowledge importing. Therefore an unified representation of elements in game including knowledge maybe a feasible approach for analyzing the relationships between game and knowledge and contributing to construct the specification of knowledge-game integration.

3 The Methodology for Importing Knowledge into Game

The paper proposes a Game General Elements Model (GGEM) specifying a unified representation for all game elements, and Game Challenge Model (GCM) which is based on the former with the purpose of identifying the essential factors that make game attractive. The two models contribute to construct a mapping mechanism between knowledge and game elements accordingly implement fully integration at particle level.

3.1 Game General Elements Model (GGEM)

No matter what category a game belongs to, it consists of some general elements such as mission, character, tool, scene, etc. In this section, a model is constructed to describe all general elements according to practical experience.

Game elements can be classified as two categories: explicit elements and implicit elements. The former can be viewed as entities in game that corresponding to objects or facts in real word and is normally visible in interface. The latter refers to invisible factors such as rules, parameters, or event that only be perceived through hint or feedback when player interacts with game environment. The model is based on concept of ontology and implemented by protégé. Figure 1 shows the framework of the model. As it implies, GameExplicitElem and GameImplicitElem stand for the explicit elements and implicit elements respectively. GameSubject and GameObject are two main typical explicit elements. GameSubject refers to the entities in game that can be controlled directly by player, while GameObject is the one that cannot be controlled directly by player and only impacted through interaction with subjects. Among implicit elements, GameRule is the key element of a game which regulates all other elements' behaviors and interaction mode between player and game environment. Therefore it is also regarded as core of a game which specifies the game nature. GameKnowledge is another implicit element which is one of the main factors to distinguish applied game with other entertainment game. Knowledge cell in game may be a concept, fact, procedure, technique, formula, or method. They may be diverse patterns according to the knowledge types and learning objective.

3.2 Game Challenge Model (GCM)

Game should be fun and attractive. But what is the essential mechanism to make played attracted by a game? The question can be converted to another issue: what is the origin of gameplay [6]. Some researchers propose ideas like dividing game into elements or units which act as block to construct a game for analyze game natures [7]. Huang states that playing experience is the core of a game [8]. It refers to synthetical perception including art enjoy, thinking process and mental feeling through playing a game. From the aspect of interaction, playing experience is affected by feeling of sense organs and body, such as immersion of 3D environment, easy controlling method, or coordination of eyes hands. From the psychology and emotion of player, experience may come from

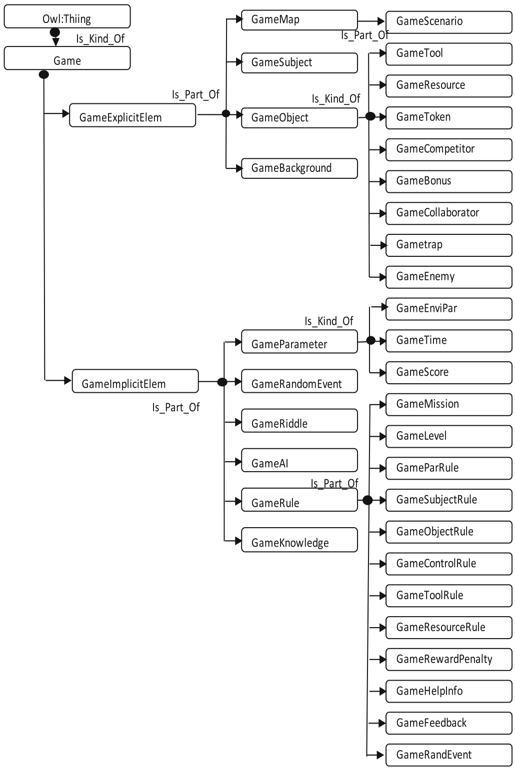

Fig. 1. Framework of game general elements model

delighted mental feeling, such as sense of achievement after a large amount of effort, or enjoyment from a splendid image and melodious music, or gratification from an exciting and tense atmosphere [9]. Therefore, game playing experiences mainly relate to two contents: one is interacting process based on rules; the other is mental feeling or body sense. Interaction process is the procedure of game challenging while mental feeling or sense may partially generated from challenging. Consequently, study on game challenge can help to identify the origin of gameplay.

In this paper, Game Challenge Model (GCM) based on GGEM is proposed to gives configuration for game challenge, aiming to address the essential mechanism of a game which makes player immersed in virtual environment. As discussed above, game challenge involves interaction process and mental feeling or sense caused by challenge, the model is focused on the interaction specifics through description of game elements behaviors and the key factors which motivate positive motions or facilitate mentality training.

Challenge comes from difference or distance from player initial state to the objective capability which is necessary for achieving game mission. That means player should spend a moderate amount efforts to reach the goal. Due to diversity of challenges of game, a hard action, tough puzzle, complicated tactics or strategy, even a simulating activity can form challenge content. Thereby the model can be classified as ActChallModel, PuzChallModel, StratChallModel, and SimlChallModel which specify tasks as performing actions, solving puzzles, making strategy, and experiencing simulation activities respectively.

A game challenge model may not compulsorily be corresponding to one specific game. Conversely, a game is not mandatorily limited to contain one challenge model. Many games are design to be synthesis of several challenges of actions, thinking, creation or other aspects. The model merely gives fundamental blocks to constitute a complex game based on the GGEM.

For any category of challenge model, it consists of main elements as illustrated in Fig. 2: PrimRule describing the key rule which regulates main elements behaviors; Mission interpreting what a player pursues; InterMode indicating how a player controls game; ChallFactor elaborating the essence that makes player attracted and kept trying to approach the goal.

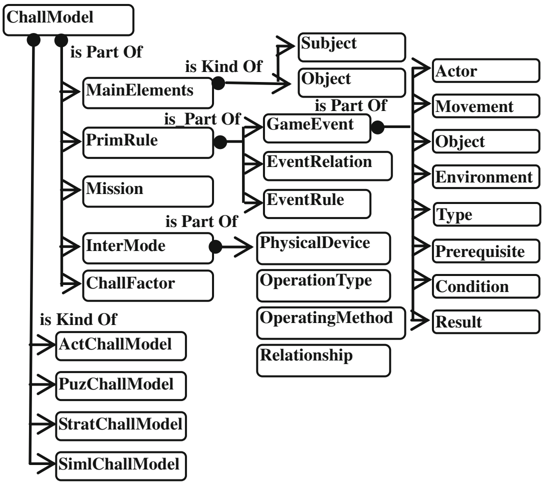

Fig. 2. Composition of game challenge model

To be in accord with GGEM, ontology is employed to construct the game challenge model. In the model, MianElements lists subject and main objects with their primary properties which can be obtained directly from game elements model. PrimRule is generalized regulations and can be viewed as valid actions set or possible events sequence. In the paper, event ontology is introduced to represent events. It normally involves dimensions of participant, action, type, occurrence, spatial or temporal information, etc. According to the definition of event ontology [10], triple-tuple expression is used for complete and efficient representation of PrimRules: {GameEvent, EventRelation, EventRule}. GameEvent is a class consisting of eight tuples referring to the six-tuple definition of event given by Liu et al. [10], it is modified and added supplementary factors for describing game event in virtual environment as {Actor, Movement, Object, Environment, Type, Prerequisite, Condition, Result}. Actor usually refers to subject of game; Movement stands for subject's movements or actions set, including description of mode, pattern, duration, intensity; Object are the one who accepts the action; Environment identifies location, time, or parameters of virtual game environment; Type indicates what category an event belongs to, such as continuous process with prosperity of duration or discrete movement occurring instantaneously; Prerequisite is trigger that initials an event; Condition means the requirements that maintain event; Result describes consequence an event produces. EventRelation refers to relationship among all possible events in the model, such as Causal or Sequential, and is used to imply possible event sequences generated by the model.

Mission specifies the objective state of game elements which indicates direction for player action. It also describes the requirements for game continuously running or thresholds for entering next level. Mission is represented as key concerned game element with definitive relationship and rules.

InterMode determines how player controls game elements. With the advancement of technologies, human-computer interaction is getting more natural and approaching to manipulation in real world. Generally, interacting operation can be classified as: (a) acquiring information from game environment including referring to help, viewing map, or reading values of parameters; (b) manipulating individual element, such as moving, rotating, creating an object, or controlling an avatar to jump and fight; (c) triggering or terminating events, for instance, creating a building, buying, or hiring employee. These operations are implemented through pressing buttons on keyboard, typing commands, using menu, icon, or tool bar, dragging or clicking entities in virtual game environment, writing or drawing objects, touching screen, converting voice into instruction or using somatosensory devices. These diverse methods give player entirely different interacting experience which greatly impacts on playability of game. For involvement of forementioned contents, InterMode is composed of three subclasses: PhysicalDevice which may be assigned as keyboard, mouse, touchscreen, force_feedback, microphone, somatosensorydevice, etc., OperationType can be InforAcq, IndivManipl, EventTrig corresponding to the three operations discussed above, OperatingMethod is specific means embodied by key, command, menu, icon, pointer, touch, voice, movement. Besides, relationships among these subclasses are needed for detailed description of how every single interacting operation is performed. Moreover, when player uses key or command for OperatingMethod, there is always no visual indicator (cursor) or physical touching directly acting on game elements. That means player need create mapping from controlling actions onto game elements behaviors through many practices to master interacting skills. Menu and icon are normally used for information acquiring and event initiation. Pointer may give a visual instruction indicating what objects to be controlled and make interaction more convenient. Touch method means physical touching to identify target. It approaches natural interactions in real world and provides more actual feeling. Voice and movement are another two untouched interaction methods and make player completely participated with his whole body.

In most cases, motivations of playing game come from curiosity for unknown world, desire for recreation, satisfaction or fulfillment from a hard work, etc. Therefore game challenge is concerning with player's psychological demands. In the model, ChallFactors summarized difficulties or novelty of game mission and psychological enjoyment achieved from the challenge. Like other components of the model, it uses event ontology with description of psychological situation during playing process.

For ActChallModel, PuzChallModel, StratChallModel, and SimlChallModel, sub classification is necessary for more detailed expression of each component. Section 4 will give a detailed instance for subclass of ActChallModel using GCM representation.

3.3 The Methodology of Mapping Knowledge onto Game Rule

Because of the educative purpose, applied game should involve knowledge leaning, skill training, or emotion cultivating. Based on the analysis of cognition progress [11–14] and game procedure [15], these two activities can be combined and therefore make a player complete a cognition task through a uninterrupted game experience rather than perform a learning activity such as reading, writing, or answer questions. For jointless integration and effective pedagogic results, imported knowledge is expected to enter game rules and to be essential parts for implementation of game mission. Generally speaking, knowledge representation [16] can be fallen into three types: Declarative knowledge which can be used to give definitions, attributes, states description of an object or a fact; Procedural knowledge mainly telling how it is applied with a manner of procedure or progress; Meta knowledge is knowledge of knowledge. In GCM, knowledge shares the unified representation to make it possible to map knowledge onto game rules. Due to the diversity of knowledge, this section proposes ontology GameKnowledge to denote knowledge in game (Fig. 3).

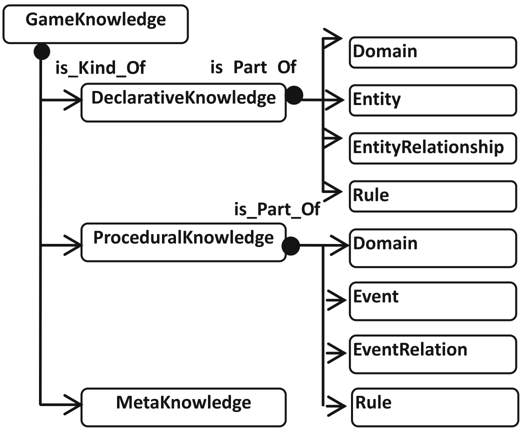

Fig. 3. Game knowledge ontology

For DeclarativeKnowledge, Domain indicates which field knowledge belongs to based on the standard classification of discipline. Entity is defined as class with attributes, used for definition, conception, or description of an object or a fact. EntityRelationship specifies spatial, temporal, topological, or taxonomic relationship among entities. Rule describes inference on entities. ProceduralKnowledge deals with knowledge of procedure, function, method, technique, etc. which generally relates to dynamic events. Event ontology is employed here with the same definition and structure of GameEvent in challenge model.

On the basis of the representations of game elements, mapping knowledge onto game rules can be depicted as follows:

(1) Declarative knowledge:
As given in Fig. 4 Entity describes object or fact which can be simulated as actor or object in GameEvent. Therefore their attributes can be presented through actor or objects behaviors. Moreover, EntityRelationship and rule explicate relationships of entities and events which possibly occur when an entity interacts with others. This part of knowledge consequently can be imported to GameEvent to facilitate describing prerequisite, condition or result of an event. Once they come to be portion of PrimRule, the knowledge is viewed as an essential mechanism to support mission implementation.

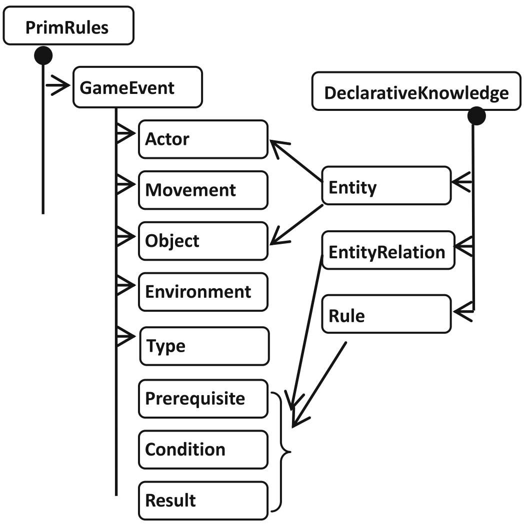

Fig. 4. Mapping declarative knowledge onto rule

(2) Procedural knowledge:
Procedural knowledge uses event ontology to explain program, method, procedure or skill which generally involves one or more dynamic events. Like GameEvent in GCM, the event in ProceduralKnowledge shares the same structure as shown in Fig. 5. Their difference may be determined by proximity from virtual game to the real world. For actually and correctly delivering knowledge, the corresponding classes in Fig. 5 should have high similarity. Consequently mapping knowledge onto game rule is transformed into constructing a similar virtual world composed of analogue contents of knowledge based on the structure of

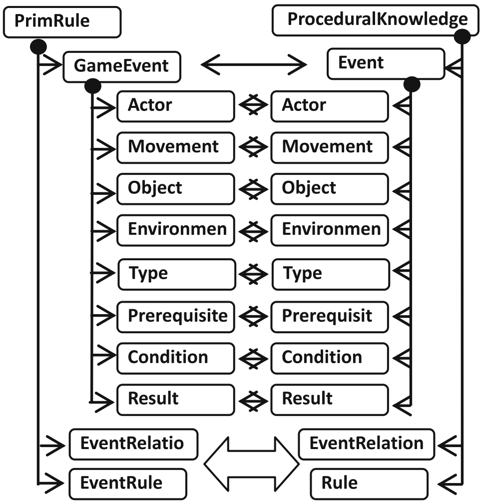

Fig. 5. Mapping procedural knowledge onto rule

appropriate GCM. Obviously, different types of challenge model have distinct detailed architecture and provide more valuable instructions for construction of virtual events and environment.

To sum up, designing applied game consists of following steps: prescribing applied scope and audiences; determining knowledge contents; arranging knowledge organization or creating knowledge ontology; selecting an appropriate GCM according to knowledge category and characteristic; mapping knowledge ontology onto game elements; improving game design.

4 A Case of Applied Game: Qbaby Picture Matching Game

To demonstrate practicability and effectiveness, an applied game, Qbaby Picture Matching game is designed according to the proposed methodology and developed using unity 3D.

The game aimed to help preschool-age children to complete cognition of color, shape, symbol, and other scientific or social knowledge which mainly are declarative knowledge contents and have nothing to do with dynamic events or procedures.

4.1 Creating Knowledge Ontology for the Game

The game is expected to contain knowledge listed as follows:

(1) Concepts related to color, shape, position, geometry; skills for identifying same colors, similar shapes, symmetric figures through comparison; skills for indicating relationship of whole and parts.

(2) Symbols of English alphabets; skills for indicating correlative symbols.
(3) Animals and corresponding food, living environments.
(4) Characterized elements of nations, countries such as building, costume and national flag.

Knowledge for children is defined as: ChlKnowledge = {Class, Relation} in which Class stands for entity or concept with attributes and Relation defines relationships between classes. Therefore knowledge framework can be simplified as following ontology in Fig. 6.

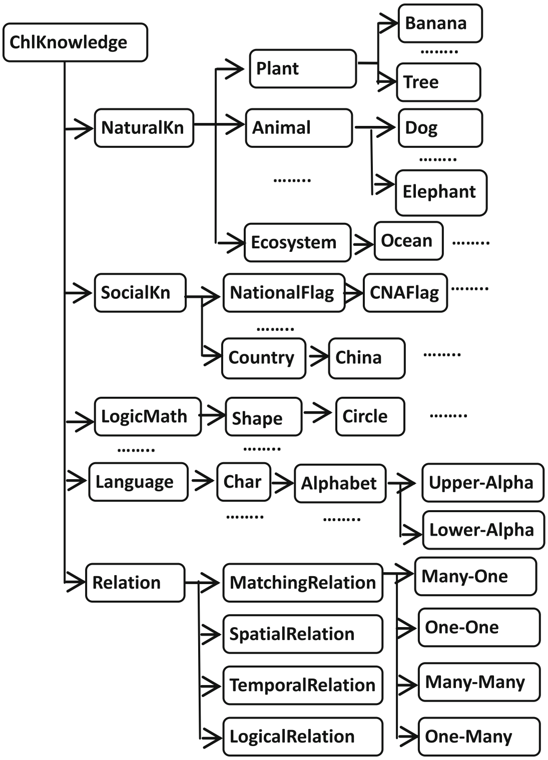

Fig. 6. Knowledge framework for children cognition

4.2 Selecting Challenge Model

For easy interaction, a subclass of PuzChallModel, MatchingChallModel is selected for simulating the learning environment and will be rewritten with more special contents based on the structure proposed in Sect. 3.2 as shown in Fig. 7. The game challenge can be described as: selecting identical or correlated icons if they can be connected using less than three straight lines which results in that the two selected icons disappear. The MainElements is Icon in game. There are generally multiple icons in one game level. So index is needed for identifying every single icon. GameEvent can be defined as Remove. Prerequisite can be stated as: two corresponding icons are selected and their positions make it possible that less than four straight lines form path from one icon to the other. A formal representation of Prerequisite is written as:

$$\begin{aligned} &\mathrm{IsActived}(\mathrm{IconN1}) \wedge \mathrm{IsActived}(\mathrm{IconN2}) \\ &\wedge \mathrm{Relation}(\mathrm{IconN1}, \mathrm{IconN2}) \wedge \mathrm{Connected} - 3(\mathrm{IconN1}, \mathrm{IconN2}) \end{aligned}$$

IsActive(Icon) is function to indicate if the icon is active. Relation(IconN1,IconN2) is function to tell if IconN1 and IconN2 have predefined relationship. Connected-3 is function to calculate possible paths consisting of less than four lines. It returns True if there exits such path(s) and False otherwise. Result of the event is altering icon state into removed and be written as AlterSta(IconN1, IconN2, removed).

Mission is the objective state of game. Suppose that there are m icons, it can be written as:

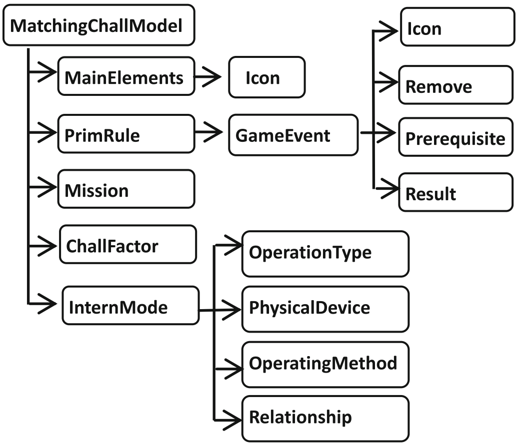

Fig. 7. Structure of MatchingChallModel

$$\begin{aligned} &\mathrm{IsRemoved}(\mathrm{IconN1}) \wedge \mathrm{IsRemoved}(\mathrm{IconN2}) \wedge \mathrm{IsRemoved}(\mathrm{IconN3})\ldots \\ &\mathrm{IsRemoved}(\mathrm{IconNm}) \wedge \mathrm{Terminate}(). \end{aligned}$$

IsRemoved(IconN) is function to tell if the icon's state is removed. Terminate() function will returns True if the game terminates. The mission motivates player in constantly trying to make all icons removed within game limited time. Therefore, ChallFactor can be described as: find the correlated icons, analyze their positions, and click them as soon as possible.

4.3 Mapping Knowledge onto the Game Rule

According to the methodology proposed in Sect. 3.3, the declarative knowledge can be mapped onto MatchingChallModel. Mapping from Entity of knowledge onto Subject or

Object is converted into mapping class onto icon in MatchingChallModel. It means that using visual or graphic icon to standing for a class or concept. Moreover, mapping EntityRelation and Rules onto event's prerequisite, condition and result can be specialized as mapping Relation of class in knowledge onto Prerequisite and result in MatchingChallModel. As given in Sect. 4.2, Prerequisite involve relationship description of icon, therefore Relation of class in knowledge can be integrated with function Relation(IconN1, IconN2) in Prerequisite expression. In brief, for mapping knowledge onto game rule means two tasks: employing graphic icon to illustrate a concept or class in knowledge; defining relationship of icon for Relation function according to the Relation of class in knowledge.

4.4 Game Implementation

The contents to be involved in the game are listed as follows: (1) Matching items of same color; (2) Matching objects of similar shape; (3) Matching animals and their food; (4) Matching whole and part; (5) Matching upper-case and lower-case letters; (6) Matching correlative items; (7) Matching notional flags and country. Each content contains twenty pairs of icons with one-to-one corresponding relationship and is designed with ten levels. The game runs on iPad using touching screen as interaction device. It has been developed by unity 3D game engine and been running online. Figure 8 gives interface screenshots of the game.

Fig. 8. Interface of Qbaby game

5 Verification of Education and Entertainment Effects of Qbaby

For verifying educative and recreational effect of the game, it is applied in a kindergarten and forty-four children are selected whose age ranging from 5 to 6. They are divided into two parts, one part with 20 children for entertainment effect verification and the other part composed of 24 children for education effect assessment. Furthermore, the second part is further randomly divided into two groups with ten children for each. To simplify the experiment, only three contents of the game are tested by two groups. They are Upper-case and Lower-case letters Matching, Correlative items Matching and Notional flags and Country Matching.

5.1 Verification of Entertainment Effect

For assessing playability and recreational effect of the game, another picture matching game, Fruit Matching, is selected for comparison. Control group is arranged to play Fruit Matching, while experimental group play Qbaby. Concerned data to be recorded contains duration of continuous playing of player's own accord, times of retrying after player fails, and final level player reaches. The experiment is performed without any limitation on time and times. Therefore, the combination of the data can imply if a player has continuous motivation on the game and how deeply he is attracted. This fact can give basis to analysis the game's playability and entertainment effect.

5.2 Assessment of Education Effect

On the other hand, for comparison educative effect of Qbaby with traditional learning materials, the two groups are arranged to adopt different learning approaches: the experimental group learn by Qbaby while the control group learn by learning materials using colorful pictures printed on paper (as shown in Fig. 9) for obtaining comparability with game interface.

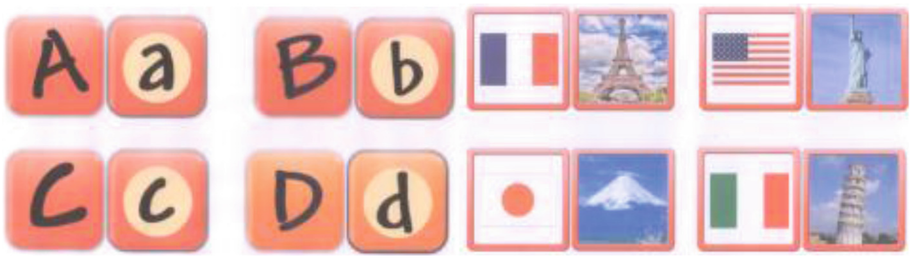

Fig. 9. Learning materials using colorful pictures

(1) Pre-test for obtaining knowledge background

Before experiment, the children are arranged to have a questionnaire to test their knowledge background about the contents that to be tested. Questionnaire consists of ten pairs of items. They are separated and printed on two columns disorderly as shown in Fig. 10. The children should find the matching pairs and link them by drawing lines. The numbers of correctly linked pairs are recorded to identify their initial knowledge levels for next comparison with post-test results.

Fig. 10. Pre-test paper

(2) Post-test for verification of didactical effect

After two groups learning and playing, they are asked to have another test using the same questionnaire in pre-test. Similarly, the numbers of correctly linked pairs are recorded for analysis.

5.3 Data Results and Analysis

The recorded data includes Table 1 for entertainment effects verification and Table 2 for pedagogic effects assessment which contains pre-test and post-test results.

Table 1. Records for entertainment effect verification

	ID	Duration (min)	Retrying times	Level reached		ID	Duration (min)	Retrying times	Level reached
Control group	1	10	6	3	Experimental group	11	8	5	4
	2	9	5	3		12	9	5	4
	3	8	4	4		13	8	6	3
	4	8	5	3		14	9	5	3
	5	9	4	5		15	9	5	4
	6	10	5	3		16	10	5	3
	7	8	5	4		17	9	5	4
	8	9	6	3		18	8	6	3
	9	7	4	4		19	9	4	4
	10	10	5	3		20	8	5	4

To examine the deference between two groups, T-test is applied to identify if two samples have significantly different means using 0.05 as significance level which is generally accepted. For the data of duration (min), P = 0.80062(>0.05), which implies that there is no significant difference on duration of playing between two groups. It shows that the two groups are basically equally interested in entertainment game (Fruit Matching) and the applied game (Qbaby Picture Matching). Similarly, for times of retrying, $p = 0.50555(>0.05)$, indicating that the individuals of two groups have basically same degree of motivation on the two games. Moreover, data of levels that the players reached produced $P = 0.72219(>0.05)$ using T-test shows the two games are more or less equally difficult for them. The above results jointly demonstrate Qbaby is definitely playable and fun enough to make player immersed for a while. Hence, the performance of entertainment is verified.

Table 2. Records of correctly linked pairs in the three contents

Group	ID	Content 1: letter matching		Content 2: correlated items		Content 3: national flag	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Control group: learning by materials	1	1	2	1	4	1	2
	2	0	4	0	4	0	4
	3	3	6	2	4	0	3
	4	2	4	1	5	2	4
	5	0	2	0	5	1	3
	6	1	5	0	4	1	3
	7	1	5	1	3	1	3
	8	0	4	2	5	3	6
	9	0	5	1	5	0	3
	10	1	4	2	6	2	4
	11	0	5	1	4	0	3
	12	2	5	0	2	0	2
Experimental group: learning by Qbaby matching game	13	0	8	1	5	1	5
	14	1	6	0	5	0	3
	15	3	8	1	5	2	4
	16	2	6	1	4	2	4
	17	1	4	0	4	0	5
	18	0	5	1	6	0	4
	19	1	6	1	5	3	5
	20	3	6	0	6	2	6
	21	0	4	2	5	0	3
	22	0	5	0	6	1	4
	23	1	6	1	6	1	4
	24	0	5	2	7	0	5

Like the entertainment verification, T-test is used for educative effect assessment. For clearly comparisons, the values of p for data in Table 2 are computed and listed in Table 3.

Table 3. Values of P for two groups using T-test

	Content 1: letter matching		Content 2: correlated items		Content 3: national flag	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
P	0.85	0.004	0.79	0.006	0.843	0.01

In Table 3, P values computed with records of pre-test for three contents are 0.850, 0.790, and 0.843 (all >0.05). It shows that the two samples have same level background on these contents knowledge. After the experiment, two groups all gain enhancement on the number of correctly linked pairs according to comparison between pre-test and post-test for same content, as indicated in Table 2. It preliminary reveals Qbaby results in improvement on the knowledge and has more or less educative effects. But to identify its advantages, one-side T-test is performed to determine if the control group mean is larger than the experimental group mean. Table 3 gives the post-test P values are 0.004, 0.006 and 0.010 corresponding to the three contents respectively. The values are all less than 0.05. It indicates that the experimental group mean is larger than the control group and consequently verifies that learning by Qbaby can produce a better educative performance compared with learning materials.

6 Conclusions

This research is focused on the methodology of integrating knowledge into game to achieve an applied game combining effects of entertainment and education. With the purpose, knowledge is expected to enter primary rules so that player will gradually increase knowledge or enhance skills during repeatedly practicing game rules thereby makes cognition and game process merged. For construction mechanism of importing knowledge into game rules, a unified representation of game elements and knowledge based on ontology is proposed. As result, the relationships and mapping mechanism between various knowledge categories and game elements, especially game challenge factors, are analyzed and constructed to provide an approach for integration of knowledge with game rule. In order to verify practicability of the methodology, an applied game, Qbaby Picture Matching game which concerns with children cognitive contents is design based on the proposed method and developed using Unity 3D. The game has been running online. For further demonstrating that the methodology can help to design a game with educative effects but not lacking recreational function, Qbaby is applied by dozens of children in a kindergarten. Meanwhile, an experiment is performed to compare knowledge levels before and after the game and identify differences between Qbaby performance with other entertainment game and traditional learning mode. With the analysis of the recorded data, a conclusion is obtained that the applied game (Qbaby) can definitely provide entrainment function and education effect. The fact can be used as evidence to indirectly verify that the proposed methodology can provide a practical reference specification for integrating knowledge with applied game.

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