The Study of Mapping Mechanism Between Game Rules and Knowledge in Educational Games: A Case of Agricultural Game Design

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Abstract. Knowledge plays very important role in educational game. The paper is aimed to investigate a mapping mechanism for knowledge combination with game. The main achievements include: a new system of classification for educational game based on learning objectives and characters of knowledge in it is proposed, based on which, a general-element model of game and its formal representation is given; knowledge is classified into eleven categories according to the characters of game to be combined; relation between knowledge and game rules are analysis and a mapping mechanism is proposed; With the mapping from knowledge to game rules, a general knowledge model for integrating with game is constructed using senary expression which involves domain, entities, relation, sequence, theorem and skills. Finally, an application of agricultural game, Virtual Farm, is introduced to validate the mapping scheme. The experiences of game playing show the combination are effective accordingly making player learn much agricultural knowledge in an unconscious way during game playing.

Keywords: Educational game · Rule · Knowledge · Mapping mechanism · Agricultural game

1 Introduction

Children and adolescents are quite happy to spend many hours playing a game just for the fun of it [1]. It, however, brings some negative impacts on physical and mental developments of children due to its unhealthy contents, such as violence. Therefore, educational game, sometimes called "serious game" or "green game" goes further than simply providing entertainment and are normally associated with education and learning new concepts and skills [2]. In addition, Ambient Insight pointed

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out that the total value of the world's game-based learning market came to US$ 1.229 billion in 2011 with the Asian-Pacific region contributing 66.15 %, predicting that the market (Asia–Pacific alone) would grow to US$ 1.723 billion in 2016 [3]. Many studies are focused on theoretic, methodologies, models, and tools for designing educational game in past years. They proposed approaches on how to make the experience route more consistent with learning process, such as GOM [4]. It gives a template with nine objects trying to propose a way to balance educational capability and character of interest. EFM [5] is another design model based on internal connection of motivation, flow, effective learning environment and educational game. Moreover, multi-agent architecture (MAA) [6] is proposed for mobile educational game. It enables development of a lightweight, flexible, and scalable game on the platform with limited resources such as mobile phones. From another point of view, knowledge, as the core of learning progress, should play a more important role in educational games. Ibáñez proposes an approach of knowledge management to support educational game development [7] through a 'Business Game' created for a large financial institution. The main idea of the approach is to integrated knowledge either directly into the game play as scenarized knowledge or an external resource. Besides, Minovic develops a model [8] for educational game trying to establish the balance between knowledge integration into game on one side and its reusability on other. Ilmi proposes iterative design and develops the 'World of Balance' Game [9]. His work efficiently leverages multiple resources to expand education and research potential within critically important areas of ecology and sustainability science. Sylvester presents a development approach: PR:EPARe [10] (Positive Relationships: Eliminating Coercion and Pressure in Adolescent Relationships), designed by a cross-disciplinary team of UK researchers from Coventry University's Studies in Adolescent Sexual Health (SASH) research group and the Serious Games Institute (SGI). His work was based on the Four-Dimensional Framework of Learning (4DF) emphasizing the context of deployment, learner profiling and the pedagogical perspective that influence the mode of representation of the learning content. Furthermore, Zarraonandia introduces a conceptual model [11] that organizes in a modular way and in different design perspectives the game features. The model contributed to the process of designing a collection of education games 'hl dc 'sq'hrhmf bghkcqdm's awareness of emergencies and domestic risks.

With the illumination of the achievements above, an idea is produced that making knowledge entered game naturally and integrated with game elements rationally, such as rules, may be a new reference for combining cognitive process and playing experience. This paper is aimed to propose a matching mechanism between game rules and knowledge for educational game design to make the balance between game playing and knowledge learning. To verify its validity, an agricultural game, Virtual Farm, is designed and implemented using the mapping approach to facilitate importing knowledge, such as virtual animal and plant growth model and agricultural products processing etc. into the game.

2 Game Classification

Games can be classification as: role playing game (RPG), action game (ACT), adventure game (AVG), strategy game (STG), simulation game (SLG), real-Time strategy game (RTS), fighting game (FGT), shooting game (STG), puzzle game (PZL), racing game (RCG), sports game (SPT), music game (MSC), etc. Due to the story line and background of RPG, STG, SLG, they are more adaptive to carry some declarative knowledge. There are many educational games using the three mentioned genres for teaching in schools. Besides, puzzle game is aimed to enhance intelligence and increase skills with comparatively easier operations and limited requirement on memory. It has become a new carrier to deliver knowledge. To support the analysis of relation between rules and knowledge, this study propose a new system of assorting the games which are usually used as educational game according to their objectives and characters: (1) elimination game, with the rule of eliminating objects when some conditions are satisfied, such as 'Russia clock'; (2) collision game, cased on the rule of eating, meeting, receiving, attacking, colliding objects and obtaining scores, such as 'Gold Miner'. Player controls one given object to snatch or avoid others to get bonus or punishment according to the properties of objects he gained; (3) action game, providing rules of controlling an actor to move forward, backward, jump and fly to pass barriers, getting scores and avoiding collision with traps, such as 'Super Mary'; (4) raising game, simulating a progress of raising animal or planting crops, with the essence of telling how the creatures grow up and providing fulfillment when products are achieved; (5) calculator game, whose rules are based on calculation on numbers, such as 'Number Crossword', 'Puzzle Number', etc.; (6) geometry-graph game, giving limited planar or three-dimensional space and geometry figures or pictures which stands for objects, governed by rules of moving, rotating, adding or removing the objects to implement the mission, such as 'Jigsaw Puzzle' and 'Klotski'; (7) physical theorem game, using model of physics principle to simulate gravitation, magnetism, optics, elasticity, inertial, collision, explosion, etc. 'Angry bird' and 'Cut the rope' are classic instances of this type; (8) logical inference game, aiming at solve riddle as objective using inference means such as cause-and-effect and condition-and-conclusion, or sorting, matching and classifying objects based on their attributes; (9) observation-memory game, with purpose of enhancing capabilities of observation and memory, such as 'QuickSpot'. (10) originality and doodle game, which provides a virtual palette, materials and tools to create pictures or products; (11) music game, introducing virtual instruments for performing notes, rhythm and music, which helps to improve the player's musical ability, such as read music notation game [12]. The classification of game mentioned above is overlapped. That is, one collision game could involve physics theorems and may have characteristic of action game.

Otherwise, from the aspect of the capability achieved through game playing, (1), (2), (3), (7) and (11) will be helpful to hand-eye coordination; (5), (6), (8) are useful to logic thought ability; (9) can train players on capacities of observation and memory; (4) is related to enhancing competence of strategy; (10) and (11) are aimed mainly at inspiring aesthetic quality and creative thinking.

3 General-Element Model of Game and Formal Representation

3.1 General-Element Model of Game

Whatever a game is, it contains some general elements. In this paper, a general-element model of game is proposed using ontology to identify elements as classes. Figure 1 shows the tree architecture of elements using protégé. The subject of game is the one which can be controlled by player. The objects in game refer to the ones that can't see directly controlled by player, such as conus, trap, monster, etc. Tool and resources can help player to achieve the goal. The details about the elements will be expatiated in the latter sections.

3.2 Rules of Game

This section is focused on analysis of rule properties. Rules in games indicate the behavior criterions of elements in game. They are (1) subject(Object) behavior rule, (2) parameters rule, (3) mission rule, (4) layer controlling rule, (5) game over or continue judgment rule, (6) game clearance rule, (7) rewards and punishments rule, (8) tool using or resource consuming rule, (9) event rule, etc.

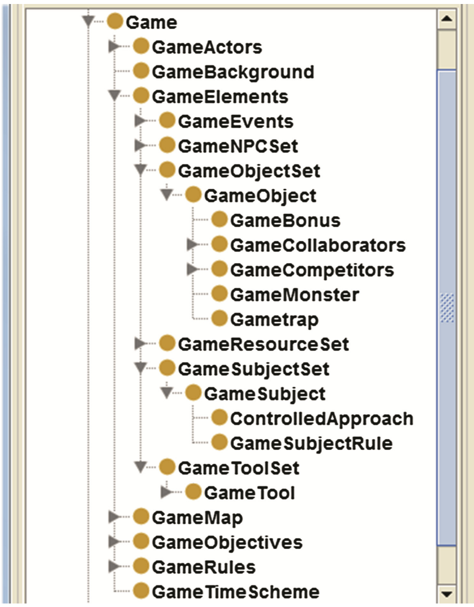


Fig. 1. General elements of games represented using ontology implemented by protégé.

Subject(Object) behavior rule describes (a) the number, color, position, state transition, speed, or movement direction of subject or object when they are out of control by player; (b) how subject acts when received player's command; (c) interaction between subjects and objects, specifying their relation and transforming rule when interaction happens.

Parameter rule indicates calculating expressions of important parameters, such as time, life of actor, temperature of environment, etc. They are closely related to subject, object and environment.
Mission rule provides description of objective to be achieved. It includes the expectant state of subject, object.
Player controlling rule prescribes interaction mode between player and game. For example, a player can rotate, move left and right, accelerate not can't move upward a clock when it is active in 'Russia clock'; a player can do nothing with an inactive block. It is worth mentioning that all controlling action should follow the rules of subject (object) behavior rule.
Rewards and punishment rule regulates rewards and punishment mechanism. Rewards include score increasing and new tool being obtained; punishments maybe result in life or score decreasing, or subject state transition.
Tool and resource usage rule is used to indicate how to use tool and resource. Tool in game is defined as the ones helping player to achieve objective and can be used many times without losing, such as rope and weapons. Resource is necessary in pursuing objective and may exhaust and only be used limited number of times, such as money, water and fertilizer in some farm game. The rule also gives how tools and resource are obtained, used, spent and how they influence the score, life, skill or state of subject.
Help information andfeedback rule are important for game playing. It can give help before action and tell player the performance he achieves used to adjust strategy for next try.

The rules above are interrelated tightly. They can be further fallen into two classes: non-interactive rule and interactive rule. The former one normally express certain facts and do nothing with condition judgment and inference; while the latter one describes the influence of elements on each other.

3.3 Representation of Rules

To give the basis of mapping analysis between game rules and knowledge, a formal representation of both is required. This section proposes a scheme using class definition for representing elements with their properties and applying first-order predicate as formal representation of rules. Following lines list partial expressions of an example: raising game.

RAG_actor(position, status, speed_value, speed_diraction, stamina, score, money)
RAG_animal(position, name, breed, price, color, size, weight, appearance, status, speed_value, speed_diraction, animal_life, animal_health, animal_age,animal_hungry)
RAG_plant(position, name, breed, price, color, height, weight, appearance, plant_life, plant_health, plant_mature, plant_ yield)
RAG_food(position, name, price, amount)
RAG_enemy(position, name, color, size, weight, appearance, status, speed_value, speed_diraction)
RAG_trap(visible, position, status, speed_value, speed_diraction)
RAG_competitor(position, name, breed, weight, appearance, compete_for, status, speed_value, speed_diraction)

RAG_tool(available, position, figure, price,amount)
RAG_resource(available, position, figure, price, amount)
RAG_event(trigger, probability, start_time, end_time, last_time, intensity,amount)
RAG is used to represent the abbreviation of raising game. *RAG_actor* is the subject of raising game. It is optional and may be omitted in some cases. The following lines are definition of actor, animal, plant, food, trap, enemy, tool, resource and event.
ISHungry is a function to tell a fact that its parameter is hungry. *ISSick* is to show that animal or plant gets sick. *ISDroughty* and *ISArid* tell plant needs water and fertilizer respectively. *Raise_Info*, *Treat_Info*, *Water_Info* and *Fertilize_Info* give help information to tell player to adopt an corresponding action.
ISHungry(RAG_animal) → Raise_Info(RAG_actor,RAG_annimal,RAG_food);
ISSick(RAG_animal) → Treat_Info(RAG_actor,RAG_annimal,RAG_tool, amount);
…
ISDroughty (RAG_plant.status) → Water_Info(RAG_actor,RAG_plant,amount);
ISArid(RAG_plant.status) → Fertilize_Info (RAG_actor,RAG_plant,RAG_resource, amount);
ISSick(RAG_plant.status) → Treat_Info(RAG_actor,RAG_plant,RAG_tool, amount);
…

The essence of a raising game is computation of parameters to simulating a creature growth. The computation model is knowledge from some relative fields, such as agriculture and farming. The objective of playing raising game is to learn an animal or plant appearance, behavior, living environment and growth course. It also trains a player to make a strategy of distributing limited money to maintain varieties of animals and plants.

4 Classification of Knowledge in Games

Knowledge is the cognition of objective word based on data and information. It can be a fact, a definition, an axiom, a theorem, a rule or a method. Generally speaking, knowledge presentation can be fallen into three types: Declarative knowledge representation describes what an object is and does nothing with how to using the knowledge. It can be used to give definition, attribute, state of an object or a fact; Procedural knowledge representation aimed to tell how the knowledge is used with a manner of procedure or progress. It usually is a rule of reasoning, operating or action sequence; Meta knowledge representation is knowledge of knowledge.

The key character of an educational game which makes itself distinguished from other game is the role of knowledge during playing. This section will give the analysis of knowledge classification, characters, and relations with other elements of game.

Knowledge, such as fact, definition, axiom, rule, theorem and method, can be imported to games. But for the aspects of game type, knowledge can be assorted as: (1) definition of an entity or fact or description of their attributes, for example, appearance of mushroom, the date of occurrence of a historical event; (2) depiction of logic, spatial or topological structure of an entity, such as architecture of computer; (3) description of relation among entities or between entities and their properties, such as mapping table between countries and national flags. (4) classification of entity set. Sometime two-level, three-level, or tree architecture is possible, such as classification of vertebrate; (5) sequence of entities or events based on logic or time. For example, food chain is composed of creatures with the relation of preying, water cycling is a sequence of events of H2O transformation; (6) inference or explanation of causality among entities involving a progress of reasoning generally, such as weather forecasting according to the cloud; (7) method, procedure or flow, such as assembling of electrical devices, escape methods when earthquake is encountered; (8) function or theorem, often used in mathematics, physics and chemistry, such as the formula of gravity computation.

From function and target point of view, knowledge can be classified as: computation model supporting game logic and learning content. The former one is one of the most important parts for game running. It commonly gives a core to implement the behavior of subject and object. For example, 'Cut the rope' using models of gravitation and elasticity simulating a complex situation of tensile when an object is pulled by several ropes. One rope being cut down causes force balance broken and consequently changes object state. The player should know the principle of models to accomplish the mission. The knowledge is transferred to player in a cryptic mode and will lose some accuracy. It means that the player only can learn qualitative analysis of an object but not master its quantitative computation details. The latter knowledge is the learning content in game. Unlike with computation model, it will be completely delivered to player with two modes: conspicuous-declarative and unconspicuous-procedural. Conspicuous-declarative knowledge normally may be in format of text, picture, video or audio. On the contrarily, visual environment, tool, subject, object, NPC of game are all carriers to express entity appearance and attributes. For example, a game with mission of indentifying esculent mushroom from poisonous ones provides a lot of visual 3D model to tell color, figure of a variety of mushrooms.

Unlike Conspicuous-declarative knowledge, unconspicuous-procedural knowledge aimed to enhance skills taking advantage of practice of game. The leaning procedure should be combined with the playing experience. That is knowledge should be designed related with elements in game.

5 Relation Between Knowledge and Game and Formal Representation

5.1 Relation Between Knowledge and Game Elements

Knowledge as computation model is generally used to support a subject or object behavior rule in game. The mapping scheme is illustrated as Fig. 2. Entity of knowledge corresponds to subject or object in game; properties is corresponding to attributes; Facts of entities specify the legal states of corresponding objects; entity's behavior can provide instruction for subject or object behavior rule design. This kind knowledge can easy be integrated into game rules.

Knowledge as definition and fact uses declarative narrate or picture to explain the definition, shape, color, function of an entity in real word. When imported into game, they can be corresponding to visual 3D model, help information, and background.

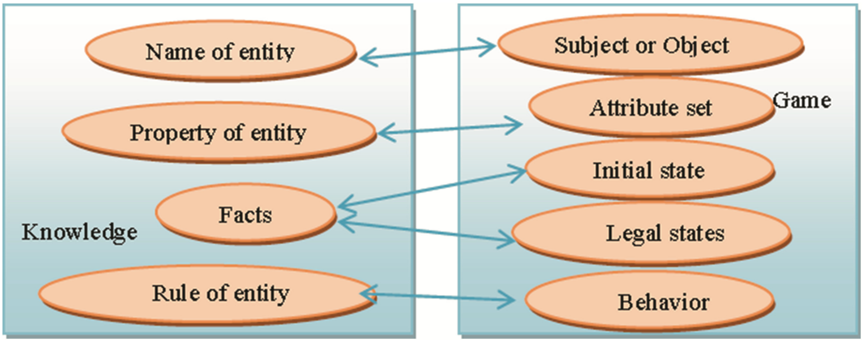


Fig. 2. Mapping scheme between knowledge and game.

Knowledge as depiction of logic, spatial or topological structure of an entity describes components of entity and their correlation. This knowledge can be represented as relations among subjects or objects when integrated with game. The relations include “is-part-of” or “is-in-front-of” usually used for classes in ontology, etc.

Knowledge as description of relation among entities and their properties use the same approach as the previous one. Relations among subjects and objects in game are carrier to hold the mapping among entities in real word. One-to-one, one-to-many, and many-to-many are main instances of the relations.

Knowledge as classification of entity set uses “is-kind-of” relation among subjects and objects in game to simulate tree system of classification of entities in real word.

Knowledge as sequence of entity or event uses sequence of subjects or objects in game to denote logic or temporal order of entities or events of real world. For example, a simulating game that teaching migratory birds behavior employs sequences of spots in virtual game for migrating route of real world.

Knowledge as inference or explanation of causality among entities is often represented by “condition → action” or “cause → effect”. On the other hand, it is coincident that game uses “A → B” for rule representation. Therefore, it is rational to using game rule like “A → B” to simulation causality among entities in real word.

Knowledge as method, procedure or flow refers to conditional procedure or unconditional procedure. Unconditional procedure knowledge can be viewed as a sequence of actions or operations and can be implemented as sequence of objects in game. Condition procedure knowledge means “when conditions are satisfied, the actions are triggered” and can also be represented by “A → B” like the previous one. For instance, in an earthquake escaping game, the rule of escaping route and skills according to environment, tool, and state in game can tell how to escape from disaster with the help of surrounding stuff in real world.

Knowledge as function or theorem can be (1) a function like f(a1,a2,a3,……an), such as $f(x) = x^2$; or 2) lile “A → B”, such as “4 is even number → 4 can be divisible by 2”, “the sum of internal angles of a triangle is 180°”. The essence of the former one is the mapping from independent variables to dependent variables and can be represented as mapping among subjects and objects in game. But sometimes, states of subjects and objects in game are discrete and only can approximatively simulate continuous function. The latter one has the same form with the previous one which using “A → B”.

5.2 Formal Representation of Knowledge in Game

To summarize what has been mentioned above, whatever knowledge is, it is no more than definition-attribute, relation, sequence, or rule. They are corresponding to subject(object) and its attribute, relation among subjects(objects), sequence of subjects(objects), and action rules of game. Therefore, a senary expression of knowledge is proposed as: *K* (*D*, *E*, *R*, *S*, *T*, *SK*)to for all knowledge that to be integrated with one game.

D: Domain, using standard Classification and code of disciplines;
E: Entity, a set of entities with their attributes using classes like general-element model of game;
R: Relation, using relations among classes;
S: Sequence, a set composed of many ordinal classes sequence;
T: Theorem, using first-order predicate;
SK: Skill, standing for what can be achieved after playing of game using a set of character string

Of course, knowledge that imported into a game is not the universal set of the knowledge in the related field. That is only a subset of the knowledge integrated with game elements. A game just partially simulates knowledge base.

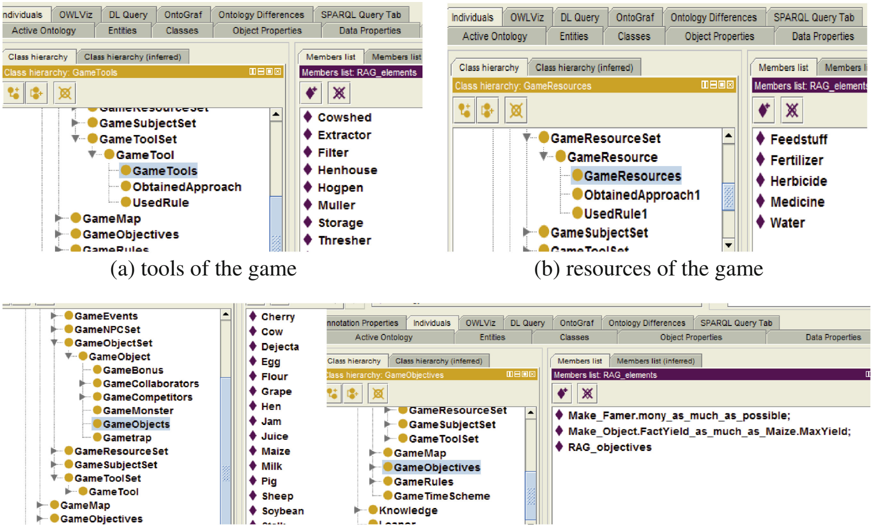
6 Application in Design of an Agricultural Game: Virtual Farm

This section will give a design of an agricultural game to illustrate the application of mapping between knowledge and game elements.

Virtual farm is a synthetical raising game providing a farm, three crops and two fruits with attributes of health-degree, mature-degree and estimated product, four species of livestock and poultry with attributes like age, cleanness-degree, health-degree, weight, size, etc. They serve as objects in game. The subject is a farmer with attributes of stamina-value, money. There are tools like thresher, tractor, etc. with attributes of price to help product processing. Tool also refers to hogpen, cowshed and henhouse with price. Game also designs resources like medicine, fertilizer, water and herbicide. To simulate real farm, rain, wind and frost will occur. The scenes include field, grocery, market, and machine district. The main elements are represented based on the general-element model as Fig. 3(a)–(d).

The knowledge to be imported into the game includes (1) growth model of animal and plant, (2) processing of agricultural products, (3) technique and requirements of preservation and (4) relations among animals and plants.

Knowledge (1) enter the game to support the game logic computation. This section gives two examples of maize and pig growth model. Maize growth model is constructed based on Ceres-Maize with introduction of irrigation, fertilization and treatment to



(a) tools of the game (b) resources of the game

(c) objects of the game (d) objectives of the game

Fig. 3. Elements representation of the agricultural game.

sickness[13] as shown in Fig. 4(a). Region model refers to soil model which provides quantity of N, P, K in soil of the region and Weather model which gives the precipitation during growing season of the region. Seed model is related to seed information, while Cultivation model interacts with player and gets information of cultivation, such as cultivation space input by player. Dynamic-Daily-Growth-Computation model performs the calculation of current state, includes biomass, weight of root, stem and leaf, and estimated product. Models of Irrigation, Fertilization and Treatment provide interaction with player. Impact-Factors-Computation model will gives factors indicating how player operations effect on the growth of maize. The above models are integrated with elements in the game as: soil model is corresponding to Field in game, parameters like quantity of water, N, P, K in model is implemented by attributes of Field. Weather model is simulated by GameEvents with its attribute of PrecipitationProbability. Seed model uses Maize and its attributes in game and Cultivation model relates to Farmer's action. Dynamic-Daily-Growth-Computation model is implemented by maize with its attributes and its behavior rules. Models of Irrigation, Fertilization and Treatment are simulated by Farmer's actions rules. Otherwise, these three models are related to GameResource of water, medicine, fertilizer, etc. The result of computation is a kind of knowledge as well. It is designed related to the GameObjective, being transferred to player using GameFeedback of game. Similarly, interactions in knowledge models are correlative with GameHelpInfo in game.

Pig growth model includes Species model, Feedstuff model, Raising model, Dynamic-Daily-Growth-Computation model, Treatment model and Impact-Factors-Computation model as shown in Fig. 4(b).

The models will output daily weigh, size, proportion of fat and protein. The models of Raising and Treatment provide interaction with player. Like maize growth model, the models of knowledge are simulated by elements in the game: Species model by Pig

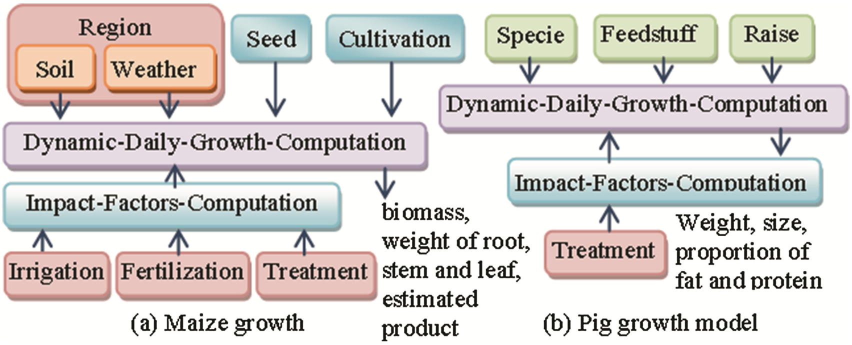


Fig. 4. Growth computation model.

in the game; Feedstuff model by GameResource of game; Dynamic-Daily-Growth-Computation model by Pig and its behavior rules; Impact-factor-Computation model by Famer with action rules and Pig in game; Raising model and Treatment model by Famer with action rules; Treatment model is related to GameEvents as well, such as probability of occurring sickness. The result of computation are represented by GameHelpInfo, GameFeedback and GameObjective.

Knowledge (2) includes: machines to be used and their functions; and processing flow. Machines and their functions are simulated by GameTools with their attributes. Processing flow is sequence of actions and can be implemented by actions sequence of Farmer in game such as threshing and milling.

Knowledge (3) involve the requirements of temperatures and humidity for preserving agricultural products and their shelf life. This kind of knowledge can be integrated with GameObjects, such as Flour, Juice, Jam, and Wine and GameTools like Storage. The storage's attributes and state are set by Farmer, and are crucial for quality of products. Therefore, knowledge (3) are related to the Farmer's action rules as well.

Knowledge (4) refers to the interrelation among animals and plant, such as dejecta of animals can be served as fertilizer for plants, while stems and leaves of some plants after harvest can used as food for animals. These can be simulated as relation of Game-Objects and gives more available operations for Farmer to save money. Therefore, the knowledge (4) also can see integrated with Farmer's action rules.

In the sum of above, the integration of knowledge and elements of game can be illustrated as Fig. 5. The game, Virtual Farm, has been developed based on the design using mapping approach above. Figure 6 gives the screenshots of the game interface to show the 3D game scenes. It has also been put online running and the results of many playing experiences of the game show that the knowledge and elements are combined well consequently make players to learn the knowledge in an unconsciously way during game playing.

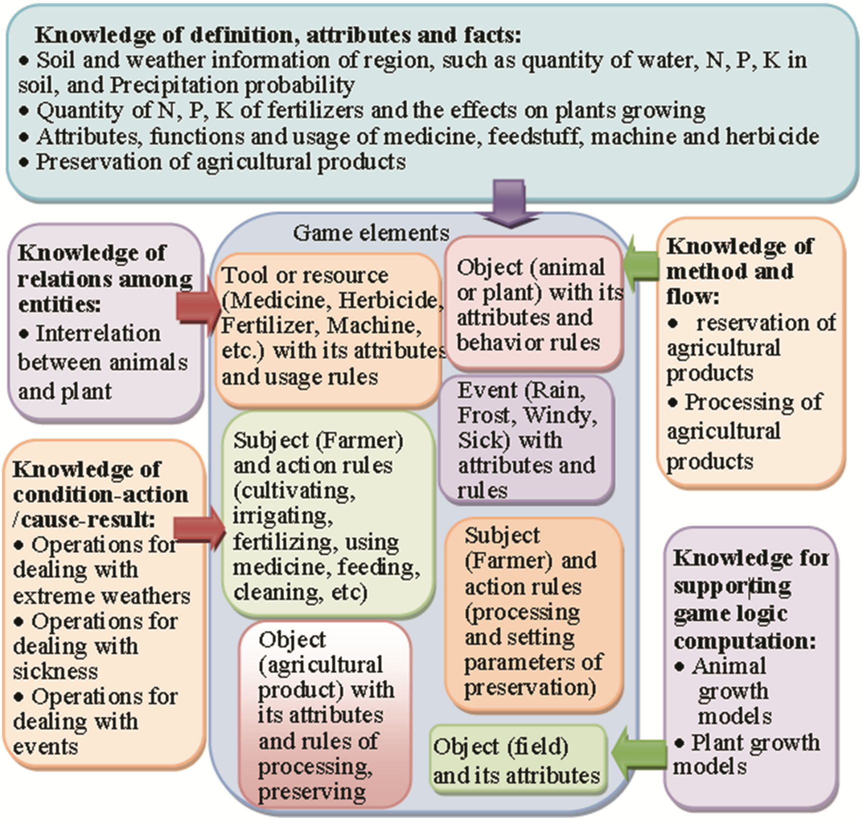


Fig. 5. Integration of knowledge and game elements in Virtual Farm.

Fig. 6. Screenshots of the game interface.

7 Conclusion

As the core of educational of game, knowledge should be integrated with elements of game. In this paper, game elements are analyzed and an approach of representation of game rules is proposed. Knowledge to be integrated into game is classified based on the characteristics related to game playing. Furthermore, a mapping scheme is proposed to indicate the relation between knowledge and rules. Then an application of agricultural game, Virtual Farm, is designed and implemented to support how the agricultural knowledge of raising and planting, processing of products, etc. are integrated with the game elements in design.

Future work includes construction of knowledge base using formal representation which helps to implement the management of knowledge in games.

References

1. Wang, G., Wu, H.: Research of education game based on virtual reality. In: Pacific-Asia Workshop on Computational Intelligence and Industrial Application 2008, pp. 921–924. IEEE, Wuhan (2008)
2. Bartolomé, N.A., Zorrilla, A.M., Zapirain, B.G.: Can game-based therapies be trusted? Is game-based education effective? A systematic review of the Serious Games for health and education. In: Proceedings of CGAMES2011 USA - 16th International Conference on Computer Games: AI, Animation, Mobile, Interactive Multimedia, Educational and Serious Games, pp. 275–282 (2011)
3. Ambient Insight, Ambient insight regional report: The 2011–2016 worldwide game-based learning market: All roads lead to mobile. [Adobe digital editions version] (2012). http://www.ambientinsight.com/Resources/Documents/AmbientInsight-Worldwide-GameBased-Learning-Market.pdf
4. Amory, A.: Building an educational adventure game: theory, design and lessons. J. Interact. Learn. Res. **129**(2/3), 249–264 (2001)
5. Song, M., Zhang, S.: EFM: a model for educational game design. In: Pan, Z., Zhang, X., El Rhalibi, A., Woo, W., Li, Y. (eds.) Edutainment 2008. LNCS, vol. 5093, pp. 509–517. Springer, Heidelberg (2008)
6. Lu, C., Chang, M., Kinshuk, Huang, E., Chen C.-W.: Architecture and collaborations among agents in mobile educational game. In: 2011 IEEE International Conference on Pervasive Computing and Communications Workshops, pp. 556–560. IEEE, Washington (2011)
7. Ibáñez, B.C., Boudier, V., Labat, J.-M.: Knowledge management approach to support a serious game development. In: 9th IEEE International Conference on Advanced Learning Technologies, ICALT 2009, pp. 420–422. IEEE, Riga (2009)
8. Minović, M., Milovanović, M., Starcevic, D., Jovanović, M.: Knowledge modeling for educational games. In: Lytras, M.D., Damiani, E., Carroll, J.M., Tennyson, R.D., Avison, D., Naeve, A., Dale, A., Lefrere, P., Tan, F., Sipior, J., Vossen, G. (eds.) WSKS 2009. LNCS, vol. 5736, pp. 156–165. Springer, Heidelberg (2009)
9. Yoon, I., Ng, G., Rodrigues H.: Iterative design and development of the 'world of balance' game: from ecosystem education to scientific discovery. In: IEEE Consumer Electronics Society's International Games Innovations Conference, IGIC, pp. 283–90 (2013)
10. Sylvester, A., Katherine, B., Samantha, C.: The development approach of a pedagogically-driven serious game to support relationship and sex education (RSE) within a classroom setting. Comput. Educ. **69**, 15–30 (2013)
11. Zarraonandia, T., Diaz, P., Aedo, I.: Designing educational games through a conceptual model based on rules and scenarios. Multimedia Tools Appl. **74**, 1–25 (2014)

12. Ni, H., Yang, Z.: The application of educational game in teaching the young children to read musical notation. In: International Conference on Artificial Intelligence and Education, ICAIE 2010, pp. 684–686. IEEE, Hangzhou (2010)
13. Hong, C., Wang, Q., Chen, Z., Jingbo, N., DeHai, Z.: Implementation of agricultural training system using game engine. In: 2nd International Conference on Education Technology and Computer, ICETC 2010, pp. 81–84. IEEE, Shanghai (2010)