

Adaptive Digital Game-Based Learning Framework

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ABSTRACT

A common teaching and learning methodology involves one that delivers knowledge to learners within a classroom environment. With the enhancement of information technology, Web-based learning has been promoted as an alternative teaching and learning methodology. Digital games, an interactive piece of technology within the multimedia learning environment, could foster the learning process effectively and interestingly especially among young learners. Researchers and game designers have noted this promising technology and proposed some frameworks and models to foster multimedia learning environment. However, most of the models do not address the learning behavior in game design, which is important to facilitate learning process in game-based learning. In view of this, this paper focuses on proposing and discussing components that leverage the pedagogical aspects in designing game-based learning environment.

Categories and Subject Descriptors

H.1.m [Models and Principles]: Miscellaneous;
K.8.0. [Personal Computing]: General – Games

General Terms

Design, Theory

Keywords

Game-based learning, educational game, game design

1. INTRODUCTION

A game is an activity that follows some rules, played by one or more individuals principally for entertainment [1]. To date, games have not only in the entertainment industries but have also started to influence the advertising, analyzing, marketing, simulating and e-learning context [2]. Games have been integrated into education to form an innovative educational paradigm. This paradigm, known as game-based learning, which utilizes the game as a medium for conveying the learning contents [3]. Pedersen (2003) defined educational games as games that emphasize on learning.

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The purpose of educational games put strong emphasis on teaching or reinforcing a learned concept than on entertainment [4]. Today, educators are interested in developing game-based learning materials because games are able to boost up the intrinsic motivation level of a learner mainly due to the highly engaging challenges and feedbacks they provide [3].

Developing a good game for players is very important because Kramer described that “a good game will stay with us all our lives” and “a good game makes us long to play it again” [5]. The objectives of educational games emphasize heavily on imparting knowledge, skills and attitude. However, looking at some current gameplay sessions, unfortunately, educational games focuses too much on text exercises, creating less interesting adventure for players. Either way round, some educational games imparted much excitement on the visual effect but failed to achieve the learning goals. Numerous game design guidelines and frameworks have been proposed and are made available in different genre of games, each having their own set of requirements. Similar to instructional design models, genres existed because of the difference in which context one applies [6]. Therefore, it is very important for designers to adopt a framework that suits the purpose well.

This paper is organized as followed: Section 1 provides the background of this case study; Section 2 illustrates some frameworks and models for Digital Game-based Learning; Section 3 presents some ideas and elements that an educational game should contain; Last section of this paper concludes and provides future directions of this review.

2. GAME-BASED LEARNING MODELS

This section discusses four frameworks and models proposed by Embi (The Design Framework for Edutainment Environment), Barendregt & Bekker (Adopted Interaction Cycle for Games), Said (The Engaging Multimedia Design Model for Children) and Amory (Game Object Model) which fall into the category of game-based learning [7-10].

The frameworks and models were analyzed based on two major components: (1) Pedagogical (difficulty to learn, psychological needs, critical thinking, exploration, challenge, engagement, competition, practice, goal setting and motivation) and (2) Game Design (interaction, storytelling, interface, simulation, construction, feedback, literacy, communication, motor skill, memory and outcome evaluation).

Table 1. Summary matrix of game-based learning frameworks and models

Components		Pedagogical									Game Design												
Elements	Models/ Frameworks	Difficulty to learn	Psychological needs	Critical thinking	Exploration	Challenge	Engagement	Competition	Practice	Goal setting	Motivation	Interaction	Storytelling	Interface	Simulation	Construction	Feedback	Literacy	Communication	Motor skill	Memory	Outcome evaluation	Total
		The Design Framework for Edutainment Environment	✓	✓			✓						✓	✓	✓	✓							
Adopted Interaction Cycle for Games										✓	✓	✓					✓			✓		✓	6
The Engaging Multimedia Design Model for Children						✓				✓		✓			✓	✓	✓					✓	7
Game Object Model			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓		15

Table 1 illustrates a summary matrix of the game design elements for the frameworks and models. All the frameworks and models emphasize greatly the interaction elements. However, only three models include goal setting, motivation and outcome evaluation in their models. Challenge, engagement, storytelling, interface, feedback and motor skill are some common elements shared in different combination of the two models.

The design framework for edutainment environment has two unique elements which are *difficulty to learn* and *psychological needs*. It explains that educational game could be appropriate for children because game could provide fun and play to fulfill the children’s psychological needs and hence motivate them.

All the elements proposed in the adopted interaction cycle for game model are shared among other frameworks and models. This model is not a general game-based learning model but focuses on the interactivity between learners and game.

The engaging multimedia design model for children has five common elements with others. However, it has two unique elements related to the game design mode, i.e. *simulation* and *construction*. Said proposed that a game should be constructed in both modes where the learner could simulate (playing some roles) and construct (make objects) in game.

Game Object Model is the holistic model that contains more elements as compared to other models. It includes seven elements that do not interact with other models, namely *critical thinking*, *exploration*, *competition*, *practice*, *literacy*, *communication* and *memory*. It has clearly included more details on both pedagogical and game design components.

2.1 The Design Framework for Edutainment Environment

Embi (2005) pointed out that there are 4 factors which must be viewed collectively i.e. storytelling, challenge, interactivity, and interface [8]. All the factors are closely related to the learners. A learner has to be interested to the storyline, feel challenges while playing, adapting into the game environment and able to handle the controlling skills in the interface.

The factors brought up in this framework are important aspects in designing good games. Learner is the most vital issue for an educational game and it becomes one of the components in the framework. The game must be specially designed for the target learners, so that the learners could easily adapt to the game. Last but not least, the outcome of the framework focuses on the achievement of learning content.

2.2 Interaction Cycle for Game

Barendregt & Bekker (2004) adapted an interaction cycle for games that describes how the interaction between a user and a computer game happens in term of cognitive and physical user actions [9].

Interaction is one important aspect that must be considered in designing a game. It helps to keep players’ attention and motivates them in continuing the game. The model proposed by Barendregt and Bekker has clearly described the interaction process between the players and computer games.

This interaction cycle could be applied in educational games too. As stated in the model, the first stage is planning. Learners should understand the objectives, rules and goals of each task in

the game. The learning content could be conveying in this stage. This is important as learners can learn about the learning content while understanding the objectives of the game. Meanwhile, learners should decide the actions to be taken to accomplish the task. After taking appropriate actions to complete the task, the game would provide feedback to learners. Based on the feedback, learners could evaluate whether the task is completed successfully or not. This might be useful in deciding whether the learners have conceived the correct information. Learners will then repeat the interaction cycle on the same task or proceed to the next task.

2.3 The Engaging Multimedia Design Model for Children

Said (2004) implemented a design model focuses on the engagement level of a learner with design features that contributed to the experience of engagement in Engaging Multimedia Design Model [10] include:

1. Simulation interaction: The learner is able to personate as another character, and the application could be a role-playing game.
2. Construct interaction: The learner makes or produces some objects in the game.
3. Immediacy: The learner observes all the events triggered by the interaction with in the game.
4. Feedback: The learner sees a learning response in the game instantly.
5. Goals: The learner understands the goal clearly. The goal could be set by the game or learner.

Said believes that learners could achieve a high engagement if all the above features are present. Besides, learners that have experience would engage much faster compared to those new players.

An educational game must highly engage the learners. Games could be designed in simulation mode, construction mode or both. The interaction between the game and learners must be done instantly where learners could understand the goals and provide solutions by taking some actions. On the other hand, the game should offer feedback to the learners for evaluation of their achievement. The concept of this model could be adapted into designing an educational game. In other words, an educational game should be designed to allow learners to simulate and construct something in the game. Meanwhile, the game has to show the goals and feedback on time. Said's model offers the learners practice problem solving and evaluation assessment. At the same time, appropriate feedback promotes the interaction between learners and the game to boost the motivation and engagement of learners.

2.4 Game Object Model

Amory (1999) proposed a model called "Game Object Model" (GOM) which combines educational theory and game design. This model was developed based on constructivist educational theory where learners to build or construct their knowledge on their own rather than conceive the knowledge from others [7].

The model consists of both pedagogical and game elements. Fun, drama, play, exploration, challenges, engagement, critical thinking, discovery, goal formation, goal completion, competition and practice are categorized as abstract interfaces which represent pedagogical elements. On the other hand, game elements that are

represented by concrete interfaces include graphics, sound, technology, interaction, gestures, visual, logic, mathematical, computer, reading, writing, speaking, short-term memory, long-term memory, manipulation and reflex [11].

GOM is the model that game designers should adopt when developing an educational game. It contains the pedagogical elements that can create a learning environment in the game which fosters the learning process. Meanwhile, the game elements in the model provide fun and enjoyment which motivate the learners and increase the interactivity between the learners and game.

3. PROPOSED COMPONENTS IN AN ADAPTIVE DIGITAL GAME-BASED LEARNING FRAMEWORK

An investigation of the features that capture and sustain the interest of learners is essential. In this study, based upon our study of the above framework and models, we have identified key features and characteristics of best practices to be considered in designing games for pedagogical purposes. First of all, we focus on the learners, then on the game design. Finally we followed with a combination of some vital features that could be helpful for developing the educational game.

3.1 Learner: The Player Who Plays the Educational Game for Learning Purposes

Most educational games focus on text exercises. Happens that the games approach is not a crucial component in motivating and enhancing a learner's learning experience [4]. Learners are the most vital issue for an educational game and it becomes one of the components in the Embi's framework [8]. The game must be specially designed for the target learners so that the learners can easily adapt to the game. Hence, before designing or selecting a game, psychological needs, cognitive development and learners' behavior, should be investigated. Their behavior of learning will affect the effectiveness and learning outcome. If learners are interested in the learning object, they would be more willing to learn and the learning process would be fostered.

3.1.1 Psychological Needs

Erik Erikson's (1980) psychosocial theory hypothesized that there are eight stages in a human's lifetime. Each stage describes the central crisis that must be resolved. For example, stage four described the children's needs at the age between 6 and 12 years old. He stated that children at this age are eager to make things either alone or with friends [12]. This becomes an issue to be addressed because learners act and behave according to what they have in their mind and they are actually doing those to satisfy their psychological needs. Without knowing the stages they are experiencing, it may be difficult for game design to produce genre of games suitable for the learner. If the learners' needs are achieved, learners might develop an interest in continuously playing the game for the purpose of learning, if they are given chances to control the game.

3.1.2 Cognitive Development

Human cognitive development also differs on different levels. It is important for designers to design or for educators to

recommend a suitable game for the learners. For example, young children between 2-7 years old are able to memorize and imagine some subjects, nevertheless, their thinking is still non-logical and non-reversible. Besides, they are dominated by their egocentric thinking. However, children aged between 7-11 should think logically about objects and events while learners who are older than 11 years old should think logically about abstract propositions and test hypotheses systematically [13].

Thus, the game designed for learners aged between 2-7 years old must be fully presented with clearly mentioned instructions. On the other hand, learners who are elder should be allowed to construct or execute some actions to complete a task with simple instructions. Given the suitable type of game, this will enhance the learning process in term of cognitive thinking.

3.1.3 Learning Behavior

Slavin (1997) has identified 9 principles of behavioral learning. The principles are role of consequences, reinforces, punishers, immediacy of consequences, shaping, extinction, schedules of reinforcement, maintenance and the role of antecedents [12]. Appropriate design which facilitates the learning behavior of learners could provide better learning environment. Suitable types of behavior are vital in constructing the game design in term of feedback and interaction.

Identifying a learner's need may sound troublesome but indeed it is a very important process because the learners' learning behavior will affect the effectiveness of the game and learning outcome of the course. An appropriate game should be developed based on a set of specific criteria that fulfills the requirements and needs of the target learners. Hence, the learners could be easily adapted into the game and be more willingness to learn.

3.2 Game Design: Elements for Educational Games

An appropriate game should be developed based on some criteria which fulfill the requirements and needs of the target learners. Apart from the learner component, game design is another component that game designers should consider when developing educational games. As proposed by Embi, storytelling, challenge, interactivity and interface [8] are equally important to the features proposed by Said, namely the simulation, construct, immediacy, feedback and goal [10]. It is important to highlight that Said concluded that a high engagement could be achieved if all the features are present. The adopted Interaction Cycle for Game also emphasizes the interaction between learner and game as Barendregt and Bekker described the interchange between cognitive and physical actions of learners [9]. Game Object Model proposed by Amory provides a better guide as it combines both pedagogical elements and game development elements [7].

Design of an educational game might affect the learning progress of learners when playing the game. Thus, the design of the game is important. From the review of the models, we suggest that the game design should contain 3 subcomponents, i.e. multimodal, task and feedback.

3.2.1 Multimodal

The first subcomponent is the Multimodal. It consists of the modality and interaction factor which are some essential issues while developing a game.

Modality is the element which manages the interaction between learner and the game. It includes the multimedia elements, interface design, and narrative. Learning would be more interesting with multimedia elements such as text, still images, sound, movies, animations, and special effects [14]. Some combinations of the multimedia elements facilitate the learning process by complimenting one another [15]. These elements could be integrated with the interface design and narration aspect. Interface design plays an important role in developing games. The interface is not only being made simple but highly meaningful. It should be constructed based on learning curves to assist beginners to focus and avoid confusion. A simple but attractive interface could help learners to adapt to the game environment easily [8, 16, 17]. The narrative element focuses on the flow of the game. Narration offers better interaction between learners and games in a meaningful way [18]. A game with a better storyline could help learners to immerse in the game and to achieve learning outcomes while having fun. These elements help in emphasizing the visual and audio of game to keep the learners' attraction and cultivate the emotions when playing the game.

Interaction is the only element that is proposed in all the frameworks and models as discussed from the previous section. The learner's interaction with game is essential as it defines how could the learners control the game and learn from it [8]. The interaction element could give better result by adopting the Interaction Cycle as suggested by Barendregt and Bekker where the interaction between a user and a computer game happens in terms of cognitive and physical user actions [9]. Interaction is one important aspect that helps to keep learners' attention and motivates them in continuing the game.

3.2.2 Task

Tasks in the game help the learners to absorb the learning content. Thus, those tasks should be designed with different levels in order to help learners adapt to the game environment. Different levels of difficulty would help learners to learn without being discouraged. Novices would feel the challenge in the beginning stage while advanced users would find other challenges further on in the game [8, 15-17]. The objectives of task facilitate determining the presentation of the game. The presentation or designation of games should be constructed based on the objectives of the tasks. For example, if the objective of a task is to introduce the layer of earth, the design of the game for the task could be constructed as "fill in the blank" in an interesting way to allow the learners to fill in the layers' names. However, an objective is different to the goal, goal is the target that the learners must achieve and is set in the game as specific tasks [10, 15]. It must be clearly verified. It is important for learners to know what they need to do in order to accomplish the task. Take the example as mentioned above, all the names of layers must be filled in and answered correctly. Meanwhile, the rules should be applied to give some constraints and restrictions during the gameplay [15, 16]. Again, when designing the "fill in the blank" game, rules could be implied as no keyboard input is allowed. Learners can only answer the questions by applying mouse inputs to click on the choices available on the screen.

3.2.3 Feedback

Feedback for learners is vital. Two models, the Engaging Multimedia Design Model and the interaction cycle for game, have included this concern as an element in the models. Clues should be given either directly or indirectly for the learners, on demand. Learners would prefer getting information on demand and just in time [19]. This could help to reduce misunderstandings and allow learners to apply the information correctly. Rewards have to be given to learners in the game [17]. This helps the learners in evaluating their assessment. Learners would be encouraged with the rewards and gain confidence in solving next task. On the other hand, if less or no rewards are obtained, learners should try to redo the same task again to gain higher achievement.

4. SUMMARY AND FUTURE DIRECTIONS

Several frameworks and models have been proposed by researchers in the field of game design. It is crucial to highlight that each framework focuses on different aspects, thus they could supplement one another. However, the development of a game to be used for entertainment is solely different from an edutainment game, and thus requires game designers to look further into the learners and learning content pedagogically. This paper has identified the essential components based on existing frameworks and models. Key features to be considered start with learner learning ability, then proceed to the game design which poses some vital features that could be helpful for developing educational game.

Our thorough study of the existing models reveals that a well designed game-based learning environment should consist of elements such as the story, challenge, goals and objectives. It should also provide feedback and outcome to help learners self-explain their learning process. All these factors could help learners in boosting up motivations and satisfaction. Thus, in conclusion, the above mentioned elements could greatly facilitate the learning process, are needed to assist game designers in constructing educational games.

This study hopes to further implement the components to investigate on the effectiveness in fostering the learning process and assist learners to achieve better performance in the subject matter.

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