15. Serious Games for Effective Learning

by Ririn Dwi Agustin -

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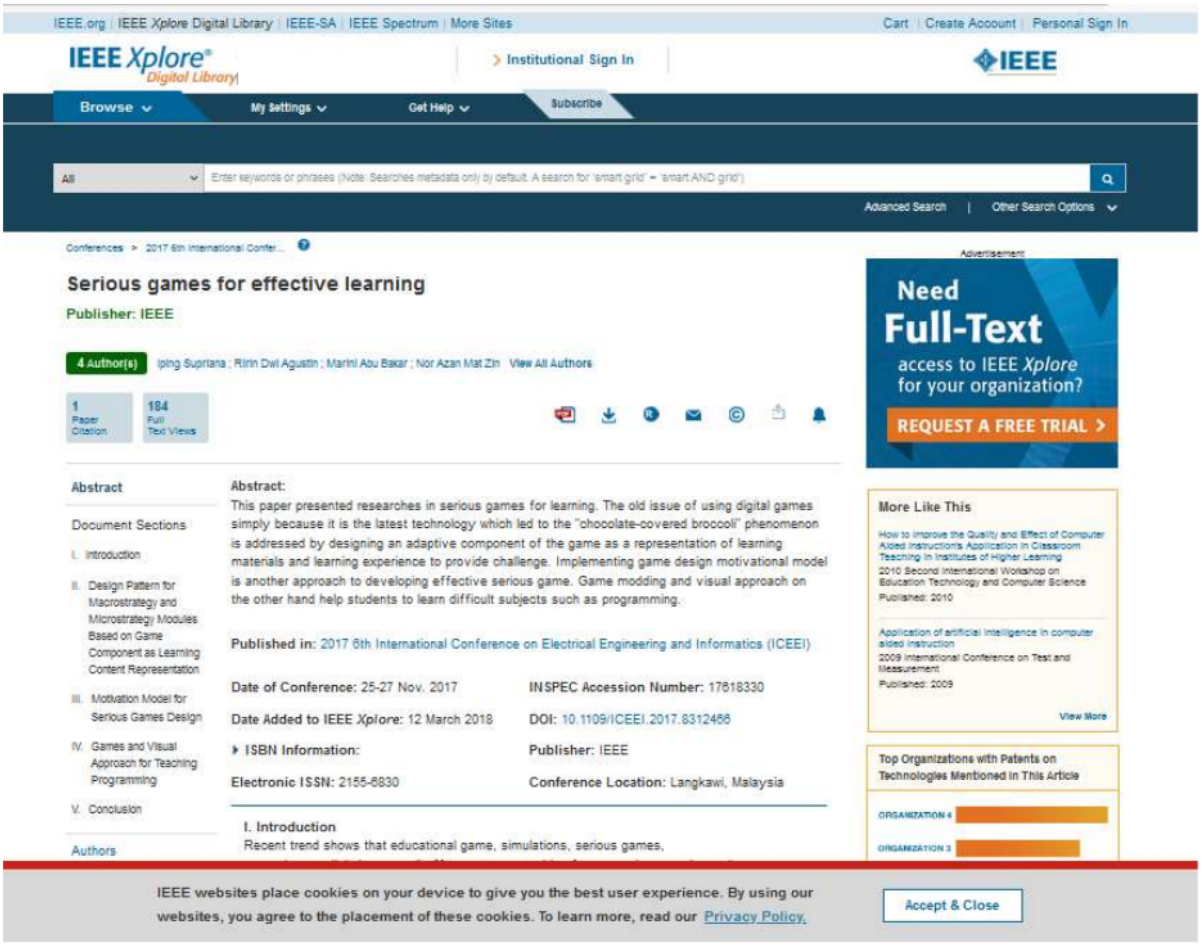
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***Abstract*—This paper presented researches in serious games for learning. The old issue of using digital games simply because it is the latest technology which led to the "*chocolate-covered broccoli*" phenomenon is addressed by designing an adaptive component of the game as a representation of learning materials and learning experience to provide challenge. Implementing game design motivational model is another approach to developing effective serious game. Game modding and visual approach on the other hand help students to learn difficult subjects such as programming.**

Keywords*—*learning content; motivation; challenge, adaptive model, serious games, game modding, visual approach, programming education

I. INTRODUCTION

Recent trend shows that educational game, simulations, serious games, entertainment digital games all offer great opportunities for appropriate practice and is being discussed in both formal and informal educational circles. Although digital games have been broadly accepted as educational technology, only recently there is integration of pedagogy and learning theories in educational games, which helps increase learning performance [1]. Digital Game-based Learning (DGBL) is defined as a combination of motivational games with curricular contents, and encompasses educational objectives and subject matter [2]. This combination has potential to make learning of academic subjects more learner-centered, easier, more enjoyable, more interesting and hence, more effective [3]. DGBL is a form of serious games, used for learning.

Nevertheless, some studies indicated that the empirical evidence to support the assumption which games can motivate players in educational field is still limited and contradictory, particularly experiments concerning the effectiveness of games for concrete educational purposes, given that previous research have focused more on motivational features than on curricular content aspects and core academic advantages [4]. Hence, in this paper we present effective cases of serious games for educational purposes, the design of which take into consideration educational theories as well as the motivational game design aspect.

The use of games for enhancing the learning process becomes important in this 21st century due to three reasons; 1) the development of commercial game along with its massive utilization [5] led to the growth of game generation. Specifically, this generation has a game-based learning skills, therefore game-based interaction makes their learning more effective; 2) *"involvement"* learning approach which refers to experience-based learning is the most effective one, as Kong-Fu-Tse (500 B.C) said "*Tell me and I'll forget, show me and I'll remember, involve me and I'll remember*". Interaction between players and the game provide experience-based learning situation; 3) Game promote players' motivation, even stimulate their physical energy to stay longer on the game [6]. Therefore, the utilization of games in promoting learning achievement is very promising.

Three aspects of game that promote motivation are challenging task, story that attracts curiosity, and fascinating reality. Challenging task is a prerequisite component that must exist in order to improve motivation [7]. A game can still be interesting even if it is only text-based or without a story. However, a task could be challenging if the game is created slightly beyond the player's skill or knowledge, hence can keep the player in a *flow state* [8]. Therefore, tasks should be created as adaptive as possible to the player's status [9].

Since 1995, there have been criticism towards using serious games for learning. One issue is the "*chocolate-covered broccoli*" phenomenon [10], where games are used to make people engaged in something they are not interested in by adding motivating elements [11]. The "*chocolate-covered broccoli*" problem can be solved if serious game designer considers educational aspects such as pedagogical and learning theories in addition to the game design aspect. One approach presented here is to generate design patterns for adaptive components of the game as a representation of learning material and learning experience to provide challenge. Using this strategy, the learning activity blend with players' activity in overcoming the game challenges.

The following Section II present educational game development researches to address the "chocolate-covered broccoli" issue surrounding educational games, by creating design pattern for modules based on game components as learning content presentation. Section III presents a game motivational design model for serious games while Section IV discusses using games and visual approach to teach programming.

II. DESIGN PATTERN FOR MACROSTRATEGY AND MICROSTRATEGY MODULES BASED ON GAME COMPONENT AS LEARNING CONTENT REPRESENTATION

In game design, a particular idea or concept that will be taught is considered as Learning Object (LO) [12]. Whereas, how an LO should be taught through adapted game element supported by the other element was identified as Learning Environment (LE). While in learning-playing process, the player will be at a state ((LS)/LE) in a defined set of LS/ state space search (LE-s). Thus, the learning process in serious game could be seen as an intelligent management of LO/LE. This principle is adopted in the proposed SGfL architecture model(Fig. 1). The identity of an LO is represented by LS variable and the identity of LE is represented by Game State (GS) variable. Since some materials are organized in macrostrategy and some in microstrategy, therefore, there are two types of LS to be considered; LS for macrostrategy and LS' for microstrategy. Hence, to manage this gaming for learning, GS needs to manage both game states in macrostrategy and GS' in microstrategy

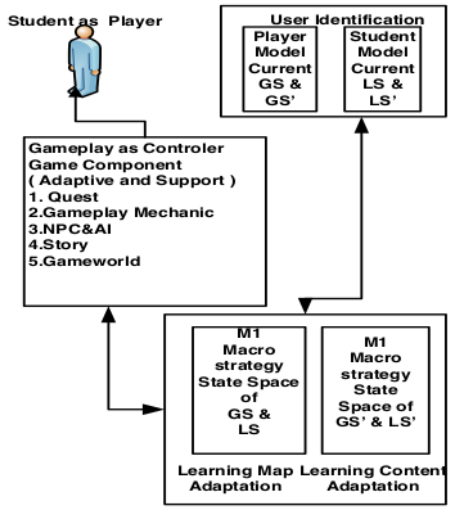

Fig. 1 SGfL architectural model

A. Game Components for Adaptive Content Representation

Feasibility analysis based on behaviour of game component (five) concluded that game mechanic must be together with NPC & AI for adaptation process. So only four types of game components can be used as adaptive representation of learning materials/ experiences.

Using Quest as representation is the simplest model. Quest can be treated like Puzzle. To assign the picture pieces from random arrangement into an orderly arrangement, from 3 x 3 until n x n pieces is an example of a simple puzzle. However, chess game is an example of puzzle game with complicated rules. In microstrategy the adaptive game component for challenging task consists of a type or n types of puzzle. In macrostrategy, there are two alternatives. First, designer design a game to activate LS (Fig. 2). The result of game design is a collection of game mechanic along with NPC/Items and uses the game mechanic to build story based on player (player story). Lastly, the designer designs gamespace and decoration that support both. A state in gaming macrostrategy is known as GS. The second alternative, as shown in Fig. 3, designer creates a storyline (plot). One plot or GS is correlated with one LS. Next, game mechanic and gameplay are designed to support the round-to-round movement in the storyline. Lastly, gameworld is created to support the story.

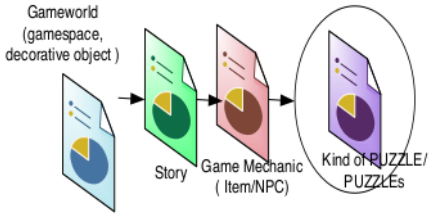

Fig. 2 Gaming design pattern with quest as adaptive component: **player story**

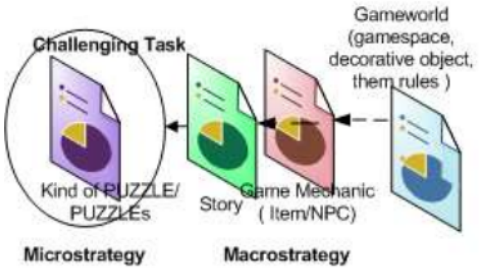

Fig. 3 Gaming design pattern with quest as adaptive component: **designer story**

In case story as challenging task, representation of learning material is a plot. This strategy is similar to a drama management. A plot was built from a tree of scene. In a scene there are some object or action options. Each option is tool to go to the other scene. The mission is to collect item or meet and talk with the NPCs in a sequence of scenes or find a particular scene which is the end of the story. In game, one scene is built from gamespace, decorative object, NPC, or item. The relation of a scene to the other scene could be causality or a confirmed order.

One LS' will correlate with a plot. It also consists of spesific game mechanic used to move from one scene to the other in the plot. One scene in a plot is called as GS'. In macrostrategy, game designer looks for gaming that could move from one LS to the other LS, equipped with the story that covers story in LS'. Gameworld support to tell the story. (Fig. 4)

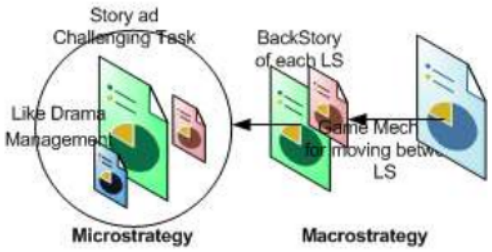

Fig. 4 Gaming design pattern with story as adaptive component

If we use game mechanic (npc/item), then form of challenging task is task in doing several actions with/toward NPC or item. NPC/Item, both have adaptive characteristics. GS' in microstrategy is related to a type of action (item, NPC, setting), while LS' could be alike with GS' or a set of GS's.

In macrostrategy, the simplest thing to support the shift of LS in gaming is game level. Therefore, GS=Level=LS. Story is linked with the course of LS and should support the provided game mechanic (item, NPC,setting). (Fig. 5)

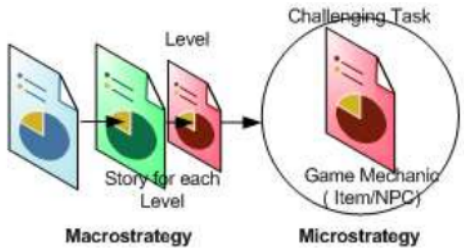

Fig. 5 Gaming design pattern with game mechanics (item/NPC) as adaptive component

Gameworld is a universe, an imaginary or simulated place in which the events of the game occur. Gameworld has many dimension: the physical, temporal, environmental, emotional, and ethical dimensions, as well as a quality called realism. Gameworld is selected as the representative of learning material if the learning content is related to nature or a situation (e.g., mountains, industrial area, etc.).

If the selected adaptive game component is gameworld, there are two solutions to carry out the task. The first one is to imitate the way to handle the story component. Next, in macrostrategy, the game mechanic uses level equipped with backstory (see Fig. 6). Secondly, to imitate the component of game mechanic (NPC/Item), Gameworld is used as a parameter in the game mechanic such that the players do the actions toward the game mechanic (e.g., imitating an adventure type game). A story will be easier to place in the gameworld, because of scene, time, and emotional dimension background has been carried by the gameworld. In macrostrategy, LS can use game level, thus LS=GS.

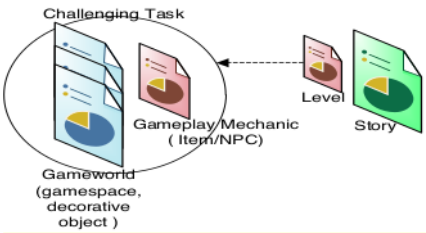

Fig. 6 Gaming design pattern with gameworld as adaptive component

Elaboration of patterns in designing microstrategy and macrostrategy in SGfL is summarised as shown in Fig. 7.

In developing the SGfL concept, the adaptive game component for microstrategy should be decided first. There are 4 game components that could be selected: puzzle, story, game mechanic (NPC/ Item). The decision of adaptive game component for microstrategy is used to determine the kind of gaming design could be used for macrostrategy.

B. Testing the pattern –a Case Study

The pattern discussed in Fig. 7 was tested with several case studies for validity. The case studies described in this paper are design patterns in Fig. 2 and Fig. 3 and puzzle as an adaptive component in microstrategy. The case is SGfL as a tool in SQL learning. The first alternative is in the '*Save the KOD Kingdom*' game with Princess Ruruna as the character (Fig.8) and the '*Altercity*' game is the second alternative with MADA as the player character (Fig. 9).

Fig. 7 Elaboration of patterns in designing microstrategy and macrostrategy in SGfL

Save the KOD Kingdom is a game about saving a kingdom from three problems; harvesting, winter season, and pest

problems. Learning outcome is mastering simple SQL. Princess Ruruna meet fairies in four different hermittage, to master SQL spells. Then, the player will face three obstacles. The design in microstrategy uses the concept of GS' = Puzzle and LS'=[GS'].

Game mechanic for *knowing* and *understanding* about SQL is spell cards classification. Game arrange puzzles to achieve *applied* of SQL. In macrostrategy, the design uses the concept of LS = GS, where gaming used to activate GS has to be selected from a spesific GS that fits the player level.

The macrostrategy interaction uses gamespace and comic as the gameworld to present story to the players. The shift of LS to LS' is conducted by showing exclamation mark (!) on the game object which is also linked to the microstrategy. Examples of the game and gameworld in microstrategy are shown in Fig. 8. Examples of the game and gameworld in microstrategy are shown in Fig. 9.

Fig. 8 Macrostrategy in Save The Kod Kingdom

Fig. 9 Macrostrategy in Save The Kod Kingdom

Altercity is a game about career management. The player is Mada, an informatics graduate working as database administrator and is preparing to get married. The game provides courses, banks, hospital, governance, and retail. Each company area is equipped with simple models (company with a few branches) until complex models (company with a lot of branches). The game also provides side jobs where the player can work as a freelancer. Gameworld also covers training places that could be used by player to get certificates to apply for jobs in the company. Several options of action provided by the game are to apply for jobs, to do daily jobs, to sign for training, to do certificate exam, to quit a job and to take side job. Besides, there is also a social life as a place for reaching the second goal, that is preparing the character to get married. See Fig. 10.

Fig. 10 Gameworld in Altercity

In microstrategy, the game uses puzzle to arrange cards (game mechanic in macrostrategy). The game mechanic also involves doing daily jobs, doing side jobs, training, doing exam, sleeping, applying for a job, and resigning from a job. In microstrategy LS' = [GS'], while in macrostrategy GS is the game mechanic (NPC/Item). LS is carrier level in a company. The relationship between LS and GS in this case is complicated (Fig. 11).

The design of game mechanic for macrostrategy involves actions such as job application, job resignation, training registration, exercise activity, certification, and side job activity, as can be seen in Fig. 12.

Fig. 11 Sample of context and game mechanic at microstrategy. Player as database administrator at minimarket.

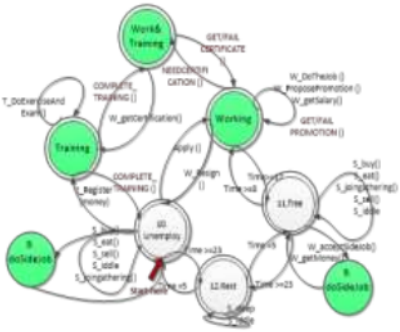

Fig. 12 Relationship between game state and game mechanic in Altercity serious game

The pattern of design solution for micro and macrostrategy for adaptive component in the form of puzzle worked in the

tested cases. However, there is a need to develop other cases before concluding a general pattern.

The next two sections present the motivation model for game design and using games and visual approach to teach programming skills.

III. MOTIVATION MODEL FOR SERIOUS GAMES DESIGN

In this research on early Jawi reading game, a motivation design model was developed [13]. The game is for pre-schoolers to learn reading Jawi, an old Malay written script. In this model, challenge is based on learning objectives, folk story and guidelines from the game design and Instructional Design (ID) theories. The story can stimulate students' intrinsic motivation and has the potential to promote learning when it is integrated into the game. The players' activity or task will maintain motivation and attention when using exciting challenges. Fig. 13 shows motivation elements in the game design model. Implementation of the model in MyJawi game prototype found that learners' motivation to learn Jawi increased after using the game and the game also has good usability.

Fig. 13 Motivation model for game design

IV. GAMES AND VISUAL APPROACH FOR TEACHING PROGRAMMING

Games and visual approaches are increasingly used in the teaching of programming [14]. Studies found that games can improve student's motivation in learning a course, especially academically demanding courses such as programming. Several types of research involving games for programming education include (i) development of game environment for use in the learning of programming [15] [16] [17], (ii) using visual development environments such as Greenfoot [18], Alice and Scratch for student to develop game [19], and (iii) development of software library that can be used to write program with visual output [20].

Our research focus in programming education are visual and game modding approaches. In the visual approach, Java software library that produce graphics and animation output is developed. Teaching module are designed in such a way that students learn the basic structure of Java by writing codes that uses the software library. An example of a software library developed is the TurtleGraphics library. The second research is learning programming through game modding. Using this approach, students write programming code to modify selected commercial game, and thus learn the basic structure of Java while modding the game.

Despite many researches discussing the game approach to programming, most programming courses in local higher learning institutions still use traditional methods for teaching either using C++ or Java programming language. Through the traditional method, the first program introduced to students is outputting of text "Hello World". Visual programming approach has been used for year one introductory programming course starting from the 2015-2016 academic session. TurtleGraphics software library is used in the first four weeks of the course. Using the TurtleGraphics library, students are introduced to the concept of objects, as well as three basic programming structures: sequential, repetition and selection structures. At the end of the fourth week, students were tested in laboratory test 1 (LT1).

In addition, students were also required to produce an 'artwork' using the TurtleGraphics library. This approach has garnered students' interests and minimize their learning anxiety at the start of the programming course. Students also demonstrated excellent achievements in the LT1 whereby 87.5% (2015/2016 academic session), and 80.1% (2016/2017 academic session) attained full scores. This is an impressive improvement, in contrast to the sessions prior to the implementation of the approach (2014/2015 session) with only 48% of the students attaining full score. Future study will focus on improving the visual approach and also implemeting game modding.

V. CONCLUSION

This paper has presented the research on serious games for education. In the first research, pedagogy and education theory are applied to game design, resulting in design pattern solution for micro and macrostrategy for adaptive component of the games. Motivational model for game design comprise of pedagogical and game elements. Games implemented using this model was found to motivate learners and has good usability. Games are also used for teaching programming, via games modding (modifying) and visual approach, which is found to be better than conventional approach for teaching beginning programming course.

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