A Gamification Approach to Getting Students Engaged in Academic Study

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***Abstract*—Serious games and gamification are emerging in many areas of society. In addition to an effective way of entertainment, games can be adopted as a persuading tool to guide person to achieve specific goal, citing their ultimate attraction. In this paper, we are interested in the mechanism and application of gamification in the field of academic education. Games feature a potential to promote students to learn in a spontaneous and effective manner, since the challenge and fun in games encourage students to hold on to the end. We propose a framework for gamification in education by integrating the procedures for designing academic courses and the game elements. A case study in digital circuit course, which is filled with diagrams, equations and is hence complicated and some kind of boring for some students, is conducted to illustrate the proposed approach in academic education.**

***Index Terms*—academic education, gamification, digital circuit course, serious games**

I. Introduction

IN the current era of knowledge explosion, education is playing a more significant role than ever. It is through education that knowledge is maintained, delivered and enlarged, while the methods of thinking and new knowledge are obtained. Learning, the act of acquiring new knowledge, always needs an instructor who can teach knowledge and methods of learning to beginners, especially in the field of academic education. Specific instructions are required (for beginners), since the scientific knowledge and methods are quite different from the general ones used in daily life and difficult to understand.

However, teaching process can fall into a mechanical and tedious procedure, due to its complicated contents and requirements of rigorous logic, while the learning process for attendee is like finishing an assignment, or a work without any pleasure. This causes involuntariness, and may further lead to inefficiency and have little effects.

In addition to entertainment, serious games [1,2] and gamification [3,4] are also emerging in many areas of society, especially in the field of education [5]. Games can guide one to learn in a voluntary manner, citing their ultimate attraction. Therefore, instructors may use game design elements to motivate attendees and thus increase their attention in courses. Since adoption could have attendees motivated and involved, it is expected to improve the effectiveness of education, thus reducing the burden on the instructor.

Serious game and gamification has been applied in some non-academic fields. For example, in its Office productivity suite, Microsoft released a game named Ribbon Hero 2 as an add-on to help people learn to use Office conveniently and effectively. Companies including SAP Community Network, Yahoo, LinkedIn, and governments such as the US military have also employed gamification in training their employees. These examples show the possibility and potential to use serious game and gamification in the field of academic education to enhance learning. In this paper, we are interested in investigating the mechanism and application of gamification in the field of academic education. Particularly, digital circuit course is selected as an application field to illustrate the method with a case study.

The rest of this paper is organized as follows. In Section II, preliminaries about gamification are introduced. Following that, the method of applying the gamification framework in education is investigated in Section III. A case study is carried out in Section IV by applying the gamification approach to a digital circuit course, as a typical example in academic education. In Section V, we discuss details of the application of game elements in the designed game for education. Section VI is the conclusion of this paper with a brief summary and future work.

II. Gamification

Gamification primarily refers to a process of making systems, services and activities more enjoyable and motivating. It aims at improving user engagement, organizational productivity, flow, employee recruitment, and learning, etc., by using game elements and game design techniques in non-game contexts. There are three key parts in the formulation: game elements, game design techniques and non-game context.

1) *Game elements:* Game elements are a kind of service that uses some game's attributes such as characters, props, achievements and ranking list to interact with players. Game elements, a significant part of the interaction between game and game players, affect the playability of a game directly. Consequently, the design of game elements should be abundant and reasonable.

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2) *Game design techniques:* In the design of a game, it should be ensured that the game is neither too difficult nor too easy, every level of the game is reasonable and designer clearly understands the motivation of players, etc. Game design techniques serve as a way of thinking, and provide a systematic method to analyze those questions above. Game design techniques, in particular, can be adopted to attract and engage users in non-game environment.

3) *Non-game context:* Non-game context means anything other than the game. This means what players are doing may still be game-like but the purpose and the rationale for the experience is something outside of the game. For example, one may play to fulfill some business objectives of his/her company, to try to learn something, to get a job, or to persist in running.

In this paper, we are interested in using game elements and the relevant design techniques to design education applications that can help enhance learning in the field of academic education.

III. Gamification Approach in Education

In this section, we propose a framework for gamification in education by integrating the procedures for designing academic courses and the game elements. The design of a game for enhancing learning could be conducted in the following five steps. The workflow is explained in the end of this section.

A. Understanding target students

A key factor to achieving the final success in an education program lies in understanding the target students. In this process, game designers should have a clear understanding of the background of target students including their age group, learning abilities and current skill-set. Issues including student group size, duration of the learning program, sequencing of skills, and the place where the program will be conducted, should be taken into consideration in researching the target audience. After the analysis to these factors, some significant 'pain points' could be concluded. More attention should be paid to these pain points in the upcoming design process. Common pain points in education include focus, motivation, skills, pride, physical, mental, and emotional factors, learning environment & nature of the course, see e.g. ref [5] for details.

B. Defining learning objectives

Every instructor should assign a specific learning goal which students are expected to achieve by the end of the learning program, and students may accomplish the desired learning goal by completing assignments, passing examinations, as well as designing and implementing team projects, etc. While some learning programs may encompass several different objectives together, the success of the education program depends on the ability of the instructor to clearly define the learning objectives that underlie the education program.

C. Structuring the learning process

It is necessary for instructors to structure the learning process into different stages, due to obstacles and accidents during students' learning process. Stages and milestones are powerful tools that enable instructors to sequence knowledge and quantity what students need to learn and achieve, and to predict obstacles that may exist in each stage. Dividing a whole education program into different stages gives instructors the priority to judge the objectives, context, and pain points, and to prepare a more effective overall game process for education.

D. Identifying resources

After identifying the stages and milestones, the instructor can identify the stages that could be gamified, and hence design the game. In designing a stage, the following terms should be taken into account.

- *Tracking mechanism:* A tool to measure students' progress.
- *Currency:* The unit of measure, which could be points, time, money, etc.
- *Level:* A specific amount of a currency used to accomplish an objective.
- *Rules:* Boundaries for what a student can or cannot do in their learning program, so as to ensure the fairness in learning environment.
- *Feedback:* A mechanism that the instructor and students can use to evaluate the progress.

E. Applying gamification elements

The raw materials of games and gamification are called game elements. In order to design a serious game, instructors should analyze how to apply different kinds of elements or pieces from games. The pyramid structure in Fig.1 divides game elements into three levels.

- *Dynamics:* Grammars, the hidden elements (constraints, emotions, progression and relationships)
- *Game mechanics:* Verbs, process that drives action forward (challenges, chance, competition/cooperation, feedback, resource acquisition, rewards, etc.)
- *Components:* Nouns, specific instances of mechanics and dynamics achievements (achievements, badges, levels, collections, points, social graph, teams, etc.)

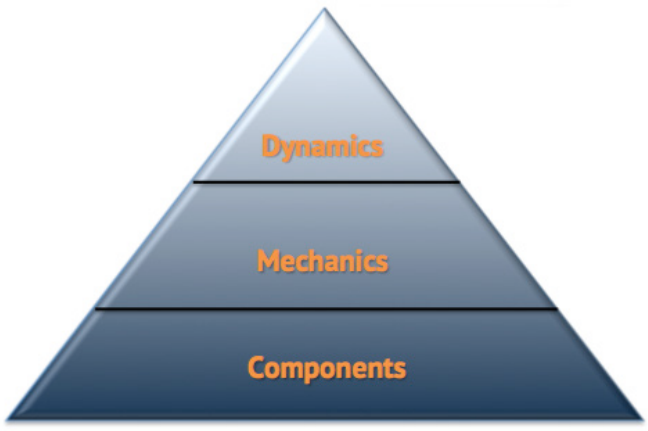

Fig.1. The model for game elements.

F. *Workflow*

By going through the above five steps (A to E) of gamifying education, instructors can effectively implement game elements in learning programs to achieve different educational objectives. Once the objectives are clear, the context helps to determine the pain points. Dividing the whole learning program into stages/ milestones makes the analysis easier. In order to qualify the progress in some stage with gamification framework, a currency-based tracking mechanism and rules are essential to develop levels and provide feedback. At last, determining different types of game elements helps instructors to gamify the education program. In addition, trail runs are necessary to adjust the elements and the game to fulfill the desired objectives based on test results.

IV. Case Study: MineCircuit

In this section, we introduce an application of gamification in digital circuit course named MineCircuit. In the game, the thinking of game design techniques is utilized, so that profound knowledge is dispatched with a recreational process.

Due to its complicated structure and contents, digital circuits are shown with a large number of diagrams and equations in traditional classes, which is a common method used in many fields of academic education. Undoubtedly, it is good to teach the scientific contents in a rigorous and logical manner. But it also makes learning in these courses rather tedious and even boring for some students in some worst case scenarios.

Alternatively, we consider using the framework of gamfication in such course to change the situation. Motivated by the fancy game MineCraft developed by the company Mojang, a game named MineCircuit is designed and developed by using Unity 3D [6]. Start screen of MineCircuit is shown in Fig.2.

Fig.2. Start screen of MineCircuit.

Three basic principles for designing the game are as follows:

1) Guide students towards more difficult problems in a step-by-step manner.

The game starts from basic tasks aiming at making students to get familiar with basic circuits' components and design methods. Then, tasks of designing some functional blocks are assigned. This process requires players to practice the contents they have learnt. In addition, these functional blocks may act as a level of abstraction that helps players to understand complex circuits in the following steps. The game levels of MineCircuit are shown in Fig.3.

Fig.3. Game levels of MineCircuit.

2) Combine design task with real world.

Sometimes examples in the real world help to understand the abstract logical circuit. For example, water may be used to understand the current, since water flows from a high position/ the source to a lower position/ the end, and current flows from a node with high potential to a node with low potential. Such examples are adopted in the game. Players are required to design a system for distributing tap water. The task of designing this system is just as same as designing a multiplexer, but in an easier to understand manner.

3) The whole learning process is based on a story.

A whole story gets players engaged until the game is finished, and players keep gaining knowledge and design techniques about digital circuit in playing the game.

An interface of the game is shown in Fig.4. As is shown in the figure, basic components in circuits are taken as the game elements. Players gain scores and pass levels by finishing different kinds of tasks, including designing circuits, completing circuits, and finding errors in existing circuits, etc. One basic version of this game is tested in a small group of students taking digital circuit course with a good feedback.

V. Discussion

In this section, we additionally explain some details about MineCircuit, to illustrate how the framework introduced in Section III is adopted and further discuss how the game could enhance education.

1) The target students are undergraduate students who major in Electronics Engineering or related professions. More specifically, the game is designed for those students who enroll in the digital circuit course and are abecedarian in this field. Before playing game, they are expected to understand related basic theoretical knowledge, and the process of playing is to make students achieve specific knowledge to a digested top.

2) The learning objective for this education game is to help target students accomplish the digital circuit course successfully including completing assignments and passing

examination. If key knowledge points such as CMOS, TTL and Three-state gate etc. could not be well understood, the students will not complete the course smoothly. Consequently, the related knowledge has been put into the game to achieve learning objectives.

3) We set up three different levels (in Fig.3) on the basis of logical order of knowledge to guarantee that the game develops in an ascending order of difficulties. Meanwhile, according to previous study, in every level, we summarized the primary difficulties encountered in the learning process in order to set up indicative information in game. Through the indicative information, students can be guided to explore the correct answer. Last but most important, the logical order of what we design in the game is consistent with that in textbook during the design of those difficulties.

4) The biggest difference of the game from other exercises is that several game elements are utilized appropriately in the design of the game. First of all, the prompt messages are sufficient to guild players in complete tasks. For instance, prompt messages shown in Fig.4 include the statement "press '5' to use 'DOCKING STATION'. It can provide 3 outputs with 1 input" and the button "EMPTY". In addition, we included some other points including timer, score, reward etc.

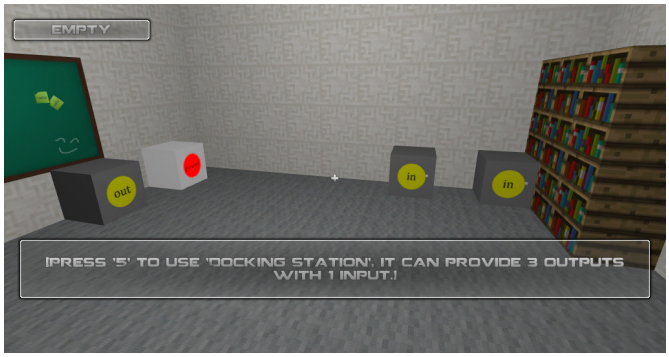

Fig.4. Game interface of MineCircuit.

as game elements in order to enrich the game.

5) Eventually, game design techniques serve as the most significant part of the game designing. Two primary design theories were applied in the game. Firstly, we take advantage of 3-dimensional scenes to stimulate students, because 3-dimensional scenes can give students a different user experience from doing exercises of the digital circuit course. Secondly, we take some methods to retain users' loyalty. As most people are inclined to securing a high score, we set up several score management mechanisms to attract students. For instance, the player can get a high score as long as he/she completes a level in one go within the shortest time.

VI. Conclusions

In this paper, the application of serious game and gamification in the field of academic education is investigated, and a framework is proposed based on the procedures for designing academic courses and the game elements. A case study is carried out to illustrate the gamification-based approach by designing and developing a game named MineCircuit for digital circuit course. As an initial study, this paper shows the possibility and potential of adopting the gamification framework in teaching and learning in the academic field to enhance the voluntariness and efficiency of students. Investigating the power of such adoption is in our on-going research.

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