

디지털 게임 기반 학습 방법을 이용한 대화형 교육 게임의 설계

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Design of the Interactive Educational Game using the Digital Game-based Learning Methodology

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요 약

본 논문에서는 개발자에게 다목적의 대화형 교육용 게임 개발을 지원하는 DGBL(Digital Game-based Learning) 기반의 교육용 게임 설계 과정을 제시하였다. DGBL은 분석, 디자인, 개발, 품질 보증 및 구현 평가 이렇게 다섯 단계로 구성되는데, 본 논문에서는 DGBL 기반의 게임 설계 과정에 포함되는 분석과 디자인 단계에 대해서만 초점을 맞추어 세부 기술을 다루었다. 먼저 첫번째 단계인 게임 분석 과정에서는 요구사항 수집, 게임 아이디어 및 학습 목표를 설정하게 되고, 두번째 단계인 게임 디자인 과정에서는 게임 구조 정립과 데이터베이스 스키마를 정의하게 된다. 본 논문에서는 이러한 DGBL 기반의 교육용 게임의 분석과 디자인 단계에 대한 접근 사례 연구로서 신입생을 위한 강사 소개 게임을 예로 들어 그 분석 과정을 제시하고, 스토리보드 형태로 디자인한 결과를 제시하였다.

ABSTRACT

This paper presents an interactive educational game design procedure using the DGBL (Digital Game-based Learning) methodology that will help developers to design a multipurpose educational game. The DGBL consists of five stages, which are Analysis, Design, Development, Quality Assurance, and Implementation & Evaluation. This paper is focusing only on the specific technologies included in the Analysis and Design stages based on the DGBL. The first Analysis stage consists of gathering requirements, determining game ideation and learning objectives, and the second Design stage consists of defining the game architecture and database scheme. In this paper, we have designed a lecturers introduction game for a new student or freshmen as a case study to apply the Analysis and Design stages based on DGBL, as well as showing the prototype result in the form of a storyboard.

키워드 : 다목적 교육용 게임 디자인, DGBL 방법론, 분석 단계, 디자인 단계, 강사 소개 게임

Keywords : Multipurpose educational game design, DGBL methodology, Analysis stage, Design stage, Lecturers introduction game

Received 29 June 2021, Revised 1 July 2021, Accepted 25 August 2021

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Open Access <http://doi.org/10.6109/jkiice.2021.25.10.1337>

print ISSN: 2234-4772 online ISSN: 2288-4165

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I . Introduction

In this day and age, games have become more and more common. Even so, many games are both entertaining and educating. Education games fall under the serious game umbrella. A serious game is a term that refers to the idea of using a game for purposes more than just entertainment [1]. It was not until 1980's that the researches found out that game has potential as a learning tool. Their main argument was that many commercial games are based on learning theory to engage players and teach them how to play games as well as putting players in the virtual world of games that can increase problem-solving skills, goal-oriented behaviour, engagement, generating a deeper understanding of complex settings, and motivation. Some also said that games could help develop strategic thinking, group decision-making, and higher cognitive skills [2].

The most significant issues are many people have a sceptical behaviour when games are used as an educational tool, especially integrating it into formal schooling. There is always a disagreement between gameplay and learning objectives and transferring the students' knowledge to the real world. However, researchers and educational practitioners started to focus on different types of games, such as serious games, multi-player games, and social games. Even online games' growth may produce more learning experiences connecting to learning at work, home, and formal learning institutions [2].

Designing an interactive game using a DGBL (Digital Game-based Learning) methodology that consists of five stages will help to develop an educational game. Combine it with a learning theory and gamification techniques such as rewards and punishment will increase the effectiveness.

The remainder of this paper is organized as follows. Section II will discuss the related existing works and researches. Section III contains a model analysis of a study case. Section IV talks about the architecture, database design, and environmental requirements for

implementing the game. Section V will discuss the prototype, including the game's storyboard. Lastly, Section VI presents the conclusions.

II . Related Works

According to [3], education should not consistently deliver traditionally. It should be reformed and utilize other methods, techniques, and technology to fulfil the need and requirements in students learning process. As stated in [4], if the level of study is increased, it will result in students losing their motivation. Educational games are meant to increase the effectiveness in delivering learning content by utilizing the advantages of games, as well as management, training, treatment, et cetera. Therefore, utilizing DGBL as an educational tool could boost students' self-esteem, improving soft skills, critical thinking, and even maintain mental health and psychological balance. When a game-based learning approach is implemented in education properly and in a student-centred way, it is considered an effective educational tool to facilitate learning procedures.

The study [5] stated that the analysis framework of a game is divided into two-part. The first framework discusses "what?" in terms of anatomy aspect and developing structure. Meanwhile, the second framework will solve the question "why?". Based on that statement, a game concept has six components: style, theme, setting, backstory & plot, and character. By using those six components, the global overview and specification of the game can be acquired. Style and theme become the base idea of backstory, character, and setting. The plot will give context about the game experience.

Game Design is the next step after gathering and finalizing components that existed in Game Concept. It then inherits materials from the game concept to be processed in game design before game technical design. In the software development world, game design is the functional requirement phase. The main component for game design is a game element, backstory and story,

game space, and gameplay. Character, item, and object is a sub-category for a Game element. Meanwhile goal, game mechanic, level, and game balance is a sub-category of gameplay. A character also has a sub-category, including PC (Player Character) and NPC (Non-Player Character). Furthermore, NPC also has a sub-category, including Support Partner, Allied, and Enemy [4].

Bloom's Taxonomy is mainly used to design learning outcomes in three cognitive domains (knowledge), psychomotor (skills), and affective (attitude or self). For the cognitive domain, there are six difficulties. 1) **Knowledge.**

This level constitutes recollection of memory and demonstration of what had been previously learned through answering fundamental concept questions. 2) **Comprehension.** This level requires students to understand a particular concept or key terms. 3) **Application.** Learners must be able to implement comprehended knowledge from level 2 to address and acknowledge concerning issues. 4) **Analysis.** Scrutiny of acquired knowledge is exercised to separate learned concepts further. 5) **Synthesis.** Data is colligated via different means of approach to form a solution. 6) **Evaluation.** Viewpoints are supported through critical means of analysis and evaluation to check whether learners fulfil the criteria. The designed interactive game for introducing lecturers will be based on this theory stated in [6].

The method of DGBL consists of five stages. The analysis stage will cover requirement and problem analysis, determine students' characteristics, statement of learning objective, game ideation, and definition of the game's teaching environment. Instructional design and game design will talk about in the design stage. The development stage will discuss developing a lesson plan, teaching resources, and developing a game prototype. The quality assurance stage will check the game's quality, game's content and improve the game's quality for quality assurance. The implementation and evaluation stage will be responsible for launching and evaluation, including modification. With this methodology, it is said

that it will be suitable to create an interactive learning game [7].

However, this paper mainly discussed the design of the game without the involvement of coding, therefore, this paper only focusing on Analysis and Design stages. In addition, game construction, including coding the game will take place at the development stage, after all of the design is finalized.

III. Concept Component Analysis

3.1. Case Study

This section discusses a study case for designing an educational game. One example of an educational game is that it can be used to introduce lecturers in universities or other educational institutions. Many universities usually held an orientation event to introduce the campus' environment to the new students, such as curriculum, infrastructure, academic system, including lecturers. Using an educational game, students can learn about their lecturers while playing games, and students can also play it anytime, anywhere. Because through the game, students are not only able to learn about their lecturers but also test how well students know their lecturer at the same time. If the game is combined with a gamification system, it can be made as a competition between the students, for example, those who have the highest score will get rewarded at the end of the orientation event.

3.2. Game Ideation

The first stage of DGBL is analysis. This stage analyzes game ideation, learning objectives, requirements, and problem analysis. Game ideation can be done by defining the game concept and game design. The interconnection of the component in Game Concept with the component in Game Design stated in [4] is depicted in Fig. 1 below.

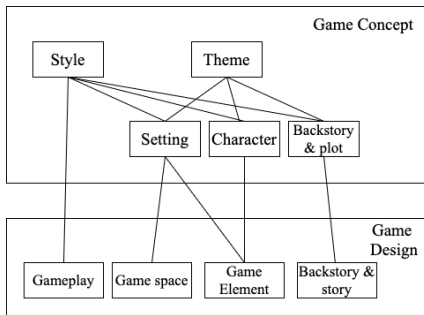


Fig. 1 Interconnection Game Concept with Game Design

When developing an educational game, this part is needed to be well defined because the game concept and game design are the backbones of the entire game. Gameplay such as unique solutions and challenging enemy, teaching player, output and feedback, non-linearity, realism modelling, input, and control act as core elements. Responsible for arranging elements and other dramatic aspects. Game Element including objects, items, and PC or NPC complements the game itself. Technology such as database, game platform, 2D graphics, and game constructing act as a tool to design interactive games. After defining the game concept and game design, the next part is to create a game scenario that will fit with the game ideation.

3.3. Bloom's Taxonomy

This section describes the usage of Bloom's taxonomy in designing an educational game. As mentioned in section II, Bloom's Taxonomy is a learning theory to design a learning outcome. There are three domains, which are cognitive, psychomotor, and affective. Each domain defines different learning outcomes, and for this study case, it will fall under cognitive domains because cognitive is related to knowledge. For lecturers' introduction, reaching level two (Comprehension) is considered sufficient, since, at level three (Application), learners need to implement what they learn from the previous level. In addition, Bloom's Taxonomy has action verbs to help determine learning outcomes further. Action verbs are a list of verbs based on each understanding level that will help instructors or teachers

create lessons and course objectives [8]. Coupled with the result of Game Ideation and Bloom's Taxonomy these action verbs can be used to create a game scenario. For this study case, the Game Scenario concerning Bloom's Taxonomy Action Verb can be depicted in Table 1. In this game scenario, the instructor can add any scenario they required according to the condition. Later, the chosen game scenario can be translated into the prototype design.

Table. 1 Game Scenario.

Game Scenario	Action Verbs
Students will be shown all of the lecturer's features	Repeating, Realizing, Studying
Students answer lecturers name from a formal picture	Approximating, Differencing, Identifying

IV. Game Architecture and Database

4.1. Game Architecture

This section describes the design stage of the DGBL, which consists of game architecture. Game architecture in this paper is to determine what functions that the game will manage and what features that the game will have. The game architecture can be depicted in Fig. 2 below.

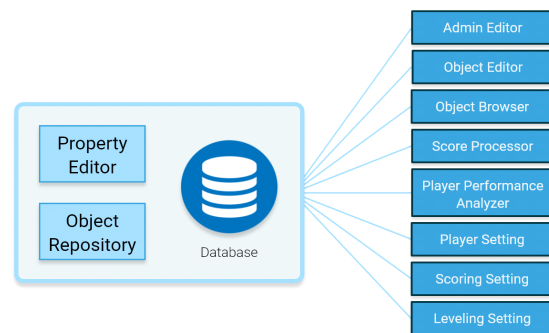


Fig. 2 Game Architecture.

In Fig. 2, the box with rounded corners contains functions that the game will manage. The property editor will manage every property shown on the game. Meanwhile, the object repository is a repository of all the

objects shown in the game. Lastly, the database is a storage to keep other supported data such as player's account, player analysis result, player's score, et cetera.

The boxes on the right depict the features of the game. Admin editor can manage the administrator that handles the CMS (Content Management System). 'Object' is representing the primary entity, or according to the case study, it represents everything related to the lecturers and it can be further detailed in several more editors according to the situation, such as Course Editor or Research Group Editor. Therefore, the Object editor can add, update or delete the primary object in the game. The score processor and player performance analyzer can calculate the player's score then analyze the result to determine the player's performance.

Object browser will help to search for the existed object in the game. The player setting can add, update or delete players. It will also show the player's playing history, including the score of each level. This feature can be used for leaderboard data.

The scoring and levelling setting is to configure how much score the player gets on every level and configure how many questions or rounds on every level, respectively.

These features are needed for the developer to make an updatable game, therefore the main content, such as lecturer's degree, or lecturer's courses, et cetera is updatable through the CMS handled by an administrator without the need to updating the whole game.

4.2. Database Scheme

The relations between every entity used in the game will be depicted using the diagram below.

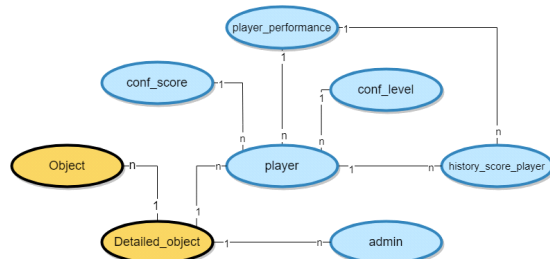


Fig. 3 Database Scheme

The database scheme in Fig. 3 only contains entities indicates that the database for an educational game can be varied according to the situation. However, for the study case, the essential entities are history_score_player to monitor players' playing progress, player_performance to set up performance thresholds, conf_level to configure how many questions a player will get in a single level, conf_score to configure how many scores the player will get in a single level, player and admin are for containing the players and administrator data respectively. The object entity is the main entity as mentioned previously in the game architecture (indicated in yellow colour), and it could be split into several detail_object entities if needed.

The cardinality depicted in Fig. 3 is could also be varied according to the situation, including a possibility of a many-to-many cardinality, which resulted in new entities to store the foreign keys.

4.3. Environment Requirement

The environment required for the smartphone and the personal computer used to develop the game is depicted in Table 2 and Table 3 below.

Table. 2 Smartphone Environment Requirements.

Smartphone
Running at least Android 5.0 Lollipop
Minimum RAM is 2GB, and storage is 16GB
Active internet connection
A minimum resolution of 1280x720 is recommended.

Table. 3 Personal Computer Environment Requirements

Personal Computer
Capable of Running Unity or similar application
Minimum RAM is 8GB, and storage is 128GB
Dual-core processor or better
Capable of running PHP and local server
Capable of running MySQL
Web Browser
Code Editor

V. Prototype Design

Similar to the game architecture and database scheme, the storyboard for an educational game is varied according to the situation. For the study case, there will be a login page depicted in Fig. 4. Every student needs to have an account for the administrator to monitor their score and performance. After that, Fig. 5 is a welcome screen that will show the student's name and other information.

Fig. 6 is the first level where students are being introduced to the lecturers. On this screen, there will be a lecturer's photo, name, and other details. The first level is the start where the game scenario as mentioned in section 3 is implemented. From Table 1, the first scenario is that the student will be shown all of the lecturer's features with the action verbs consist of repeating, realizing, and studying. This particular scenario is then translated into Fig. 6 where repeating is represented by students have to re-type to lecturer's name in the designated column input, realizing and studying is represented by showing all lecturer's feature and information on the screen for the students to realize regarding about the information, and then study the information for the preparation for the next level.

After this screen, the game will continue to another level where students will be tested with a series of scenarios already planned in Game Ideation in the analysis phase. The second game scenario is that the student answer lecturer's name from a formal picture with the action verbs consists of approximating, differencing, and identifying. In the prototype perspective, this game scenario can be translated as showing the lecturer's formal picture, then there will be three to four multiple choices where students can choose their answer. By doing this, the students can differentiate between one lecturer and another for them to then approximate the lecturer's name. After choosing the answer, the result will help the students identifying the lecturers. The reason why approximate is used is that at the first round new students tend to vaguely remember the lecturer's

name, therefore students tend to guess or to approximate if they are facing this scenario.

In Fig. 7, after the students finished all the levels, there will be a total score and a performance evaluation of whether they pass or not by using a specific parameter, for this example, is "Very Good." to evaluate their performance and as the basic foundation if another gamification technique is required to increase the competitiveness between students.

The initial storyboard of an educational game will be depicted in Fig. 4 to Fig. 7 below.

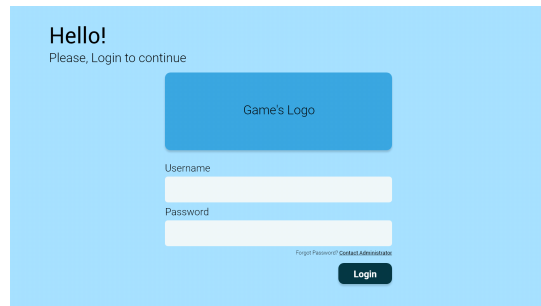


Fig. 4 Login Screen

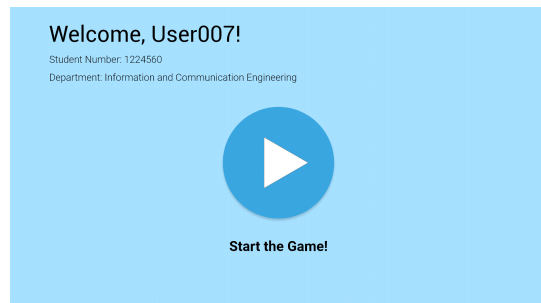


Fig. 5 Welcome Screen

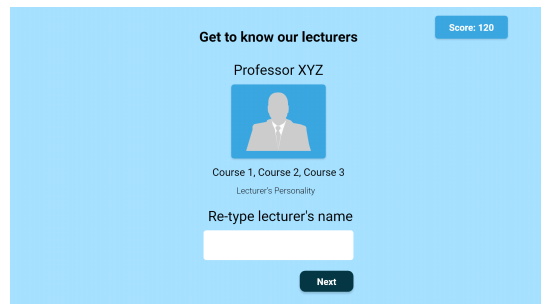


Fig. 6 Play Screen

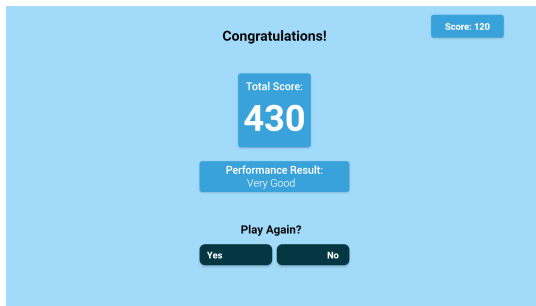


Fig. 7 End Level Screen

As mentioned before, the play screen, depicted in Fig. 6, is just an example of one level. It could be expanded into several more levels according to the needs of the situation. After defining the Game Ideation using the Game Concept-Game Design scheme, determining the learning outcome using Bloom's Taxonomy, and designing the game architecture and database scheme, the process can be continued to the next stage which is the Development stage. The purposed design in this research is mainly to be developed using Unity game engine with C# programming language. However, this purposed design will also work for other game engines such as Unreal Engine, or even to be embedded in a mobile application that was build using Java, Kotlin or Swift.

VI. Conclusion

To design a game using DGBL methodology, the core element would be the game ideation and learning theory. By following the Game Concept-Game Design scheme, game ideation can be made.

Planning game ideation with consistency also plays a considerable role in designing the game. The game needs to be relevant to the learners and gradually increase from easy to difficult in terms of challenge, game mechanics, explorable environment, or the storyline.

Using Bloom's Taxonomy, along with the action verbs, the instructor can decide which learning outcome they need from the learner. After determining the game ideation and the learning outcome, the game scenario

can be made.

In the Design stage, the game architecture will determine the features and function of the game, and the database scheme will determine the needed entities and cardinality for the game, to create a proper information flow and data storage.

The 'object editor' function in the game architecture and 'object' entity in the database scheme are allowed to be modified by adding or substituting it with all the necessary and suitable objects according to where it is going to be implemented (i.e., for lecturers introduction, it can be added or substituted by lecturers editor, courses editor, research group editor, etc). Both the game architecture and database scheme in this paper act as a basic architecture that can be modified according to each specific occasion.

Making a prototype in a form of a storyboard is required in the Design stage, and also to help the next stage, which is the Construction stage. Making a prototype would give an overall understanding of how the game would work in terms of User Interface and User Experience.

Based on the following DGBL method, therefore, it is possible to create an interactive game for the lecturer's introduction. Lastly, this method is applicable to create an educational game for other educational purposes whether is for primary school, middle school, high school, or even people introduction in general.

REFERENCES

- [1] P. Backlund and M. Hendrix, "Educational games - Are they worth the Effort? A literature survey of the effectiveness of serious games," in *5th International Conference Games Virtual Worlds Serious Application*, United Kingdom: UK, pp. 1-8, 2013.
- [2] B. Gros, "Digital Games in Education : The Design of Game-Based Learning Integration of Digital Games in Learning and e- Learning Environments : Connecting Experiences and Context," *Journal of Research on Technology in Education*, vol. 40, no. 1, pp. 23-38, Nov.

- 2007.
- [3] T. Anastasiadis, G. Lampropoulos, and K. Siakas, "Digital Game-based Learning and Serious Games in Education," *International Journal of Advances in Scientific Research and Engineering*, vol. 4, no. 12, pp. 139-144, Dec. 2018.
- [4] T. B. Yoon and J. K. Park, "Design and Implementation of a Card Game for Chemical Education," *Asia-pacific Journal of Multimedia Services Convergent with Art, Humanities, and Sociology*, vol. 6, no. 8, pp. 567-576, Aug. 2016.
- [5] R. D. Agustin, "Kerangka Analisis Komponen Konsep Dan Desain Game," *Jurnal Ilmiah Teknologi Informasi Terapan*, vol. III, no. 2, pp. 86-95, Apr. 2017.
- [6] M. M. Mahmud, Y. Yaacob, C. R. Ramachandiran, W. S. Ching, and O. Ismail, "Theories into Practices: Bloom's Taxonomy, Comprehensive Learning Theories (CLT) and E-Assessments," pp. 22-27, Feb. 2019.
- [7] S. Soeheri, "DGBL-ID (Digital Game Based Learning) Sebagai Arsitektur Perancangan Game Edukasi," *Eksplora Informatika*, vol. 6, no. 1, pp. 71-80, Sep. 2016.
- [8] L. W. Andreson, D. R. Krathwohl, P. W. Airasian, K. A. Cruikshank, R. E. Mayer, P. R. Pintrich, J. Raths, and M. C. Wittrock, *A Taxonomy for Learning, Teaching, and Assessing. A Revision of Bloom's Taxonomy of Educational Objectives*. New York: NY, David McKay Company, Inc, 2001.



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