

Model Canvas and Process for Educational Game Design in Outcome-Based Education

Ratima Damkham, Natasha Dejdumrong, Priyakorn Pusawiro

Abstract—This paper explored the solution in game design to help game designers in the educational game designing using digital educational game model canvas (DEGMC) and digital educational game form (DEGF) based on Outcome-based Education program. DEGMC and DEGF can help designers develop an overview of the game while designing and planning their own game. The way to clearly assess players' ability from learning outcomes and support their game learning design is by using the tools. Designers can balance educational content and entertainment in designing a game by using the strategies of the Business Model Canvas and design the gameplay and players' ability assessment from learning outcomes they need by referring to the Constructive Alignment. Furthermore, they can use their design plan in this research to write their Game Design Document (GDD). The success of the research was evaluated by four experts' perspectives in the education and computer field. From the experiments, the canvas and form helped the game designers model their game according to the learning outcomes and analysis of their own game elements. This method can be a path to research an educational game design in the future.

Keywords—Constructive alignment, constructivist theory, educational game, outcome-based education.

I. INTRODUCTION

THE world has numerous advances in technologies, such as computers and smartphones. Technologies are created to facilitate and assist humans in many ways, such as in education and transportation. There are activities created from the usage of innovation. Playing video games is a popular activity for children and adults far and wide that is brought about by the utilization of innovation. Therefore, the game industry is continuously growing around the world. The game market shares in 2019 had increased to 4.6 trillion baht globally and 22 billion baht in Thailand [1]. Moreover, different ages show interest in playing games, mostly ranging from 18 to 24 years old [1]. Consequently, video games are great alternatives in increasing the interest of a child in some activities.

In education, it is the process of transferring knowledge to learners. Teachers need to find ways of teaching methods to increase learning and practice the skills of the children. One problem that arises in traditional teaching is that students lack interest in learning. Teachers must find teaching methods that can capture the interest of students, such as creating instructional videos and media. Therefore, an educational game is one of the alternative methods of catching the learner's

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attention [2]. A game that offers knowledge and supports learning is called an "Educational game". Digital Educational Games (DEGs) provides knowledge, skills, and fun of the game to players [3]. While playing the game, players will learn and practice the skills the game offers. The goal of educational games is to increase the learning motivation and reduce player's boredom with learning content [4].

Creating DEGs is a challenge because DEGs should maintain a balance between educational contents and the fun of the game [5]. In addition, DEGs do not have a general method for evaluating players [6]. This study presents digital educational game model canvas (DEGMC) and digital educational game form (DEGF) to help to design the ways of learning while enjoying and assessing the learner's ability. The strength of DEGMC is that it helps designers to get an overview of their game during design, plan their own game from learning outcomes, and support their game learning design by citing constructive alignment. Furthermore, DEGF can help designers to the deep design after using DEGMC. This study was based on learning outcomes and constructivism theory so that methods can support the player's learning and can indicate a player's ability level. Additionally, designers can use their design plan in DEGMC and DEGF to write their own game design document (GDD). GDD is a document that describes the details of developing games [7]. This document is used to design games for group projects and customers. The main objective of DEGMC and DEGF is to design games that can support the learning contents of educational games.

II. LITERATURE REVIEW

There are different kinds of research papers that discuss the important components in designing games and DEGs. There are also various learning and motivation theories used to support various methods. The authors refer to these works to develop DEGMC and DEGF.

A. Guideline Factors in Designing Educational Games

This paper refers to research that presents the game factors in creating DEGs. These factors are found in systemic literature. The factors could be used as a reference for the game designers to create important parts in their own DEGs.

Shi and Shih presented the macrodesign concept that explained key game design factors to use for designing and checking the educational game design [2]. The macrodesign concept was created by survey research in the past. The authors described the thinking process that could help design DEGs and combine teaching contents with their games by using the

11 factors of DEGs. The concept could reduce the recklessness of the game design and create exciting games. The inadequacy of this paper focuses on the game fun rather than supporting the learning process of the players. The paper argues that the excitement of the games could increase the players' interest in the learning content of the game.

Gari et al. presented "Gamification in Computer Science Education" [8]. The objective of the paper was to help students to study programming by using a game. The gamification was a solution that used game elements to increase engagement, improve the player experience, and adjust the view of the players. The authors had 11 gamification elements that could engage with the users from the systematic literature review. In this paper, gamification showed that students' performances could be improved by using the elements. The limitation of the research is that the paper focuses only on computer science topics and the constraint of the research sources.

B. Natural Funativity

The game has Natural Funativity [9] in increasing the fun of the game. The details are described as follows:

1) *Physical Fun* is designed from the coordination skills of the player, such as using hands and eyes to play the game. The player's training and collecting items in the game can give enjoyment to players.

2) *Social Fun* is related to the players' interaction in the game. Social fun occurs while playing games and discussing the game content with other players.

3) *Mental Fun* is the mental state or the mood of the players relating to the designed features and sound effects of the game. The sounds that suit the game purpose increase the attention of the players to the game.

C. Eight Kinds of Fun

MDA [10] is the research that represents the framework in creating games. The components include *mechanics*, *aesthetics*, and *dynamics* that describe the relationship of the game design and game analysis. The aesthetics present the eight kinds of fun games: *Sensation*, *Challenge*, *Fellowship*, *Fantasy*, *Discovery*, *Narrative*, *Expression*, and *Submission*.

D. Motivation Theory

The motivation theory can be used to engage players to play their DEGs. Maslow's Hierarchy of Needs [11] is a popular motivation theory. The theory presents the basic needs of the human and describes them by the pyramid style. Maslow's Hierarchy of Needs consists of *Physiological*, *Safety*, *Love and belonging*, *Self-Esteem*, *Cognitive*, *Aesthetic*, *Self-Actualization*, and *Transcendence Needs*.

E. Outcome-Based Education and Constructive Alignment

Outcome-based Education (OBE) [12] [13] is an interesting educational system that is used in teaching and supports students' competence in working. OBE focuses on learner learning outcomes receive from the course. Teachers can identify students' competence after the end of the course

and design lessons and activities that can support students' competency. OBE has clear criteria for assessing learners and corresponds to learning outcomes.

OBE is an education that develops the knowledge and skill of the learners. The teachers can arrange the list of learning outcomes in their courses. It supports the student's self-learning because learners can sort out knowledge by themselves. The sorted knowledge is supported by Constructivism Theory [14], which is a learning theory in creating new learning based on prior understanding. Sometimes in teaching theories on some topics, traditional education may be appropriate to teach. It depends on the purpose and method for measurement performance to choose teaching methods that are suitable for content and learners.

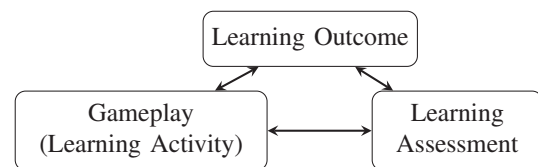


Fig. 1 Constructive Alignment [15]

Constructive Alignment (CA) [15] is the instructional design and assessment method suitable for the course's learning outcomes determined. Teachers should set aligned learning activities, learning outcomes, and assessments (in Fig. 1). It ensures that the curriculum can enable learners to learn and evaluate their competence.

F. Business Model Canvas

Business Model Canvas (BMC) [16] is a tool that helps to design a business through factors that cover the essential elements of a business. The character of BMC is a large canvas that allows designers to write their own designs in the boxes. The advantage of BMC can help designers understand the overall business easily and analyze the designed business carefully. However, BMC might make designers forget to consider factors other than factors within the canvas.

There are works that present design thinking through the canvas such as, the design of purposeful prototypes [17] and Massive Open Online Courses (MOOC) [18]. The canvas can help to design and solve complex problems completely.

III. METHODOLOGY

A. Concept of DEGMC and DEGF

This research presents a digital educational game model canvas (DEGMC) for early DEGs design and digital educational game form (DEGF) for detailed DEGs design based on DEGMC.

DEGMC is the tool that helps designers to brainstorm ideas in designing DEGs and creates DEGs systematically with the concept of the CA method. The tool helps design the DEGs in the plan basic stages of the game. The advantages of DEGMC allow visualization and recheck their own design.

DEGF is a form created for designers to answer questions about the created DEGs. The form is a detailed design based

on DEGMC before starting to write GDD and develop the games. The advantage of the DEGF that it asks more clear questions following the design in DEGMC. It is a method to complete the supporting game design of the DEGMC. In addition, *game design checklist* is designed based on the motivation theory and researches presented in the design factors in creating games and DEGs. It ensures that the designers' design is enjoyable and gets the attention of the players.

B. Development of DEGMC and DEGF

The concept of DEGMC is to design DEGs by defining the learning outcomes of the game. Designers can define the list of learning outcomes consistent in the learning order of players (supported by Constructivism). For example, the first sequence outcome should be followed by the second sequence outcome. After that, design the gameplay and learning assessment to measure the players' competency. The advantages of canvas could help them to see an overview of the design. It makes the learning outcomes, gameplay, and learning assessment of the design have the same alignment (supported by CA) and direction as other game elements. In addition, DEGF helps to design the details of the game design that was created in DEGMC and review the game elements through the game design checklist. It allows designers to answer questions about the games they completely designed and be able to expand to write the GDD.

The process for developing the canvas and form is to review the research on educational game elements, motivation theory, GDD, and OBE concepts. After reviewing the given concepts, we collect the game design checklist and elements for DEGMC and DEGF based on the factors and theories discussed. The selected factors are the most reviewed in many types of research and the basis for game design. In designing the tools, the relationship of the elements is detected and arranged in sequence. The boxes in the canvas are related and arranged accordingly and attached to each other to allow the users to design the game easily, as shown in Fig. 3. They are arranged in different positions by detecting the association of topics. Parent and child elements are chosen for the canvas to see the overall feature of the element designed in the canvas before detailing the design in DEGF.

C. The Structure and Usage of DEGMC and DEGF

The steps in creating the game (in Fig. 2) includes the process of designing games, creating games, evaluating games, and applying evaluation results to improve the game design. The DEGMC and DEGF tools usage are in the design phase. The designer can design a game by using the tools and use that design to write the GDD.

Designers can start filling fields in the canvas of DEGMC (in Fig. 3) if designers have requirements. Alternatively, the designer can start from the left-hand side and go to the right side of the canvas if the designer does not know where to start. In DEGMC, the designer can write a draft first to see an overview of the game. After filling in the canvas, the designer can continue answering questions in DEGF to detail

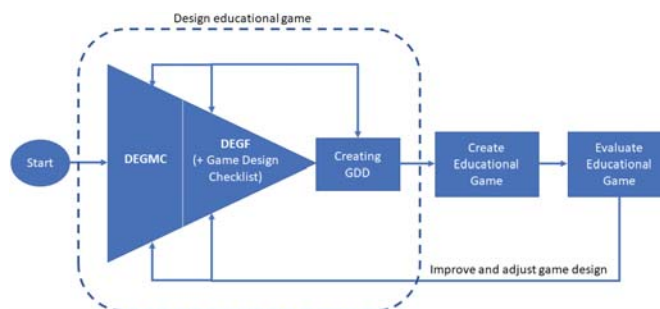


Fig. 2 The usage of DEGMC and DEGF

the design following DEGMC. Right after filling the DEGF data, designers review the fun of the game created through the game design checklist. The designers confirm the fun of the game through the motivation theory and game design research that are presented on the checklist table.

Game Target Group	Learning Outcome	Game Name	Learning Assessment	Game Factor Measurement
Learning Topic		Gameplay		
Type of Game		Goal		
Player Experience			Game Tutorial & Content	Extra Component
Appearance & Emotion of Game			How to teach and suggest player	
Game Platform & Controller			How to adjust game's level is suitable for player	
		How to play		
Storytelling & Character Design		Game Flow Design		Side Quest Socializing Badge Avatar Collection
	Fantasy / Narrative / Mystery / Climax			

Fig. 3 Digital Educational Game Model Canvas

The canvas and form have five main elements. Even though DEGMC and DEGF have the same main elements, they still have some differences in detail, in Table I. The main elements of the tools in designing DEGs are as follow:

- 1) **Introductory Data in Designing a Game** is the basis for designing a game that defines the goals and scopes of the creators' own design. This element consists of 7 sub-elements:
 - i. *Game Name*: where the designers set the name of the game.
 - ii. *Game Target Group*: where the designers define the target group of games.
 - iii. *Type of Game*: where designers classify the type of game to be designed.
 - iv. *Player Experience*: Designers identify the player feelings.
 - v. *Appearance & Emotion of Game*: where the designers shape the emotion of the game. Designers can paste a preview that is like their game. They would want to create to see the game theme easily.
 - vi. *Game Platform & Controller*: where the designers define the devices that use to control the game.
 - vii. *How to create games*: where the designers define the programs or devices to design a game.

TABLE I
THE COMPONENT OF DEGMC AND DEGF

Component of DEGMC and DEGF		DEGMC	DEGF
Introductory data in designing a game	Game Name	✓	✓
	Game Target Group	✓	✓
	Type of Game	✓	✓
	Player Experience	✓	✓
	Appearance and Emotion & of Game	✓	✓
	Game Platform & Controller	✓	✓
Storytelling and character design	How to create games	✗	✓
	Storytelling	✓	✓
	Fantasy	Not required	✓
	Narrative	Not required	✓
	Mystery	Not required	✓
	Climax	Not required	✓
Learning design	Storyline	✗	✓
	Character	✓	✓
	Learning Topic	✓	✓
	Learning Outcomes	✓	✓
	Game Goal	✓	✓
	How to play	✓	✓
	Technical for Playing	✗	✓
	Learning Assessment	✓	✓
	Game Factor Measurement	✓	✓
	How to teach player	✓	✓
	How to suggest player	✓	✓
Game flow design	How to adjust game's level suitable for player	✓	✓
	Learning Assessment Table	✗	✓
Extra component	Game flow design	✓	✓
	Side Quest	Not required	✓
	Socializing	Not required	✓
	Badge	Not required	✓
	Avatar	Not required	✓
Collection	Not required	✓	

2) **Storytelling and Character Design** is the elements to design the game stories and characters. The game story should be created and defined as follows:

- i. *Fantasy*: The fantasy of the story that make the story more interesting.
- ii. *Narrative*: How to convey the story to the players.
- iii. *Mystery*: The plot of the story invites players to follow the game's story.
- iv. *Climax*: Climax point of the subject matter. It could be a solution to prove the mystery of the game.
- v. *Storyline*: Designers define the storyline of a story.

3) **Learning Design** is the learning design of the game based on the principle of CA, which consists of 8 elements:

- i. *Learning Topic*: This is where the designers set the learning topic of the game.
- ii. *Learning Outcomes*: These are the outcomes of the designers learning output from the tools. Designers define the series of outcomes to support the players learning.
- iii. *Learning Assessment*: Requirements for measure the players learning (It refers to *Learning Outcomes* and has the same alignment as *Gameplay*.)
- iv. *Gameplay*: Designers establish the core of the game and consider the three factors to manage the game which are *Game Goal* (The objectives of the core game), *How to play* (The solution to play the game), and *Technique for playing* (It identifies assistive devices or techniques that a player can use to assist in playing the game.). The factor

refers to *Learning Outcomes* and has the same alignment as *Learning Assessment*.

- v. *Game Factor Measurement*: The factors in a game to be used to measure the players' abilities based on *Learning Assessment*.
- vi. *Game Tutorial and Content*: It consists of two topics that include *How to teach the player* (A method for teaching players or teaching content to players) and *How to suggest player* (A method for suggesting players when a player answers or solves a problem incorrectly).
- vii. *How to adjust the game's level is suitable for play*: It is a way to improve player learning and adjust the difficulty of the game to suit the players.
- viii. *Learning Assessment Table*: It is the table to define the score criterion from *Game Factor Measurement*. It can explain the level of players via the game. It is the learning evaluation of players via DEGs.

4) **Game Flow Design** is the writing of the diagram that describes the learning outcomes and storyline. It can help designers to see the learning order in the game.

5) **Extra Component** is the part that can attract players and increase the game fun. The detail of each factor are as follows:

- i. *Side Quest*: It is the additional mini-game in the game. It is a factor in reducing the tension of players from the main game. If the player is not relaxed, the player may not continue playing the games. The side quest makes players unwind and free from stress.
- ii. *Socializing*: It is an extra component of the game that increases the engagement of the players in the game. It builds the competition in the game, For example, the multiplayer system and leaderboard.
- iii. *Badge*: It is a part to indicate the ability and rise the power of the players. The designer can design this factor to support players to play repeatedly at the desired level.
- iv. *Avatar*: It is a character creation that indicates the identity and expression of the player. Creating a character in the game gives the players a chance to feel free within the game and create a feeling of reality.
- v. *Collection*: It is the factor that refers to the player collecting game items in the game. For example, collecting characters, weapons, etc. This factor gives a belonging feeling to the players' gameplay.

The game design checklist is shown in Table II. The game design checklist consists of 9 checklists:

- 1) *Goal* is the setting of the goal of the game.
- 2) *Mechanism* is the checklist that determines how to play and control the game.
- 3) *Story* is the checklist that talks about the story of the game and the characters. The game story is reasonable and provides a feeling for the players. It must define the narrative methods to the player clearly. For example, text box/character dialogue.
- 4) *Game Level* is the checklist that determines the level of the game and the sub-quests of the game. It defines the game level that suitable for the player's level.
- 5) *Social* is a social factor that players will gain from games such as leaderboard, play with friends, and society.

TABLE II
GAME DESIGN CHECKLIST

Game Checklist Design		8 Kinds of Fun [10]	Natural Funativity [9]	Maslow's Hierarchy of Needs [11]	Game Factors and Game-Based Learning Design Model [2]	Gamification in Computer Science Education: a Systematic Literature Review [8]
Goal		-	-	-	Game goals	-
Mechanism		-	Physical Fun	-	Game Mechanism / Interaction	Points / Punishment / Feedback
Story	A story that seems realistic and provide feeling to the players	Sensation	Physical Fun Mental Fun	Aesthetic Needs	Sensation	Storylines
		Fantasy	Mental Fun	-	Game Fantasy	
	Text box / Character dialogue	Narrative	Mental Fun	-	Narrative	
Game Level		Challenge	Mental Fun	Self-Esteem Needs / Cognitive Needs	Challenge	Challenges / Levels / Progress Bars / Visualizations
Social		Fellowship	Social Fun	Love Needs / Self-Transcendence Needs	Sociality	Leaderboards
Mystery		Discovery	-	Safety Needs / Physiological Needs	Mystery	-
Freedom thinking for player		Discovery / Expression	-	Self-Actualization Needs	Freedom	Avatar
Collection		Submission / Discovery	-	Belongings Needs (Aggregation)	Game Value	-
Achievement		Challenge	-	Self-Actualization Needs	-	Badges

- 6) *Mystery* is a list of finds that hides interesting mysteries in the game for players to search during the game, for example, ester eggs and secrets in the game.
- 7) *Freedom thinking for player* is the checklist that determines the elements of the game that give freedom to the player. Players have the freedom to choose and use independent team selection or freedom to create a character, such as knowing the elemental combo of the characters. This factor can make the player feel proud.
- 8) *Collection* is a checklist related to collecting items within the game, such as collect weapons and game characters.
- 9) *Achievements* are a part of the ability and the pride of players through game via achievements or badges.

segment in the game totally (4 out of 5) at a moderate to a high quality level.

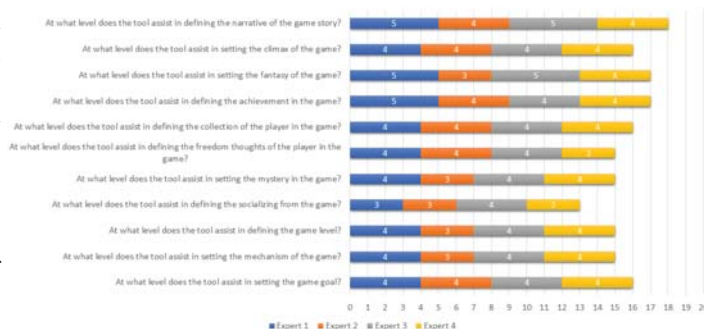


Fig. 4 The questionnaire result in the game fun from the DEGMC and DEGF part

IV. THE EVALUATION AND RESULT OF DEGMC AND DEGF

After creating DEGMC and DEGF, four experts have evaluated this method in the DEGs field through questionnaires. The authors prepare a simple game that is designed by using the canvas and form. After presenting the tools and the simple game to the experts, the authors provide a questionnaire to experts. The questionnaire focuses on four parts that include the overview of the DEGMC and DEGF, game fun from the DEGMC and DEGF, learning from the DEGMC and DEGF, and performance of the simple game.

The questionnaire in the overview of the DEGMC and DEGF part is created for the evaluation overview performance of the tools. The questionnaire results are indicated that DEGF helps to analyze components of game design completely (4.25 out of 5), balances the game fun and learning design (4.25 out of 5), and checks the overview of the game design (4.25 out of 5) at a high to an excellent level. Similarly, DEGMC can assist in checking a review of the game design (4.25 out of 5) at a high to an excellent level. However, it can balance the game fun and learning plan (3.75 out of 5) and examine the

The 11 questions in the questionnaire in the game fun from the DEGMC and DEGF part are created from the game design checklist that referred to game design research and motivation theory. The questionnaire results are moderate to a high-quality level, in Fig. 4. Therefore, the questionnaire concludes that DEGMC and DEGF can support game design based on the fun factor of the game. From the questionnaire, the tools are distinctive in helping to design the game's storyline with a fantasy, the story's narrative, and the achievements of the game. However, the tools are needed to develop social-related designs in the game, for example, the design of multiplayer and leaderboard systems.

The questionnaires' checking the learning process from the DEGMC and DEGF part is created and referred to the nine events of instruction of Gagné [14]. The questionnaire is used to assess the tools whether it can help design the learning condition of the players. The questionnaire results are moderate to high-level, in Fig. 5. It shows that the tools can support designers to create the learning design in DEGs.

In the questionnaire in performance of the simple game part,

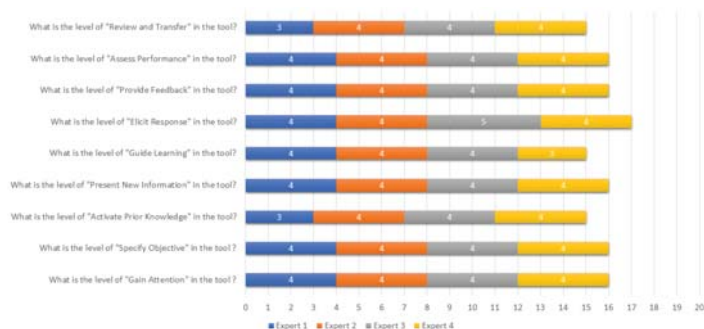


Fig. 5 The questionnaire result in learning from the DEGMC and DEGF part

the authors design the simple game named "The Witch". This game objective is to support learners in studying logic gate. Hence, this questionnaire asks about this simple game. As a result, DEGs designed by the tools can plan the player's learning from the learning outcomes (4.25 out of 5) at a high to an excellent level, define the player learning's evaluation by using the tools (4.25 out of 5) at a high to an excellent level and balance the game fun and learning design of the simple game (4 out of 5) at a high level.

For this questionnaire, the lists that need to be improved or edited in the canvas and form are identified as follows:

- 1) The work will be adjusted by DEGMC's compartment elements and positions in helping designers balance the fun and learning in DEGs.
- 2) The work will adjust some words in the tools for better meaning for users such as the word freedom and mystery.
- 3) The work will be appended to the design of the player learning's progress in DEGF.
- 4) The work will improve the game level and multiplayer design for a more flexible and detailed design.

Additionally, after revisions of the tools, "The Witch" will continue to develop for using to evaluate the tool's performance.

V. CONCLUSION

The DEGMC and DEGF aim to help designers plan effective DEGs and support the learning of the player. It helps the designers to look into the overview and analysis of their own designed game components. The canvas and form guide the learning in the game and create the learning evaluation via DEGs from using learning outcomes that they define. It designs the gameplay and the learning assessment by referring to constructive alignment. This theory can help the game designers to layout the gameplay and evaluation in the same way. In generating DEGMC and DEGF, the components were selected by choosing the most cited and fundamental factors for game design based on researches and motivation theory to arrange and design in canvas and form. Additionally, the game design checklist is used to verify the fun of their own game.

It shows that the results of the evaluation of the four experts are the tools that can assist designers in creating DEGs. The tools can help analyze the game completely in fun and learning parts. Moreover, it can design the gameplay and determine how to assess players through the game from learning outcomes.

Furthermore, the experts' comments will be introduced to improve DEGMC and DEGF in the next work phase.

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