After the Spread of COVID-19: A Study of Board Game Design Factor for Game-Based Learning

Songwut Egwutvongsa
King Mongkut's Institute of Technology Ladkrabang

Nutthapong Tongmoon
King Mongkut's Institute of Technology Ladkrabang

This research had the objective to study the design factors of board games for game-based learning by being classified into two parts: 1) Studying the design factors for board games for learning through a systematic review. 2) Studying the design factors for board games of the customers' needs from the quality function deployment technique based on the data gathered from structured questionnaires. The population group comprised 100 board game customers, and the results found that there were two significant factors in designing the board game for promoting learning with the customers' needs that were related to the playing patterns or the mechanisms. Thus, both factors enabled the players to gain the motivation for participation in learning through the board games, including the design factors of the board games for promoting learning until they could respond to customer satisfaction at the same level as existing board games that are appropriately sold in the markets.

Keywords: design factors, board game, game-based learning, systematic review, quality function deployment

INTRODUCTION

Game-based learning (GBL) is considered a popular active pattern for learning at present, especially for reducing the limitations of learning through practice and intellectual learning skill development. Moreover, it can enhance emotions in social and cultural contexts, including decision-making through practices and retesting while playing games (Bratitsis et al., 2021; Fan et al., 2015; Gillern & Alaswad, 2016). Additionally, it can promote motivation from participation for achieving effective learning goals (Gee, 2003; Van Eck, 2007). This used the method of testing as a new pattern of the challenge to promote to the learners for gaining knowledge and amusement simultaneously, as well as applying to solving problems in real life through various appropriate ways (Gee, 2007).

Recently, board games have been increasingly used for game-based learning (Graham, 2016) because they display equal potential through their digital patterns in the design of game-based learning (Radzi et al., 2020). Furthermore, they have the outstanding feature that is to bringing complex learning content for modeling with the game's stories by promoting the players to participate in playing the roles or making interaction with other players (Berland & Lee, 2011; Treher, 2011; Yusof et al., 2016). Significantly, they can be played by using planning or new strategy development characteristics to create achievements with

the game's goals in a short time (Tsai et al., 2020; 2021). Then, this would aid the players to understand the basic learning contents more than the digital games by deleting the physical characteristics inside the games (Rogerson & Gibbs, 2016). Additionally, learning with board games can produce equal learning effectiveness with other active learning patterns based on the decision-making method through playing games. As a result, these games have outstanding features that cannot be found in other active learning patterns (Pawa et al., 2020).

OBJECTIVES

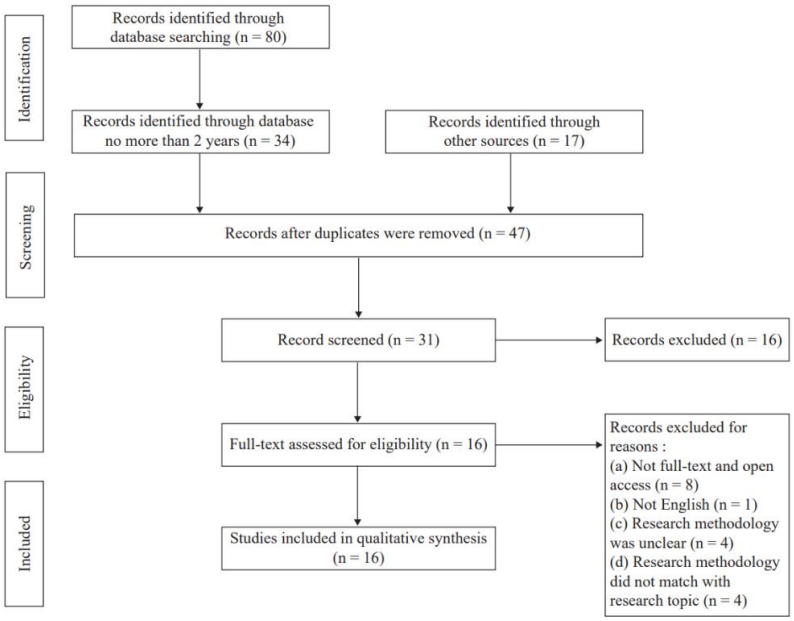
This article provides to study of board game design factors for game-based learning to make board games effective for learning and respond to the customers' requirements by using a systematic review and quality function deployment (QFD) and assess the satisfaction of the players**.**

METHOD

Literature Review

From the literature review of studying game-based learning at present, it was found that most of the studies focused on the design factors of using the digital patterns of game-based learning (Plass et al., 2015). However, nowadays, there are only a few research articles that could be selected for studying and determining the guidelines for board game design to promote learning because of the lack of clarity. As a consequence, the designer would still not know if the board games that could be used for promoting learning would offer importance on any particular factor, especially for the choice of suitable problems with the board game's guidelines to promote learning with an unclear effective assessment. On the other hand, it should be confirmed that there is one guideline that can be applied to the board game's design for promoting learning in real life. Unfortunately, at this point, there are no research articles that have studied and regulated the guidelines of the board game's design to promote learning, which could respond to the customers' needs in real life (Sousa, 2020).

FIGURE 1
PRISMA SEARCH STRATEGY FOR THE BOARD GAME DESIGN FOR LEARNING



Studying the Relevant Design Factors of Board Games for Learning From a Systematic Review

The researcher made a systematic review of the relevant research articles to study the design factors of board games for learning purposes. The researcher began by searching for articles from the database of Mendeley Data, followed by gathering relevant articles about board game design for learning by using the keywords, "Game-based learning", "Board game", and "Design" that were retrieved on June 10, 2021. Moreover, the search was regulated by looking for articles not exceeding more than two years. As a result, 34 research articles were found in Mendeley Data, including an additional 17 articles in other databases. After that, the titles and the abstracts were taken into consideration until 31 articles remained. Later, the researcher determined the selection standard of the articles by studying the board game design factors that could promote learning; this consisted of many rules: (a) Being articles with complete research contents that were available with an open access pattern, (b) written in the English language, (c) able to explain about the design method with the board game's diagrams for promoting learning, and (d) being the design result with the learning contents of the board games. Finally, there were 15 research articles remaining that proved to be an appropriate qualification as the selection standard for the studies. Figure 1 shows the flow of the search process using the PRISMA search strategy diagram.

The researcher used the 15 selected research articles to study the design factors of board games by promoting learning according to the LEAGUE Conceptual Framework (Tahir & Wang, 2018). Moreover, this was created for solving problems by specifying the main design factors of GBL, which aimed to analyze the internal game factors to specify the positive factors of the board game's design; this could promote learning from the research articles more clearly for analysis (Table 1).

TABLE 1
GAME FACTORS ANALYSIS OF THE RESEARCH ARTICLES THROUGH SYSTEMATIC REVIEW

Author& Year	Game Definition			Game Narrative			Game Mechanics		Game Resources			Game Aesthetics		Game Play			
	Game Goals	Game Rules	Game Tasks	Player Characters	Storyline	Fantasy/Fiction	Game Interactions	Game Controls	Game Tutorial	Rewards & Resources	Game Customizability	Multimedia Elements	Game Visualization	Challenge	Strategy	Pace & Adequate Levels	Game Feedback
Cheng et al., 2019	✓	✓	✓	✓	✓	-	✓	✓	-	✓	✓	-	✓	✓	✓	-	✓
Lin et al., 2019	✓	✓	✓	-	✓	-	✓	✓	-	-	-	-	✓	✓	✓	-	✓
Lin et al., 2019	✓	✓	✓	-	✓	-	✓	✓	-	-	-	-	✓	✓	✓	-	✓
Wangenheim., 2019	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓
Hsu, & Chen, 2020	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	-	-	✓	✓	✓	-	✓
Lanezki et al., 2020	✓	✓	✓	-	-	-	✓	✓	-	✓	✓	-	✓	✓	✓	-	✓
Michael et al., 2020	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	✓	✓	✓	✓	-	✓
Neves et al., 2020	✓	✓	✓	-	✓	-	✓	✓	-	-	-	-	✓	✓	✓	-	✓

Pawa et al., 2020	✓	✓	✓	-	-	-	✓	✓	✓	-	✓	-	✓	✓	✓	✓	✓
Sousa, 2020	✓	✓	✓	-	✓	-	✓	✓	-	-	-	-	✓	✓	✓	✓	✓
Tsai et al., 2020	✓	✓	✓	-	✓	-	✓	✓	✓	-	✓	-	✓	✓	✓	-	✓
Radzi et al., 2020	✓	✓	✓	✓	✓	-	✓	✓	-	✓	✓	-	✓	✓	✓	-	✓
Liu et al., 2021	✓	✓	✓	-	✓	-	✓	✓	-	-	-	-	✓	✓	-	-	✓
Lin et al., 2021	✓	✓	✓	-	-	-	✓	✓	-	-	-	✓	✓	✓	-	-	✓
Tsai et al., 2021	✓	✓	✓	✓	✓	-	✓	✓	-	✓	✓	-	✓	✓	✓	-	✓
Total	**15**	**15**	**15**	**6**	**12**	**2**	**15**	**15**	**4**	**6**	**7**	**3**	**15**	**15**	**13**	**2**	**15**

Note: This analysis table has adapted from Game factors according to the LEAGUE Conceptual Framework (Tahir & Wang, 2018)

The analysis studied the relevant factors of the board games design to promote learning, which was conducted through a systematic review of the research articles. The conclusions of the factors were summarised as follows:

1. Definition of the games: It was found that all the research articles mentioned this factor that was an important one and relevant to the "game goals". Thus, it should demonstrate the goals clearly to the players for their understanding of the learning objectives and the result after playing the board games. Moreover, the "game rules" became the factor of the game patterns including the factor of the "game tasks" for the players to gain the learning procedure from the relevant practice skills to solve the problems successfully with the goals.
2. The game narrative: It was found that most of the studied research articles involved a "storyline" as the main point because this was the designing factor for the players to understand the games' stories. It was also the factor to determine the mechanisms in the games that consisted of many interesting stories to assist the players to have a sense of participation in the games by following the "player characters", which were used as a "role play" that was related to the characters in the games. Additionally, the "fantasy or fiction" type of game was related to the factor from two research articles that were used in the procedure of the board games design. This was conducted by studying most of the research articles that used stories from a real design situation with the original board game's contents.
3. The game mechanics: This was one of the factors that was connected with the game definition and game narrative that comprised the "game interactions" to stimulate the players to participate in the stories or with other players while playing the games. This included the "game controls" for aiding the players to determine their playing patterns at the appropriate level, and these two factors were significant for the players to gain analytical skills to solve the problems while playing the games.
4. The game resources: This was one of the factors that gave different importance to the board game design for learning. Furthermore, it mostly emphasized "game customizability", as the factor to adapt to the game patterns from the players' different abilities, followed by "rewards and resources" or the factors to determine the importance of the game components, such as items, prizes, or scores to be added or reduced at any time.
5. The "game tutorial": This was the factor that was used in a complex game pattern beyond any player's performance. Mostly, it could demonstrate the playing method before starting the games for the players to know the playing methods effectively and reduce any errors while playing the games.
6. The game aesthetics: This was one of the factors that were connected to the game narrative through the design with "visualization" to make the board games more interesting, including

the "multimedia elements" that were used for designing with normal playing patterns to reduce the limitation of some aspects of board game playing, such as recording scores between the different players.

7. The gameplay: This was one of the factors that were congruent with the game definition and game mechanics, which consisted of "challenges" or the motivating factor with customer performance, followed by "strategy" to be used for the players when creating the playing patterns from the existing mechanisms to solve the problems in the games. "Game feedback" was used after finishing the games by telling the actual feeling and "pace and adequate" levels or the connecting factors with the challenges, especially if the board games were more difficult than the players' performance. As such, there was less opportunity to achieve the goal in the games due to the lack of stimulation to the challenges that decreased the motivation for learning.

Studying the Relevant Design Factors of Board Games From Quality Function Deployment (QFD)

The researcher studied the factors of the board game design that would be appropriate to the customers' needs by using the technique of quality function deployment (QFD) (Cohen, 1995). A matrix was used to plan the design or the house of quality (HOQ) for application to the analysis of the design factor of the board games. This was classified into the following steps:

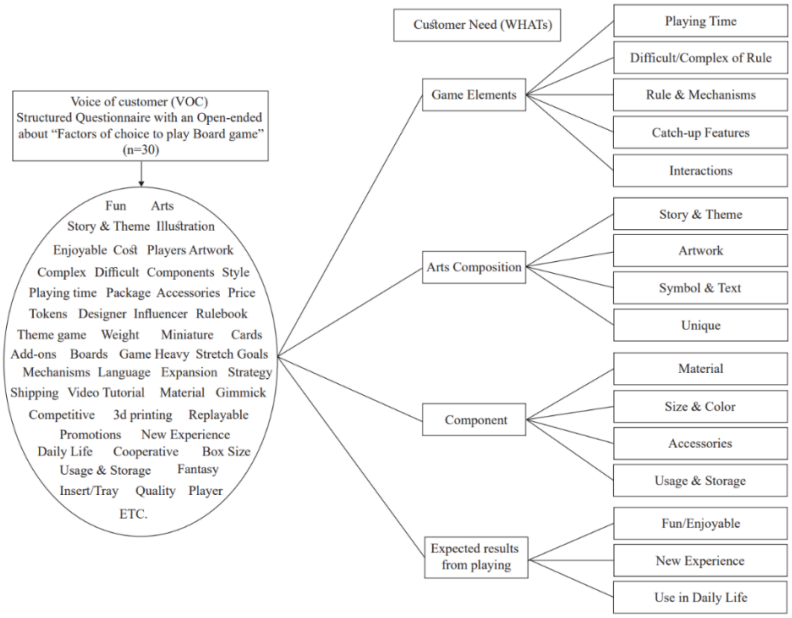
Step 1: Gathering Customers' Requirements of the Voice of the Customer (VOC) and Finding the Importance Level (IMP) From the Customers' Needs (WHATs)

The first step was the factor analysis of the board game design to be suited to the voice of the customer (VOC) by applying the gathered tools, such as an open-ended structured questionnaire. This involved the selection factor of choosing the board game and the target groups that had a group sampling of 30 board game customers from a board game cafe in Lat Krabang, Bangkok (Figure 2**).**

FIGURE 2
COLLECT PRIMARY DATA WITH GROUP SAMPLING TO FIND THE VOICE OF THE CUSTOMER (VOC)

After that, the information of the VOC was brought to be grouped as the customers' needs (WHATs) through the connection of four factors with a tree diagram: **1)**Internal Components in the Games 2)Arts Component Design 3)Equipment in the Games and 4**)**Expected Results from Playing the Game (Figure 3**).**

FIGURE 3
DATA CONVERSION TO SET UP THE GROUP OF THE VOICE OF THE CUSTOMER (VOC) AS CUSTOMERS' NEEDS (WHATS)



Next, the researcher built the tool of the customers' needs (WHATs), such as a close-ended structured questionnaire. Using a five-point Likert scale rating, the information was analyzed for the factors in designing a board game with the most important level (IMP). This was related to the informants for the designing factors of the board games; namely, 100 board game customers group sampling from the "Board Game Lounge TH" groups. Thus, this was selected for stratified random sampling with a level of reliability of 95% with a discrepancy of ±10% according to Yamane (1973). The questionnaires were distributed by September 6, 2021. The researcher allowed for one week to collect the data and gained the result as shown in Table 2.

TABLE 2
THE IMPORTANCE LEVEL (IMP) FROM THE CUSTOMERS' NEEDS (WHATS) AFFECTING THE SELECTION FACTORS OF THE BOARD GAMES

Main Factor	Subfactor List: Board game Players (n = 100)	$\bar{x}$	S.D	IMP
Game Elements	1. Playing time	3.58	1.08	High
	2. Difficulty/complexity of the rules	3.95	0.81	High
	3. Rules & mechanisms	4.30	0.83	High
	4. Catch-up features	3.84	1.04	High
	5. Interactions	4.13	0.87	High
Total		3.96	0.88	High
Arts Composition	1. Story & theme	3.93	1.00	High
	2. Artwork	3.98	0.90	High
	3. Symbol & text	4.23	0.86	High
	4. Unique	4.39	0.71	High
Total		4.13	0.83	High

Component	1. Material	4.01	0.92	High
	2. Size & color	3.93	0.83	High
	3. Accessories	3.56	1.04	High
	4. Usage & storage	3.98	0.94	High
Total		3.87	0.90	High
Expected results from playing	1. Fun/enjoyable	4.84	0.37	Very High
	2. New experience	4.22	0.80	High
	3. Use in daily life	2.75	1.39	Medium
Total		3.96	0.88	High

The analysis of the impact (IMP) from the customers' needs (WHATs) from 100 board game customers group sampling showed the results as follows:

1. The first important factor for the board game design was an arts composition ($\bar{x}$ = 4.13; S.D. = 0.83) with the most needed subfactor as unique ($\bar{x}$ = 4.39; S.D. = 0.71), followed by symbol and text ($\bar{x}$ = 4.23; S.D. = 0.86), and artwork ($\bar{x}$ = 3.98; S.D. = 0.90)**.** Then, the above important three factors assisted the games to be more interesting with the board game design in the markets. In addition, this showed that the least score factor was story and theme ($\bar{x}$ = 3.93; S.D. = 1.00), especially for some customers who viewed that there were too many stories in the design contributing to the decreased motivation for playing the board games. However, other customers preferred playing board games with many stories and felt impressed with the games.
2. The second important factor for the board game design was the game elements ($\bar{x}$ = 3.96; SD = 0.88) with the most needed subfactor as rule and mechanisms ($\bar{x}$ = 4.39; SD = 0.71), followed by interactions ($\bar{x}$ = 4.23; SD = 0.86) and difficulty or complexity of the rules ($\bar{x}$ = 3.98; SD = 0.90). Then, the above important three factors assisted the games to be more suitable for the customers' needs. In this case, the regulations and the mechanisms of the games were too complex, thus resulting in the decrease in board game comprehension until the board games became no longer attractive. This was also followed by the catch-up features ($\bar{x}$ = 3.84; SD = 1.04), which was the factor that regulated the board game playing patterns, such as the competitive game patterns had to be designed with mechanisms. As a consequence, the players with the least scores had to follow the scores of the other players, except for the participation games without using this factor and the playing time ($\bar{x}$ = 3.58; SD = 1.08), which each player would have different emotions with each board game round. Thus, the time to play the game was only the set boundaries for basic board game playing.
3. The third important factor for board game design was the expected results from playing ($\bar{x}$ = 3.96; SD = 0.88) with the most needed subfactor being fun or enjoyable ($\bar{x}$ = 4.84; SD = 0.37). In addition, the above two factors were important ones that allowed the design of all kinds of games, so a good board game design should assist the players to have participation and fun from the beginning of playing the games, followed by a new experience ($\bar{x}$ = 4.22; SD = 0.88). Then, the greater the interest in the board game design, the greater the need for the players to play the board games and use in daily life ($\bar{x}$ = 2.75; SD = 1.39), which was the factor that most players neglected. Then, the playing of board games was used to make fun among friend groups or families; however, it could be applied in daily life at a reduced level.
4. The last important factor for the board game design was component ($\bar{x}$ = 4.13; SD = 0.83) with the most needed subfactor as material ($\bar{x}$ = 4.01; SD = 0.92), followed by usage and storage ($\bar{x}$ = 3.98; SD = 0.94) because the playing equipment was the moving factor. Then, the selection of durable materials to prevent the equipment from being damaged or lost was an important subject, especially for any equipment to be damaged resulting in the usability to replay the board games, which was followed by the size and colour ($\bar{x}$ = 3.94; SD = 0.83), and the last factor or accessories ($\bar{x}$ = 3.56; SD = 1.04). Some additional equipment also had a high price

without the necessity to be used for playing with the board games, except for the additional equipment design to have the beauty for attracting the players to be interested in playing the board games.

Step 2: Determination of the Target Value (HOWs) and Technical Correlations of the Guidelines for the Design of Board Games

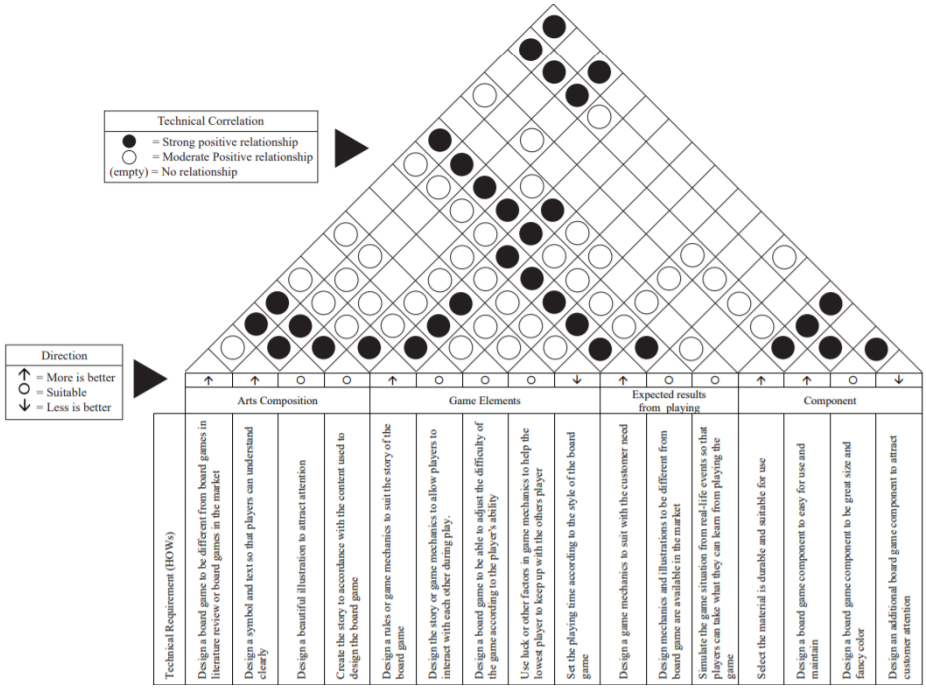
The determination of the target value (HOWs) was brainstormed with the customers' needs (WHATs) in the research team for the board game design, as it should fit most customers' needs. Then, it could be regulated for the technique goals as the symbols to know the directions of the designed board game consisting of 1) ↑ = the more is better, 2) ○ = the same level and 3) ↓ = the less is better. This was determined with the design goals from 16 subjects as shown in Table **3.**

TABLE 3
THE TARGET VALUE (HOWS) AND DIRECTIONS FOR THE DESIGN OF BOARD GAMES

Customer Need (WHATs)		Target Value (HOWs)	Direction
Arts Composition	Unique	Design a board game to be different from board games in literature review or board games in the market	↑
	Symbol & Text	Design a symbol and text so that players can understand clearly	↑
	Artwork	Design a beautiful illustration to attract attention	○
	Story & Theme	Create the story to accordance with the content used to design the board game	○
Game Elements	Rule & Mechanisms	Design a game mechanics to suit the story of the board game	↑
	Interactions	Design the story or game mechanics to allow players to interact with each other during play.	○
	Difficult/Complex of Rule	Design a board game to be able to adjust the difficulty of the game according to the player's ability.	○
	Catch-up Features	Use luck or other factors in game mechanics to help the lowest player to keep up with the others player	○
	Playing Time	Set the playing time according to the style of the board game	↓
Expected results from playing	Fun/Enjoyable	Design a game mechanics to suit with the customer need	↑
	New Experience	Design mechanics and illustrations to be different from board game are available in the market	○
	Use in Daily Life	Simulate the game situation from real-life events so that players can take what they can learn from playing the game.	○
Component	Material	Select the material is durable and suitable for use	↑
	Usage & Storage	Design a board game component to easy for use and maintain	↑
	Size & Color	Design a board game component to be great size and fancy color	○
	Accessories	Design an additional board game component to attract customer attention	↓

After that, the target values (HOWs) were analyzed for the relationships of the technical correlation in each pair. Moreover, this could create the design guidelines for the board game that would be appropriate to the customers' needs at the highest level by giving the symbol to be placed into two patterns. This had the most effective relationship by being replaced with "●" and the least effective relationship by being replaced with "○". Then, this had the displaying effect in the same direction, or the contrasting direction (Figure 4).

FIGURE 4
TECHNICAL CORRELATIONS OF THE TARGET VALUE (HOWS)



Step 3: Priority Relationships of the Target Value (HOWs)

The researcher brainstormed with the research team to determine the level of the score of the WHATs and HOWs as a matrix relationship. This was classified into four levels consisting of the first rank with "9" as the excellent relationship, the second rank with "3" as the moderate relationship, the third rank with "1" as the less relationship, and the fourth rank with "0" as no relationship and others. After that, the scores were calculated to find the important weight of the technique requirement before applying all results to make the priority relationships that were divided into two parts:

1) Absolute technical requirement importance (AI) was used for the formula for the calculation which was the IMP × the level of the scores of the relationship factor.
2) Relative technical requirement importance (RI) was used for the formula for the calculation that was

$$\frac{\text{Absolute Technical Requirement Important(AI)}}{\textit{Absolute Technical Requirement Important Sum}(\sum \text{AI})} \times 100$$

After completing all the analysis procedures, the result from the first procedure was utilized to create the house of quality (HOQ), which included the WHATs being placed on the left hand and bringing the IMP from the WHATs to be placed together. Next, the technical correlations were placed above the house roof, and then it was applied for the matrix relationships to be placed in the middle of the house. Finally,

the technique requirement importance was placed at the bottom as the house base, thus making the priority relationships (Figure 5).

FIGURE 5
PRIORITY RELATIONSHIPS OF THE TARGET VALUE (HOWS)

Relationships of IMP and HOWs
9 = Very strong relationship
3 = Strong relationship
1 = Weak relationship
(empty) = No relationship

	Customer Need (WHATs)	No.	Technical Requirement (HOWs)	IMP	B-1 Design a board game to be different from board games in literature review or board games in the market	B-2 Design a symbol and text so that players can understand clearly	B-3 Design a beautiful illustration to attract attention	B-4 Create the story to accordance with the content used to design the board game	B-5 Design a rules or game mechanics to suit the story of the board game	B-6 Design the story or game mechanics to allow players to interact with each other during play.	B-7 Design a board game to be able to adjust the difficulty of the game according to the players ability	B-8 Use luck or other factors in game mechanics to help the lowest player to keep up with the others player	B-9 Set the playing time according to the style of the board game	B-10 Design a game mechanics to suit with the customer need	B-11 Design mechanics and illustrations to be different from board game are available in the market	B-12 Simulate the game situation from real-life events so that players can take what they can learn from playing the game	B-13 Select the material is durable and suitable for use	B-14 Design a board game component to easy for use and maintain	B-15 Design a board game component to be great size and fancy color	B-16 Design an additional board game component to attract customer attention	
Arts Composition	Unique	A-1	4.39	9	3	3	3	9	3	3	3	0	3	9	3	3	3	9	9	
	Symbol & Text	A-2	4.23	9	9	9	3	1	1	1	1	0	1	9	0	0	0	9	3	
	Artwork	A-3	3.98	9	9	9	3	3	3	0	0	0	3	9	3	0	0	9	3	
	Story & Theme	A-4	3.93	9	9	3	9	9	3	3	3	9	1	9	9	0	0	3	3	
Game Elements	Rule & Mechanisms	A-5	4.30	9	9	1	3	9	9	9	9	9	9	9	9	0	1	0	0	
	Interactions	A-6	4.13	0	3	0	3	3	9	3	1	3	0	0	0	0	0	0	0	
	Difficult/Complex of Rule	A-7	3.95	1	3	0	3	9	3	9	3	3	3	1	1	0	0	0	0	
	Catch-up Features	A-8	3.84	0	0	0	0	3	0	1	9	0	0	0	0	0	0	0	0	
	Playing Time	A-9	3.58	0	0	0	1	3	3	1	1	9	3	0	0	0	1	0	0	
Expected results from playing	Fun/Enjoyable	A-10	4.84	9	3	1	3	9	3	3	3	3	9	9	3	3	1	1	3	
	New Experience	A-11	4.22	9	3	3	3	9	3	3	3	1	3	9	3	3	1	1	9	
	Use in Daily Life	A-12	2.75	0	0	0	3	3	3	1	1	0	0	0	9	0	0	0	0	
Component	Material	A-13	4.01	3	0	0	0	0	0	0	0	0	1	1	0	9	9	9	3	
	Usage & Storage	A-14	3.98	3	0	0	0	0	0	0	0	0	1	1	0	9	9	9	1	
	Size & Color	A-15	3.93	3	1	3	0	0	0	0	0	0	0	1	0	3	9	9	9	
	Accessories	A-16	3.56	3	1	3	0	0	0	0	1	0	3	3	0	0	0	0	9	
	Priority Relationships			1	5	14	12	3	7	11	9	13	8	2	10	16	15	4	6	Total
	Absolute Technical Requirement Important			319.40	220.04	143.12	149.32	289.74	175.02	153.18	155.50	149.27	169.45	295.56	155.06	124.05	137.63	241.53	211.85	3,089.72
	Relative Technique Requirement Important (%)			10.34%	7.12%	4.63%	4.83%	9.38%	5.66%	4.96%	5.03%	4.83%	5.48%	9.57%	5.02%	4.01%	4.46%	7.82%	6.86%	100%

The priority relationships of the HOQ considered the design objectives of the board games that fitted with the customers' needs. The three most highly ranked objectives were as follows: 1) The different components of the game design in the research articles and the markets (10.34%), 2) the mechanical design with the board game pictures that varied from the markets (9.57%). This was noticed by the similarity of the first and the second objectives, except for the components of the game design with the overall design of the board games from the stories, mechanism, diagrams, as well as the parts and all the equipment. The design guidelines to promote learning focused on the mechanism design and the game diagrams as the main part, which were provided that the mechanism design and the diagrams were similar to the games sold in the markets or requiring uniqueness, in which the players would not be interested in playing the board games. 3) The regulations design or the mechanism of the games to be suitable with the board game stories (9.38%). Therefore, the more the regulations could be designed, or the mechanism is made more obvious, the more this could stimulate the players to understand the stories or the game objectives for learning more quickly. After that, this was related to the specific component design for the board game, such as the size of the design and colours of the equipment or the symbols and the fonts of the board games with beauty, which was relevant to the picture design for responding to the customers similar to the first objective.

Step 4: The Newly Presented Factor From the Experimental Process of Designing Board Game Products to Verify the Validity.

There Are steps for creating a new board game as follows:

1) Determine design guidelines by applying factors from education to design a new board game by presenting the story of the COVID-19 virus to be used as the main point in the design of new games.

2) Determine the content and playing method by creating content and a story as well as a method to play board games aimed at building knowledge about methods to protect oneself from COVID-19.
3) Actual prototyping by prototyping and testing with consumers who are interested in new board games.
4) Real trial by having consumers join to play a new board game and get educated about how to protect themselves from COVID-19.

According to the process of evaluating research, board game products were created to promote learning while meeting consumer needs. Besides, it experimented with prototype products based on the principles of new board game design. Then, it is involved with presenting the content to the world after the COVID-19 pandemic, which is used to try with consumer groups.

FIGURE 6
RESULTS OF BOARD GAME DESIGN DEVELOPED USING THE NEW DESIGN FACTOR

Once a prototype is produced, the prototype for the new board game is tested with a group of target consumers to assess their satisfaction with playing the board game and the ability to increase their knowledge. In this case, the researcher used the world after the COVID-19 pandemic as an example to evaluate the board game design factors. Further, the environment in which the board game is played will be appropriately arranged, and the outcomes of the game will be assessed in terms of enjoyment, knowledge, and thinking skills, as well as other aspects (Elverdam et al., 2007).

FIGURE 7
A GROUP PLAYING BOARD GAMES TO PROMOTE KNOWLEDGE OF THE WORLD AFTER THE COVID-19 PANDEMIC

According to the CFA validation process and the creation of structural equations, the facts are confirmed in this step. Besides, there is a CFA number of four factors, which is the result obtained from the experimental use of the newly-developed board game. After that, it inputs the confirmation of the structural equation model to design a new board game by using data that includes the satisfaction level of the board game players for analysis. In this case, Cronbach's Alpha = .715, indicating that the questions used to collect data are at a moderate level. In addition, it can be used to collect data for suitable analysis, which shows the results of the First Order analysis of factors affecting consumer choice. In this case, it has been tested for the measurement model from four factors affecting the selection of new board games for analysis of the observed variables.

TABLE 4
ANALYSIS OF SECOND ORDER FOR BOARD GAME DESIGN FACTORS

Latex Variable	**Art**			**Element**			**Expected**			**Component**			r^2
Observable Variable	β_i	b_i	***SE***	β_i	b_i	***SE***	β_i	b_i	***SE***	β_i	b_i	***SE***	
Art / story, theme	.46	1.00	-	-	-	-	-	-	-	-	-	-	.214
Art / artwork	.20	.31	. 110	-	-	-	-	-	-	-	-	-	.040
Art / symbol, text	.15	.24	. 105	-	-	-	-	-	-	-	-	-	.022
Art / unique	.12	.18	. 091	-	-	-	-	-	-	-	-	-	.015
Element / playing time	-	-	-	.48	.84	. 173**	-	-	-	-	-	-	.235
Element / difficult, complex of rules	-	-	-	.47	.97	. 206**	-	-	-	-	-	-	.224
Element / rules, mechanisms	-	-	-	.33	.64	.174**	-	-	-	-	-	-	.108
Element / catch-up features	-	-	-	.34	.65	.1 31**	-	-	-	-	-	-	.114
Elements / interactions	-	-	-	.50	1.00	-	-	-	-	-	-	-	.255
Expected / fun, enjoyable	-	-	-	-	-	-	.31	.36	.103**	-	-	-	.099
Expected / new experience	-	-	-	-	-	-	.78	1.00	-	-	-	-	.611
Expected / use in daily life	-	-	-	-	-	-	.48	.58	. 110**	-	-	-	.228
Component / material	-	-	-	-	-	-	-	-	-	.42	.63	.1 64**	.178
Component / size, color	-	-	-	-	-	-	-	-	-	. 5 8	. 8 8	.192**	.340
Components / accessories	-	-	-	-	-	-	-	-	-	.62	1.00	-	.388
Component / usage, storage	-	-	-	-	-	-	-	-	-	.35	.63	. 187**	.124

	Factors in board game design			R^2
latent variable	β_i	b_i	***SE***	
Art	1.44	1.00	-	2.081
Element	1.15	. 7 9	. 136**	1.311
Expected	.95	.95	.139**	.901
Component	.72	.59	.116**	.523

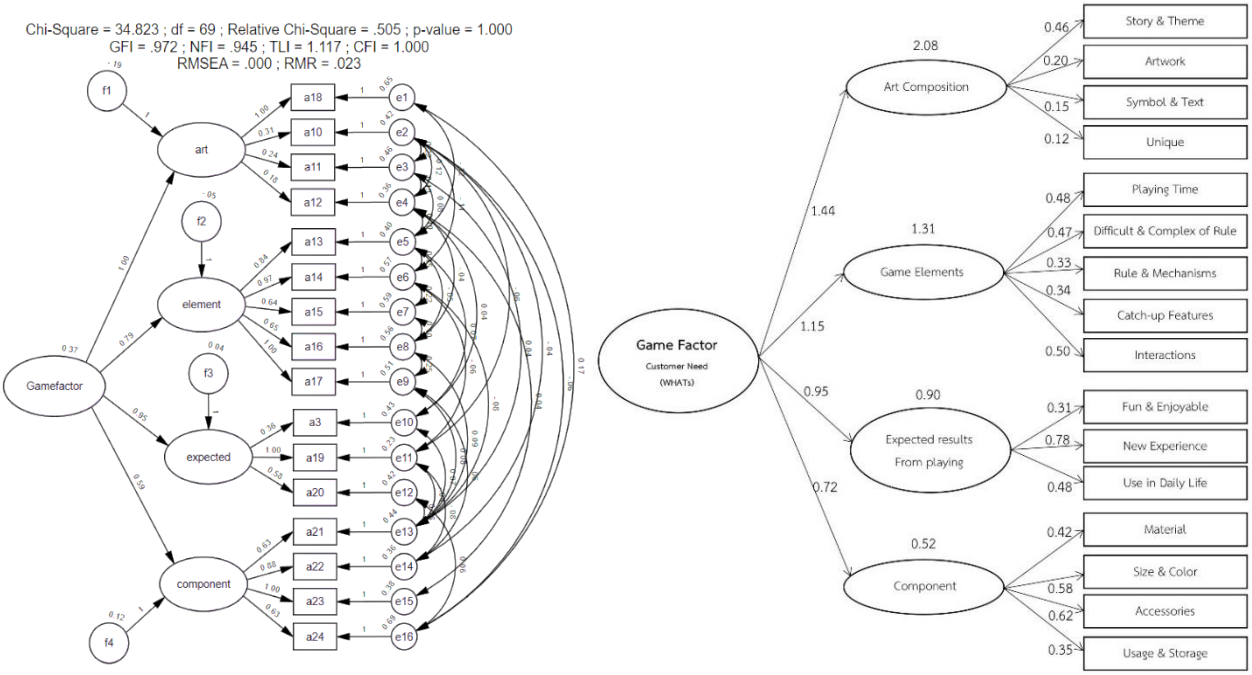
χ^2= 30.948 , df = 67 , relative *χ^2= .462 , p = 1.00 , RMSEA = . 000 , RMR = . 022 , GFI = . 975 , AGFI = . 954 , NFI = . 951 , TLI = 1.127 , CFI = 1.000*
CMIN = 34.823, PGFI = .493

** P < .05 ; ** P < .01*

According to the second analysis results, it is involved with the feeling of satisfaction when the players try to use the newly-developed board game. Besides, the model conformance index for the Amos (AMOS) program was obtained according to the criteria of Schumacker & Lomax (2010), to be shown as follows χ^2= 30.948, df = 67 , relative χ^2= .462, p = 1.00, RMSEA = .000 , RMR = .022, GFI = .975, AGFI = .944, NFI = .951, TLI = 1.127, CFI = 1.000, CMIN = 34.823, PGFI = .493. Then, the conformity index meets the specified criteria, relative. χ^2 less than 2 indexes RMSEA, RMR to be less than .05, GFI, AGFI, NFI, TLI to be greater than .95, and AGFI to be greater than .90, corresponding to the newly-developed board game design factor. In this case, it can be applied according to the concepts of Diamantopoulos & Siguaw (2000) and Kelloway (2015) concerning the feelings that affect player satisfaction with the newly-developed board game, consisting of four elements: 1) Art Composition Factor, 2) Game Elements Factor, 3) Expected Results from Playing Factor, and 4) Component in which all 4 factors affect the need or feeling of satisfaction towards the newly-developed board game.

Besides, when arranging the factors affecting the players' satisfaction with the board game, it showed high levels to low levels as follows:1) Art Composition Factor (1.44; 1.00), 2) Game Elements Factor (1.15; 0.79), 3) Expected Results from Playing Factor (0.95; 0.95), and 4) Component (0.72; 0.59) to be presented as a diagram.

FIGURE 8
SECOND ORDER REPORTING OF STANDARDIZED ESTIMATES AND FINAL STRUCTURAL EQUATION MODEL



According to the importance of the observed variables for each component, ordering can be achieved as follows:

First place is the art composition factor, which is measured from four observable variables, with Story & Theme as the most important followed by artwork, symbol & text, and uniqueness as the standard score coefficients of variable weights that were 0.46, 0.20, 0.15, and 0.12, respectively.

Second place is the game elements factor, which is measured from five observable variables, with interactions as the most important followed by playing time, difficulty & complexity of rules, catch-up features, and rule, & mechanisms from the standard score coefficients of variable weights that were 0.50, 0.48, 0.47, 0.34, and 0.33, respectively.

Third place is the expected results from playing factor, which can be measured from three observable variables, with new experience being the most important followed by use in daily life and fun & enjoyable from the standard variable weight of score coefficients that were 0.78, 0.48, and 0.31, respectively.

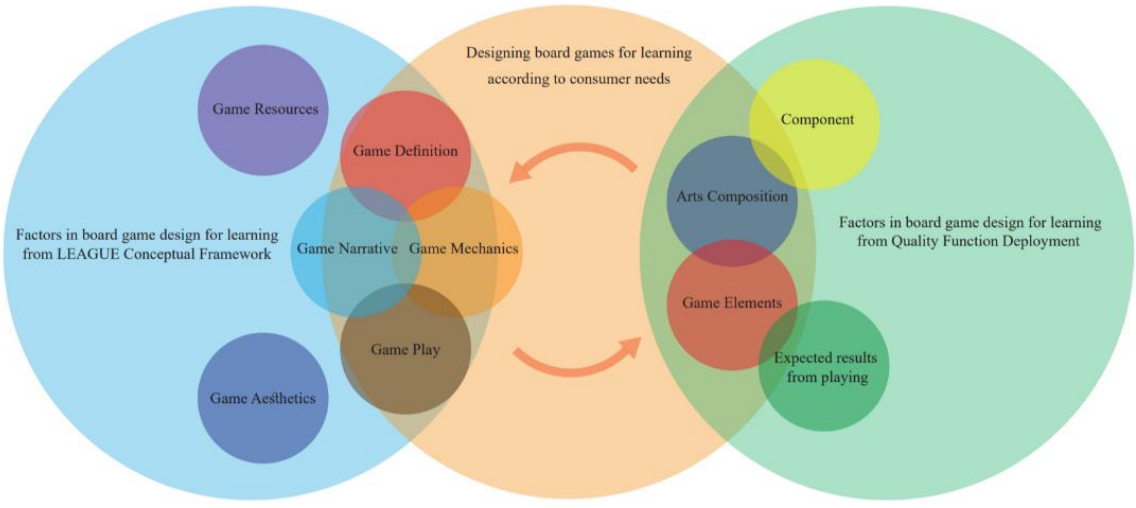
Fourth place is the component factor, which is measured by four observable variables. Accessories are the most important, followed by size & color, material and usage & storage from the standard score coefficients of variable weights that were 0.62, 0.58, 0.42, and 0.35, respectively.

DISCUSSION

The study of the board game design factors for game-based learning used two patterns of analysis techniques, which focused on two aspects: 1) Gameplay and mechanism, and 2) story and artwork. However, the two patterns of the analysis techniques were different in some parts. The design of the board game for learning from a systematic review gave importance to the design mechanism by the learning content to promote learning and allow the players to practice skills for gaining a good effective learning result more than the designed illustration within the board game. Nevertheless, in the part of the design of the board game, which used the analysis from quality function deployment (QFD), this gave importance to designing unique stories and beautiful illustrations, especially for designing unique gameplay and essential mechanics. This was because if the designed board game had the same gameplay or mechanics as a game on the market, this may result in customers being less motivated to play board games.

The results of this analysis were consistent with the study of the design factors of game-based learning in many research articles. These studies stated that a board game for learning should be designed with a balance of the mechanism for the players to develop their strategies with the proper abilities (Garris et al., 2002) and should consist of three main components, such as strategies, luck, and knowledge skills. Thus, if there was a lack of any factor or there were too many factors, this may result in the insufficiency of motivation for the players to learn by playing games (Hawkinson, 2013). In addition, the story design of the games, would depend on the complexity of the games because the more complex the games, the more importance of their stories (Killi, 2005), and the design of the beautiful pictures inside the games could promote all factors to have more effectiveness (Plass et al., 2015). Therefore, according to the result of the two patterns, it could bring the factor to be integrated with the relationship to determine the guidelines of the board game design to promote the appropriate learning of the customers' needs.

FIGURE 9
RELATIONSHIPS AMONG THE DESIGN FACTORS OF THE BOARD GAMES FOR LEARNING AND THE DESIGN FACTORS FROM QUALITY FUNCTION DEVELOPMENT (QFD)



The structural equation modeling is based on the satisfaction of the newly-developed board game group. Moreover, it is based on all four factors derived from Systematic Review and Quality Function Deployment **(**QFD) techniques, which can be summarized to assess player satisfaction. Then, when all four factors and sixteen observable variables were added to the analysis, Confirmatory Factor Analysis (CFA) has been found that the priority of the factors affect the satisfaction of the players for the newly-developed board game as follows: 1) Art Composition, 2) Game Elements, 3) Expected Results from Playing, and 4) Component and others. Thus, the board game design has paid attention to the nature of the artistic element following the idea that humans tend to devote themselves to applied arts because of the characteristics of taste and preferences for each period along the line. In this case, the work designed for each period always manifests a unique identity that corresponds to each of those moments, according to the idea by Rasulov Murad Absamatovich (Absamatovich et al., 2021; Egwutvongsa et al., 2022)**.** Additionally, the second priority is the game and its elements, which every player cares about. Therefore, it is important to deliver a feeling of fun while playing, which happens in the minds of the players. This is the initial element that will result in the player's enthusiasm for playing board games in terms of having the right individual player participation. In the same way, the importance of success in board games will include the elements of the game and the importance of the players' personal tastes (Thiel et al., 2015; Ferro, 2021)**.** Thus, expected results from playing can affect the minds of the players. This is because players tend to assess the feelings that arise, both during and after playing, in the form of the feelings that occur within their minds, as well as their passion, fun, excitement, fear or challenge, and others. After that, all that exists in the abstraction resulting from playing board games can often create a stimulus to reflect players' behavior. Thus, it is the infatuation or desire to play continuously according to the concept of Héctor Fuster and his team concerning opinions and the importance of playing to enhance knowledge and arouse higher interest (Foster et al., 2014; Stoeber et al., 2011). Besides, the fourth component is consistent with the criteria that creative design should create a board game product contributing to accumulation. In the same way, increasing knowledge is based on the ideas of Jorge Gaete et al., which concern indirectly influencing the players' experience after playing board games. Most of the time, it also encourages learning based on the experience being perceived when the player is playing the game. Finally, it impacts the skills or knowledge that are accumulated from repeated play, which is similar to the ability to remember and understand stories that have been inserted into a redesigned board game (Gaete et al., 2017; Egwutvongsa et al., 2021).

According to the four factors that were examined, the correlation for the importance of each factor affects the satisfaction of the players with the newly-developed board game that was correlated. Besides, the various components of the board game can be seen in two aspects, according to Cameron Browne et al., which describe the general characteristics of the game, including 1) the nature of the game's intangible abstraction, and 2) the nature of the tangible forms of the game (Browne et al., 2010; Ijsselsteijn et al., 2007; Egwutvongsa, 2021). Therefore, both of these characteristics directly influence the chances of success in new board game designs because the players touch both concrete objects while playing, such as the board, walking tiles, and playing cards, among others. Similarly, it involves excitement, provocation, and aesthetics as well as other aspects concerning the fusion of various elements until it becomes a complete board game that can meet the needs of players and create knowledge for the enhanced effectiveness of players.

CONCLUSION

From the study design factors of board games for learning from a systematic review and the study from the voice of the customer (VOC) by quality function deployment (QFD), it could be concluded that to design the board games for promoting learning suitably with the customers could be classified into two important factors: 1) Gameplay and mechanism, and 2) story and artwork. This was consistent with Shi and Shih (2015), who mentioned that the guidelines to design game-based learning should have a mechanism congruent with the game stories or contents to generate good participation or learning experiences with amusement through the interaction between the players or during the different game stories. Thus, the best mechanism must be sufficiently flexible for the players to have independence with selecting the actions

inside the games, including increasing the challenges for learning that would be suitable to their abilities to prevent their lack of motivation while playing the games.

Furthermore, Tahir and Wang (2019) recommended that the guidelines to design game-based learning should pay attention to the approach or process of the design, such as building a prototype to test that the game mechanics could be appropriately linked to the learning objectives and could attract players to develop their skills and engage through emotional responses. This would include the use of design models to evaluate the actual performance with the advantage of the design guidelines that could be used to effectively support the use of board game designs to promote learning.

ACKNOWLEDGEMENTS

This work was financially supported by King Mongkut's Institute of Technology Ladkrabang Research Fund. The research was achieved by the supporting fund of the budget for the 2022-2023 fiscal year from the School of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand. According to the research fund contract no. 2565-02-03-00**1**.

REFERENCES

Absamatovich, R.M., & Kizi, A.M.B. (2021). Methodological Basis of Creation, Organization and Decoration of Platter's Artistic Composition in Applied Art. *The American Journal of Applied Sciences*, *3*(4), 298–310. https://doi.org/10.37547/tajas/Volume 03 Issue 04-42

Berland, M., & Lee, V.R. (2011). Collaborative strategic board games as a site for distributed computational thinking. *International Journal of Game-Based Learning*, *1*(2), 65–81. https://doi.org/10.4018/ijgbl.2011040105

Bratitsis, T., Kontovounisiou, A., & Kiriazoglou, M. (2021). A board game proposal for teaching informatics related topics in early childhood education. *SHSHS Web of Conferences 102*, 01001 ETLTC2021. https://doi.org/10.1051/shsconf/202110201001

Browne, C., & Maire, F. (2010). Evolutionary Game Design. *IEEE Transactions on Computational Intelligence and AI in Games*, *2*(1), 1–16, https://doi.org/10.1109/TCIAIG.2010.2041928.

Cheng, P.-H., Yeh, T.-K., Tsai, J.-C., Lin, C.-R., & Chang, C.-Y. (2019). Development of an issue-situation-based board game: A systemic learning environment for water resource adaptation education. *Sustainability*, *11*(5), 1341. https://doi.org/10.3390/su11051341

Cohen, L. (1995). *Quality function deployment*. Addison Wesley Longman.

Eck, R.V. (2007). Six ideas in search of a discipline. In B.E. Shelton & D.A. Wiley (Eds), *The design and use of simulation computer games in education*. Sense Publishing.

Egwutvongsa, S. (2021). Influence Factors on Industrial Handmade Products Designed from Sugar Palm Fibers. *Strategic Design Research Journal*, *14*(2), 456–470. https://doi.org/10.4013/sdrj.2021.142.06

Egwutvongsa, S., & Seviset, S. (2021). Ideas for Creation: A Comparison of the Learning Results of Three-Dimensional Images between Active Learning and Child-Centered Education of Product Design Students. *International Journal of Emerging Technologies in Learning*, *16*(11), 273–288. https://doi.org/10.3991/ijet.v16i11.21597

Egwutvongsa, S., Seviset, S., & Piramgran, T. (2022). Heuristic Strategies: Achieving Influence Motivation with Success to Design Industrial Products in Projects from the Department of Architectural Education and Design. *International Journal of Emerging Technologies in Learning*, *17*(5), 4–21. https://doi.org/10.3991/ijet.v17i07.25181

Elverdam, C., & Aarseth, E. (2007). Game Classification and Game Design: Construction Through Critical Analysis. *Games and Culture*, *2*(1), 3–22. https://doi.org/ 10.1177/1555412006286892

Fan, K-K., Xiao, P.W., & Su, C. (2015). The effects of learning styles and meaningful learning on the learning achievement of gamification health education curriculum. *EURASIA Journal of*

Mathematics, Science & Technology Education, *11*(5). https://doi.org/10.12973/eurasia.2015.1413a

Ferro, L.S. (2021). The Game Element and Mechanic (GEM) framework: A structural approach for implementing game elements and mechanics into game experiences. *Entertainment Computing*, *36*, 100375. https://doi.org/10.1016/j.entcom.2020.100375

Fuster, H., Chamarro, A., Carbonell, X., & Vallerand, R.J. (2014). Relationship Between Passion and Motivation for Gaming in Players of Massively Multiplayer Online Role-Playing Games. *Cyberpsychology Behavior and Social Networking*, *17*(5), 292–297. http://doi.org/10.1089/cyber.2013.0349

Gaete, J., Valenzuela, D., Rojas-Barahona, C., Valenzuela, E., Araya, R., & Salmivalli, C. (2017). The KiVa antibullying program in primary schools in Chile, with and without the digital game component: Study protocol for a randomized controlled trial. *Trials*, *18*, 75. https://doi.org/10.1186/s13063-017-1810-1

Garris, R., Ahlers, R., & Driskell, J.E. (2002). Games, motivation, and learning: A research and practice model. *Simulation & Gaming*, *33*(4), 441–467. http://doi.org/10.1177/1046878102238607

Gee, J.P. (2003). *What video games have to teach us about learning and literacy*. London, Palgrave Macmillan.

Gee, J.P. (2007). *What video games have to teach us about learning and literacy* (Revised and Updated Edition). London, Palgrave Macmillan.

Gillern, S.V., & Alaswad, Z. (2016). Games and game-based learning in instructional design. *International Journal of Technologies in Education*, *23*(4), 1–17. http://doi.org/10.18848/2327-0144/CGP/v23i04/1-7

Graham, L. (2016). *Millennials are driving the board games revival*. Retrieved from www.cnbc.com/2016/12/22/millennials-the-boardgames-revival-catan-pandemic.html

Hawkinson, E. (2013). Board game design and implementation for specific language learning goals. *The Asian Conference on Language Learning 2013*. *Conference Proceedings*, pp. 317–326. Retrieved from http://papers.iafor.org/wp-content/uploads/papers/acll2013/ACLL2013_0169.pdf

Hsu, H.L., & Chen, Z.H. (2020). Applying component-based strategy to design an educational board game for children to learn Chinese characters. *28th International Conference on Computers in Education*, Conference Proceedings, *1*(1), 448–453. Retrieved from https://scholar.lib.ntnu.edu.tw/en/publications/applying-component-based-strategy-to-design-an-educational-board--2

Ijsselsteijn, W., Nap, H.H., Kort , Y.D., & Poels, K. (2007). Digital game design for elderly users. *Proceedings of the 2007 conference on Future Play (Future Play '07)*, (pp. 17–22). Association for Computing Machinery, NY, USA. https://doi.org/10.1145/1328202.1328206

Killi, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and Higher Education*, *8*(1), 13–24. https://doi.org/10.1016/j.iheduc.2004.12.001

Lanezki, M., Siemer, C., & Wehkamp, S. (2020). Changing the game neighbourhood: An energy transition board game, developed in a co-design process: A case study. *Sustainability*, *12*(24), 10509. https://doi.org/10.3390/su122410509

Lin, H.C.K., Lin, Y.H., Wang, T.H., Su, L.K., & Huang, Y.M. (2021). Effects of incorporating augmented reality into a board game for high school students' learning motivation and acceptance in health education. *Sustainability*, *13*(6), 3333. https://doi.org/10.3390/su13063333

Lin, Y.L., Huang, S.W., & Chang, C.C. (2019). The impacts of a marine science board game on motivation, interest, and achievement in marine science learning. *Journal of Baltic Science Education*, *18*(6), 892–923. https://doi.org/10.33225/jbse/19.18.907

Liu, H.Y., Chen, P.H., Chen, W.J., Huang, S.S., Chen, J.H., & Yao, C.T. (2021). The effectiveness of a board game-based oral hygiene education program on oral hygiene knowledge and plaque index of adults with intellectual disability: A pilot study. *International Journal of Environmental Research and Public Health*, *18*(3), 946. https://doi.org/10.3390/ijerph18030946

Radzi, S.H., Tan, W.H., & Yusoff, A. (2019). Shipping management simulation game for teaching and learning in higher education: A quasi-experimental study. *Malaysian Journal of Learning and Instruction*, *16*(2), 155–186. https://doi.org/10.32890/mjli2019.16.2.6

Radzi, S.H., Ying, T.Y., Abidin, M.Z., & Ahmad, P.A. (2020). The effectiveness of board game towards soft skills development for higher education. *Elementary Education Online, 19*(2). https://doi.org/10.17051/ilkonline.2020.02.111

Rogerson, M.J., & Gibbs, M. (2016). Finding time for tabletop. *Games and Culture*, *13*(3), 280–300. https://doi.org/10.1177/1555412016656324

Shi, Y.R., & Shih, J.L. (2015). Game factors and game-based learning design model. *International Journal of Computer Games Technology, 549684*, 1–11. https://doi.org/10.1155/2015/549684

Sousa, M. (2020). A planning game over a map: Playing cards and moving bits to collaboratively plan a city. *Frontiers in Computer Science*, *2*(37), 1–12. https://doi.org/10.3389/fcomp.2020.00037

Stoeber, J., Harvey, M., Ward, J.A., & Childs, J.H. (2011). Passion, craving, and affect in online gaming: Predicting how gamers feel when playing and when prevented from playing. *Personality and Individual Differences*, *51*(8), 991–995. https://doi.org/10.1016/j.paid.2011.08.006

Tahir, R. & Wang, A.I. (2019). Insights into design of educational games: Comparative analysis of design models. *Advances in Intelligent Systems and Computing*, pp. 1041–1061. https://doi.org/10.1007/978-3-030-02686-8_78

Tahir, R., & Wang, A.I. (2018). Codifying game-based learning: The LEAGUE framework for evaluation. *Proceedings of the 12th European Conference on Game Based Learning (ECGBL 2018)*, pp. 677–686. Sophia Antipolis, France. Retrieved from https://eric.ed.gov/?id=EJ1245096

Thiel, S.K., & Lehner, U. (2015). Exploring the effects of game elements in m-participation. In *Proceedings of the 2015 British HCI Conference (British HCI '15)* (pp. 65–73). Association for Computing Machinery, NY. https://doi.org/10.1145/2783446.2783587

Treher, E.N. (2011). *Learning with board games*. Retrieved from http://www.destinagames.com/pdf/Board_Games _TLKWhitePaper_May16_2011r.pdf

Tsai, J.C., Chen, S.Y., Chang, C.Y., & Liu, S.Y. (2020). Element enterprise tycoon: Playing board games to learn chemistry in daily life. *Education Sciences*, *10*(3), 48. https://doi.org/10.3390/educsci10030048

Tsai, J.C., Liu, S.Y., Chang, C.Y., & Chen, S.Y. (2021). Using a board game to teach about sustainable development. *Sustainability*, *13*(9), 4942. https://doi.org/10.3390/su13094942

Wangenheim, G.V.C., Medeiros, G.A.D., Filho, R.M., Petri, G., Pinheiro, F.D.C., Ferreira, M.N.F., & Hauck, J.C. (2019). Splash code a board game for learning an understanding of algorithms in middle school. *Informatics in Education*, *18*(2), 259–280. https://doi.org/10.15388/infedu.2019.12

Yamane, T. (1973). *Statistics: An introductory analysis* (3rd Ed.). Harper and Row.

Yang, Y.-T.C. (2012). Building virtual cities, inspiring intelligent citizens: Digital games for developing students' problem solving and learning motivation. *Computers & Education*, *59*(2), 365–377. https://doi.org/10.1016/j.compedu.2012.01.012

Yusof, S.A.M., Radzi, S.H.M., Din, S.N.S., & Khalid, N. (2016). *A study on the effectiveness of task manager board game as a training tool in managing project*. https://doi.org/10.1063/1.4960914