Chang, M. et al. (Eds.) (2019). Proceedings of the 27th International Conference on Computers in Education. Taiwan: Asia-Pacific Society for Computers in Education

A Study on Flow Experience and Learning Effectiveness of RFID Educational Board Game System

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Abstract: This study used the Arduino Mega board to develop related peripheral modules such as RFID cards, combined with SD card to record the data, analyze the data and feedback, and used this board game system to teach the computer hardware and software. This study's course took the "Information Literacy and Application" which is the compulsory general education in a university in northern Taiwan. The study participated in the experiment for a total of 40 people in the first year of the university department of foreign language, and divided into the experimental group of 23 people, control group 17 people, the experimental group used the "Hello, Computer !" learning board game which is self-development and design, and the control group used the discussion method to teach, implement the learning outcome test and flow questionnaire after class. The results show that if used this study's learning board game, the experimental groups' learning outcomes were improved clearly, and in their opinion that this board game had a significant effect on learning, furthermore, when experimental group was engaged in the learning board game of this study, all had high level of flow.

Keywords: Game-based learning, flow experience, learning effectiveness

1. Introduction

Game is one of the memories that accompanies most people's growth. In the present digital generation, the game appeared in our lives in a variety of ways, such as digital games, online games or unplugged board games. Each game was formed with its background and the purpose it wanted to achieve, it could be entertainment, puzzle or even learning, however, regardless of its purpose, the only changeless was that the development which was born for innovation (Wang, 2015). From the learning perspective, gamification is not the same as game, game is an organized play, combined learning with games, and after repeated practice (Forst, Wortham, & Reifel, 2001), through the rules and competition for entertainment or the purposes of education, and gamification used game design and mechanics, stimulate students' motivation in learning and solve the problem(Matsumoto, 2016). In recent years, pedagogy has changed greatly with the development of the times, instructors had new ideas about the way of teaching, they were no longer just using traditional teaching modes such as blackboards and didactic (Matsumoto, 2016). More and more instructors used the entertainment of the game itself to attract students' attention, because of the learning board games had the advantages of unplugged and can promote learner interaction, therefore more instructors were trying to apply it to teaching activities(Wang, Chen, Hou & Li, 2017; Li, Wang, Chen, Kuo, & Hou, 2017). Gamification has been considered a new generation of trends (Yu-Ping Kang, Jung-Chin Liang, Yu-Chin Chai, 2014), this trend has changed the teaching habits of the past, try to integrate the emerging game-based learning into more formal courses, it can help the instructors to establish communication with students more effectively (Barzilai, & Blau, 2014). In addition, game-based learning can enhance learners' learning experience, there were also have significant outcomes (Connolly, Stansfield, & Hainey, 2011), the reason was that the nature of game-based learning can appeal students' interest in learning, and interest will bring students' motivation in learning. In the process of experiencing games, discover more interesting ways to learn (Embi, & Hussain, 2005), achieved the goal of strengthening learning (Chen,

2014). However, although game-based learning can improve learning motivation and learning effectiveness, but there were not have systematic record and analysis of the learning process (Adams, & Clark, 2014). In this study, we took the learning computer hardware and software interface for an example, developed and designed the RFID pairing games, and exploring learning process, flow and learning outcomes of students in the game-based learning, let the instructors understand students' learning problem, and then improve the teaching methods or give appropriate remedial teaching.

2. Literature Review

In recent years, pedagogy has changed greatly with the development of the times (Matsumoto, 2016), instructors had new ideas about the way of teaching, they were no longer just using traditional teaching modes such as blackboards and didactic, instead used the game way to teaching, and used the entertainment of the game itself to attract students' attention. This study hopes to increase the interest of students who are non-department of computer science backgrounds in learning computer hardware by the ways of game-based learning. Gamification has been considered a new generation of trends (Yu-Ping Kang, Jung-Chin Liang & Yu-Chin Chai,2014), this trend has changed the teaching habits of the past. Integrating games into education is what this study hopes to achieve, if can apply the trend of game-based learning to each type of teaching, then can bring the great assist to learning motivation. This study is mainly aimed at students who are non-department of computer science backgrounds, used the game-based learning and traditional learning two ways, and discussing whether the game-based learning is really better than the traditional learning, so that in the future can be applied to more teaching.

2.1 Game-based Learning

Prensky(2007) pointed out that there were twelve characteristics of digital game learning, each is entertaining, gameplay, regularity, target, human-machine interaction, results and feedback, adaptability, sense of victory, conflict competitive and challenging, problem solving, social interaction, image and plot. Integrate these features into teaching, thereby assisting students in learning, and through the challenge and sense of victory of the game, motivate students' motivation, and make happiness in an entertaining environment (Bawa, Watson, & Watson, 2018). Game-based learning is characterized by the integration of educational content into the game, and can also achieve the equal learning effect as traditional teaching (Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013), therefore, the game-based learning can also achieve the same teaching purpose. Hogle (1996) pointed out that the game has four advantages for learning, each is to cause the motivation and raise the interest, retention of memory, provide practice and feedbacks and can provide a high level of thinking, but for the effectiveness of game-based learning, usually depends on the student’s goal set for the challenge of this game (Liao, Chen, & Shih, 2019), instructors must also pay attention to the game progress all the time, when students encountered problems during the game, instructors must provide appropriate assistance, ensure that students participate in the game fully.

2.2 Flow Experience

The flow is described the feeling of individual express their internal motivation(Csikszentmihalyi, 1975), flow experience is that a person is fully engaged in the activity, enjoy the process, and only respond to the goals of the activity (Csikszentmihalyi, 1985), and mentally accompanied by distortion of time and space, let individual self-awareness reduce. When the individual is in the flow experience, the spiritual will be concentrated, almost not be influenced by any feeling, and almost not find anything. As long as there is a passionate and positive response to the activity, it will make individuals unable to aware of the information that is not related to the activity, and the ongoing activity has become the purpose, that is flow experience (Csikszentmihalyi, 1997). This study was teaching by the way of game and combined with teaching elements, stimulated students' interest in learning by the appeal of the game itself, and let students in the flow experience, achieve the teaching purpose. Csikszentmihalyi (1990) points out that flow have nine traits: clear objectives, challenge and skill balance, concentrated on the

task, sense of control, combination of action and consciousness, ignore external, time distortion and self-achievement experience. As long as there are nine traits, naturally, it will enter the flow. Csikszentmihalyi (1997) consider that there are three main characteristics of generating the flow:1. Clear objectives: Individuals have a clear goal for what they want to do, then easy to enter the flow state. 2. Immediate Feedback: Individuals have immediate feedback on what they want to do, can also make yourself in the flow. 3. Challenge and Skill balance: Challenges and skills must be match, if the challenges is higher than the skills, then will feel anxious about the game, if the challenges is lower than the skills, then will make individuals feel board, if your ability is low and the challenge is too low, then will generate a fairly shallow flow, therefore, it's necessary to challenge the appropriate challenge with sufficient ability, can make individuals wholeheartedly enter the game, and then generate the flow.

3. Methods

3.1 System Framework

This study is based on the self-developed and designed RFID educational board game system "Hello, Computer !" as the main experimental tool, and system architectures as shown in figure 1, used Arduino microprocessor as the system core, and combined with RFID, buzzer, button, color LCD and other Arduino peripheral modules, used the SD card to store the game process. This system used the RFID-RC522 module as the game card and sensing interface for the game, because each RFID card has a unique UID code feature, therefore, set all the card functions in the game to RFID cards, through sensing and identifying each RFID card, verify whether the cognitive design is meet by pairing and combining. At the end of game, using the data conversion program of our system, convert the game data into a series of visual charts, and provided it to instructors, so that instructors can quickly and effectively understand students' learning situation after using this system. In this study, using the Arduino as our main board, and set the full of game mechanisms in the system, so that it became the different game cards. During the game, in response to the game mechanism set by the system, through the sensing and use LCD as a game screen, as shown in figure 2, show the news and images in the game, and connect the buzzer to emit correctly or not sounds. Students use RFID game cards to play for the whole game, and this system hereby collects all the data from game processes, conduct subsequent analysis and feedback to instructors.

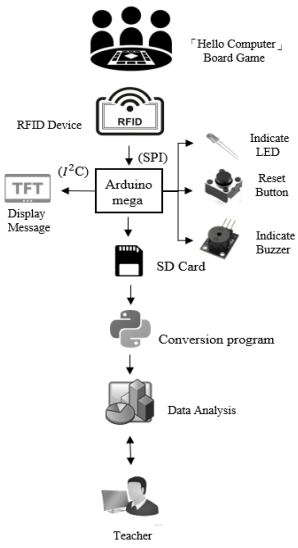


Fig1. System Framework

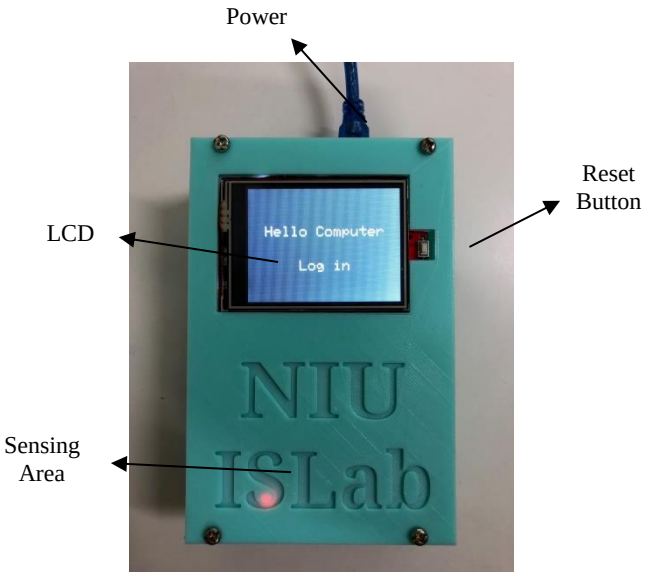


Fig2. System Interface

3.2 Research Participants

This study's course took the “Information Literacy and Application” which is the compulsory general education in a university in northern Taiwan, the course is a single semester and two credits. Implementing “Programming” course for ten weeks of eighteen-week course planning, and implementing computer software and hardware interface peripheral teaching for three weeks, two hours a week, participants in the experiment for a total of forty people in the first year of the university department of foreign language, and divided into two groups, the experimental group of twenty-three people and control group seventeen people, and all the participants are students who non-department of computer science backgrounds. This study used the pretest and posttest experimental design, in the seventeen members of control group, divided into 5 groups, two groups have 4 people, and three groups have 3 people, control group adopted the “Group Discussion”, as shown in figure 3, this study established 5 LINE groups and joined each group member, the tester issues a question, and students discusses and answers the discussion question within the group. In the twenty-three members of experimental group, divided into 6 groups, one groups have three people, and five groups have four people, the experimental group used the game-based learning by the self-developed “Hello, Computer !” learning board game, as shown in figure 4, beside to the pretest and posttest, also implement a flow questionnaire, the content of the test is based on the flow experience questionnaire compiled by Pearce (2005) et al., the questionnaire contains 8 questions including “entertainment”, “concentration” and “control”(Cronbach $\alpha = 0.907$), and the answer is scored using a Likert scale 5-point scale.

Fig3. Control Group do the Group Discussion *Fig4.* Experimental Group do the Learning Board Game

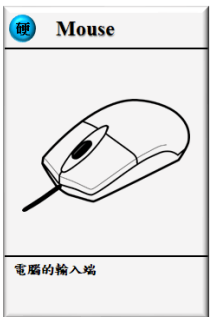
3.3 Group Discussion

In the way of the teaching, the control group used the traditional group discussions, we randomly divided the members of the control group into 5 groups, and organized the relevant knowledge of the computer peripheral into 7 questions. At the beginning of the course, we sent a discussion question to the group, and the discussion time is 10 minutes, during this time, students of the control group discussed each other and answered the question, and after the time is up, the next discussion question will be sent. If students have any questions or need to help during the discussion, we also have member answering questions within the group. Through these discussion questions are selected by this study, and able to get help immediately when confusing, so as to improve students learning outcomes.

3.4 “Hello, Computer ！”Learning Board Game

This study took the computer peripheral as an example, we divided computers into software and hardware two categories, included the components within the motherboard. Used the form of sensing RFID game card pairing to play the game, the cards are divided into five types, and illustrate as follows: First type: User Card, as shown in figure 5, this is the most important card for this system. It represents the identity ID of each player in the system, and it will automatically record all the data of the player

during the game. When player starts, must be used the player's own User Card first, and waiting for the system to confirm identity to enter game screen, then can start the pairing. Second type: Green Card, as shown in figure 6, this type contains the hardware interface and system program of the computer. After the system successfully identifies the ID, this card can be sensed on the game screen, and entering the "Green Card Mode". Third type: Blue Card, as shown in figure 7, this type contains the hardware peripheral and program language of the computer. When system entering the "Green Card Mode", then can sense this card, and the buzzer and LCD will show the result of the pairing after sensing. Fourth type: Reward and Penalty Card, as shown in figure 8, after system show the result of pairing, if successful, then you can draw a reward card, otherwise, draw a penalty card. This card is used in the game screen, then can add or deduct points. Fifth type: Red Card, as shown in figure 9, this type contains the necessary components in the host computer. When the player pair successfully draws the reward card, have probability will get it, and used in the game screen, then can add double points, and collect a certain number can win earlier. The detailed game rules are as follows:1. Divide green and blue into 2 card piles, Red Card pile, Green Card recycle pile, and Blue Card discard pile. 2. At the beginning, randomly give 1 Green Card and 3 Blue Cards for each player. 3. Before starting the round, player must first log in to the player's User Card. 4. Players can only login to the "Green Card Mode" once per round. 5. Before you login the Blue Card for pairing, players must login the Green Card. 6. Before logging in the Green Card, you can choose to draw out one Blue Card or randomly change the Green Card once. 7. Matching in your own round. 8. The same Green Card can be paired with Blue Card infinitely, if successful, you can continue to pair, if fail, you must recycle the Green Card, discard the Blue Card, and end of round. 9. If you pairing fail and result in you have no Green Card can use, in the next round, the player only can draw out the Green Card. 10. If your Blue Card and Green Card paired successfully, then you can get the Blue Card's score. 11. The Red Card doesn't need to be paired, you can use after logging in the User Card. 12. The Green Card recycle pile cannot be drawn out. If there is no Green Card in the Green Card pile, then can put back the Green Card from the Green Card recycling pile. If there is no Blue Card in the Blue Card pile, then the game is finish. 13. If you collect the CPU, Motherboard, Power Supply, HDD and any Operation System in advance, then you can win directly



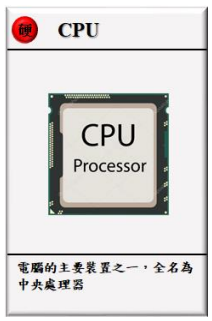


*Fig5.*User Card *Fig6.*Green Card *Fig7.*Blue Card *Fig8.*Penalty Card *Fig9.*Red Card

4. Results

4.1 Learning Outcomes

In this study, the experimental group used the "Hello, Computer !" learning board game, and control group used the traditional group discussion teaching, improve students' cognition and application of computer peripherals. This study adopted the Wilcoxon signed rank test, analysis of the pretest and posttest scores of the experimental group and the control group respectively, and practicality of teaching methods, observe whether the flow and the learning outcomes of the experimental group are different from the control group. As shown in table 1, both of the experimental group and control group have significant progress(experimental group $z = -3.96$, $p = .000 < .05$, control group $z = -3.02$, $p = .003 < .05$), indicate that after the students in the experimental group and the control group separately perform the "Hello, Computer !" learning board game and the group discussion activities, they are all have significant progress of learning outcomes for the computer peripherals, about the comparison of

progress extent, posttest average score of the experimental group improved by 19.83 points, although the control group also has a significant improvement, but compared to the experimental group, control group only increased by 8.3 points. Therefore, it was found that the learning outcomes of game-based learning was better than traditional group discussion teaching in this study.

Table 1

Pretest and Posttest Wilcoxon signed rank test of Experimental Group and Control Group

Group	Number of Participants	Stage	Average	SD	z	p
Experimental	23	Pretest	22.91	14.95	-3.96	.000
	23	Posttest	42.74	16.65		
Control	17	Pretest	32.00	12.65	-3.02	.003
	17	Posttest	40.30	13.58		

P <.05

4.2 Teaching Practicality

On the other hand, as shown in table 2, teaching practicality analysis of the teaching methods in the experimental group and the control group (EP4: Before playing this board game, how much do you know about the computer hardware interface and programming language?, EP5: After playing this board game, how much do you know about the computer hardware interface and programming language?, CP4: Before the group discussion, how much do you know about the computer hardware interface and programming language?, CP5: After the group discussion, how much do you know about the computer hardware interface and programming language?), the results show that, the experimental group consider the "Hello, Computer !" learning board game has significant differences in the cognition of the computer peripherals ($z = -3.27$, $p = .001 < .05$), but the control group consider there is no significant difference in group discussion for teaching ($z = -1.00$, $p = .317 > .05$). As a result, this study found that using the "Hello, Computer !" learning board game, it can more effectively enhance students' cognition of the computer peripherals.

Table 2

Teaching Practicality Wilcoxon signed rank test of Experimental Group and Control Group

Group	Number of participants	Questionnaire	Average	SD	z	p
Experimental	23	EP4	2.26	.92	-3.27	.001
	23	EP5	2.91	.60		
Control	17	CP4	2.47	.62	-1.00	.317
	17	CP5	2.59	.71		

P <.05

4.3 Flow Experience

In respect of the flow experience, compare the difference between the "Hello, Computer !" learning board game and the traditional group discussion for the experimental group and the control group respectively, as shown in table 3, the average of the experimental group in the flow experience dimension is 3.81, it is higher than the median 3-point which in the 5-point scales, and the average of the control group in the flow experience dimension is 2.90, it is lower than the median 3-point which in the 5-point scales. This result indicates that when the experimental group is conducting the "Hello, Computer !" learning board game teaching activity, all have a phenomenon of entering the flow, representing the experimental group with a high degree of concentration in game-based learning activities, compared to the control group, there is no obvious phenomenon of entering the flow. Therefore, this study indicated that when the experimental group is during game-based learning, all can focus on the game activities, this can help students' improve learning motivation.

Table 3

Average and Standard Deviation of Flow Experience Questionnaire in the Experimental Group and Control Group

Dimension	Experimental Group (N=23)		Control Group(N=17)	
	Average	SD	Average	SD
Entertainment	3.88	0.60	2.84	1.21
Concentration	3.86	0.57	2.88	1.14
Control	3.63	0.63	3.00	1.22
Flow experience	3.81	0.53	2.90	1.15

4.4 "Hello, Computer ！"Data Feedback

During the game, this system will automatically record all the game processes of students. After the game, integrate all the system's game data, and convert to a visual chart, feedback to instructions as a reference for teaching. The feedback content is divided into interface and user mode two categories, and illustrate as follows: 1. The game way is pairing, represent the computer interface and peripherals are matched each other (e.g: SATA and HDD). This game divides the pairing interface into SATA, USB, PCIe, PS/2, TRS, Wired Network, Wireless Network, VGA, DVI, HDMI and divides the system program into Compiler, Assembler, Interpreter, a total of thirteen kinds. This system can calculate the success rate of each interface being paired to make a pie chart, and instructions based on the success rate of various interfaces, understand students' cognitive level of different computer peripherals. Figure 10 is the PCIe interface with the lowest pairing success rate among the 13 interfaces in the experiment, PCIe is mainly applied to the use of components in the motherboard, for the non-Department of Computer Science backgrounds students, they may have less chance to know. Figure 11 is the USB interface with the highest pairing success rate among the 13 interfaces in the experiment, USB is very familiar for most students, the reason is that USB is currently the most common to use. This system can also analyze individual game data for each student, make a bar chart and give feedback to instructions, as shown in figure 12, so as to understand students' cognitive level and learning situation.

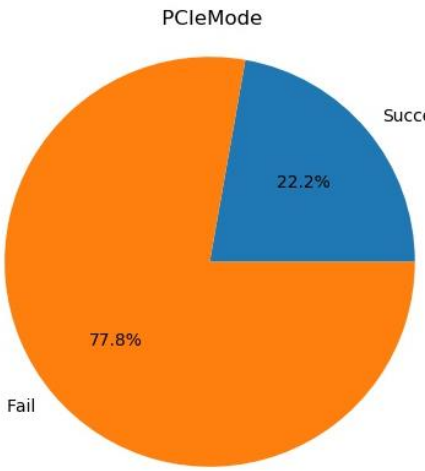


Fig10. Low Success Rate

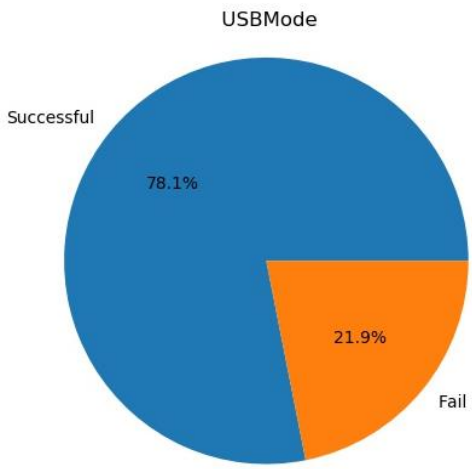


Fig11. High Success Rate

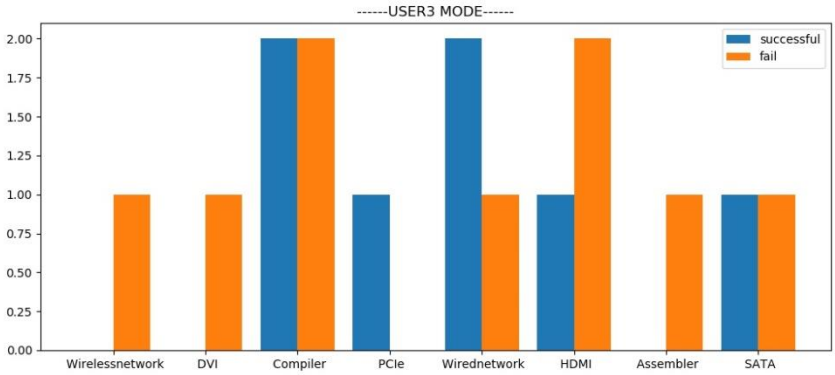


Fig12. Student's Game Data

5. Conclusions

This study used the "Hello, Computer !" learning board game and traditional group discussion two teaching methods, exploring whether the difference between the both on cognitive of teaching for the computer peripherals, and their flow experience. The study found that, whether it's the experimental group or the control group, both of all have significant effect in learning outcomes for the computer peripherals, but compare the progress extent of two groups from pretest and posttest, the experimental group progress score is higher than the control group score of 12. This study also pointed out that experimental group think that using "Hello, Computer !" learning board game can help them improve their cognition of computers. However, the control group think that group discussion has no great effect on cognitive teaching of computers, representing to use game-based learning by this board game has a significant effect on cognitive teaching of computers, but the group discussion did not. Furthermore, about the degree of flow experience, the average of flow experience by the experimental group is 3.81, is higher than median 3, show that using the this learning board game to teach, students all in the high degree of flow, but the average of flow experience by the control group is 2.90, is lower than median 3, representing the flow is not very well. In terms of system mechanism, in addition to the basic one-to-one pairing mechanism, this system also set the multi pairing mechanism of the cards, so that students can also learn higher levels of cognitive content in the game.

6. Future Work

At present this system is only used for the computer peripherals, depend on set each RFID card as a game card for the computer peripheral, so this study hopes to apply the board game system to different teaching. According to the needs of instructions, set different teaching elements in the RFID cards. In this way, any teaching that can be done in a matched manner, all can be applied to this system.

References

Adams, D. M. & Clark, D. B. (2014). Integrating selfexplanation functionality into a complex game environment: Keeping gaming in motion, Computers & Education 73(1), 149-159.

Barzilai, S. & Blau I. (2014). Scaffolding game-based learning: Impact on learning achievements, perceived learning, and game experiences, Computers & Education 70(2), 65-79.

Bawa, P., Watson, S. L., & Watson, W. (2018). Motivation is a game: Massively multiplayer online games as agents of motivation in higher education. Computers & Education, 123(2), 174-194.

Byron R. & Leighton R. (2009). Total Engagement: Using Games and Virtual Worlds to Change the Way People Work and Businesses Compete. Harvard Business Press, 177.

Chen, Z. H. (2014). Exploring students' behaviors in a competition-driven educational game, Computers in Human Behavior 35(1), 68-74.

Connolly, T. M., Stansfield, M., & Hainey, T. (2011). An alternate reality game for language learning: ARGuing for multilingual motivation. Computers & Education, 57(1), 1389-1415.
Csikszentmihalyi, M. (1975). Beyond Boredom and Anxiety. San Francisco: Jossey-Bass.
Csikszentmihalyi, M. (1985). Emergent Motivation and the Evolution of the Self. In D. A. Kleiber & M. Maehr (Eds.), Advances in Motivation and Achievement (Vol. 4, pp. 93-119). Greenwich, CT: JAI Press.
Csikszentmihalyi, M. (1997). Finding flow: The psychology of engagement with everyday life. New York: Harper Collins.
Csikszentmihalyi, M. (1990). Flow: The psychology of optimal experience. New York: Harper & Row.
Embi Z. C. & Hussain H. (2005), Analysis of local and foreign edutainment products - An effort to implement the design framework for an edutainment environment in Malaysia. Journal of Computers in Mathematics and Science Teaching, 24(1), 27-42,.
Forst, J. L., Wortham, S. C., & Reifel, S. (2001). Play and Child Development. New Jersey: Prentice Hall
HogleJ. G., (1996). Considering Games as Cognitive Tools: In Search of Effective "Edutainment" University of Georgia Department of Instructional Technology.
Liao, C.-W., Chen, C.-H., & Shih, S.-J. (2019). The interactivity of video and collaboration for learning achievement, intrinsic motivation, cognitive load, and behavior patterns in a digital game-based learning environment. Computers & Education, 133(2), 43-55.
Lieberoth, A. (2015). Shallow Gamification, Testing Psychological Effects of Framing an Activity as a Game, Games and Culture 10(3), 229-248
Matsumoto, T. (2016). Motivation Strategy Using Gamification. Creative Education, 7(10), 1480-1485.
Matsumoto, T. (2016). The Flipped Classroom Experience of Gamified. Creative Education, 7(10), 1475-1479.
Pearce, J. M., Ainley, M., & Howard, S. (2005). The ebb and flow of online learning. Computers in Human Behavior, 21(5), 745-771.
Prensky, M. (2007). Digital Game-Based Learning. New York: McGraw-Hill.
Wang, S. M., Chen, K. T., Hou, H. T., & Li, C. T. (2017). A science history educational board game with augmented reality integrating collaborative problem solving and scaffolding strategies. The 25th International Conference on Computers in Education, Christchurch, New Zealand.
Wang, L., et al. (2015). Mining Experiential Patterns from Game-Logs of Board Game, International Journal of Computer Games Technology, 1-20.
Wouters, P., van Nimwegen, C., van Oostendorp, H., & van der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. Journal of Educational Psychology, 105(2), 249–265.
Kang, Y. P., Liang J. C., Chai Y.C. (2014). An Innovative Design of Board Game Device, *International Journal of Kansei Information*, 125-130.