Hindawi
Scientific Programming
Volume 2022, Article ID 7481798, 9 pages
https://doi.org/10.1155/2022/7481798

Research Article

Enhancing Problem-Solving Ability through a Puzzle-Type Logical Thinking Game

Ting-Sheng Weng

Department of Business Administration, National Chiayi University, Chiayi 600, Taiwan

Correspondence should be addressed to Ting-Sheng Weng; politeweng@yahoo.com.tw

Received 28 October 2021; Revised 23 December 2021; Accepted 18 February 2022; Published 24 March 2022

Academic Editor: Wenbing Zhao

This study explored the influence of creativity and learning attitude through game-based learning. The subjects were sixth grade elementary school students, and a logical thinking game was developed to stimulate the students' learning interests. A questionnaire survey was conducted on 121 students, and the result shows that the students' creativity has a significant and positive effect on their learning attitude and problem-solving ability. In addition, learning attitude has a significant and positive effect on the students' problem-solving ability. Moreover, creativity elicited a direct effect on problem-solving ability. This study verified that the proposed puzzle-type logical thinking game can train and improve the logical thinking ability of learners.

1. Introduction

Problem-solving ability has been valued in education. Present educational approaches have encouraged learning through practical problems or cases, inspiring learners to demonstrate creative thinking, and designing solutions to problems. Actual life problems or difficulties are optimal learning examples [1]. The concept of STEM (science, technology, engineering, and mathematics) has gradually been valued and applied in engineering education in colleges and universities [2, 3].

Prensky named the learners in the recent decade as the "digital natives," meaning that they are accustomed to using various technological products in their lives. Games have an open point of view and can bring people the desire to create and invest, and such elements have motivated people's willingness to take on risks and explore [4]. According to Prensky [5], the ideal digital game-based learning is a method to increase learner engagement and generate higher learning achievements. To improve problem-solving ability, learners' creativity must first be stimulated, and game-based teaching is a feasible approach to create this stimulation. Using games to present the teaching contents not only makes the contents more vivid but also inspires the imagination of learners and triggers more creativity. Thus, game-based teaching is an effective method for eliciting creative thinking [6–10]. Li [11] used tangram puzzles as a representation of mathematics and posited that it could stimulate game-based learning intention. Knowledge can be internalized in the process of puzzle playing, and speed and skill refinement can also be generated during the game-playing process. Gao [12] stated that games can stimulate learners' enthusiasm for learning and inspire their initiative, independence, and creativity. Through playing games, learners can immerse themselves in those activities and are encouraged to think about, understand, digest, and absorb details from concrete imaginary thinking to abstract thinking. Therefore, learning interest and knowledge grow naturally in a relaxed and pleasant atmosphere. Furthermore, game-based learning also helps to cultivate learners' thinking ability and quality, learning attitude, awareness and methods of observing surrounding objects, inferential logic, exploration spirit, and ability to think outside the box to achieve logic creation.

However, conventional educational toys that exist as physical entities have no characterization orientation, as their representational state is fixed. Digital learning appears to be the solution to this problem, as it uses multimedia applications to create a variety of educational platforms (e.g., video images, dynamic images, and model simulations), in which teaching materials can be presented in various characterizations that enrich the learning process. In game-based teaching, multimedia special effects and interactive characteristics can attract learners' attention, thereby enhancing their learning motivation and improving their problem-solving abilities [13, 14]. Through game-based practices in the context of digital games, learners can be guided to become "experiencers" and personally solve multilevel problems created in the games. The creativity and problem-solving ability that the learners accumulated could lead them to become knowledge creators that provide solutions to real-world problems [15].

It is evident that teaching content and educational methods can stimulate learners' creativity, problem-solving ability, and solution development efficacy [16–20]. Learners' creativity has a direct effect on their problem-solving ability and may affect learning attitude, which has an indirect effect on their problem-solving ability.

Therefore, this study suggests that the use of multimedia technology is a viable approach to developing a more interactive and stimulating puzzle-type logical thinking game that allows learners to engage in creative thinking, thereby affecting their learning attitude and improving their problem-solving ability. This study aims to explore the influences of digital learning tools on learners' learning attitude, problem-solving ability, and creativity. More specifically, this study intends to verify whether game-based learning can enhance learners' creative thinking and further influence their learning attitude and generate positive effects on their problem-solving ability.

2. Literature Review

2.1. Game and Learning Attitude. Many learners hold a passive attitude toward learning. Attitude toward science refers to whether a person likes or dislikes science or has "a positive or negative feeling about science" [16]. Xu and Liao [21] used mathematics learning as an example to demonstrate that students may be uninterested in learning mathematics due to learning disabilities, poor language ability, and difficulties in understanding abstract symbols. They suggested that image interface guidance in games could help learners to understand mathematical logic concepts. Su and Xie [22] mentioned that game-based teaching activities can easily inspire learners' explorative ability toward a certain subject, enhance their learning attitude, attract their attention to problems, and improve their problem-solving ability. Zheng and Liu [17] proposed that mission-based games can promote cooperation and discussion among peers. Compared with conventional paper-based tests, learners' learning motivation, attitude, and achievements were substantially improved after playing mission-based games. Yang and Li [19] experimented with a mathematics game and found that the absolute use of technology can be a helpful learning tool for developing children's number sense [19].

It is very important to create an environment that can promote and maintain learners' interest [23]. Hwang et al. [24] pointed out that players' attitudes affect their subsequent use of the game, and players attach great importance to their game experiences [25, 26]. The desire to overcome obstacles in the game experience will encourage players to find ways to achieve breakthroughs and solve problems, which in turn improves their problem-solving ability. As mentioned above, the teaching methods that employ puzzle-type logical thinking games can improve learners' learning motivation and attitude, enable learners to focus on how to complete a challenge, and stimulate the brain's hidden creativity during a short play time. In the process of attempting to complete a challenge, learners tend to brainstorm and identify the optimal approaches to succeed by repeatedly reviewing and evaluating the chosen approach, identifying problems, and overcoming obstacles. Finally, positive learning experiences can be accumulated from game-based learning.

It is effective to learn subjects through games with logical thinking factors. For example, Sun-Lin and Chiou [27] used a game-based learning strategy to support algebra variable learning and found that their proposed method could effectively enhance students' learning methods and learning attitudes. Hwa [28] took the mathematics classes of first to third grade students in Chinese elementary schools as subjects and found that game-based learning is superior to the traditional classroom instruction in terms of students' logical thinking, learning attitude, and optimizing the teaching process.

2.2. Creativity. People that think creatively tend to confidently put forward different opinions and try solutions that are different from the status quo. They may combine the knowledge of different fields to solve problems and persist instead of giving up in times of difficulties and no progress. Moreover, they may even deliberately set aside a problem temporarily and return to the problem later after searching for the solution from a new perspective [29–31]. Lee and Therriault [32] suggested that creativity is a high-level cognitive activity generated by idea association, as well as divergence and convergence of thought by individuals, through the collection of data and memory. Gilhooly et al. [33] also posited that creativity and thinking mode are correlated. Xiao [34] proposed that improvements in learners' creativity can be achieved through intrinsic motivation, teaching content, and the reading atmosphere in the learning environment. In terms of teaching, open-ended questions and extended questions can encourage learners to think repeatedly and enhance their creativity. Furthermore, Xiao [34] stated that creativity includes the aspects of adventure, curiosity, imagination, and challenge. Xiao further suggested that creativity is inspired and enhanced by parental creativity education, creativity life experience, and daily life experience.

In addition, teachers' instructional strategies can inspire students' creativity. Yang et al. [35] designed the educational strategy of robot-assisted instruction to support students' learning achievements. The results showed that an appropriately designed teaching strategy can enable students to think and recognize learning materials through the interactive models.

Based on the definitions in previous literature, this study defined creativity as follows. Teachers use open teaching materials to guide learners to think independently and inspire learners to develop new ideas and actions outside of in-class assignments; by helping the learners to probe into the root of problems and relevant causes, teachers can guide learners to consider possible approaches to solving these problems.

2.3. Game-Based Learning and Problem-Solving Ability. In problem solving, the process is equally important as the outcome [36]. Polya [37] suggested that problem solving is an explicit or cognitive behavioral process in which various possible effective solutions are proposed for the problematic situation, and individuals select the most effective solution for implementation. Liao and Wang [38] stated that in problem solving, the thought process is crucial. They summarized the psychological process as problem identification, understanding the nature of the problem, collecting relevant information, taking problem-solving actions, and engaging in postevaluation. The "problem" in their study was the gap between the goal and current situation, and problem solving is a process in which an individual applies one's knowledge to the problem to obtain solutions. Lin and Huang [18] argued that problem-solving attitude is the basis for problem-solving ability. They posited that problem-solving attitude and ability affect individuals' thoughts and motivations when dealing with problems.

Nevertheless, conventional education models have a limited effect on the cultivation of problem-solving ability. Most learners are accustomed to relying on teachers' guidance and lack the ability to think independently. Therefore, appropriate teaching activities could cultivate learners' creativity and problem-solving ability [39]. Yang [40] stated that receptive or inquiry-based teaching is not the only valid teaching method, but it should be conducted simultaneously. The goal of teaching is not merely imparting knowledge but to help learners understand thinking and the thought process. Teaching should not only be for imparting knowledge but also to help learners understand thinking and the thought process; when knowledge concepts are understood and appropriately applied, they can be effectively used to help learners solve problems and cultivate their thinking ability.

Tang [20] posited that competition in society is becoming more intense, and that while problem-solving ability has gradually been recognized and valued, it has become an indispensable ability for talented people. Nevertheless, traditional education models have reduced learners' interest in learning and have failed to improve their problem-solving ability. Tang stated that developing a game-based learning model is imperative to improving learners' problem-solving ability. Huang et al. [41] indicated that game scores are significantly correlated with learners' graphic reasoning, creative thinking, and problem-solving abilities. Furthermore, game scores are related to learners' higher-order thinking ability. Therefore, games are suitable tools for training learners' creativity and problem-solving ability. Zheng [42] stated that mathematics-based games in elementary schools could train learners' problem-solving ability.

Many related studies have explored learning outcomes from game-based learning integrated with education in the field of digital learning [43–46], with system development [47] as the research goal. This study investigated whether game-based learning has a positive effect on learners' problem-solving ability by exploring the creativity learning attitude and the psychological level of learners.

With highly developed multimedia technology, creativity educational materials with sound and light effects and visual animation can be designed. An interactive interface with visual elements, such as images, can be designed to meet the learners' needs. Liao and Wang [38] designed an exploratory game and added an element of fun to the learning process. Their game produced excellent learning outcomes and significant improvement in the subjects' problem-solving ability. Moreover, they demonstrated that game scenarios can influence problem-solving methods and cultivate learners' creativity and thinking from different perspectives. Game-based learning activities can enhance learning motivation and inspire learners to apply their creative thinking skills in a team setting to solve problems. By adopting game-based teaching activities, novel teaching methods or various highly interactive teaching models can be developed [48, 49].

Among various digital games, computer games have attracted the attention of young students, as well as children. Game-based education is still effective in guiding and inspiring children's judgmental thinking abilities. There are numerous research studies exploring the effectiveness of game-based learning and many curricula adopting learning games [50–54]. In particular, puzzle-type logical thinking games can lead learners to engage in creative thinking and develop problem-solving ability.

3. Research Method

This study used Flash software to develop a puzzle-type logical thinking game on the website (Figures 1 and 2). Figure 3 presents a schematic of a stroke-completing game as a test tool for a creative thinking activity. The research tool involved a puzzle game that has not been frequently applied in general teaching, and it was designed to stimulate young students' curiosity and interest in learning. This study took sixth grade elementary school students as the subjects. The questionnaire survey method was adopted to measure the subjects' creativity, learning attitude, and attitude toward game-based learning and problem solving. The data were collected based on the four dimensions of creativity, learning attitude, attitude toward game-based learning, and attitude toward problem solving.

3.1. Research Scope and Participants. This study was based on a puzzle-type logical thinking game. Purposive sampling was used to select learners who participated in science exhibition activities. Among the 150 participants, there were 121 valid participants, with a valid response rate of 80.6%.

3.2. Research Tools. The research structure of this study is presented in Figure 4. A linearly structured model was used to establish the relationship between and different influences

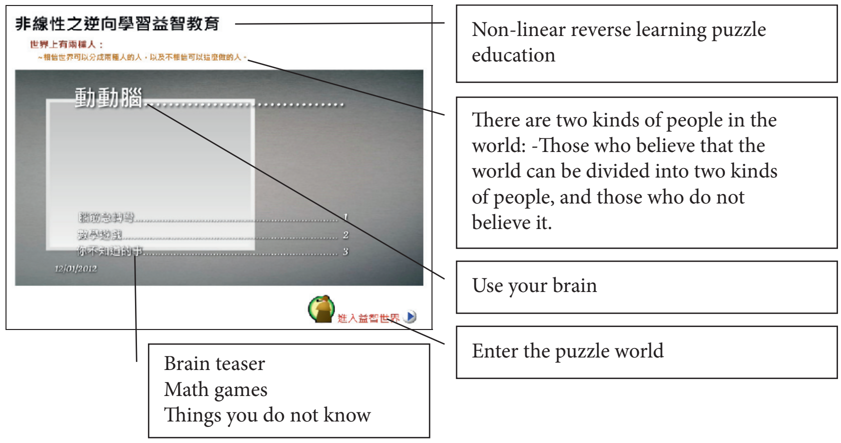

Figure 1: Puzzle game portal.

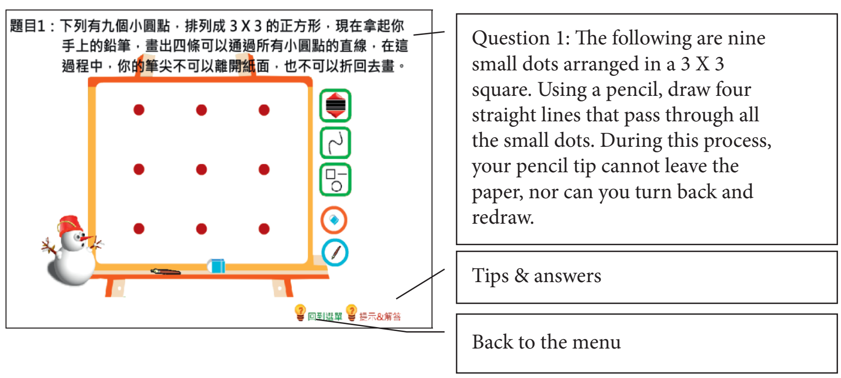

Figure 2: Screen of “thinking after corner-turning“ puzzle game.

of the four dimensions of creativity, learning attitude, attitude toward game-based learning, and attitude toward problem solving. The items for the attitude toward game-based learning, learning, creativity, and problem solving were modified from the questionnaires of Chu et al. [55]; Chen et al. [56]; Cao and Zhou [57]; Amabile [29]; Zhou and George [58]; and Lin and Huang [18], respectively. For this questionnaire survey, a 5-point Likert scale was used for measuring the three dimensions of creativity, learning attitude, and problem solved.

There were 121 valid samples in this study, which is likely to deviate from the assumption of normal distribution. Compared to AMOS, which assumes normal distribution based on a large sample, SmartPLS uses a PLS-SEM model that supports the assumption of abnormal distribution. Therefore, this study used SmartPLS M2.0.3 for statistical analyses. The operational definitions of the four dimensions are shown in Table 1.

3.3. Experiment Procedure. The experimental procedure is as follows: (1) the researchers explained the game to the subjects; (2) the subjects played the game; (3) questionnaires were distributed; (4) questionnaires were collected; and (5) data analyses were performed.

For data analysis, structural equation modeling was employed to measure the directions of influence among the four dimensions. Reliability and validity analyses were used to examine whether the questionnaires used in this study was suitable for analysis, and effective results were obtained.

3.4. Reliability and Validity Analyses. The scales used in this study were modified from existing studies. Thus, Cronbach's α value of each dimension ranged from 0.697 to 0.926, which satisfied the reliability of index requirements. Moreover, the scales were also modified based on the expert opinions, confirming that the scales have satisfactory expert validity (Table 2).

4. Results

A linearly structured model was applied to determine the relationships and influences between the four dimensions. Furthermore, the SmartPLS M2.0.3 software suite was used to test the relationship between the four dimensions and goodness of fit of the model. The linear model is shown in Figure 5. The overall model goodness of fit was determined using the overall goodness of fit of validation mode and observation data. A higher goodness of fit of a model indicates that it is highly feasible. The results of this study indicate that most of the overall model indices fitted well with ideal values (Table 3); thus, the goodness of fit of the model was within an acceptable range.

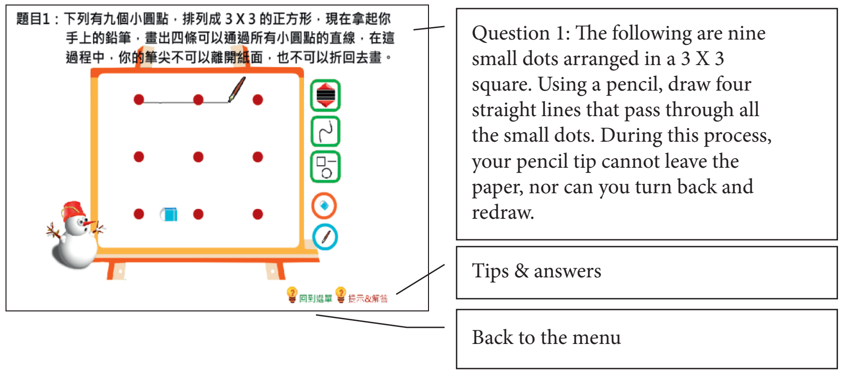

Figure 3: Stroke movement.

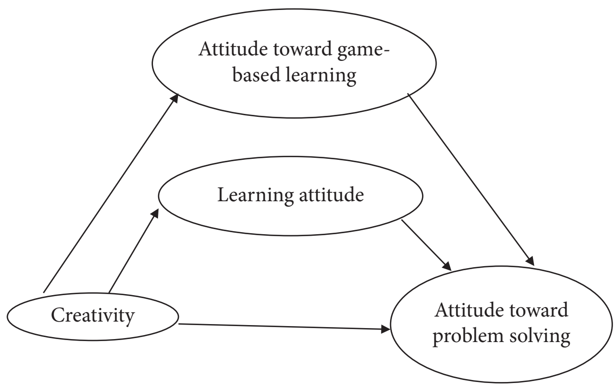

Figure 4: Research model.

Table 1: Dimensions, definitions, and citations.

Dimensions	Definitions	References
Creativity	Students evaluate whether they are producing answers in classwork that can be used to solve assignments because of the tool	Lee and Therriault [32]; Gilhooly et al. [33]; Yang et al. [35]
Learning attitude	Students' cognition and values of "learning"	Koballa and Crawley [16]; Su and Xie [22]; Garcia et al. [23]; Xu and Liao [21]; Yang and Li [19]; Hwang et al. [24]
Attitude toward game-based learning	Students' cognition and evaluation of learning content or learning activities using this research tool	Richard [48]; Huang et al. [41]; Lee and Lee [47]; Tang et al. [49]; Zheng [42]; Halloluwa et al. [43]; Muñoz et al. [45]; Vrugte et al. [46]; Lee et al. [44]
Attitude toward problem solving	Students' cognition and values of "problem solving"	Polya [37]; Li [39]; Yang [40]; Liao and Wang [38]; Lin and Huang [18]; Tang [20]

Table 2: Reliability and validity analyses.

Dimension	Cronbach's α
Creativity	0.917
Learning attitude	0.717
Attitude toward game-based learning	0.697
Attitude toward problem solving	0.926

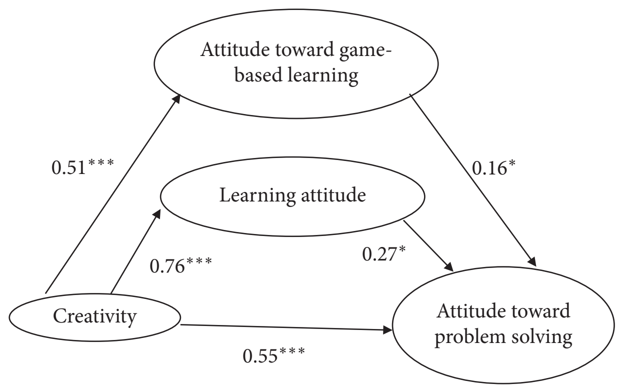

Figure 5: Results of research model.

Table 3: Goodness of fit of the overall model.

Adaptation index	χ^2 test	χ^2/df	GFI	AGFI	PGFI	RMSEA	NNFI	CFI
Suggested values	$p > 0.05$	<3.0	>0.9	>0.9	>0.5	<0.08	>0.9	>0.9
Research model	$\chi^2 = 2131.869,\ p \le 0.001$	1.991	0.823	0.678	0.622	0.092	0.566	0.719

The relationships between creativity, learning attitude, attitude toward game-based learning, and problem-solving are described as follows (Figure 2 and Table 4):

(1) Learner's creativity has a significant and positive effect on learning attitude, attitude toward game-based learning, and problem solving ($\beta_1 = 0.51$, $t = 3.955$; $\beta_2 = 0.76$, $t = 6.201$; $\beta_3 = 0.55$, $t = 4.017$).

(2) Learning attitude and attitude toward game-based learning have a significant and positive effect on problem solving ($\beta_4 = 0.16$, $t = 2.022$; $\beta_5 = 0.27$, $t = 2.309$).

(3) Learners' creativity has a direct effect, an indirect effect, and a total effect of 0.55, 0.2868, and 0.8368, respectively, on problem solving.

According to the analysis results, creativity, learning attitude, and attitude toward game-based learning affect problem solving. This finding is consistent with the setting of the original research (Figure 1), suggesting that learning attitude, attitude toward game-based learning, and creativity have a significant effect on the ability of learners to solve problems while faced with difficulties. The results of the linear model analysis indicate that creativity also affects learning attitude and attitude toward game-based learning. This result implies that learners' willingness to accept new things may influence their learning attitude and attitude toward game-based learning (Table 4).

Table 4: Path coefficients affecting the dimensions.

Path			Standardized coefficients	p values
Learning attitude	<---	Creativity (β_1)	0.51***	≤0.001
Attitude toward game-based learning	<---	Creativity (β_2)	0.76***	≤0.001
Attitude toward problem solving	<---	Learning attitude (β_4)	0.16*	0.043
Attitude toward problem solving	<---	Attitude toward game-based learning (β_5)	0.27*	0.021
Attitude toward problem solving	<---	Creativity (β_3)	0.55***	≤0.001

***$p < .00$; *$p < .05$; **$p < .01$.

This study explored the relationships among learning attitude, attitude toward game-based learning, and creativity regarding problem solving. The results indicate that creativity, learning attitude, and attitude toward game-based learning have significant effects on problem solving. The findings of this study can be further explored by referring to digital learning. This type of learning can be improved by integrating game-based learning into problem-solving tasks.

5. Conclusion and Suggestions

Computer-aided instruction not only improves problem-solving ability but also learning attitude [59, 60]. This study found that for learners and the general public, learning attitude and attitude toward game-based learning considerably affect their problem-solving ability. In addition, the results of this study confirmed that creativity and learning attitude are crucial and are affected by learners' willingness to learn and the actions taken.

This study treated sixth grade elementary school students as the subjects. Future studies can conduct surveys on learners in different countries. Moreover, qualitative interviews can be conducted to analyze the problem-solving process of the learners and the factors affecting changes in their attitudes toward game-based learning. After these results are obtained, more variables can be generated to identify factors that may influence learners' problem-solving ability. The analysis results may allow teachers to identify optimal learning methods that could enhance learners' problem-solving ability. According to the results of this study, creativity, learning attitude, and attitude toward game-based learning strongly affect problem-solving ability.

The rules of games often lead to constraints that limit thinking within a prescribed range, like a bird in a cage. When looking at certain things and thinking about certain problems, individuals are susceptible to being restrained by traditional thinking and being unable to break through and innovate.

Whether in life or education, it is very important to have the ability to solve problems in the environment, to break game rules to find solutions. Thus, it is recommended that researchers can design more puzzle-type learning games in the future for children or educational units to train students' ability to break through habitual thinking and develop adaptability as an instinct.

The contribution of this study is to demonstrate that game-based learning concept can serve as a basis for remedial education or course management and as reference for curriculum design and interactive models.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

References

[1] D. S. Hu, "Why do people need to learn mathematics—philosophical thinking of mathematical meaning," *Journal of Mathematics Education*, vol. 4, pp. 54–57, 2010.

[2] C. M. Hung, G. J. Hwang, and I. Huang, "A project-based digital storytelling approach for improving learners' learning motivation, problem solving competence and learning achievement," *Journal of Educational Technology & Society*, vol. 15, no. 4, p. 368, 2012.

[3] M. Taub, R. Azevedo, A. E. Bradbury, G. C. Millar, and J. Lester, "Using sequence mining to reveal the efficiency in scientific reasoning during STEM learning with a game-based learning environment," *Learning and Instruction*, vol. 54, pp. 93–103, 2018.

[4] L. E. Hicks, "Infinite and finite games: play and visual culture," *Studies in Art Education*, vol. 45, no. 4, pp. 285–297, 2004.

[5] M. Prensky, "Digital natives, digital immigrants part 1," *On the Horizon*, vol. 9, no. 5, pp. 1–6, 2001.

[6] J. H. Chen, "The Learning Activities of Mathematics to Fuse Both of Plays and Toys," National Science Council Project, NSC94-2515-S-168-001, Taipei, Taiwan, pp. 1–21, 2006.

[7] X. Lin, *Smart Kid's Favorite Puzzle Game: Brain Teaser*, Chemical Industry Press, Beijing, China, 2014.

[8] A. All, E. P. Nuñez Castellar, and J. Van Looy, "Assessing the effectiveness of digital game-based learning: best practices," *Computers & Education*, vol. 1, pp. 90–103, 2016.

[9] C. J. Lin, G. J. Hwang, Q. K. Fu, and J. F. Chen, "A flipped contextual game-based learning approach to enhancing EFL learners' English business writing performance and reflective behaviors," *Journal of Educational Technology & Society*, vol. 21, no. 3, pp. 117–131, 2018.

[10] E. Yukselturk, S. Altıok, and Z. Başer, "Using game-based learning with kinect technology in foreign language education course," *Journal of Educational Technology & Society*, vol. 21, no. 3, pp. 159–173, 2018.

[11] Y. Li, "Interesting tangram puzzle teaching games," *Mathematics Teaching*, vol. 2, pp. 8–11, 2015.

[12] J. Gao, "Correlation analysis of influence of mathematical games on creativity thinking," *Course Education Research*, vol. 12, pp. 257-258, 2015.

[13] T. Y. Chuang and W. F. Chen, "Effect of computer-based video games on children: an experimental study," *Educational Technology & Society*, vol. 12, no. 2, pp. 1–10, 2009.

[14] J. W. Fan and X. Z. Zhou, "Research on the integration of computer animation into the teaching design of mathematics at primary school," *New Horizons*, vol. 58, no. 3, pp. 133–148, 2010.

[15] M. F. Zhan, "Fostering learning paradigm shift with game-based learning," *Journal of Advanced Technology and Management*, vol. 1, no. 1, pp. 47–60, 2011.

[16] T. R. Koballa and F. E. Crawley, "The influence of attitude on science teaching and learning," *School Science & Mathematics*, vol. 85, no. 3, pp. 222–232, 1985.

[17] Q. P. Zheng and W. Y. Liu, "A study on the compared effects of blockade-running assessments and paper-and-pencil tests on junior high school learners' math learning," *Science Education Monthly*, vol. 338, pp. 16–28, 2011.

[18] S. H. Lin and Y. C. Huang, "Relationship between academic frustration tolerance and problem-solving attitude of college learners in Central Taiwan," *Global Mental Health E-Journal*, vol. 2, pp. 25–44, 2011.

[19] D. C. Yang and M. N. Li, "Assessment of animated self-directed learning activities modules for children's number sense development," *Educational Technology & Society*, vol. 16, no. 3, pp. 44–58, 2013.

[20] G. Y. Tang, "Primary school mathematics education game designed for problem-solving ability training," *Reading and Write Periodical*, vol. 13, 2015.

[21] Y. X. Xu and G. Z. Liao, "Investigation on graphic thinking process of mathematics addition games for underachievement

elementary school learners," *International Journal on Digital Learning Technology*, vol. 4, no. 1, pp. 17–41, 2012.
[22] X. L. Su and X. Y. Xie, "The study of science game incorporated into elementary school natural science and technology instructions on problem–solving ability," *Journal of Scientific and Technological Studies*, vol. 40, no. 1, pp. 47–68, 2006.
[23] R. M. C. Garcia, C. D. Kloos, and M. C. Gil, "Game based spelling learning," in *Proceedings of the In 38th Annual Frontiers in Education Conference*, Saratoga Springs, NY, USA, October 2008.
[24] M.-Y. Hwang, J.-C. Hong, H.-Y. Cheng, Y.-C. Peng, and N.-C. Wu, "Gender differences in cognitive load and competition anxiety affect 6th grade students' attitude toward playing and intention to play at a sequential or synchronous game," *Computers & Education*, vol. 60, no. 1, pp. 254–263, 2013.
[25] J. C. Yen, "A study on the experience value, consumer motivation and repurchase intention of PC online games," *Tamsui Oxford Journal of Tourism*, vol. 15, pp. 1–16, 2019.
[26] J. J. Lo and W. J. Kuo, "Impact of personality type and time pressure on players' gameplay experiences, attitudes, and performance," *Research of Educational Communications and Technology*, vol. 124, pp. 53–68, 2020.
[27] H. Z. Sun-Lin and G. F. Chiou, "Effects of comparison and game-challenge on sixth graders' algebra variable learning achievement, learning attitude, and meta-cognitive awareness," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 13, no. 6, pp. 2627–2644, 2017.
[28] S. P. Hwa, "Pedagogical change in mathematics learning: harnessing the power of digital game-based learning," *Journal of Educational Technology & Society*, vol. 21, no. 4, pp. 259–276, 2018.
[29] T. M. Amabile, "The social psychology of creativity: a componential conceptualization," *Journal of Personality and Social Psychology*, vol. 45, no. 2, pp. 357–376, 1983.
[30] M. A. Collins and T. M. Amabile, "Motivation and creativity," in *In Handbook of Creativity*, R. J. Sternberg, Ed., Cambridge University Press, Cambridge, UK, 1999.
[31] S. K. Yin, C. C. Yang, and F. R. Liu, "Creativity Design of Serious Games by Students of Engineering and Design – Subproject 1: Curriculum Development of Planning and Marketing," pp. 1–32, Ministry of Science and Technology, Taipei, Taiwan, 2005, MOST103-2511-S230-002-MY3.
[32] C. S. Lee and D. J. Therriault, "The cognitive underpinnings of creativity thought: a latent variable analysis exploring the roles of intelligence and working memory in three creativity thinking processes," *Intelligence*, vol. 41, no. 5, pp. 306–320, 2013.
[33] K. J. Gilhooly, L. J. Ball, and L. Macchi, "Insight and creative thinking processes: Routineandspecial," *Thinking & Reasoning*, vol. 21, no. 1, pp. 1–4, 2015.
[34] J. C. Xiao, "The relationship between schools' climate of creativity, teachers' intrinsic motivation, and teachers' creativity teaching performance: a discussion of multilevel moderated mediation," *Contemporary Educational Research Quarterly*, vol. 19, no. 4, pp. 85–125, 2011.
[35] Y. Yang, Y. Long, D. Sun, J. Van Aalst, and S. Cheng, "Fostering students' creativity via educational robotics: an investigation of teachers' pedagogical practices based on teacher interviews," *British Journal of Educational Technology*, vol. 51, no. 5, pp. 1826–1842, 2020.
[36] E. D. Gagne, C. W. Yekovich, and F. R. Yekovich, *The Cognitive Psychology of School Learning*, Harper Collins, New York, NY, USA, 2nd edition, 1993.
[37] G. Polya, *Mathematical Discovery: On Understand Learning, and Teaching Problem Solving*, Scribner's, New York, NY, USA, 1981.
[38] G. Z. Liao and D. M. Wang, "The Design and Effectiveness Study of Using Creativity Gear Game with Touch Interfaces for Game-Based Learning Problem Solving Ability," National Science Council Project, NSC 99-2410-H-134-015-MY2, , pp. 1–80, 2012.
[39] L. Y. Li, "Strategies for cultivating problem awareness in science teaching in junior middle school," *Journal of Shanghai Educational Research*, vol. 5, pp. 81–85, 2011.
[40] Q. X. Yang, "Discussion on "integration of numbers and shapes" in primary school mathematics education," *Forum on Contemporary Education*, vol. 2, pp. 68–70, 2011.
[41] W. J. Huang, W. J. Qiu, and W. Q. Jiang, "A study of the relationships among the scores of Othello game and fourth graders' reasoning ability, creativity ability, and problem-solving ability," *Research and Development in Science Education Quarterly*, vol. 47, pp. 19–46, 2007.
[42] R. L. Zheng, "Research on game design of elementary mathematics education for developing problem-solving ability," *Journal of Jiamusi Education Institute*, vol. 8, pp. 1–51, 2014.
[43] T. C. Halloluwa, D. Vyas, T. R. Sahama, P. Hewagamage, and H. Usoof, "Interaction design for tablet based edutainment systems for mathematical education of primary learner," in *Proceedings of the 2015 Fifteenth International Conference on Advances in ICT for Emerging Regions (ICTer)*, Colombo, Sri Lanka, August 2015.
[44] Y. H. Lee, N. Dunbar, K. Kornelson et al., "Digital game based learning for undergraduate calculus education: immersion, calculation, and conceptual understanding," *International Journal of Gaming and Computer-Mediated Simulations*, vol. 8, no. 1, pp. 13–27, 2016.
[45] H. T. Muñoz, R. F. Gesa, and S. Baldiris, "Augmented reality game-based learning for mathematics skills training in inclusive contexts," *IE Comunicaciones: Revista Iberoamericana de Informática Educativa*, vol. 21, p. 4, 2015.
[46] J. Vrugte, T. Jong, S. Vandercruysse, P. Wouters, H. Oostendorp, and J. Elen, "How competition and heterogeneous collaboration interact in prevocational game-based mathematics education," *Computers & Education*, vol. 89, pp. 42–52, 2015.
[47] H. S. Lee and J. W. Lee, "Mathematical education game based on augmented reality," in *Technologies for E-Learning and Digital Entertainment*, pp. 442–450, Springer, Berlin, Germany, 2008.
[48] V. E. Richard, "Digital game-based learning: it's not just the digital natives who are restless," *Educa*, vol. 41, pp. 16–30, 2006.
[49] S. Tang, M. Hanneghan, and A. El Rhalibi, "Introduction to games-based learning," in *Games-Based Learning Advancements for Multi-Sensory Human Computer Interfaces: Techniques and Effective Practices*, T. Connolly, M. Stansfield, and L. Boyle, Eds., IGI Global, Hershey, PA, USA, pp. 1–17, 2009.
[50] M. Griffiths and M. N. O. Davies, "Research noteExcessive online computer gaming: implications for education," *Journal of Computer Assisted Learning*, vol. 18, no. 3, pp. 379-380, 2002.
[51] B. Paras and J. Bizzocchi, "Game, motivation, and effective learning: an integrated model for educational game design," in *Proceedings of DiGRA 2005 Conference: Changing Views – Worlds in Play*, Vancouver, Canada, June 2005.

[52] B. Kim, H. Park, and Y. Baek, "Not Just fun, but serious strategies: using meta-cognitive strategies in game-based learning," *Computers & Education*, vol. 52, no. 4, pp. 800–810, 2009.

[53] K. A. Wilson, W. L. Bedwell, E. H. Lazzara et al., "Relationships between game attributes and learning outcomes: review and research proposals," *Simulation & Gaming*, vol. 40, no. 2, pp. 217–266, 2009.

[54] J. M. Yien, C. M. Hung, G. J. Hwang, and Y. C. Lin, "A game based learning approach to improving students' learning achievements in a nutrition course," *Turkish Online Journal of Educational Technology*, vol. 10, no. 2, pp. 1–10, 2011.

[55] L. J. Chu, C. L. Li, and J. L. Guo, "Influence of flow experience on learning effect in interactive multimedia materials," *Journal of Cultural Enterprise and Management*, vol. 6, pp. 1–24, 2011.

[56] Y. H. Chen, Y. M. Yeh, K. C. Li, M. S. Li, and M. H. Qiu, "Compilation of primary school students' scientific attitude scale and related factors," *Journal of National Tainan Teachers College*, vol. 24, pp. 1–26, 1991.

[57] Z. P. Cao and W. Z. Zhou, "Compilation of the national mathematics attitude scale," *In Proceedings of the Academic Symposium on Education in 1998-1999 Academic Year*, vol. 3, pp. 1211–1245, 1998.

[58] J. Zhou and J. M. George, "When job dissatisfaction leads to creativity: encouraging the expression of voice," *Academy of Management Journal*, vol. 44, no. 4, pp. 682–696, 2001.

[59] C. Y. Zhang and C. C. Dong, "To problem solving or not to problem solving? A comparison of different CAI effectiveness," *Chinese Journal of Science Education*, vol. 8, no. 4, pp. 357–377, 2000.

[60] P. S. Georgilakis, G. A. Orfanos, and N. D. Hatziargyriou, "Computer-assisted interactive learning for teaching transmission pricing methodologies," *IEEE Transactions on Power Systems*, vol. 29, no. 4, pp. 1972–1980, 2014.