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Growth-mindset intervention effects and the relationship of mindset, hope belief, and self-efficacy during creativity game-based learning

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ABSTRACT

To date, few online game-based learning studies have focused on developing children's growth creativity mindset (growth CM). This study, therefore, aimed to develop a game-based learning system to help children develop their growth CM. Additionally, we investigated the relationship between growth CM, hope belief, and creativity self-efficacy after game-based learning. Participants consisted of 132 fourth and fifth graders. With a pretest-posttest control group design, the experimental group completed a four-week intervention, whereas the control group received regular computer classes. Four types of creativity mindsets were identified: growth-internal, growth-external, fixed-internal, and fixed-external. The findings suggest that it is easier to overcome fixed CM than to enhance growth CM through game-based learning. Moreover, growth CM contributes to the development of hope belief and creativity self-efficacy, whereas fixed CM undermines hope belief and creativity self-efficacy in a game-based environment. Finally, hope belief is a mediator between growth CM and creativity self-efficacy. The findings of this study have implications for the design of a game-based learning system used to enhance growth CM, hope belief, and creativity self-efficacy.

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KEYWORDS
Game-based learning; children; growth mindset; creativity self-efficacy; hope belief

Introduction

Previous findings (Li et al., 2020; Paek & Sumners, 2019) have suggested that a creativity mindset (CM) influences the development of creativity; CM refers to beliefs about one's natural creative abilities (Li et al., 2020; O'Connor et al., 2013; Paek & Sumners, 2019). A growth CM refers to the belief that creativity is a malleable ability that can be cultivated through creative training and learning. In contrast, a fixed CM refers to the belief that creativity is an unchangeable ability (Karwowski, 2014).

The cultivation of a malleable view of creativity can promote an individual's creative achievement (Li et al., 2020). Few studies have employed digital game-based learning to enhance children's CM. In our pioneering studies (Yeh et al., 2022; Yeh et al., 2023), we found that well-scaffolded game-based learning with the context of a story helps strengthen children's learning motivation and growth CM. To fortify the learning effects, we adapted the previous learning systems and developed the Game-based Learning System for Creativity Mindset (GBL-CM) in this study, by which we hoped children could become more positive about their creativity development.

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In this study, we use creativity self-efficacy as an indicator of creative development. Creativity self-efficacy involves confidence in producing creative outcomes; it is a critical trait to creative performance (Tierney & Farmer, 2002, 2011; Wang et al., 2018; Yeh, Chen, et al., 2019b). Creativity self-efficacy is most effectively enhanced through mastery experience (Bandura, 1997, 2012). Accordingly, practices of creativity skills and enhancement of growth CM from GBL-CM can be effective in facilitating creativity self-efficacy. Additionally, we are interested in understanding whether the enhancement of growth CM would also strengthen hope belief. Hope belief refers to a cognitive process of thinking about an individual's goals, as well as the motivation to move toward and the ways to achieve those goals (Snyder, 2002). It has been found that hope belief closely relates to self-efficacy (Duggleby, Doell, Cooper, Thomas, & Ghosh, 2014) and growth mindsets (e.g. Lee, 2018; Lee et al., 2018). Therefore, the employment of GBL-CM may bring about positive learning outcomes on growth CM, hope belief, and creativity self-efficacy. Moreover, growth CM may enhance children's hope belief and further facilitate children's creativity self-efficacy.

In brief, this study tries to develop the GLS-CM, through which we seek to facilitate children's growth CM, hope belief, and creativity self-efficacy, as well as decrease their fixed CM. Additionally, we seek to analyze the relationships between CM, hope belief, and creativity self-efficacy.

Creativity mindset and game-based learning

CM is believed to have a large impact on individuals' creative ability (e.g. Li et al., 2020; 2013; Paek & Sumners, 2019). CM is typically distinguished into two types of mindsets: the fixed CM and the growth CM (e.g. Hass et al., 2016; Karwowski, 2014; Karwowski et al., 2019). Those with a fixed CM view their creativity as a fixed ability and believe that little can be done to change it. In contrast, those with a growth CM believe that one can develop one's creativity through learning or training (Dweck, 2012). Recently, Yeh et al. (2023) extended the two-type CM theory to a two-dimensional theory. Based on the dimensions of "learning plasticity" and "locus of control", they proposed four types of creativity mindsets: growth-internal control (GI), growth-external control (GE), fixed-internal control (FI), and fixed-external control (FE). Holders of GI believe that creativity can be improved through self-learning; holders of GE believe that creativity can be improved in good learning environments or through others' help; holders of FI believe that creativity is an inborn ability and therefore not possible to improve through self-learning; finally, holders of FE believe that creativity cannot be improved, even in a good learning environment or with the help of others. Importantly, the growth CM comprises GI and GE; the fixed CM consists of FI and FE (Yeh et al., 2023).

In the past decade, many studies have examined the relationship between mindsets and creativity-related learning, such as creative achievement (e.g. Li et al., 2020; O'Connor et al., 2013), creative problem-solving (e.g. Karwowski, 2014; Royston & Reiter-Palmon, 2019), and creative thinking (O'Connor et al., 2013). These findings suggest the importance of developing effective interventions to cultivate students' growth CM. Numerous growth mindset strategies have been developed to enhance the effectiveness of teaching and learning. A key concept in growth-mindset strategies is the neuroplasticity, or malleability, of the brain. It has been found that teaching students about neuroplasticity alters how students think (Dweck, 2012; Paunesku, 2013; Yeager & Dweck, 2012). Additionally, it is crucial for students to understand that their abilities can be cultivated through effort and to recognize the different concepts and behaviors associated with a growth mindset and a fixed mindset (Rissanen et al., 2019). Research has suggested that language, words, and praise used in interventions can significantly influence a student's mindset (Brock & Hundley, 2018; Cimpian et al., 2007). In particular, words of praise should focus on process rather than ability (e.g. you are truly smart) (Brock & Hundley, 2018), as an emphasis on the latter may negatively affect students (Jonsson & Beach, 2012; Rissanen et al., 2018). In addition, mastery of creativity skills helps develop growth CM and creativity self-efficacy (e.g. Bandura, 2012; Pretz & Nelson, 2017; Puente-Díaz & Cavazos-Arroyo, 2017). Incorporating the aforementioned growth mindset strategies, we designed the GLS-CM. Digital game-based learning has been recognized as an effective learning

tool for its advantages in time management, low cost, and broad access (All et al., 2015). It has been widely applied to various subjects in primary education such as science (Hussein et al., 2019), mathematics (Deng et al., 2020), language (Yang & Chen, 2020), and creativity (Hsiao et al., 2014). Previous studies have demonstrated that digital game-based learning can enhance learners' attention (Liu et al., 2021; Ramos & Melo, 2019) and stimulate students' cognitive development (Ramos & Melo, 2019). Additionally, several empirical studies have shown significant effects of game-based learning on learners' engagement (Khan et al., 2017; Schwartz & Plass, 2020), flow experience (Hamari et al., 2016; Hsieh et al., 2016; Hung et al., 2015), and self-efficacy (Hung et al., 2014).

Recently, digital game-based learning has been found to be effective in enhancing elementary school students' creative learning outcomes although only a few studies have been conducted. Regarding interventions or designs, most past studies focused on the training of creativity skills. Hwang et al. (2014) developed a peer assessment-based game in a science course at an elementary school; students considered the game as an effective learning strategy to improve their creativity. In the same vein, Chang (2013) developed online creative problem-solving activities for fourth-grade students to improve students' technological creativity. Hsiao et al.'s (2014) provided a learning environment for finding the best solutions for 16 tasks by using creative thinking. Finally, our previous studies (Yeh, Chang, et al., 2019; Yeh, Chen, et al., 2019b; Yeh et al., 2020) emphasized the intervention of mindful learning or self-determination to enhance mastery experience and self-efficacy of creativity. More recently, we pioneered incorporating the learning of growth CM into game-based learning systems for elementary school children (Yeh et al., 2022; Yeh et al., 2023). In these studies, we did not directly introduce the concept or strategies of growth CM to children during game-based learning; we integrated some strategies for growth CM into the learning systems and assumed that enhancement of positive thinking and creativity skills would further enhance self-efficacy and growth mindsets. Built on these study findings, we postulated that direct intervention of CM could bring about better learning outcomes. We, therefore, adapted our previous design and developed the GLS-CM which incorporates the introduction of brain plasticity and growth mindsets, as well as more direct practices of growth CM through games and practices (e.g. bingo games, sentence classification, positive thinking of problem-solving).

Growth mindsets, hope belief, and creativity self-efficacy during game-based learning

The construct of hope has been studied across disciplines using various populations. Related findings consistently indicate that hopeful people are more effective than others in achieving goals (Coduti & Schoen, 2014). According to Snyder (2002), hope belief has three components: goals, agency thinking, and pathways thinking. Goals are at the center of hope theory because they create routes and fuel motivation. Pathway thinking involves the ability to generate various routes from the present to desired goals. Finally, agency thinking involves intention, confidence, and the ability to follow various pathways toward desired goals; this motivational component helps people overcome blockages and impediments (Feldman & Snyder, 2005; Snyder, 2002). Hopeful people believe they can accomplish their goals by applying agency and pathway thinking. A sizeable body of literature has shown that hope has a strong connection to variables of positive psychology such as well-being (Ong et al., 2018), self-efficacy (Duggleby et al., 2014), optimism (Rand, 2018), mindful attention awareness (Loo et al., 2014), and superior academic achievement (Chen et al., 2020; Feldman & Kubota, 2015; Gallagher et al., 2017; Dixson et al., 2018).

Several studies found a positive relationship between hope and growth mindsets (Hwang & Lee, 2020a, 2020b; Lee et al., 2018). Similarly, Dixson (2022) found that both components of hope—agency and pathways—were positively related to growth mindsets. In the context of creativity, we expect that a growth mindset would render a person more motivated to learn and the practices of creativity skills would also help the person develop specific goals and higher levels of agency and pathway thinking. We, therefore, hypothesize that a growth CM would positively influence hope belief.

Finally, creativity self-efficacy refers to self-confidence in one's ability to generate creative ideas and achieve creative outcomes (Yeh & Lin, 2018). Belief in one's creativity affects the quality of human functioning through cognitive, motivational, affective, and decisional processes (Bandura, 1997). People's beliefs in their efficacy relate to whether they think pessimistically or optimistically in self-enabling or self-debilitating ways (Bandura, 2012). Additionally, belief in self-efficacy influences how well people motivate themselves and persevere in the face of difficulties in pursuing their goals as well as their outcome expectations and causal attributions of success and failure (Bandura, 2012). Self-efficacy is therefore very important in successful learning. Importantly, it can be effectively enhanced through the achievement of mastery experience (Bandura, 1997).

It has been found that CM and creativity self-efficacy are closely related (e.g. Hass et al., 2017; Pretz & Nelson, 2017; Puente-Díaz & Cavazos-Arroyo, 2017; Yeh et al., 2023). In the same vein, it is found that growth mindsets accounted for meaningful percentages of academic self-efficacy (Dixson, 2022) and that hope belief is associated with growth mindsets (e.g. Hwang & Lee, 2020a, 2020b; Lee et al., 2018) and self-efficacy (Dixson, 2022; Duggleby et al., 2014). These findings suggest that growth CM may strengthen children's hope belief in goal setting, agency thinking, and pathway thinking. As a result, they are more willing to take on challenges and more possible to achieve mastery experience, which may further enhance creativity self-efficacy.

Given the benefits of digital game-based learning and the aforementioned close relationship between mindsets, hope belief, and self-efficacy, we assumed that employing a growth CM intervention through digital game-based learning would help overcome learners' fixed CM and enhance their growth CM, which would also help strengthen their hope belief and creativity self-efficacy. Moreover, learners' growth CM may carry positive influences on their self-efficacy both directly and indirectly through hope belief at the end of the intervention. In contrast, fixed CM would carry negative influences on these routes.

The present study

Incorporating the aforementioned growth CM strategies of enhancing children's understanding of neuroplasticity, growth mindsets, positive thinking, and mastery of creativity skills (e.g. Brock & Hundley, 2018; Rissanen et al., 2019; Pretz & Nelson, 2017; Puente-Díaz & Cavazos-Arroyo, 2017; Schmidt et al., 2015), we designed the GLS-CM as an intervention and proposed a theoretical framework of the concerned variables of this study (see Figure 1). A control group pretest-posttest design was employed to examine the intervention effects on creativity mindsets, hope belief, and creativity self-efficacy. Additionally, we examined the relationship between creativity mindsets, hope belief, and creativity self-efficacy after the intervention. The following hypotheses were proposed:

- l The GLS-CM intervention would positively influence participants' growth CM. After the intervention, the experimental group's growth CM would be enhanced, whereas that of the control group would not.
- l The GLS-CM intervention would negatively influence participants' fixed CM. After the intervention, the experimental group's fixed CM would decrease, whereas that of the control group would not.
- l The GLS-CM intervention would positively influence participants' hope belief. After the intervention, hope belief among the experimental group would be enhanced, whereas that of the control group would not.
- l The GLS-CM intervention would positively influence participants' creativity self-efficacy. After the intervention, creativity self-efficacy would be enhanced among the experimental group, whereas that of the control group would not.
- l At the end of the intervention, the growth CM would interact with the fixed CM and then influence creativity self-efficacy both directly and indirectly through hope belief. However, the influence of the growth CM on the other variables would be positive and that of the fixed CM would be negative.

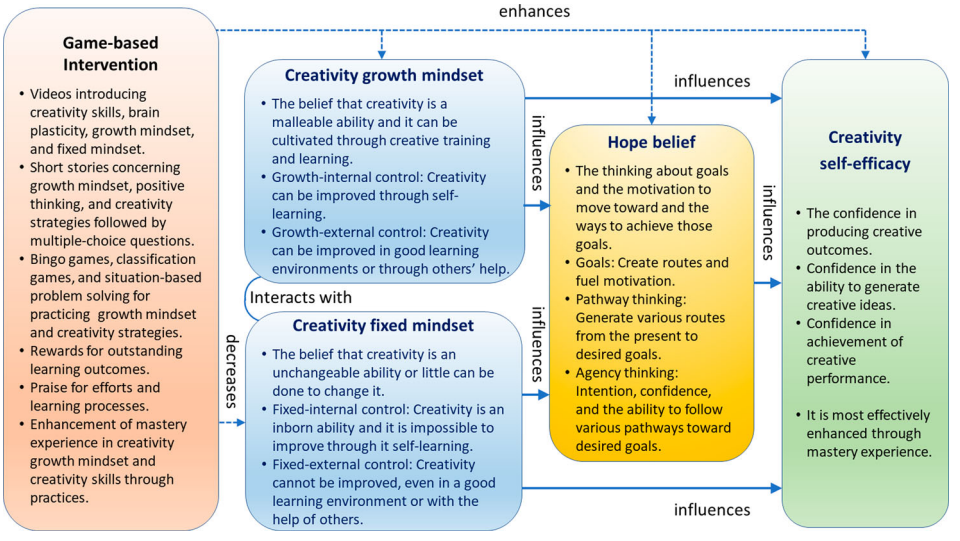

Figure 1. The theoretical framework.

Method

Participants

The participants were 132 fourth and fifth graders selected from seven classes in two elementary schools in rural areas of Taiwan. The participants included 68 boys (51.5%) and 64 girls (48.5%). Seventy of the children were assigned to the experimental group (52.2%) and 64 were assigned to the control group (47.8%). Written informed consent was obtained from all participants' parents, and each participant was paid approximately 5 USD. The study was approved by the Research Ethics Committee of the University where the study was conducted (approval number: NCCU-REC-201612-I058).

Instruments

Creativity mindset inventory (CMI)

CMI was employed to measure participants' creativity mindsets. The CMI is a 6-point Likert-type scale ranging from 1 to 6 points, representing "strongly disagree" to "strongly agree." With 12 items, the CMI included four factors: growth-internal control (GI), growth-external control (GE), fixed-internal control (FI), and fixed-external control (FE). Cronbach's α values for the four factors were 0.823, 0.824, 0.878, and 0.900, respectively. Confirmatory factor analysis (CFA) results showed that the CMI has good reliability and validity: goodness-of-fit index (GFI) = 0.968; adjusted goodness-of-fit index (AGFI) = 0.943; root mean square error of approximation (RMSEA) = 0.032; normed fit index (NFI) = 0.971; incremental fit index (IFI) = 0.993; and comparative fit index (CFI) = 0.993. Moreover, the composite reliability (ρ_c) coefficients for GI, GE, FI, and FEI were 0.827, 0.830, 0.814, and 0.852, respectively. The average variance extracted (ρ_v) values of four factors were 0.615, 0.620, 0.594, and 0.658 (Yeh et al., 2023). See Appendix A for test items.

The hope inventory (HPI)

The Hope Inventory (HPI) (Lee & Yeh, 2009) was used to measure participants' perception of hope belief. The HPI, with 19 items, is a 5-point Likert type scale that is scored from 1 to 5 points,

representing "strongly disagree" to "strongly agree," respectively. The HPI consists of three factors: goal setting (6 items), agency thinking (6 items), and pathways thinking (7 items). Cronbach's α coefficients for the three factors and the total score of the HPI were 0.816, 0.810, 0.829, and 0.911, respectively. CFA results showed that the HPI has decent reliability and validity: GFI = 0.892, AGFI = 0.863, RMSEA = 0.078, NFI = 0.952, IFI = 0.973, and CFI = 0.962. See Appendix A for test items.

Inventory of self-efficacy in creativity digital games

The Inventory of Self-Efficacy in Creativity Digital Games (IS-CDG) (Yeh & Lin, 2018) was employed to measure participants' self-efficacy during game-based creativity learning. The IS-CDG is a 6-point Likert Type scale scored from 1 to 6 points, representing "strongly disagree" to "strongly agree," respectively. The IS-CDG includes two factors: the ability to generate creative ideas (6 items) and the achievement of creative performance (3 items). Cronbach's α coefficients for the two factors and the total score of the ISE-DG were 0.908, 0.844, and 0.927, respectively. Moreover, both EFA and CFA showed that the ISD-DG has good validity. See Appendix A for test items.

Reflection questionnaire

A reflection questionnaire that included ten questions was employed to understand the participants' impression of game-based learning, by which we examined the mechanisms of effective intervention. Questions 1–3 were about creativity self-efficacy. Questions 4 and 5 were about rewards, Bingo games, and videos. Questions 6–8 were about brain plasticity and growth CM. Questions 9 and 10 were about growth CM and belief (see the result session for test items).

Procedure and experimental design

A quasi-experimental design was employed. The study involved a four-week experiment with a pretest-posttest control group design. Participants of the same class were randomly assigned to the control group or the experimental group. While the experimental group received interventions conducted through the GLS-CM, the control group focused on how to use Word to process documents and how to use PowerPoint to make a good presentation; some simple assignments were assigned for practice during the class. The learning content and assignments were not related to the interventions employed in the experimental group. The GLS-CM games were connected by a story describing how a clown tries to collect color balls during important eastern and western festivals. The GLS-CM was revised from our previous creativity learning systems (Yeh, Chang, et al., 2019; Yeh et al., 2022; Yeh et al., 2023). Except for some of the creativity skills training activities that were replaced by growth CM training activities, the learning of brain plasticity and CM as well as some interesting games were added.

The GLS-CM, designed as an individual learning system, was employed to fortify elementary school children's growth CM, the positive thinking of hope belief, and creativity self-efficacy. The GLS-CM consisted of eight games, with each game requiring 20–30 min to complete. The following features were incorporated into the GLS-CM to achieve our goals. (1) Videos introducing creativity skills, brain plasticity, growth mindsets, and fixed mindset; (2) short stories about growth mindsets, positive thinking, and creativity strategies followed by multiple-choice questions asking about the implications of the stories; (3) bingo games for strengthening growth mindsets and brain plasticity; (4) sentence classification games for identifying growth mindsets and fixed mindsets; (5) situation-based problem solving for practicing growth mindsets and creativity strategies; (6) rewards and praise for efforts and learning processes to encourage engagement, growth CM, hope belief, and creativity self-efficacy; (7) facilitation of mastery experience to enhance growth CM, hope belief, and self-efficacy through practices. While playing games, the teacher walked around to monitor students' learning to make sure that they were not doing something else via the computer. Additionally, the teacher provides immediate help when they encountered technical problems with using the computer. Some screenshots are shown in Figure 2; the training focus and practice activities are described in Table 1.

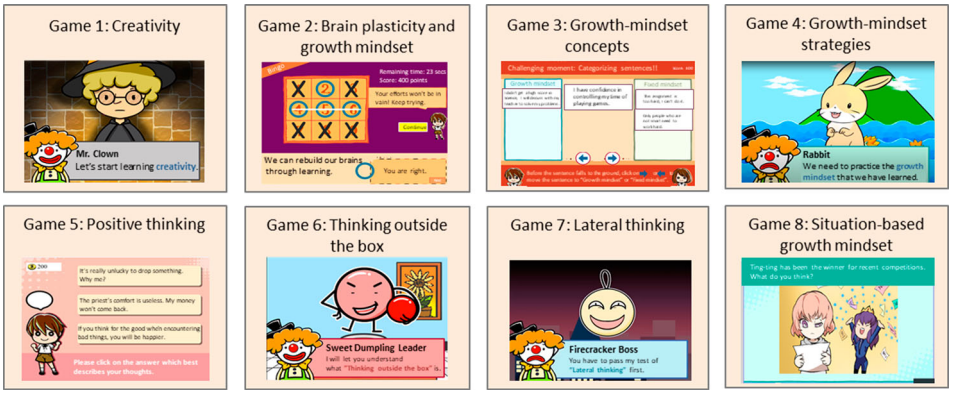

Figure 2. Exemplifying screens for the GLS-CM.

Table 1. Contents, time limits, training focuses, and practice activities of the GLS-CM.

Contents	Time	Training focuses and activities
Game 1	20 mins	Bingo games for strengthening the growth mindset after watching videos introducing growth mindset. There were 9 yes-no questions, such as "Only geniuses can be creative."
Game 2	20 mins	Bingo games for strengthening brain plasticity and growth mindset after watching videos. There were 9 yes-no questions, such as "We can rebuild our brains through learning."
Game 3	20 mins	Sentence classification games for understanding mindsets. Sentences describing the growth or the fixed mindset fell from the top. Participants had to sort the sentences to the left (growth mindset) or the right (fixed mindset) before the sentences fell to the bottom.
Game 4	20 mins	Practices in using strategies to enhance the growth mindset through videos and multiple-choice questions.
Game 5	20 mins	Practices in positive thinking. Short stories concerning positive thinking followed by multiple-choice questions.
Game 6	20 mins	Practices in thinking outside the box through short stories and multiple-choice questions.
Game 7	30 mins	Practices in lateral thinking through short stories and multiple-choice questions.
Game 8	30 mins	Practices of growth mindset through situation-based problems followed by questions, such as "You and Ting-ting are both constant winners of the card design competition in the class, but Ting-ting has been the winner in recent competitions. What would you think?"

In the first week, all participants completed the pretest of creativity mindsets and provided background information. Then the experimental group received the GLS-CM, whereas the control group took regular computer classes with no creativity-related learning contents or activities. In the fourth week, all participants completed the posttest, which consisted of the same measures as the pretest (see Figure 3).

Results

Preliminary analysis

Using the pretest score for each CM as the covariance, gender as the independent variable, and the posttest score of each CM as the dependent variable, we conducted six one-way ANCOVAs to examine gender differences in the improvement of CM. No significant gender differences were found in the improvement of growth-internal control (GI), growth-external control (GE), fixed-internal control (FI), and fixed-external control CM-GI, CM-GE, CM-FI, or CM-FE.

Self-reflection on learning effects

Ten questions were asked to gain an understanding of the participants' impressions of the creativity game. *M*s and *SD*s are shown in Table 2. The results showed that the participants' feelings toward learning were very positive. All means were above 5 points on a 6-point Likert-type scale.

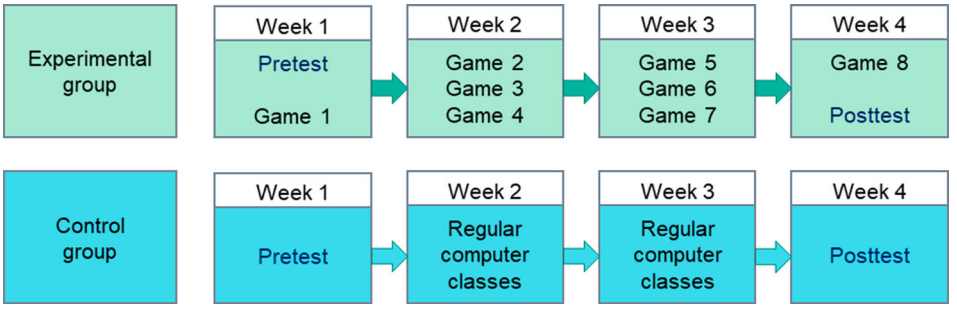

Figure 3. Procedures of experimental design.

Table 2. *M*s and *SD*s in the reflection questionnaire.

	Items	*M*	*SD*
1	I felt that this creativity game was interesting.	5.351	.976
2	The games increased my creativity.	5.214	.992
3	The games enhanced my confidence in producing creative ideas.	5.198	.956
4	The extra reward for a high score in Bingo games motivated me to try harder when playing the games.	5.176	.980
5	The Bingo game enhanced my understanding of what the videos were trying to tell us.	5.321	.797
6	The games made me aware that our brain networks can be changed through learning.	5.260	.908
7	The games encouraged me to train my brain.	5.008	.996
8	The games made me understand the importance of a growth mindset.	5.290	.916
9	The games motivated me to enhance my growth mindset.	5.153	.924
10	The games motivated me to learn and try new things.	5.229	.916

Analysis of instructional effects

Using Test (pretest vs. posttest score of CM) as the dependent variable and Group (control vs. experimental) as the independent variable, we conducted a mixed design analysis of variance (ANOVA) to examine the effects of Group on the improvement of CM. *M*s and *SE*s for CM are shown in Figure 4. No significant effects were found regarding GI or GE in the main effects or interaction effects, although the experimental group had more improvement than the control group. However,

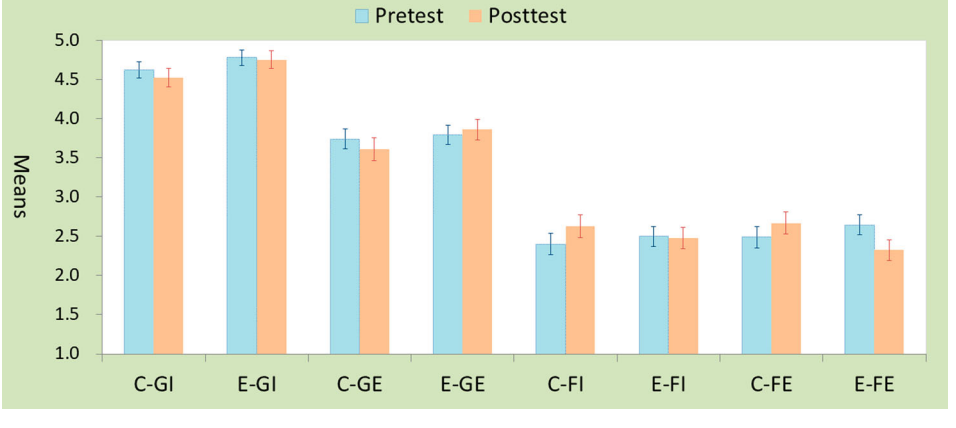

Figure 4. Ms and SEs of the creativity growth mindset and fixed mindset for the control and experimental groups. Note. C = Control group. E = Experimental group. GI: Growth-internal control. GE: Growth-External control. FI: Fixed-Internal control. FE: Fixed-External control.

Table 3. The effects of group on creativity mindset.

	ANOVA				
Source	*MS*	*F* (1, 130)	*p*	η^2_p	Post hoc test (Bonferroni)
	Growth-internal control				*ns.*
Test	0.237	0.518	0.473	0.004	
Group	2.477	2.275	0.134	0.017	
Test × Group	0.065	0.142	0.707	0.001	
	Growth-external control				*ns.*
Test	0.053	0.122	0.727	0.001	
Group	1.556	0.823	0.366	0.006	
Test × Group	0.595	1.364	0.245	0.010	
	Fixed-internal control				*ns.*
Test	0.707	1.056	0.306	0.008	
Group	0.042	0.023	0.879	0.000	
Test × Group	1.069	1.597	0.209	0.012	
	Fixed-external control				*ns.*
Test	0.327	0.457	0.500	0.004	
Group	0.593	0.342	0.560	0.003	
Test × Group	4.219	5.900*	0.017	0.043	G1: Pretest > Posttest

Note. G1 = Experimental group.
* $p < .05$.

significant interaction effects were found for FE × Group, $F(1, 130) = 5.900$, $p = 0.017$, $\eta^2_p = 0.043$. Analysis of the simple main effect revealed that the fixed external control mindset among children in the experimental group declined, $F(1, 69) = 4.400$, $p = 0.040$, $\eta^2_p = 0.060$, whereas among children in the control group, it did not (see Table 3).

Using Test (pretest vs. posttest score of hope belief) as the dependent variable and Group (control vs. experimental) as the independent variable, we conducted a mixed design ANOVA to examine the effects of Group on improvements in hope belief. The results showed an overall significant impact on hope belief, Wilks' $\Lambda = 0.957$, $p = 0.018$, $\eta^2_p = 0.043$, as well as a significant interaction effect on hope × Group, F (1, 130) = 5.784, $p = 0.018$, $\eta^2_p = 0.043$. Analysis of the simple main effect revealed that children in the experimental group outperformed those in the control group in the posttest of hope belief. Moreover, while hope belief increased among children in the experimental group, among children in the control group, it did not. These findings suggest that the employed learning system improves hope belief among children.

Additionally, using Test (pretest vs. posttest score of creativity self-efficacy) as the dependent variable and Group (control vs. experimental) as the independent variable, we conducted a mixed design ANOVA to examine the effects of Group on improvements in creativity self-efficacy. See Figure 5 for the *M*s and *SE*s of hope belief and creativity self-efficacy. The results showed an overall significant effect on creativity self-efficacy, Wilks' $\Lambda = 0.945$, $p = 0.007$, $\eta^2_p = 0.055$. Further analyses found a significant main effect of Group on creativity self-efficacy, $F(1, 130) = 4.361$, $p = 0.039$, $\eta^2_p = 0.032$, as well as a significant Test × Group interaction effect on creativity self-efficacy, $F(1, 130) = 7.541$, $p = 0.007$, $\eta^2_p = 0.055$. Analysis of the simple main effect revealed that children in the experimental group outperformed children in the control group in the posttest on creativity self-efficacy. Moreover, while creativity self-efficacy was enhanced among members of the experimental group, it was not among members of the control group (see Table 4). These findings suggest that the employed learning system enhances children's creativity self-efficacy.

Path model analysis

Structural equation modeling was employed to investigate the relationships among the posttest scores of growth CM, fixed CM, hope belief, and creativity self-efficacy (see Figure 6). Due to the small sample size, we first tested the normality of the data distribution. According to Hair, Black, Babin, and Anderson (2010), data is considered to be normal if skewness is between -2 to +2 and

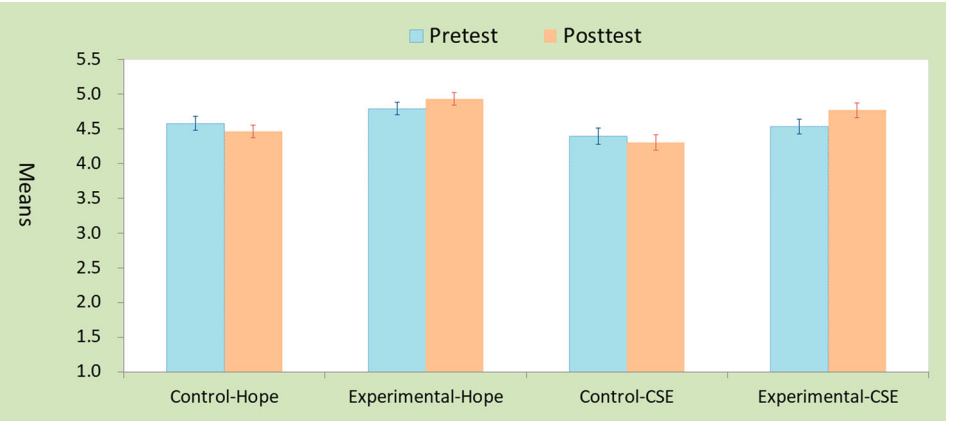

Figure 5. Ms and SEs of hope belief and creativity self-efficacy for the control and experimental groups.

Table 4. The effects of Test and Group on hope and creativity self-efficacy.

	ANOVA				
Source	*MS*	*F* (1, 130)	*p*	η_p^2	Post hoc test (Bonferroni)
Hope belief					
Test	0.010	0.054	0.817	0.000	*ns.*
Group	7.744	8.137*	0.005	0.059	G1 > G2
Test × Group	1.105	5.784*	0.018	0.043	T2: G1 > G2; G1: T2 > T1
Creativity self-efficacy					
Test	0.386	1.602	0.208	0.012	*ns.*
Group	6.010	4.361*	0.039	0.032	G1 > G2
Test × Group	1.817	7.541*	0.007	0.055	T2: G1 > G2; G1: T2 > T1

Note. Group: 1 = Experimental group; 2 = control group; T1 = pretest; T2 = posttest
* $p < .05$.

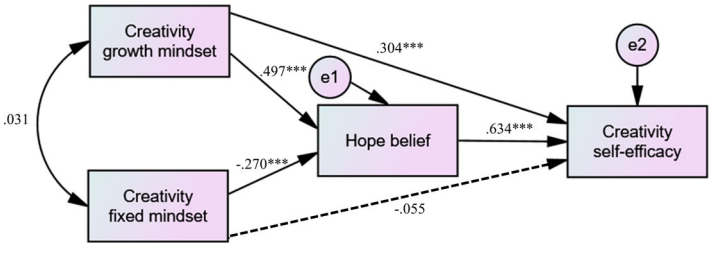

Figure 6. Results of the path model.

kurtosis is between -7 to +7. The result showed that the data were normally distributed as skewness was between −0.155–0.579 and kurtosis was between -0.987–0.183 for all variables in the path model. Therefore, the maximum likelihood estimation was employed in the path model analysis. The results reveal that the growth CM positively and directly influences hope belief ($\beta = 0.497$, $p < .001$), whereas the fixed CM negatively and directly influences hope belief ($\beta = -0.270$, $p < .001$). Additionally, the results show hope belief positively and directly affects creativity self-efficacy ($\beta = 0.634$, $p < .001$).

On the other hand, the direct effect of the growth CM on creative self-efficacy was 0.304 ($p < .001$), and the indirect effect of the growth CM on creative self-efficacy, through hope belief, was 0.316 (0.497 × 0.634). Therefore, the total effect of the growth CM on creative self-efficacy was 0.620

(0.304 + 0.316). In contrast, the direct effect of the fixed CM on creative self-efficacy was −0.055 (p = 0.269), and the indirect effect of the fixed CM on creative self-efficacy through hope belief was −0.171 (−0.270 × 0.634). Thus, the total effect of the fixed CM on creative self-efficacy was 0.226 (- 0.055 plus - 0.171). The results suggest that a growth CM has a stronger influence than a fixed CM on creativity self-efficacy. Moreover, hope belief is an important mediator between creativity mindsets and self-efficacy.

Discussion

Although many growth mindset intervention studies have been conducted (Burnette et al., 2018; Burnette et al., 2020; DeBacker et al., 2018; de Carvalho & Skipper, 2020; Porter et al., 2020), there have been few studies of game-based interventions geared toward improving children's growth CM. Therefore, this study developed the GLS-CM, which we used to investigate improvements in learning among children by way of CM, hope belief, and self-efficacy. Four hypotheses were proposed. Except for the hypothesis concerning growth CM, the hypotheses were supported. Specifically, the findings suggest that GLS-CM is effective in reducing children's fixed-external control mindset and in enhancing hope belief and creativity self-efficacy. Additionally, preliminary analysis revealed no gender differences, suggesting that GLS-CM is gender bias-free.

To date, several studies have shown the effectiveness of growth-mindset interventions (e.g. DeBacker et al., 2018; Schleider & Weisz, 2018). Studies have also shown that a fixed mindset can be shifted to a growth mindset through growth mindset intervention (Baynard, 2021). However, few game-based digital interventions geared toward enhancing a growth CM have been developed. In this study, we found that although the four-week experimental instruction through the GLS-CM could decrease children's fixed-external control mindset, neither the growth-internal control mindset nor the growth-external control mindset was significantly enhanced However, the experimental group performed better concerning external growth mindset than the control group, although the effect was not significant, suggesting that students tend to believe a good educational environment or helpful educational resources cultivate creativity.

The findings of this study also suggest that it is easier to overcome a fixed mindset than to enhance a growth mindset through game-based learning. Based on past findings (e.g. Pretz & Nelson, 2017; Rissanen et al., 2019; Yeager & Dweck, 2012), the GLS-CM includes strategies for enhancing growth CM; it starts with an enhancement of the concept of creativity and that of CM. Then, the method emphasizes the importance of the brain and the cultivation of a growth CM. In addition, positive thinking, thinking outside the box, reverse thinking, and lateral thinking are integrated into the learning system to enhance their creativity, growth CM, hope belief, and self-efficacy. Bingo games, situation-based problems, and mindset classification games are employed to improve children's growth CM and reduce their fixed CM. The participants felt that the games enhanced their understanding of growth mindsets and that brain networks can be changed through learning. Thus, the games encouraged the children to train their brains and seek to enhance their growth mindset. However, the low magnitude of the changes in a fixed mindset and the insignificant effects on the growth creativity mindset suggests that the practices explored may not be sufficient, although the participants were very positive about the design of the game-based learning (see Table 1).

Additionally, the findings suggest that GLS-CM enhances children's hope belief and creativity self-efficacy, which supports our hypothesis. Hope belief involves goal setting, agency thinking, and pathways thinking (Lee & Yeh, 2009; Snyder, 2002). Hopeful people tend to set ambitious goals and accomplish future goals through workable plans (pathways) and willpower (agency) (Snyder, 2002). Obtaining rewards in the GLS-CM may stimulate goal setting; verbal encouragement to keep trying and the experience of success may enhance agency thinking; the introduction of strategies and practices geared toward the development of a growth CM and creativity may strengthen pathways thinking. As a result, fortified hope belief may further enhance creative self-efficacy. Our

argument is also supported by the path analysis of the influences of growth CM on hope belief and creativity self-efficacy. In other words, the results here are in line with findings that hope belief, a growth mindset, and creativity self-efficacy are closely related (Dixson, 2022; Hwang & Lee, 2020a, 2020b) and that growth-mindset intervention can significantly enhance self-efficacy (e.g. Burnette et al., 2020; Orvidas et al., 2018). Interestingly, we found that a fixed CM did not significantly interact with a growth CM and then directly influence creativity. However, a fixed CM was found to negatively influence creativity through hope belief. These results suggest that a fixed CM and a growth CM are not necessarily negatively related and that a strong fixed CM may undermine the development of hope belief and creative self-efficacy.

Conclusions

To date, no digital game-based learning studies have been conducted to improve children's growth CM, hope belief, and creativity self-efficacy in generating creativity. Accordingly, we developed the GLS-CM to help children develop a growth CM mindset, overcome their fixed CM, strengthen hope belief, and gain efficacy in creative performance. Additionally, we investigated the interrelationship between growth CM, fixed CM, hope belief, and creativity self-efficacy after game-based learning. The findings have implications for how to design a game-based learning system that enhances children's creativity development. The findings also help distinguish the influences of different types of creativity mindsets on hope belief and creativity self-efficacy, shedding light on instructional design.

Limitations and implications

Due to the tight schedule of the school curriculum, only four weeks with one class each week were available for experimental instruction. Game-based learning had to be tailored to meet this constraint. Although students' growth CM did not significantly improve, students' fixed-external mindset significantly declined; their hope belief and creativity self-efficacy also enhanced. These findings suggest that game-based learning can produce positive learning outcomes but that boosting a growth CM may require more practice and a longer training period. Further studies in the classroom or in a game-based learning context should extend the experimental period and offer more opportunities for success in creative performance to strengthen students' growth CM. Nevertheless, the findings of this study suggest boosting creative self-efficacy may start with employing growth CM strategies to enhance hope beliefs as well as to decrease fixed CM. On the other hand, children in this study tend to hold a high level of growth-internal control belief. Accordingly, providing a supportive environment for such self-learning is vital for creativity development.

In addition, individual beliefs interact with broader economic forces in shaping student motivation, engagement, and achievement (Wormelli, 2018). The participants of this study only included children from rural areas who had lower socioeconomic status than those in the major cities in the country where the study was conducted. Such sampling is based on the findings that students of low socioeconomic status or who are academically at-risk might benefit from mindset interventions (Sisk et al., 2018). However, socioeconomic status might interact with the intervention and influence the development of a growth CM. Further intervention studies may include children from a broader range of socioeconomic status to better understand whether socioeconomic factors would influence changes in children's mindsets.

Finally, this study found that interventions focused on a growth CM and creativity can enhance children's hope belief and hope belief plays as a mediator between CM and self-efficacy during creativity game-based learning. Some activities that enhance children's hope belief may help optimize the learning effects. No previous studies have included hope belief—which is crucial for goal-setting, self-confidence, and strategy utilization—in game-based learning. Game-based learning designers

and classroom instructors may consider developing interventions that strengthen hope belief, thereby enhancing creativity. Moreover, further studies may include more personal traits in the path model we examined to build a more comprehensive growth CM model.

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Appendix A The employed inventories

Table A1. The test items of the creativity mindset inventory.

	Growth Mindset
Factor 1: Growth-Internal locus of control (GI)	
1	As long as I work hard, my creativity can be greatly improved.
5	I can improve my creative ability through self-learning.
9	I can be more creative as long as I am willing to learn.
Factor 2: Growth-External locus of control (GE)	
2	My creativity can be improved with the help of good teachers.
6	I am willing to learn creativity and I can become more creative when there is a good learning environment.
10	My creativity can be substantially improved when I have sufficient learning opportunities.
Fixed mindset	
Factor 3: Fixed-Internal locus of control (FI)	
3	It is hard to improve my creativity even if I work hard to improve it through self-learning.
7	Even if I am willing to learn creativity, it is hard for me to become more creative.
11	Even if I work hard by myself, my creativity won't be substantially improved.
Factor 4: Fixed-External locus of control (FE)	
4	It is hard to improve my creativity even if I have good luck and meet good teachers.
8	Even if there is someone to tutor me, it's hard for me to become more creative.
12	Even if I have sufficient learning opportunities, my creativity won't be substantially improved.

Table A2. Test items of the Inventory of Hope belief.

	Factor 1: Agency thinking
1	I am confident that I can complete many things.
4	I believe that I can adapt well to difficult situations.
7	I believe that I will succeed someday as long as I keep my faith and work hard.
10	I believe that any difficulty has its solutions.
13	I believe that any challenge or difficulty contributes to self-growth.
16	I believe that I will have a good life.
Factor 2: Goal	
2	I can effectively carry out my plans.
5	I can set specific goals for the future and work toward the goals as planned.
8	To achieve my goals effectively, I make a detailed plan and implement it step by step.
11	I have strong confidence and motivation to accomplish my goals
14	I can focus on my goals, overcome obstacles, and solve problems.
18	I can come up with many strategies and solutions to achieve my goals effectively.
Factor 3: Pathway thinking	
3	I can apply experience to solve current problems.
6	I can learn from the successes of others to achieve my goals.
9	I can reflect on my past failures to avoid repeating the same mistakes and improve my chances of success.
12	I can think outside the box and come up with effective solutions to problems.
15	I can see setbacks as challenges and keep moving toward my goals.
17	When I encounter difficulties, I can think of alternatives to solve them.
19	When I encounter setbacks in pursuit of my goals, I can seek support and assistance from others.

Table A3. The test items and self-efficacy in creativity digital games.

No	When playing the game,
	Factor 1: Ability to generate creative ideas
4	I believe that I can come up with many creative problem-solving solutions.
5	I believe that my creativity can be constantly improved.
6	I believe that I can come up with many creative ideas.
7	I believe that I can become a creative person.
8	I believe that my creativity can be improved as long as I try hard to learn.
9	I believe that I can produce creative works.
	Factor 2: Achievement of creative performance
1	I feel that I am a creative person.
2	I feel that I am more creative than most of my classmates.
3	I feel that "being creative" is one of my characteristics.