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Mindful learning: A mediator of mastery experience during digital creativity game-based learning among elementary school students

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ABSTRACT

With the mounting empirical evidence of the benefits of mindfulness, the researchers of the present study incorporated mindful learning in digital game-based learning of creativity. A two-phase study was conducted to (1) develop the *Inventory of Mindful Learning Experience in Digital Games* (IMLE-DG); and (2) develop a training program of *the Digital Game-based Learning of Creativity* (DGLC), by which the relationship among achievement goal, self-determination, mindful learning, and mastery experience during digital game-based learning of creativity were investigated through experimental instruction. One hundred and eighty-one 3rd to 6th graders were used in the development of IMLE-DG, and 95 3rd and 4th graders were included in the six-week experimental instruction through the DGLC. The results suggest that the IMLE-DG has good reliability and validity. The Cronbach's α coefficient was 0.974 and exploratory factor analysis yielded three factors: curiosity and open-mindedness, attention and grit, and emotion regulation. Confirmatory factor analysis also showed that the three-factor structure was a good-fit model (Goodness-fit-index = 0.913). Moreover, analytical results showed that achievement goal and self-determination influenced mastery experience through mindful learning experience, suggesting that mindful learning is a crucial mediator of mastery experience in digital game-based learning of creativity. With key features of story-based, interdisciplinary, and 3-D design, The DGLC provides an original and valuable vehicle for creativity learning. In addition, the incorporated mechanisms (rewards, free choices, immediate feedback, and peer-evaluation) for enhancing goal achievement, self-determination, and mindful learning shed light on the design of game-based learning and creativity instruction.

1. Introduction

With the rise of globalization and information technology, cultivating creativity has become the top priority for excelling in the face of fierce competition (Gaspar & Mabic, 2015). In the last decade, many studies have found that digital games can enhance learning motivation and learning outcomes (e.g., Ahmad & Jaafar, 2012; Chen & Sun, 2016; Hung, Hwang, Lee, & Su, 2012; Perrotta, Featherstone, Aston, & Houghton, 2013; Sung & Hwang, 2013). However, only a few studies have focused on creativity skills (Kao, Chiang, & Sun, 2017; Yeh, Lai, Lin, Lin, & Sun, 2015). Notably, no researchers have developed a digital creativity game-based learning system for elementary school children that includes the training of both creativity dispositions and skills. Creativity dispositions such as perseverance and positive thinking are essential to the learning of creativity (Yeh, 2017).

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Developed from the traditional mindfulness concept (Creswell, Way, Eisenberger, & Lieberman, 2007), mindful learning refers to a flexible state of mind in which people are actively engaged in the present, aware of new things, and sensitive to context (Langer, 2000); it helps improve attention, cognitive flexibility, problem solving, emotion, and working memory (Levy, Jennings, & Langer, 2001; Ostafin & Kassman, 2012). These characteristics of mindful learning seem to be crucial to the achievement of mastery experience during creativity game-based learning. Mastery experience refers to the personal experience of success (Bandura, 1997). Digital games can attract learners' attention, as well as encourage repetition of targeted behaviors or skills (Cohen, 2016); a well-designed creativity helps increase mastery experience of creativity. Such an experience can be influenced by the need of an achievement goal and self-determination. Achievement goals help construct a framework for how people interpret and experience a learning event, which guides learning efforts toward competence-relevant activities (Bandura, 1997; Bounoua et al., 2012). Self-determination comprises the needs for competence, relatedness, and autonomy, and is essential to facilitating propensities for growth and integration (Deci & Ryan, 2000). Self-determination and achievement goals many influence mindful learning during game-based learning.

To date, no studies have measured Lagarian mindful learning during creativity game-based learning. The present study aimed to develop the Digital Game-based Learning of Creativity (DGLC) and *the Inventory of Mindful Learning Experience in Digital Games* (IMLE-DG) to provide effective instruments for investigating interactions of player-related traits during digital creativity game-based learning. An experimental design was also conducted to examine the mediation effect of mindful learning on achievement goal, self-determination, and mastery experience during creativity game-based learning.

2. Literature review

Game-based learning refers to learning that uses games to help learners achieve desired learning outcomes in an educational environment; it may facilitate motivation, skills, and better learning outcomes through challenging game content (Admiraal, Huizenga, Akkerman, & Dam, 2011; Qian & Clark, 2016; Sera & Wheeler, 2017). Hwang, Hsu, Lai, and Hsueh (2017) employed computer games for problem-based English listening in an elementary school and found increased student motivation. The implementation of mindful learning within game-based learning is still limited, especially in applications of creativity game-based learning. We hereby propose a theoretical framework as in Fig. 1 to guide our arguments in this article.

2.1. Mindful learning in creativity game-based learning

Mindful learning is a term derived from the concept of mindfulness (Langer, 2016). Mindfulness is thought to be a fundamental concept in Buddhist meditation practices (Creswell et al., 2007) and has been explored more recently by a variety of psychological researchers (McKenzie, 2013). Mindfulness emphasizes "the awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment by moment" (Kabat-Zinn, 2003, p.144). In the context of education, mindfulness in learning refers to the continuous creation of new categories, openness to new information, and an implicit awareness of multiple perspectives (Langer, 2016), which may be practiced via neglecting distractions, ignoring unhelpful self-chatter, and concentrating on the here and now. In addition, applying mindfulness to learning may help enhance performance, motivate personal development, improve physical and emotional health, reduce stress, and manage exam related demands more confidently (Hassed & Chambers, 2014).

Although mindful learning has recently garnered great attention from researchers across disciplines, and a few researchers (Bodner & Langer, 2001) have developed related inventories, no inventories of mindful learning in game-based learning have been developed. A commonly used measure of mindfulness is the Langer Mindfulness/Mindlessness Scale (MMS) developed by Bodner and Langer in 2001. The MMS includes four subscales: novelty seeking, novelty producing, flexibility, and engagement. Confirmatory

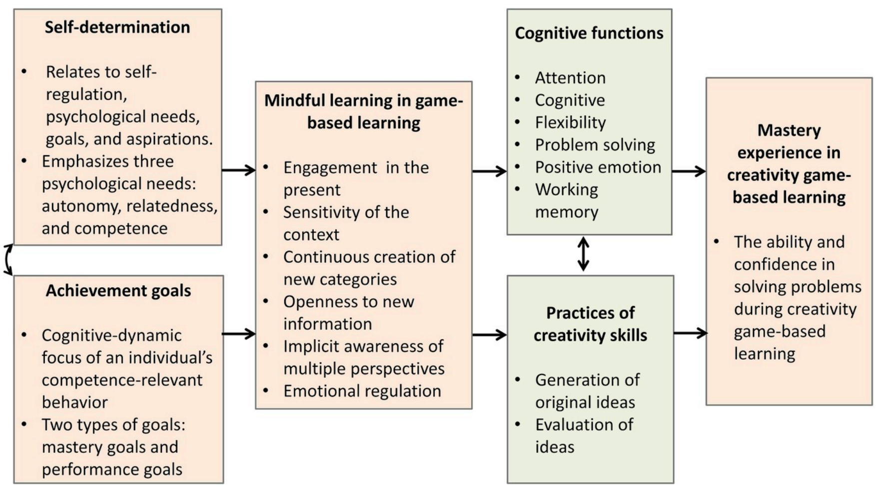

Fig. 1. A theoretical frame of how mindful learning mediates learning in creativity games.

factor analysis (CFA) indicates that the four-factor mindfulness model had good construct validity: goodness-of-fit index (GFI) = 0.97. Regarding reliability, the Cronbach's α coefficient for the 21-item MMS was 0.85 (Bodner & Langer, 2001). Later, the MMS was shortened into 9 items (Haigh, Moore, Kashdan, & Fresco, 2011). CFA indicates that the one-factor mindfulness model had good construct validity and reliability: the comparative fit index (CFI) = 0.993 and Cronbach's α coefficient was 0.85. Based on these inventories, this study tried to integrate these concepts of domain-general mindful learning into the context of game-based learning and, further, to develop a domain-specific mindful learning inventory.

Theories of creativity suggest that the creative process involves the interactions between divergent thinking and convergent thinking (Yeh, 2017). It has also been suggested that creative processes are greatly influenced by working memory, emotion (Yeh et al., 2015; Yeh, Lai, & Lin, 2016; Yeh, Tsai, Hsu, & Lin, 2014), as well as two key processes of creative cognition: the generation of possible solutions or ideas to solve a problem, and the evaluation of the value or utility of ideas in terms of their novelty and usefulness (Lin & Vartanian, 2017). These cognitive processes are closely related to Langer's (2016) arguments about mindful learning. Moreover, the results of a longitudinal experimental study (Langer, 2016) revealed that mindfulness could increase memory, positive affect, competence, and creativity. Furthermore, people usually have no difficulty in paying attention to play because the stimulus in a play situation is constantly changing (Langer, 2016). Game-based learning provides environments that have the promise and potential to promote mindful learning (Sedig, 2008). It was found that when learners paid mindful attention to novel games, class engagement and performance were enhanced through the retention of information (Auman, 2011). Therefore, it is reasonable to speculate that mindful learning could be an important mediator during creativity game-based learning.

2.2. The influence of self-determination and achievement goals on mindful learning

Mindfulness has been linked up with autonomous motivation and with various positive psychological and behavioral outcomes (Keng, Smoski, & Robins, 2011; Weinstein & Ryan, 2011). Self-determination and achievement goals are closely related to autonomous motivation; they may interact and then influence mindful learning.

Self-determination theory (SDT) is a theory of human motivation, development, and wellness; it tackles basic issues such as self-regulation, psychological needs, as well as goals and aspirations (Deci & Ryan, 2008). Furthermore, it emphasizes three psychological needs: autonomy, relatedness, and competence. These abilities are essential for understanding the content and process of goal pursuits (Deci & Ryan, 2000). Recently, some study findings have demonstrated the positive and close association between self-determination and mindfulness in non-game situations. In a sleep-related study, it was found that the need for self-determination was related to mindfulness (Campbell et al., 2015). In a qualitative study of employee outcome, it was found that mindfulness-based practices were positively related to self-determination and persistence (Glomb, Duffy, Bono, & Yang, 2011). In the same vein, it was found that mindfulness was associated with increased levels across the psychological needs for self-determination (Wicher, 2017), as well as being associated with self-regulation (Friese & Hofmann, 2016) which is known as the foundation of self-determination (Erwin, Robinson, McGrath, & Harney, 2017). In light of the aforementioned findings, we reason that learners with a high level of self-determination may learn mindfully in creativity game-based learning.

With regard to the influence of achievement goals on mindful learning, Brown and Ryan (2003) claimed that when the impact of goals have been explored, the role of mindfulness becomes a salient concern. Achievement goals are regarded as the cognitive-dynamic focus of an individual's competence-relevant behavior (Elliot, 1997). They help construct a framework for how people explain and experience learning events (Bounoua et al., 2012). Early theories posited two goal types—mastery goals and performance goals, whereas more recent theories have included two key dimensions, approach and avoidance, to the framework (Elliot & McGregor, 2001). Elliot and McGregor (2001) proposed a 2 (definition of competence) × 2 (valence of competence) model of achievement goals, which includes four types of achievement goals: mastery-approach, performance-approach, mastery-avoidance, and performance-avoidance goals. A learner with performance-approach goals wants to have his or her ability appraised as being greater than others, while individuals with performance-avoidance goals avoid negative outcomes such as performing poorly compared with others (Hulleman, Schrager, Bodmann, & Harackiewicz, 2010). A learner with mastery-approach goals desires to learn as much as possible, overcome a challenge, or increase his or her level of competence, while with mastery-avoidance goals, a person avoids lacking mastery or failing to learn as much as possible (Wolters, 2004). To date, no study has investigated how Lagarian mindful learning mediates achievement goals and mastery experience in game-based learning concerning creativity. A related study found that mindfulness and task orientation (i.e., mastery orientation) were positively correlated in athletes (McCarthy, 2011).

Although the two-dimension achievement goals seem to help more clearly define the relationship between achievement goals and learning outcomes in adults, these goals are more challenging to distinguish between in elementary school children. A recent study (Yeh & Lin, 2018) of inventory development with elementary school children participants found that performance-approach goals and performance-avoidance goals were converged into performance goals, and mastery-approach goals and mastery-avoidance goals were converged into mastery goals. Notably, these two types of goals were found to be positively correlated. This study therefore measures performance goals and mastery goals, and postulates that both types of achievement goals would carry effects on mindful learning during creativity game-based learning.

2.3. The mediation effect of mindful learning on mastery experience of creativity

In this study, mastery experience of creativity is the concerned learning outcome. Bandura (1997) claimed that mastery experiences can be achieved through four mechanisms: acquisition of required knowledge and skills, progressive goal setting, feedback on performance, and practice of skills in diverse settings. In game playing, mastery experiences are a vital part of video games (Starks, 2014). In this study, mastery experience of creativity refers to the ability and confidence in solving problems during creativity game-based learning.

Mastery experience can also be regarded as a process through which a player remains engaged and continues pressing forward in a game (Huang & Yeh, 2016). When learning mindfully, the learner channels this divergent thinking process by taking multiple perspectives to find multiple solutions that fit the context (Langer, 1993). In addition, when mindful strategies are implemented, students have significant opportunities to exercise the skills of creativity, collaboration and communication (Davenport & Pagnini, 2016). Similarly, Halloluwa, Usoof, and Hewagamage (2014) pointed out that game-based learning may foster mindful learning by capturing the full attention of the users, resulting in a better learning experience. Accordingly, mindful learning plays a very important role in gaining mastery experience in digital creativity game-based learning.

In an investigation, Yeh and Lin (2018) found that the motivation for achieving both mastery goals and performance goals, as well as self-determination, carried indirect effects to mastery experience during digital game-based learning. Moreover, Hassed and Chambers (2014) indicated that practicing mindfulness helps improve working memory that, in turn, improves long-term memory and results in a sense of completion and mastery. They also pointed out that mindfulness can enhance creativity and that, when the creative process in the mind is flowing, it accompanies enjoyment, confidence, and a feeling of mastery. Mindfulness may also regulate achievement goal orientation through enhanced self-regulation and achievement emotions (Howell & Buro, 2011). Through this finding, along with the aforementioned arguments and findings regarding the relationship between achievement goals and self-determination on mindful learning, we postulate that pupils who hold a high level of achievement goals and self-determination may be inclined to learn mindfully and, as a result, improve their mastery experience during creativity game-based learning. To confirm these relationships, a two-phase study was conducted.

2.4. Hypotheses of this study

In phase 1, this study aimed to develop the *Inventory of Mindful Learning Experience in Digital Games* (IMLE-DG) that is suitable for measuring pupils' mindful learning experience with regard to mindful cognition and mindful emotion while playing digital games; no hypotheses were proposed. In phased 2, this study aimed to investigate the relationship of achievement goals, self-determination, mindful learning, and mastery experience during digital creativity game-based learning. We conducted experimental instruction and speculated that mindful learning could be an important mediator during the creativity game-based learning. The following four hypotheses were proposed:

- Self-determination would enhance mindful learning during creativity game-based learning; learners with a higher level of self-determination would gain more mindful learning experience during the game-based learning.
- Achievement goals would enhance mindful learning during creativity game-based learning; learners with a higher level of achievement goals would gain more mindful learning experience during the game-based learning.
- Mindful learning would enhance mastery experience during creativity game-based learning; learners with a higher level of mindful learning experience would gain more mastery experience during the game-based learning.
- Self-determination and achievement goals would interact with each other, and then influence mastery experience through mindful learning during the creativity game-based learning.

3. Method

3.1. Participants

Purposive sampling was employed to include 181 third to sixth graders (97 boys and 84 girls) in the development of the IMLE-DG. The sample was composed of 46 third graders (25.4%), 52 fourth graders (28.7%), 39 fifth graders (21.5%) and 44 sixth graders (24.3%). Moreover, 43 third and 52 fourth graders (50 boys and 45 girls) were selected from four classes in an elementary school to participate in the experimental design; these participants were rewarded with a Pokemon USB stick.

3.2. Instruments

3.2.1. Digital game-based learning of creativity (DGLC)

Personal characteristics of creativity include a set of dispositions (attitudes, tendencies, and motivation) and skills (Simonton, 2000; Sternberg & Lubart, 1996; Yeh, 2017). Strategies of positive thinking and attitude, such as being humorous, grateful, and perseverant, as well as thinking outside the box and reverse thinking, may help strengthen dispositions of creativity (Yeh, 2017). As for enhancement of creativity skills, most of the creativity training or research put emphases on divergent thinking only. While the training of divergent thinking may induce more original ideas, training of convergent thinking may be required for producing valuable solutions. Therefore, a training program for creativity that integrates both divergent and convergent thinking is likely to produce better learning results. In addition, strategies such as sensitivity in observation (Yeh, 2006), lateral thinking (De Bono, 1995), mind mapping (Buzan, 1996), and SCAMPER (Eberle, 1996) all have been suggested as effective strategies. SCAMPER represents the following seven thinking skills: substitution, combination, adaptation, modification, putting to other uses, elimination, and reversing. This study integrated these training strategies of dispositions and skills into the DGLC.

The DGLC, developed by PHP, MySQL, Unity, C#, and Flash, was employed to investigate the relationship among the participants' self-determination, achievement goals, mindful learning experience, and mastery experience during creativity game-based learning.

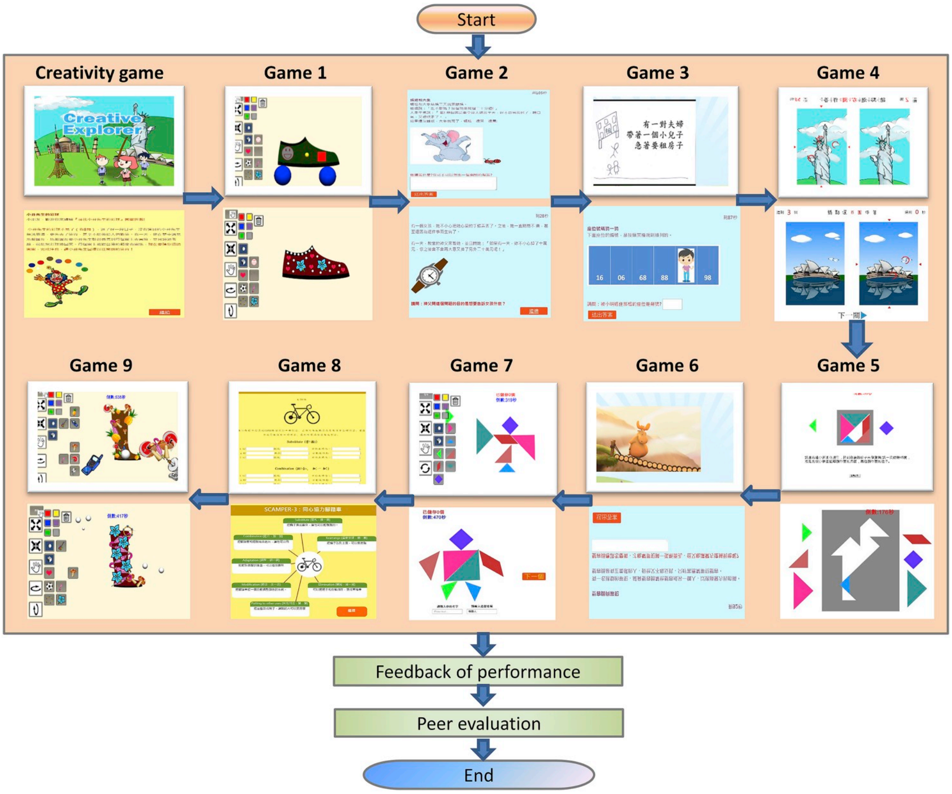

Fig. 2. Contents and procedures of the DGLC.

The DGLC (see Fig. 2) was composed of a story entitled "Searching for the clown's color balls" that was connected by important festivals in Chinese and American culture. The DGLC included nine games, ranging from 10 min to 15 min for each game. The participant was encouraged to help the clown find one color ball in each game, except for in Game 1. The contents and the training focuses of the DGLC for the games are depicted in Table 1.

3.2.2. Inventories

The employed inventories were *Inventory of Mindful Learning Experience in Digital Games* (IMLE-DG) developed in this study, as well as *Inventory of Achievement Goal in Digital Games* (IAG-DG), *Inventory of Self-determination in Digital Games* (ISD-DG) and *Inventory of Mastery Experience in Creativity Digital Games* (IME-CDG) (Yeh & Lin, 2018). They were 6-point Likert-type scales with response

Table 1
Contents, time limits, and main training focuses of the DGLC.

Content	Time (mins)	Training focuses
Game 1: Warm up—Designing shoes	15	Creative product design: Through 3-D drawing via Unity
Game 2: The Chinese New Year (The golden ball)	10	Positive thinking and attitudes (e.g., humor, perseverance, gratitude) toward problem solving: Through animations, open-ended questions, sentence creation, and immediate feedback.
Game 3: The Lantern Festival (The red ball)	10	Thinking outside the box and reverse thinking: Through short stories, authentic problems, open-ended questions, and immediate feedback.
Game 4: The Dragon Boat Festival (The orange ball)	10	Sensitivity in observation: Through finding differences between two pictures or analyzing patterns in a given picture.
Game 5: The Mid-autumn festival (The yellow ball)	10	Convergent thinking: Through moving and rotating a tangram to complete jigsaw puzzle tasks.
Game 6: The National Day of ROC (The green ball)	10	Lateral thinking: Through animations, open-ended questions, and immediate feedback.
Game 7: The Halloween (The black ball)	15	Divergent thinking: Through moving and rotating the tangram to create products.
Game 8: The Thanksgiving (The blue ball)	15	SCAMPER and mind mapping: Through thinking out creative ideas from the seven perspectives of SCAMPER and the illustration of mind maps.
Game 9: The Christmas gift (The purple ball)—Designing a Christmas boot.	15	Creative product design: Through 3-D drawing via Unity

Table 2
The results of reliability analyses, exploratory factor analyses, and confirmatory factor analyses.

	IAG-DG (Achievement goals)	ISD-DG (Self-determination)	IME-CDG (Mastery experience)
No. of items	12	13	9
Factors and sampled test items	1. Performance goals (6 items): "I hope I can get higher scores than others."	1. Autonomy and self-regulation (7 items): "The games provide many opportunities for me to freely develop my own thinking."	1. Ability to solve problems (5 items): "I can think out the solutions quickly."
	2. Mastery goals (6 items): "I try to learn more problem solving skills during game playing."	2. Competence (6 items): "I can achieve the goals I set."	2. Confidence in solving problems (3 items): "I am confident in developing creative ideas and solving problems."
Range of factor loadings	.658 to .855,	.519 to .886	.606 to .879
Variance explained from EFA	76.960%	63.364%	73.277%
Correlations between each factor and total score	.952 and .933, *ps* < .01	.956 and .942, *ps* < .01	.953 and .896, *ps* < .01
Cronbach's α coefficients	Total: .960 Factors: .943, and .905	Total: .933 Factors: .887, and .881	Total: .903 Factor:.860 and .819
CFA: Model fit	$\chi^2(N = 176, df = 51) = 103.027$ ($p < .05$); GFI = .917; RMR = = .073; NFI = .947; IFI = .973; CFI = .972.	$\chi^2(N = 176, df = 26) = 79.867$ ($p < .05$); GFI = .919; RMR = .076; NFI = .915, IFI = .941; CFI = .940.	$\chi^2(N = 176, df = 18) = 48.397$ ($p < .05$); GFI = .932; RMR = .071 NFI = .933, IFI = .957, and CFI = .957.
CFA: Construct reliability for factors	.907 and .876	.882 and .864	.799 and .755
CFA: Average variances extracted	.621 and .546	.601 and .615	.448 and .521

Note. CFA: Confirmatory factor analysis. GFI: goodness-of-fit index; RMR: the root mean square residual; NFI: the normed fit index; IFI: the incremental fit index; CFI: the comparative fit index.

options ranging from "totally disagree" to "totally agree." The IMLE-DG measured the participants' experience of mindful cognition and mindful emotion during game playing; the IAG-DG measured the participants' orientation of achievement goals during game playing; the ISD-DG measured the participants' level of self-determination during game playing; and the IME-CDG measured the participants' level of mastery experience while playing creative games.

Integrating related inventories and literature (Auman, 2011; Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2007; Haigh et al., 2011; Halloluwa et al., 2014; Langer, 2016), we tried to develop a mindful learning experience inventory in the context of digital game playing. We proposed that mindful learning experience during game playing should include both the cognitive and emotional aspects; such mindful learning refers to a flexible state of mind in which people remain curious, open-minded, attentive, and persistent during the game playing. Moreover, mindful people are able to regulate their emotions to successfully level up or complete a task. Based on this definition, we developed the pretest version of the IMLE-DG, which included 19 items. Results of reliability and validity analyses of IMLE-DG are shown in the results section. The result of reliability analyses, exploratory factor analysis (EFA), and confirmatory factor analysis (CFA) of the other inventories (Yeh & Lin, 2018) are depicted in Table 2. The results show that all the inventories have good reliability and validity.

3.3. Experimental design and procedures

The pretest of the IMLE-DG was administered in the classroom by the participants' teacher with a time limit of 15 min. With regard to the experimental instruction, two classes of third graders and two classes of fourth graders participated in this study. The experimental instruction administered through the DGLC was designed as a part of their computer course. All experimental procedures were conducted in the computer laboratory at the participants' school. Specific experimental procedures are illustrated in Fig. 3. To enhance learning effects, participants were informed at the beginning that the games would improve their creativity and that the higher the score they obtained from the games, the better gift they would receive. Immediate feedback regarding their score in each game was also displayed at the end of each game. Moreover, free choices of objects for creative design were provided. With 9

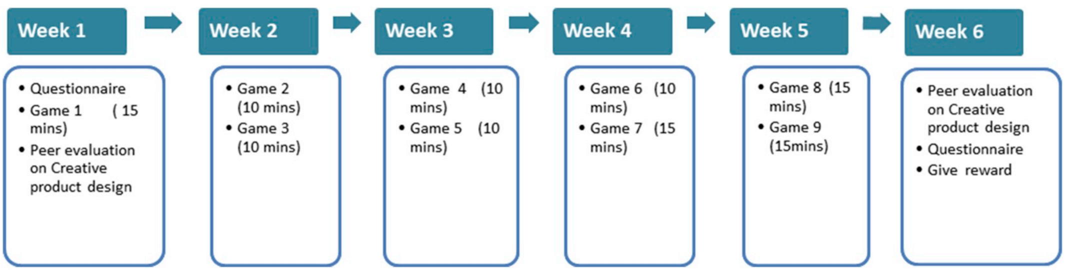

Fig. 3. Procedures of experimental design.

Table 3
The factor loadings of mindful learning experience ($N = 181$).

No	Factor and items	Factor loading		
	When playing a digital game,	1	2	3
Factor 1: Curiosity and open-mindedness (Cronbach's α = .947)				
2	I have a strong curiosity to try different levels or tasks of a game.	.853		
1	I have an open mind to think out all the possible ways to level up or complete tasks of the game.	.808		
3	I want to know how to crack difficult levels or tasks in a game.	.634		
Factor 2: Attention and grit (Cronbach's α = .955)				
4	I like challenging levels or tasks.		.962	
6	I maintain an optimistic attitude when striving to level up or complete tasks.		.815	
7	I believe that my performance is improving.		.814	
5	I can focus on the problem I am solving in each level or task.		.747	
Factor 3: Emotion regulation (Cronbach's α = .971)				
12	I can stay calm when striving to level up or complete a task.			.943
9	I can hold back sadness and encourage myself not to get dejected when I cannot level up.			.906
13	I feel happy when successfully leveling up or completing a task.			.920
8	I can stay happy when striving to level up or complete a task.			.857
11	I feel happy if I see some improvement in game performance.			.868
10	I can happily accept my game performance, even if I don't achieve my goal.			.851

games in total, the learning lasted for 6 weeks with 40 min in each week. Notably, peer evaluations in game 1 and game 9 were employed to rate the popularity and creativity of the designed products. In each class, three participants were rated to be the most popular, and three participants were rated as the most creative. The winners were rewarded with a $5 USD gift. Upon the completion of each task, feedback with regard to the winning score and options for choosing gifts would be displayed on the screen. All these added elements in the procedure were designed to encourage goal achievement, self-determination, mindful learning, and mastery experience in creativity.

4. Results

4.1. Development of the IMLE-DG

Item analysis, exploratory factor analysis, internal-consistency reliability, and confirmatory factor analysis were employed to examine the reliability and validity of the IMLE-DG. Finally, 13 items were kept in the IMLE-DG. Principal Component Analysis and Direct oblimin were employed in factor extraction and rotation when conducting exploratory factor analysis. The results yielded three factors: curiosity and open-mindedness (3 items), attention and grit (4 items), and emotion regulation (7 items). With factor loadings ranging from 0.634 to 0.962, 88.72% of the total variance was explained by the three factors (see Table 3). The correlations between each of the factors and the total score were 0.905, 0.929, and 0.947($ps < .001$). . Moreover, the item-total correlation coefficients ranged from 0.814 to 0.879.

Confirmatory factor analysis CFA indicated that the IMLE-DG had good construct validity and reliability. Using the maximum likelihood estimation method, $\chi^2(N = 181, df = 56) = 119.442$ ($p < .001$), GFI = 0.913, AGFI = 0.858, RMR = 0.073, RMSEA = 0.079. In terms of relative fit measures, NFI = 0.964, RFI = 0.950, IFI = 0.981, and CFI = 0.980. Finally, values of the composite reliability (ρ_c) of the three factors were 0.949, 0.956, and 0.969. The average variance extracted (ρ_v) values were 0.861, 0.844, and 0.839, respectively.

Using gender as the independent variable, and using subscales of the IMLE-DG as the dependent variable, we conducted multivariate analysis of variance (MANOVA) to examine gender difference in the IMLE-DG. The results showed there were no gender differences on the scores of mindful learning, Wilks' $\Lambda = 0.988$, $p = .531$, $\eta_p^2 = .012$. The purpose of this study was to develop a reliable and valid inventory for measuring pupils' mindful learning experience in creativity games. The analytical results indicate that, with no gender differences, the developed inventory has good reliability and validity.

4.2. Self-evaluation of learning effects

Since the mastery experience can only be measured after playing the games, we requested the participants to self-evaluate their creativity ability and creativity confidence before and after conducting the DGLC by answering two questions. The questions were "What score would I use to describe my ability of creativity (1–10)?" and "What score would I use to describe my confidence of creativity (1–10)?" The self-evaluation was scored from "1" point to "10" points, representing "very weak" to "very strong".

Using Repeated Measure Analysis of Variance (Repeated measure ANOVA), we examined whether there were aptitude (Low vs. High) × treatment effects (Pretest vs. Posttest) interaction effects on the participants' self-evaluation of creativity ability and creativity confidence. The aptitude variables included in this study were achievement goal, self-determination, mindful learning experience, and mastery experience; each of the independent variables was split at the median into two groups (Low vs. High). The results (see Table 4) showed that all main effects of the examined aptitudes on the improvement of creativity ability were significant, $F(1, 93) = 5.263$ to 7.297, $p = .024$ to $.008$, $\eta_p^2 = .054$ to $.073$. Moreover, the interaction of achievement goal × treatment effect was significant, $F(1, 93) = 4.487$, $p = .037$, $\eta_p^2 = .046$. The followed simple main effect analyses showed that pupils with a higher

Table 4
The Effects of Achievement Goals, Self-Determination, Mindful Learning, and Mastery Experience on Self-Evaluation of Changes is Creative Ability and Confidence.

Source	ANOVA				Comparison
	MS	*F* (1, 93)	*p*	η_p^2	
Achievement goals					
Ability	81.751	5.263*	.024	.054	2 > 1
Achievement Goal × Ability	9.016	4.487*	.037	.046	2b > 2a 2 > 1
Confidence	96.482	6.385*	.013	.064	2 > 1
Self-determination					
Ability	108.862	7.143**	.009	.071	2 > 1
Confidence	127.373	8.619**	.004	.085	2 > 1
Mindful learning experience					
Ability	111.046	7.297**	.008	.073	2 > 1
Confidence	131.404	8.918**	.004	.088	2 > 1
Mastery experience					
Ability	108.385	7.109**	.009	.071	2 > 1
Confidence	139.417	9.518**	.003	.093	2 > 1

Note. 1 = low-score group of the independent variable; 2 = high-score group of the independent variable. a = pretest; b = posttest. *$p < .05$. **$p < .01$.

achievement goal level significantly improved their creative ability, whereas those with a lower achievement goal level did not significantly improve their creative ability. The results (see Table 4) also revealed that all main effects of the examined aptitudes on the improvement of creativity confidence were significant, $F(1, 93) = 6.385$ to 9.518, $p = .013$ to .003, $\eta_p^2 = .064$ to .093.

4.3. The influence of self-determination and achievement goals on mindful learning experience

To examine the effects of self-determination and achievement goal on mindful learning, we separately used the score of self-determination and achievement goal as independent variables, and used the subscale scores of mindful learning (curiosity and open-mindedness, attention and grit, and emotion regulation) as dependent variables to conduct one-way MANOVAs. In these analyses, the independent variables were split at the median into two groups (Low vs. High). Fig. 4 shows the *M*s and *SE*s for groups with different levels of self-determination and achievement goals.

The results showed significant group effects of self-determination on mindful learning experience, Wilks' $\Lambda = .751$, $p < .001$, $\eta_p^2 = 0.249$. The subsequent ANOVA revealed significant group effects on curiosity and open-mindedness, attention and grit, and emotion regulation, $F(1, 93) = 19.988$, $\eta_p^2 = 0.177$, $F(1, 93) = 16.951$, $\eta_p^2 = 0.154$, and $F(1, 93) = 29.770$, $\eta_p^2 = 0.242$, $ps < .001$, respectively. Comparisons of the means indicated that participants with a higher level of self-determination had higher scores on all the three indices of mindful learning experience than those with a lower level of self-determination.

The results also showed significant group effects of achievement goals on mindful learning experience, Wilks' $\Lambda = .699$, $p < .001$, $\eta_p^2 = 0.301$. The subsequent ANOVA revealed significant group effects on curiosity and open-mindedness, attention and grit, and emotion regulation, $F(1, 93) = 28.703$, $\eta_p^2 = 0.236$, $F(1, 93) = 21.755$, $\eta_p^2 = 0.190$, and $F(1, 93) = 36.514$, $\eta_p^2 = 0.282$, $ps < .001$, respectively. Comparisons of the means indicated that participants with a higher level of achievement goal had higher scores on all the three indices of mindful learning experience than those with a lower level of achievement goals.

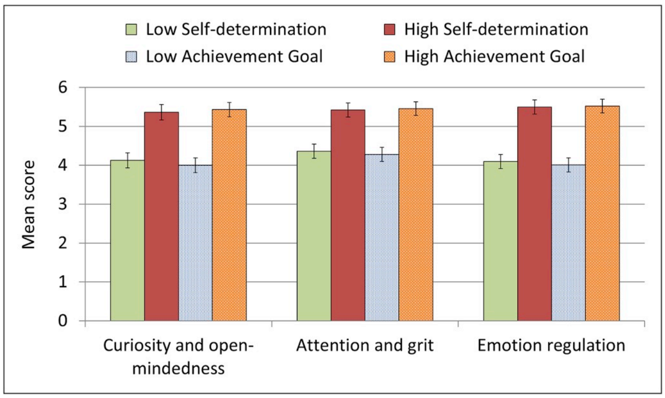

Fig. 4. *M*s and *SE*s of mindful learning experience for the low- and the high-score group of self-determination and achievement goals.

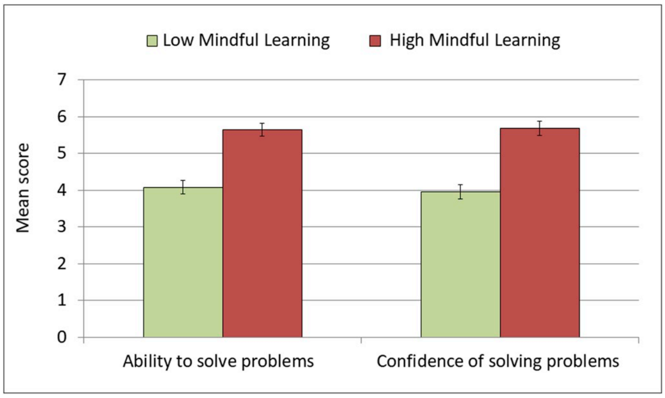

Fig. 5. *Ms* and *SEs* of mastery experience for the low- and the high-score group of mindful learning experience.

4.4. The influence of mindful learning experience on mastery experience

The effect of mindful learning experience on mastery experience was examined by one-way MANOVAs followed by ANOVAs with the subtest scores of mastery experience (ability to solve problems and confidence in solving problems) as the dependent variables. In these analyses, mindful learning experience was split at the median into two groups (Low vs. High). Fig. 5 shows the *Ms* and *SEs* of mastery experience for the low- and the high-score group of mindful learning experience.

4.5. The path model of self-determination, achievement goals, mindful learning experience, and mastery experience

Structural Equation Modeling conducted through AMOS 21 was employed to test the proposed model. In the proposed model, we hypothesized that achievement goals would interact with self-determination and directly influence mastery experience and indirectly influence mastery experience through mindful learning experience during creativity game-based learning. Preliminary fit criteria, overall model fit, and the fit of the internal structure of the model were first examined (Bagozzi & Yi, 1988). Results of analyses revealed that all estimated parameters in this study met the criteria. The important values of the model are depicted in Fig. 6.

Moreover, the following three dimensions of indices (Hair, Black, Babin, Anderson, & Tatham, 2006) were employed to examine the overall model fit of the proposed model: absolute fit measures, relative fit measures, and parsimonious fit measures. The absolute fit measures suggested that the model was a good-fit model: χ^2 (N = 95, df = 23) = 25.911, p = .305. The goodness-of-fit index (GFI = 0.939), the root mean square error of approximation (RMSEA = 0.037). The relative fit measures (NFI = 0.814, RFI = 0.709, IFI = 0.975, and CFI = 0.972) indicated that the model was acceptable. Finally, the parsimonious fit measures (PNFI) = 0.505 and parsimonious comparative fit index (PCFI) = 0.583; these results also suggested that the model was acceptable.

In addition, all direct effects were significant ($ps < .05$). The standardized regression weights of all observed variables were ranged from 0.70 to 0.98, $ps < .001$, suggesting that the proposed model had a good fit of internal structure. Overall, the results suggest that the model was a good-fit model. The standardized direct effects, indirect effects, total direct effect of the latent variables are depicted in Table 5. With regard to direct effects, the effect of self-determination on mindful learning was a little bit stronger than that of achievement goals on mindful learning. Notably, the direct effect of mindful learning on mastery experience was very strong. In addition, explained variance of mindful learning was 0.66 and that of mastery experience was .86; explained variance of all observed variables ranged from 0.81 to 0.95.

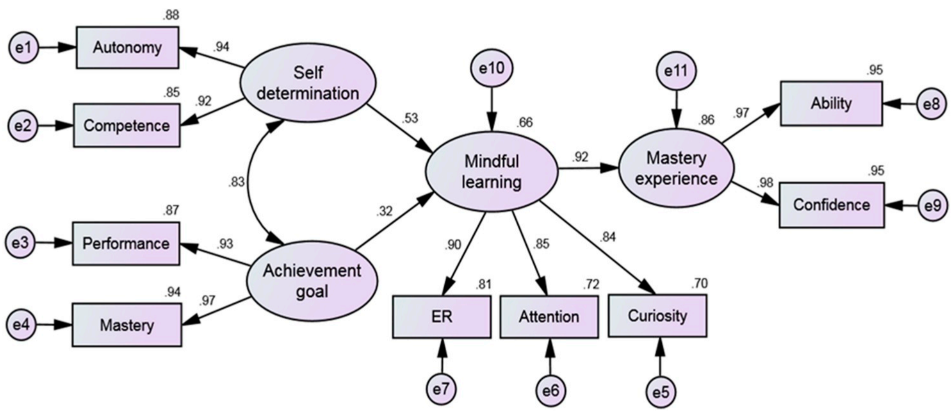

Fig. 6. Results of the proposed path model—mindful learning as a mediator.

Table 5
Direct, indirect, and total effects of the revised model.

Paths between variables	Direct effect	Indirect effect	Total effect
Self-determination– > Mindful learning	.53		.53
Achievement goals– > Mindful learning	.32		.32
Self-determination– > Mastery experience		.49	.49
Achievement goals– > Mastery experience		.30	.30
Mindful learning– > Mastery experience	.93		.93

5. Discussion and conclusions

5.1. The effectiveness of mindful learning inventory and training program

The lack of available instruments for assessing mindful learning within this changing digital world inspired us to create an inventory for evaluating mindfulness within digital games. The results in phase 1 of the study suggest that, with no gender differences, the IMLE-DG has good reliability and validity. Based on Langerian concepts, three factors were derived and evaluated for accuracy: curiosity and open-mindedness, attention and grit, and emotion regulation. All of these concepts relate to mindful learning. Curiosity and open-mindedness are integral to the process of contemplating many alternative perspectives and openness to new categories. Attention and grit directly relate to the process of staying in the present moment and paying attention to subtle changes whether they are big or small, internal or external (Davenport & Pagnini, 2016). Emotional regulation improves with mindfulness training as a result of reduced mental health symptoms (Fung et al., 2018).

In phase 2 of the study, we developed the DGLC and examined the mediation effect of mindful learning on achievement goals, self-determination, and mastery experience during creativity game-based learning through an experimental design. We first examined whether the participants felt that their ability and confidence in their creativity improved after engaging in the DGLC through a six-week experimental instruction. The results indicated that, in general, the participants felt that their creative ability and confidence improved after the experimental instruction. These findings support the effectiveness of the DGLC and the importance of incorporating stories, rewards, free choices, immediate feedback, and peer-evaluation.

The DGLC that was designed to improve creative dispositions and skills featured nine games that were connected with stories to increase motivation. It started with a warm-up activity of designing a shoe. Then, enhancement of creativity disposition and self-confidence were rovided through short films and practices pertaining to positive attitudes and thinking, thinking outside the box, and reverse thinking. Following these activities, the program emphasized sensitive observation, convergent thinking, lateral thinking, divergent thinking, SCAMPER, and mind mapping. Finally, the integration of creative thinking was applied in the creative product design of a boot. In addition, 3-D design was implemented for the game 1 and game 9 design activities. Researchers (Saorín et al., 2017) found that the use of 3-D design programs improved students' creativity. The 3-D design in our study offered hands-on experience for students to implement what they had learned through the game-based learning program. Hands-on experiences and maker-centered leaning have been suggested as important tools for facilitating inspiration and interest for interdisciplinary learning (Clapp & Jimenez, 2016).

The DGLC also employed peer-evaluation as feedback to stimulate creative thinking and mastery experience after designing products in game 1 and game 9. It has been found that exposing participants to the ideas of others could improve creativity (Fink et al., 2010). Our findings support such positive effects of feedback. Furthermore, an additional element of the creativity training in the DGLC was design. There is a natural overlap between design and creativity, and recent researchers have explored these connections through functional magnetic resonance imaging (Liu, Chang, Yang, & Liang, 2018; Saggar et al., 2017). We further combine these two concepts with 3-D design and games in the systematic learning of creativity.

5.2. The mediation effects of mindful learning on mastery experience during creativity game-based learning

The findings of the present study shed light on the mediation effects of mindful learning on mastery experience during the process of creativity learning in a game-based environment. The analytical results suggest that mindful learning is a dominant mediator between pupils' self-determination, achievement goals, and mastery experience during the creativity game-based learning; the pupils' self-determination and achievement goals interactively influence their mastery experience through mindful learning, and mindful learning has a very strong impact on mastery experience. However, self-determination seems to have a stronger influence on mastery experience than achievement goals.

Mindful learning encourages openness to new information, awareness of varying perspectives, and the pursuit of novelty (Langer & Moldoveanu, 2000); it is a process of actively noticing new things about the self, others, and present context (Bercovitz, Pagnini, Phillips, & Langer, 2017). Mindful learning also helps to enhance the efficiency of working memory and mastery experience (Davenport & Pagnini, 2016; Hassed & Chambers, 2014). The findings of this study support these arguments and suggest that mindful learning is crucial for the achievement of mastery experience in g creativity ame-based learning.

Achievement goals guide learning efforts toward competence-relevant activities (Bounoua et al., 2012; Elliot, 1999). By informing students that the games would improve their creativity, that a higher score obtained from the games could be rewarded with gifts, as well as through displaying the obtained scores of each game, we expected to see that those with a higher level of achievement goals would exhibit a higher level of mindful learning and mastery experience. The hypothesis was confirmed and the results support that achievement goals help construct a framework for learning toward the achievement of mastery experience (Bounoua et al., 2012; Elliot, 1999).

In this study, we also provided choices of objects for creative design to increase the sense of autonomy in self-determination, in addition to encouraging guided practices of creativity dispositions and skills to enhance the sense of competence in self-determination. The findings of this study revealed that the higher the level of self-determination one perceived, the more mindful learning one would engage in, and a stronger level of mastery experience would be achieved. Overall, the findings here support that the integrated, autonomous functioning of self-determination relates to awareness (Brown & Ryan, 2003), mindfulness (Campbell et al., 2015; Wicher, 2017)), and optimal functioning of learning (Deci & Ryan, 2000).

Integratedly, mindful learning may regulate achievement goal orientation and self-determination through facilitated cognitive functions and practices of creativity skill, which further enhances mastery experience. In other words, the findings of our study support that mindful learning plays an important mediation role for how achievement goals and self-determination influence mastery experience in digital creativity game-based learning.

6. Conclusions

Mindful learning and creativity are both highly valued for school education and life-long learning. In addition to developing an original training program for creativity and a valid instrument for measuring mindful learning during game-based learning, this study aimed to understand how players' traits would influence their mastery experience during digital creativity game-based learning. A two-phase study was conducted and all the proposed hypotheses were supported.

The results in phase 1 of the study suggest that, composed of three factors, the mindful learning inventory has good reliability and validity. The results of phase 2 of the study suggest that the creativity game-based learning system developed in this study provides an effective vehicle for creativity training and assessment for aptitude-treatment interactions. Through the learning system, we found that participating pupils became more confident in their competences of creativity; we also found that achievement goals and self-determination influenced mastery experience in creativity via mindful learning, which has implications for both the classroom and the use of game-based learning. Moreover, the learning system is characterized by the training of both creativity skills and dispositions, as well as the integration of 3-D design, hands-on experience, and creative products. Some mechanisms of encouraging goal achievement, self-determination, mindful learning, and mastery experiences, such as stories, rewards, free choices, immediate feedback, and peer-evaluation, were also integrated to enhance learning effects. The cognition and interdisciplinary-based learning system for creativity, and the mediation effects of mindful learning during game-based learning, distinguish our current study as original and valuable to the field of research and instruction in game-based learning.

7. Limitations and suggestions

We did not employ a pretest of mastery experience in this study for three reasons. First, mastery experience can be only assessed after learning. Secondly, this study focused on understanding how personal traits would interact and influence mastery experience in creativity game-based learning. Thirdly, the experimental instruction was not long enough for dynamic assessment of mastery experience. We considered the entire training program to be a complete learning experience for creativity dispositions and skills. Due to the limitations of the curriculum design at the sampled schools, the maximum experimental instruction period possible was 6-weeks, and we were only able to run the program once. To employ a dynamic assessment of mastery experience requires a second run of a parallel or more advanced training program. Further studies can try to find schools that are able to cooperate in conducting a longer training program or more intensive experimental instruction. Then, dynamic assessment at different time points can be achieved to get a deeper understanding of how personal traits interact and influence mastery experience in creativity game-based learning in the long run. If time permits, some interviews can also be conducted to get more information from the players.

Moreover, since the experimental instruction takes a long time to complete, only 95 pupils were included in the path model. For a SEM path model to be stable, a bigger sample size is required. To compensate for this limited sample size, however, we also conducted ANOVAs and MANOVAs. The results were consistent with the findings in the SEM analysis. In our study, mindful learning was found to be a crucial mediator for achieving mastery experience during game-based learning. Further studies can investigate how mindful learning would interact with other personal traits to influence the learning of creativity.

Increasing incentives for mindful learning is critical to the success of a game-based learning program. As evidenced by the findings of this study, connecting games through stories may enhance curiosity and attention. Moreover, providing scores and gifts as well as allowing free choices for designing components may encourage goal achievement and self-determination, which may further enhance mindful learning and mastery experience. Further studies can try to use different strategies to encourage mindful learning during digital game-based learning.

Finally, to improve pupils' mastery experience in creativity, both creativity skills and dispositions should be included. Moreover, creative design, hands-on experience, immediate positive feedback, as well as mechanisms for encouraging goal achievement, self-determination, and mindful learning should all be included in instruction or curriculum design for game-based learning in creativity.

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