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Effects of Mindful Learning Using a Smartphone Lens in Everyday Life and Beliefs toward Mobile-based Learning on Creativity Enhancement

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ABSTRACT: To date, no study has examined whether enhancing mindfulness in everyday life through varied smartphone-based interventions involving photo taking could improve creativity or whether the beliefs toward mobile-based learning would influence such mindfulness learning effect. This study, therefore, developed the inventory "Beliefs toward Mobile Devices for Creativity Learning" and designed four interventions to validate the feasibility of such a new approach. One hundred and eighty-three college students participated in the inventory development, and 149 college students, who were randomly assigned to a control group (Group 1) or one of the three experimental groups, participated in a one-week experimental instruction. While Group 1 did not receive any smartphone intervention, the experimental groups used their smartphones to take photos with different emphases for four days and to share the photos with imaginative narratives on a designated website. Group 2 emphasized free choices of photo taking (self-determination), Group 3 emphasized self-determination and idea sharing, and Group 4 emphasized self-determination in varied categories and idea sharing. The results suggest the developed inventory has good reliability and validity; moreover, incorporating both self-determination and knowledge sharing lead to the best learning effect. Notably, beliefs toward mobile-based learning influence intervention effects on the enhancement of creativity self-efficacy. Accordingly, even a small amount of mindful learning in everyday life using a smartphone lens may enhance creativity. This study provides a valid instrument and smartphone-based mindfulness approach for ubiquitous learning of creativity.

Keywords: Creativity, Knowledge sharing, Mindful learning, Self-determination, Smartphone

1. Introduction

The field of education has recently applied mindful pedagogies because of the known benefits of improved attention (Zilcha-Mano & Langer, 2016), cognitive flexibility (Haller, Bosman, Kapur, Zafonte & Langer, 2017), and creativity (Baas, Nevicka, & Velden, 2020; Langer, 2000; Wang & Liu, 2016; Yeh, Chang, & Chen, 2019a). Mindfulness is characterized by the continuous creation of new categories, an implicit awareness of multiple perspectives, and openness to new information (Langer, 2016); these characteristics are all critical to creativity, which has been regarded as a top educational goal across educational levels. Empirical findings have also revealed overlapping concepts between mindfulness and creativity (Davenport & Pagnini, 2016; Bercovitz, Pagnini, Phillips & Langer, 2017; Yeh et al., 2019a). In addition, a recent study (Yeh, Chen, Rega, & Lin, 2019b) showed that mindful learning enhanced self-efficacy in game-based learning. Accordingly, facilitating creativity and creative self-efficacy through mindful learning can be an effective approach for creativity instruction.

A convenient and efficient way to improve mindful learning and creativity is to practice such cognitive processes through devices people commonly use in everyday life. The smartphone has become an essential piece of equipment for people in modern societies; it is not only an important instrument for learning (Ashford, Giorgi, Mann, Sherritt, Ungar, & Curtis, 2020; Farley et al., 2015) but also for capturing beautiful moments in life. The vast majority of people enjoy sharing photos on social media using smartphones. When people take and share photos with smartphones, and if they could be a little bit more mindful and imaginative about the photos they take, would they be more creative (Question 1)? Moreover, research findings have suggested that self-determination and knowledge sharing may enhance mindful learning (Yeh, Yeh, Chen., 2012; Yeh et al., 2019a; Yeh & Lin, 2015) and creativity (Peterson, Aljadeff-Abergel, Eldridge, VanderWeele, & Acker, 2020; Kremer, Villamor, & Aguinis, 2019). Would smartphone-based mindfulness interventions with varied types of self-determination and knowledge sharing carry different effects on the improvement of people's creativity? (Question 2). Finally, identifying critical personal traits that may moderate intervention effects helps achieve

optimal learning (Yeh & Lin, 2015). Would people's beliefs toward using mobile devices for creativity learning influence the smartphone-based mindfulness interventions (Question 3)?

To date, no study has employed smartphone-based mindfulness interventions through photo taking in everyday life to enhance the ability and self-efficacy of creativity. To answer the aforementioned questions, we developed an inventory and designed four interventions based on a theoretical framework, by which we attempted to examine what kind of mindfulness interventions might be more effective and whether people's beliefs toward using mobile devices for creativity learning would moderate such learning effect. Hopefully, a new smartphone-based approach would be proposed to advance the theories and ubiquitous learning of creativity.

2. Related work

2.1. Mindfulness

Mindfulness is considered a secularized adaptation of Eastern Buddhist convention, and it is usually defined as "paying attention in a particular way: on purpose, in the present moment, and nonjudgmentally" (Kabat-Zinn, 1994, p. 4). The Western psychological perspective of mindfulness was pioneered by Langer (1989). Conceiving mindfulness within a cognitive information-processing framework, Langer (2012) pointed out that mindfulness is easy to learn, thus making it appealing to those unwilling to meditate. According to Langer (2012), mindfulness can be increased by paying attention to novelty, trying to be flexible in evaluations and perceptions, and questioning previous points of view that have been taken for granted.

Education is one of the areas to which mindfulness has been commonly applied in recent years. When people engage in mindful learning, they avoid forming mindsets that unnecessarily confine them (Langer, 2000). Langer (2016) proposed that a mindful learning approach possesses three characteristics: "the continuous creation of new categories, openness to new information, and an implicit awareness of more than one perspective" (p. 4). Along the same line, Ben-Ari (2002) proposed that mindful movement is different from incidental movement in that it occurs as a result of active learning. In this study, we define mindfulness as a mindful learning process in which individuals actively and consciously pay attention to the things they are curious about or interested in, and further, try to bring about new meanings or original thinking from these ordinary or special things.

2.2. Mindfulness, creativity, and creative self-efficacy

The concept of self-efficacy was originally proposed by Bandura (1977) who claimed that self-efficacy refers to beliefs in one's abilities to organize and execute the actions essential for producing given outcomes; individuals with self-efficacy act with forethought, self-reactiveness, and self-reflectiveness (Bandura, 2001). As such, self-efficacy is an important predictor for behaviors pertaining to attention and motivational processes in learning (Bandura, 2012). According to Bandura (1997), self-efficacy involves efficacy expectations and outcome expectations, and these two expectations influence how much efforts and what actions an individual will take to achieve the learning outcomes (Bandura, 1997; Woolfolk, 2016). More recently, some researchers have employed the concept of self-efficacy in creativity studies and suggest that creative self-efficacy is critical to creative performance (Tierney & Farmer, 2002; Wang, Liu & Shalley, 2018) and that it involves one's intrinsic motivation to perform creative behaviors (Gong, Huang & Farh, 2009). Integrating the concept of self-efficacy and the learning of creativity, this study defines creative self-efficacy as the belief in one's ability to produce creative ideas or solutions and the confidence in achieving creative performance.

Regarding the relationship between mindfulness and creativity, it can be explained through the cognitive processes of creativity. Creative processes are greatly influenced by working memory and emotion (Augello et al., 2016; Vartanian, 2019; Yeh, Lai, & Lin, 2016; Yeh, Lai, Lin, Lin, & Sun, 2015). Working memory involves in integration, processing, and retrieval of information, as well as the maintenance and manipulation of task-relevant information to guide subsequent behavior (Autin & Croizet, 2012); it may influence creativity via attention to task-related information (Yeh, Tsai, Hsu, & Lin, 2014). Mindfulness involves the self-regulation of attention with curiosity and open-mindedness (Bishop et al., 2004) as well as creativity and self-regulation (Pang & Ruch, 2019); it also contributes to awareness, cognitive flexibility, and emotion regulation, which are critical to creativity performance (Yeh et al., 2019b). Accordingly, mindfulness may influence creativity through enhancing attention, working memory efficiency, and emotional regulation.

On the other hand, few studies have explored the relationship between mindfulness and creativity self-efficacy. However, the positive relationship between mindfulness and creative self-efficacy has been supported by a related review (Caldwell, Harrison, Adams, Quin, & Greeson, 2010) and empirical studies in varied contexts (e.g., Greason & Cashwell, 2009; Zheng & Liu, 2017; Yeh et al., 2019b). For example, Greason and Cashwell (2009) found that mindfulness was a significant predictor of counseling self-efficacy and that attention was a mediator of that relationship. Along the same line, Zheng and Liu (2017) found that abusive supervision on employee self-efficacy can be buffered by employee mindfulness. Mindfulness may bolster coping abilities that help decrease negative thoughts, which undermine self-efficacy (Gärtner, 2013). In addition, creative self-efficacy was found to be influential to creative performance (Wang, Liu & Shalley, 2018). In light of these positive relationships between mindfulness, creativity, and self-efficacy, we assumed that a smartphone-based learning with emphasis on mindfulness would enhance learners' creativity and creativity self-efficacy.

2.3. Mindful learning interventions through smartphones

Mindfulness is a natural human ability as well as a set of skills that can be fostered and developed via a regular meditation practice or specifically customized interventions (Iani, Lauriola, Cafaro, & Didonna, 2017). Many different mindfulness programs or interventions have been shown to be effective in varied areas (Creswell, 2017). For example, it was found that focused attention mindfulness meditation improved executive functioning, attentional control, and emotion regulation of older adults (Polsinelli, Kaszniak, Glisky, & Ashish, 2020). In a training program emphasizing mindfulness, compassion, and social-emotional skill training, teachers' sense of efficacy, interpersonal mindfulness in teaching, and the interpersonal reactivity measures of perspective taking and personal distress were improved (Tarrasch, Berger & Grossman, 2020). Studies of Langerian mindfulness have also shown positive effects on attention (e.g., Levy, Jennings, & Langer, 2001; Zilcha-Mano & Langer, 2016) and cognitive flexibility (e.g., Haller et al., 2017).

To date, most empirical studies on Langerian mindfulness used selected components from Langer's theory, for example, noticing distinctions, multiple perspectives, or producing novelty. These techniques, although unconventional and different from one study to another, were successful in inducing a state of Langerian mindfulness, which has shown positive effects on learning (e.g., Lawrie, Tuckey & Dollard, 2018; Miralles-Armenteros, Chiva-Gómez, Rodríguez-Sánchez & Barghouti, 2019; Ostafin & Kassman, 2012; Stewart & Bower, 2019) and creativity (e.g., Grant, Langer, Falk & Capodilupo, 2004; Langer, 2000; Wang & Liu, 2016). Accordingly, interventions of mindfulness may facilitate attention and cognitive flexibility and then enhance creativity and creative self-efficacy. To maximize the intervention effect, this study adds two components into the smartphone-based intervention: knowledge sharing and self-determination.

Study findings have suggested that knowledge/idea sharing enhanced the improvement of creativity and creative self-efficacy. Kremer et al. (2019) indicated that knowledge sharing is a critical factor that contributes to creativity and innovation. Yeh et al. (2019b) found idea sharing is an important mechanism for improving creativity and creative self-efficacy during game-based learning. Along the same line, Yeh and Lin's (2015) findings suggested that encouraging knowledge sharing through observation learning of peer assignments online contributed to college students' creativity improvement. Other studies also demonstrated that knowledge sharing was positively related to team creativity, which was mediated by absorptive capacity and knowledge integration (Hu, Erdogan, Jiang, Bauer & Liu, 2018; Men, Fong, Luo, Zhong & Huo, 2019; Sung & Choi, 2020; Zhang, Sun, Jiang, & Zhang, 2019). Knowledge sharing may facilitate creativity through self-awareness and self-reflection (Yeh et al., 2012) as well as paying attention to novelty, which are critical to mindful learning and creativity (Langer, 2012, 2016). This study therefore requested the participants to share their tasks on a designated website to enhance knowledge sharing and, further, facilitate mindful learning and creativity.

On the other hand, self-determination involves the concepts of choice, self-control, and self-management (Peterson et al., 2020). Self-determination theory (SDT) suggests that autonomous motivation comprises the intrinsic motivation and the internalized extrinsic motivation (Ryan & Deci, 2017); people have an active tendency toward growth and development, which leads to optimal functioning (Ryan & Deci, 2000). Three basic psychological needs required to reach this optimal functioning are autonomy, competence, and relatedness (Ryan & Deci, 2000; Vansteenkiste & Ryan, 2013). It has been found that self-determination influenced mastery experience of creativity through mindful learning experience (Yeh et al., 2019a); under the freedom of task choice condition, participants were more likely to show social creativity (Gu, Hu, Ngwira, Jing & Zhou, 2016). Based on these empirical findings, this study incorporated the concept of autonomy to enhance mindful learning and creativity. Autonomy refers to the feelings of volition, free choice, and psychological freedom in one's behavior (Long, Wang, Liu & Lei, 2019). In this study, we allowed free choices of tasks to boost autonomy.

2.4. Influences of beliefs toward smartphones on mindful learning interventions

According to aptitude-treatment interactions (ATIs), understanding the interaction between learners' aptitude and treatment helps create a learning environment in which the treatment matches the aptitude of the learner and, further, in which the optimal learning effect can be achieved (Yeh & Lin, 2015). The aptitude of concern in this study was the beliefs toward mobile devices for creativity learning. To measure this aptitude, we developed an inventory for this study called "Beliefs toward Mobile Devices for Creativity Learning" (BMD-CL). Creativity involves a set of dispositions, knowledge, and skills related to creativity (Yeh et al., 2019a). BMD-CL, therefore, refers to the beliefs that mobile devices contribute to the enhancement of creativity skills or strategies, the motivation and knowledge sharing of creative ideas, and the efficiency of creativity learning. When people hold positive beliefs toward using mobile devices to enhance creativity, they may conduct more self-regulated learning, which involves self-initiated reactions and learning motivation, and such processes facilitate task interest, task choice, and persistence (Zimmerman, 2011). Moreover, such positive beliefs may bring about enjoyment and positive emotions, which contribute to creative performance (Boyle, Connolly, & Hainey, 2011; Yeh & Lin, 2015).

2.5. Hypotheses of this study

While most college students frequently take photos with smartphones, few students mindfully learn from the photos they take. To date, no study has integrated smartphones and mindfulness interventions with emphases on self-determination and knowledge sharing to enhance college students' creativity, especially in a way that is relevant to students' daily lives. This study attempted to propose such a new approach to enhance college students' creativity and creative self-efficacy. Meanwhile, college students' beliefs toward using mobile devices to improve creativity was also considered; to achieve this goal, the BMD-CL was developed first. Specifically, this study aimed at examining whether enhancing mindfulness in everyday life through varied smartphone-based interventions (with self-determination and/or knowledge sharing) would have different effects on college students' improvement of creativity and creative self-efficacy, as well as whether BMD-CL would influence such a training effect. The following hypotheses were proposed.

- Hypothesis 1: Smartphone-based mindfulness interventions in everyday life would enhance college students' creativity. Specifically, practicing mindful learning in everyday life by taking photos and writing imaginative narratives would enhance college students' creativity.
- Hypothesis 2: Varied types of smartphone-based mindfulness interventions would have different effects on the improvement of college students' creativity. In other words, college students who took the intervention with emphases on both self-determination and knowledge sharing would outperform those who did not take any intervention or those who took the intervention without opportunities for self-determination or knowledge sharing.
- Hypothesis 3: Smartphone-based mindfulness interventions would have positive effects on college students' improvement in creative self-efficacy, and such effects would be influenced by BMD-CL. Specifically, college students who took any of the mindfulness interventions would have better improvement in creative self-efficacy than those who did not take any intervention. On the other hand, those who were at a higher level of BMD-CL would outperform those who were at a lower level of BMD-CL in creative self-efficacy.

3. Methods

3.1. Participants

All participants, aged from 20 to 30 years old, were recruited through an online ad posted on a campus website. Participants in the inventory development stage were 183 college students (61 males and 122 females; *M*age = 20.97; *SD*age = 1.469); they were rewarded with approximately $3 USD. Participants who joined the one-week experimental instruction were 160 college students; they were randomly and evenly distributed into four groups with gender consideration. However, some participants dropped out during the experimental period. Finally, the valid sample size was 149 (35 males and 114 females; *M*age = 21.21; *SD*age = 1.565): Group 1 (G1) = 40, Group 2 (G2) = 37, Group 3 (G3) = 34, and Group 4 (G4) = 38. The control group (G1), who only took the pretest and the posttest, were rewarded with approximately $7 USD, whereas the experimental groups (G2, G3, and G4), who took the pretest, intervention, and the posttest, were rewarded with approximately $35 USD. This study was approved by the Institutional Review Board of National Chengchi University, Taiwan and written informed consent was obtained from all participants.

3.2. Instruments

3.2.1. Beliefs toward Mobile Devices for Creativity Learning (BMD-CL)

The instrument BMD-CL, with 13 items, was developed to measure college students' beliefs toward mobile devices for creativity learning. BMD-CL is a 6-point Likert-type scale from 1 point to 6 points, representing strongly disagree to strongly agree. The reliability and validity information are shown in the results section.

3.2.2. Inventory of Creativity Self-Efficacy

The Inventory of Self-Efficacy in Creativity Digital Games (Yeh & Lin, 2018) was adapted into the Inventory of Creativity Self-Efficacy (ICSE) in this study to measure the participants' level of creative self-efficacy. The adaptation only removed the situation description "during game playing." The ICSE is a 6-point Likert-type scale from 1 point to 6 points, representing strongly disagree to strongly agree. With a total of 9 items, the ICSE includes two factors: Ability to generate creative ideas (6 items) and Achievement of creative performance (3 items). Exploratory factor analysis revealed that the total variance explained by the two factors was 73.27%. The items include statements such as "I believe that I can come up with many creative ideas" and "I am more creative than most of my classmates." The Cronbach's α coefficients of the ICSE and the two factors were .927, .908, and .844, with factor loadings of .606 to .879, 73.27% of the total variance was explained by the two factors.

3.2.3. Creativity tasks

In this study, we requested the participants in the experimental groups to upload the photos they took to a designated website. For each photo, we requested the participant to write an imaginative narrative. Examples are shown as Figure 1. The imagination score, ranging from 0 points to 5 points, was rated by two trained coauthors based on their consensus. The rubrics for the scoring are as follows: 0: Roughly describes the content of the photo, but no associative thinking; 1: Associates the external features of the photo with some concrete objects/things/uses, but no descriptions of the situation; 2: Associates the concrete objects/things in the photo with self-experiences (e.g., feelings, memories, problems); 3. Associates the abstract concepts in the photo with self-experiences (e.g., feelings, memories, problems); 4: Associates the concrete objects/things or the abstract concepts in the photo with situations beyond one's own experiences; 5: Associates the concrete objects/things or the abstract concepts in the photo with situations beyond one's own experiences with vivid or touching descriptions. The rubrics were decided based on the discussion and consensus of the authors after reading 30 participants' imaginative narratives.

Observation:
I was about to eat this orange today when I noticed that it had a strange line on its side.

Imagination: What do you imagine?
This line is just like the scar from a Caesarean section left on a mother's belly. The skin sacrifices itself with no complaint; it allows the wind to blow it, the sun to scorch it, and the rain to drench it just to protect the fresh pulp inside. The wrinkles and freckles on the outside and the soft and juicy pulp inside have a strong contrast.

Figure 1. An example of uploaded photos and imaginative narratives

3.2.4. Reflection questionnaire

To understand the participants' beliefs toward the interventions of knowledge sharing and self-determination at the end of the experiment, we requested the related groups (G3 and G4) to complete a 6-point Likert-type

reflection questionnaire, which included 7 items with response options from 1 point to 6 points, representing strongly disagree to strongly agree. The items are displayed in the results section.

3.3. Procedures and interventions for the experiment

Data were collected through a website designed by the researchers. For the inventory development, participants completed BMD-CL online. For the experimental instruction, our central idea was that, for the smartphone-based mindfulness intervention, which emphasized mindfulness, self-determination, and knowledge sharing online would enhance mindfulness and imagination toward surrounding things in everyday life, which would further foster creativity and creative self-efficacy. Meanwhile, BMD-CL would interact with the interventions and influence the learning process (see Figure 2 for the framework). Self-determination involves the concepts of choice, self-control, and self-management (Peterson et al., 2020). In this study, we employed the concept of self-determination by allowing participants to freely take photos

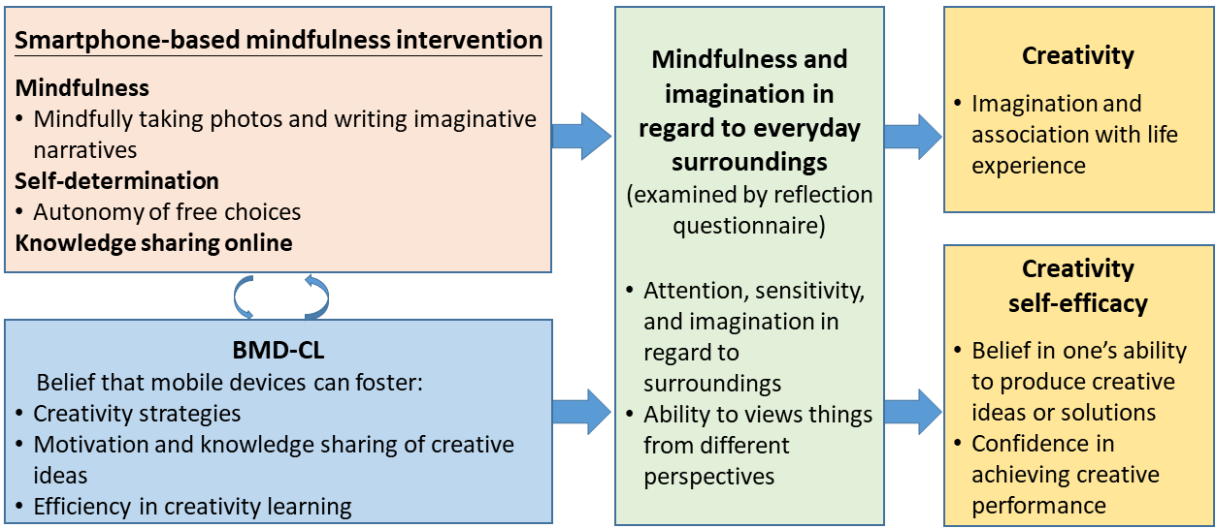

Figure 2. The framework of the experimental instruction

To further understand the influence of the intervention components, this study employed a pretest-posttest control group design that included four groups. During the one-week experimental period, the control group, Group 1, did not receive any intervention, whereas the experimental groups, Groups 2, 3, and 4, were requested to use their smartphones to take photos with different emphases for four days and to share the photos with imaginative narratives on a designated website. Group 2 had emphases on complete free choices of photo taking only, Group 3 had emphases on complete free choices of photo taking and idea sharing, and Group 4 had emphases on free choices of photo taking in varied categories and idea sharing. The restriction of categories was based on the importance of multiple-perspective thinking of mindfulness and creativity (Langer, 2016)

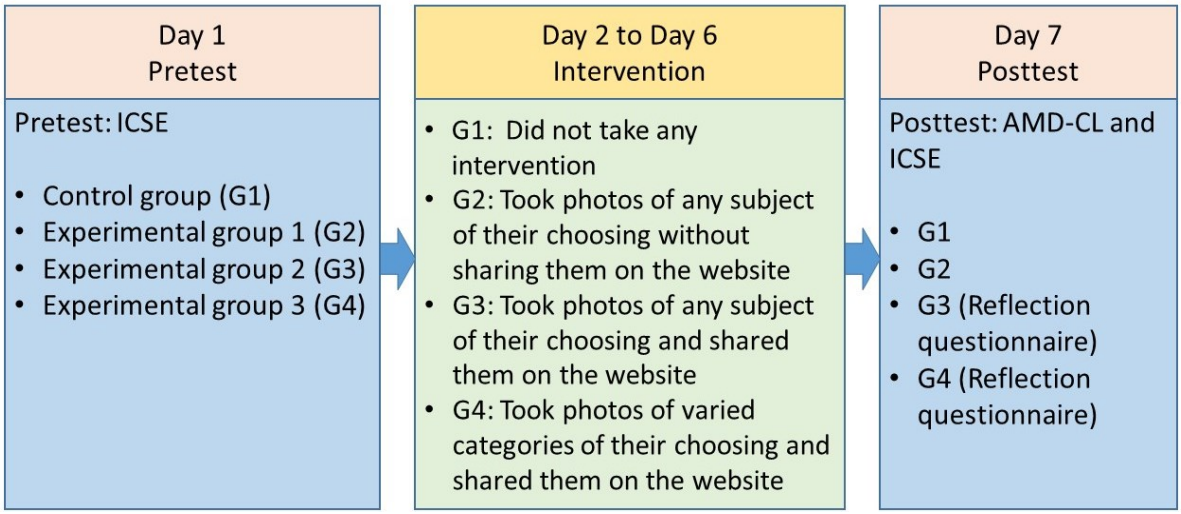

Figure 3. Procedures and interventions for the experiment

On day 1, all participants completed the pretest. From day 2 to day 6, the participants in the experimental groups took the assigned interventions; they were requested to take two photos each day, with four days in total during the 5-day period. These instructions were given under the consideration that the participants might not be able to take photos for five consecutive days. On day 7, all participants completed the posttest (see Figure 3 for detailed interventions).

4. Results

4.1. The development of BMD-CL

4.1.1. Exploratory factor analysis and reliability analysis

In this study, we used AMOS windows 21.0 to run the confirmatory factor analysis and employed SPSS windows 21.0 to run all the other analyses. Exploratory factor analysis, internal-consistency reliability, and confirmatory factor analysis were employed to examine the reliability and validity of BMD-CL. Finally, 13 items were kept in BMD-CL. Principal Component Analysis and direct oblimin were employed in factor extraction and rotation when conducting exploratory factor analysis. The results yielded three factors: strategy enhancement (5 items), motivation and knowledge sharing (4 items), and efficiency (4 items). With factor loadings ranging from .480 to .902, 69.55% of the total variance was explained by the three factors (see Table 1). The correlations between each of the factors and the total score were .919, .783, and .865 (ps < .001), respectively. The Cronbach's α of BMD-CL and the three factors were .917, .861 (strategy enhancement), .846 (Motivation and Knowledge sharing), and .870 (efficiency). Moreover, the item-total correlation coefficients ranged from .528 to .802.

4.1.2. Confirmatory factor analysis

The three-factor structure with 13 items extracted from the exploratory factor analysis was validated by confirmatory factor analysis with maximum likelihood estimation. Confirmatory factor analysis results indicated that BMD-CL has good construct validity and reliability: $\chi^2(N=183, df=58) = 103.395$ ($p < .05$); goodness-of-fit index = .921; root mean square residual = .046; root mean square error of approximation = .066; incremental fit index = .967; comparative fit index = .967. Moreover, the composite reliability values were .861, .851, .852, and the average variance extracted values were .557, .591, and .589 (see Table 1).

Table 1. The factor loadings of BMD-CL ($N = 183$)

No	Factors and items	Factor loading		
		1	2	3
Factor 1: Strategy enhancement (α = .861)				
9	Mobile devices help enhance my multi-perspective thinking.	.817		
8	Mobile devices help enhance my creative skills, such as brainstorming, storytelling, etc.	.805		
10	Mobile devices help me produce unique ideas.	.745		
13	Mobile devices help enhance my abilities of observation and sensitivity.	.735		
12	Mobile devices help me elaborate my ideas.	.573		
Factor 2: Motivation and knowledge sharing (α = .846)				
6	Mobile devices are great tools for knowledge co-creation.		.862	
3	Mobile devices help me express and share creative ideas quickly.		.861	
5	Mobile devices are great tools for collecting creative ideas.		.804	
7	Mobile devices provide many learning opportunities.		.569	
Factor 3: Efficiency (Cronbach's α = .870)				
2	Using mobile devices is an efficient way to learn creativity.			.902
1	Using mobile devices can effectively improve my creativity.			.843
4	It is easy to bring about creative ideas through mobile devices.			.677
11	Mobile devices help me produce many creative ideas quickly.			.480

4.2. Attitude toward the interventions

To understand the participants' smartphone use in everyday life, we asked them a few questions. The participants reflected that, while using smartphones during the study, they spent 1.18 hours on curriculum-related learning, 2.27 hours on personal interests unrelated to curriculum learning, 2.75 hours on social media, 2.14 hours listening to music or watching movies, and 1.06 hours playing games. These results revealed that smartphones have become an essential tool for college students' learning and social life.

This study assumed that Group 3 and Group 4 would have better learning effects for the implementation of knowledge sharing and self-determination. We designed a 6-point Likert-type reflection questionnaire to understand the participants' feelings toward the interventions. The results revealed that the participants had a positive attitude toward the interventions (see Table 2); they became more attentive, sensitive, and imaginative about things around them, suggesting an effective mindfulness intervention.

Table 2. Mean and standard deviation of the reflective questions

Question	Group 3		Group 4	
	M	*SD*	*M*	*SD*
1. This smartphone activity has made me more attentive to my surroundings.	4.82	.846	4.86	.887
2. This smartphone activity, although not lasting a long time, has enhanced my sensitivity toward my surroundings.	4.64	.859	4.59	.832
3. This smartphone activity has enhanced my ability to views things from different perspectives.	4.76	.792	4.78	.886
4. This smartphone activity has enhanced my ability to view my surroundings imaginatively.	4.70	.770	4.57	1.015
5. This smartphone activity has enhanced my everyday creativity.	4.42	.902	4.30	1.077
6. During this smartphone activity, I frequently reviewed others' uploaded assignments.	4.12	.960	4.30	.878
7. I have carefully read others' uploaded assignments.	3.79	1.023	3.95	1.104

4.3. Group differences on enhancement of creativity

To understand the learning progress of the three experimental groups, we scored each participant's creativity based on the imaginative narratives they had uploaded. Each participant had uploaded 8 photos with imaginative narratives. A Repeated Measures Analysis of Variance, with Group (G1, G2, G3, and G4) as the between variable and Day (Day 1 [D1] vs. Day 2 [D2] vs. Day 3 [D3] vs. Day 4 [D4] creativity score) as the within variable, was employed to examine group differences in creativity improvement. The results revealed a significant main effect of Day, $F(3, 103) = 26.306$, $p < .001$, $\eta^2_p = .202$; participants' creative performance on D3 and D4 was better than that on D1 and D2, and the performance on D2 was better than that on D1. In addition, there was a significant Day × Group interaction on creativity, $F(3, 103) = 5.425$, $p < .001$, $\eta^2_p = .094$. Results of simple main effect were as follows: No group differences were found on D1; on D2, G4 outperformed G2 and G3; on D3 and D4, G3 outperformed the other groups. Within each group, G2 and G3 performed better on D3 and D4 than on D1 and D2, and G4 performed better on D2–4 than on D1 (Table 3 and Figure 4).

Table 3. Group differences on enhancement of creativity

Source	ANOVA				Post hoc test
	MS	*F* (3, 103)	*p*	η^2_p	
Day	11.807	26.306***	.000	.202	D3 & D4 >D1 & D2; D2 > D1
Day x Group	2.435	5.425***	.000	.094	D2: G4 > G2, G4 > G3 D3: G3 > G4; D4: G3 > G4 G2: D3 & D4 > D1 & D2 G3: D3 & D4 > D1 & D2 G4: D2, D3 & D4 > D1
Group	2.237	2.244	.111	.041	*ns.*

Note. D1 = Day 1; D2 = Day 2; D3 = Day 3; D4 = Day 4. G1 = Group 1; G2 = Group 2; G3 = Group 3; G4 = Group 4. ***$p < .001$.

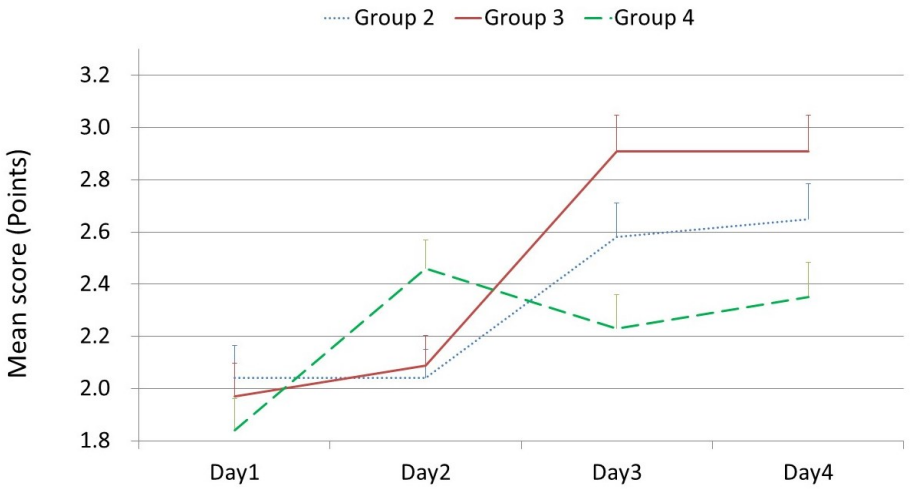

Figure 4. Mean and standard deviation of the creativity score for the three experimental groups

4.4. Effects of BMD-CL and intervention groups on creative self-efficacy

With Group A (intervention groups: G1, G2, G3, and G4) and Group B (Low and High BMD-CL) as the between variable, the pretest score of creative self-efficacy as the covariance, and the posttest score of creative self-efficacy as the dependent variable, we conducted a two-way Analysis of Covariance to examine whether beliefs toward mobile devices would influence the improvement in creative self-efficacy. The cut-points of the BMD-CL groups were the median. The results revealed a significant Group A main effect, $F(3, 129) = 2.671$, $p = .050$, $\eta^2_p = .058$, as well as a significant Group B main effect, $F(3, 129) = 6.108$, $p = .015$, $\eta^2_p = .045$. However, the Group A × Group B interaction effect was not significant. Post hoc test revealed that the experimental groups (G2, G3, and G4) had better improvement in creative self-efficacy than the control group (G1). Moreover, those who had a higher level of BMD-CL improved more in creative self-efficacy than their counterparts (Table 4 and Figure 5).

Table 4. Effects of Intervention x BMD-CL intervention on enhancement of creative self-efficacy

Source	Analysis of Covariance				Post hoc test
	MS	*F*(3, 129)	*p*	η^2_p	
Corrected Model	10.284	33.946***	.000	.678	
Intercept	4.360	14.393***	.000	.100	
Pretest of ICSE	66.145	218.339***	.000	.629	
Group A	.809	2.671*	.050	.058	G2, G3, G4 > G1
Group B	1.850	6.108*	.015	.045	High > Low
Group A × Group B	.144	.476	.700	.011	

Note. Group A: Intervention group; Group B: BMD-CL group. $^{*}p < .05$; $^{***}p < .001$.

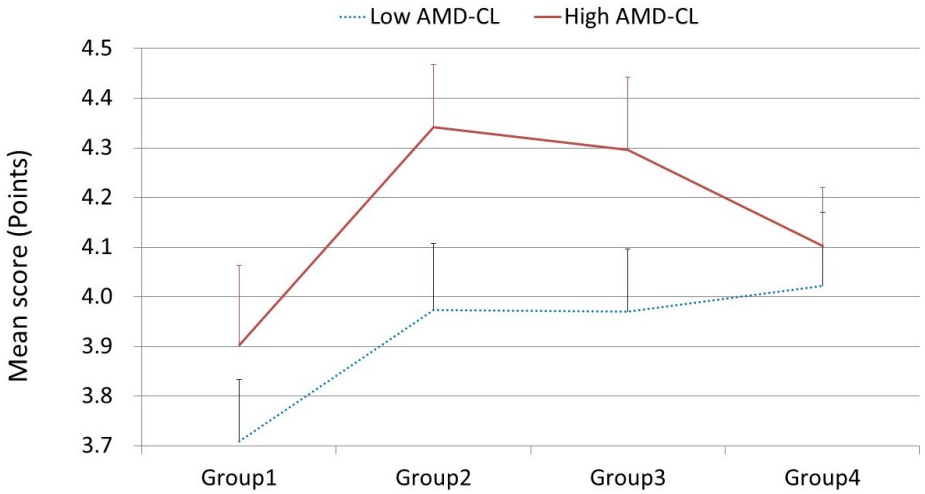

Figure 5. Mean and standard deviation of the ICSE score for BMD-CL groups in the intervention groups

5. Discussion

This study aimed at examining whether enhancing mindful learning in everyday life through varied smartphone-based interventions would improve creativity as well as whether the beliefs toward mobile-based learning would influence such a training effect. To achieve these goals, we first developed BMD-CL; then, we employed a pretest-posttest control group design to conduct an experimental instruction. The results suggest that BMD-CL has good reliability and validity. The Cronbach's α coefficient was .917, and the confirmatory factor analysis showed that the three-factor structure was a good-fit model (Goodness-fit-index = .921).

Regarding intervention effects, we employed four groups (one control group and three experimental groups with varied interventions) to test the three hypotheses we proposed. The results support H1 and suggest that practicing mindful learning in everyday life by taking photos and writing imaginative narratives can enhance college students' creativity. Specifically, we found that, overall, the participants in the experimental groups had improved their creativity during the experimental period as evidenced by the fact that their performance on D3 and D4 was better than that on D1 and D2. Moreover, they became more attentive, sensitive, and imaginative about things around them after the interventions, which was revealed through the reflection questionnaire. These results support that Langerian mindfulness has positive effects on learning (Miralles-Armenteros et al., 2019; Yeh et al., 2019a), attention (Zilcha-Mano & Langer, 2016), cognitive flexibility (Haller et al., 2017), and creativity (Grant et al., 2004; Yeh et al., 2019b). When people are in this state of mindfulness, they are actively engaged in the present, conscious of new things, and sensitive to context; moreover, mindfulness leads to benefits such as an increase in competence as well as a boost in memory, creativity, and positive affect (Langer, 2000). These cognitive mechanisms are crucial to creative performance.

To explore the optimal learning effect, this study integrated smartphone-based learning and mindful learning interventions with varied design by incorporating self-determination and/or knowledge. In addition, this study incorporated the concept of dynamic assessment by measuring the participants' performance for four days. The significant Day × Group interactions on creativity revealed that G4, which was requested to freely take photos in different categories and share photos online, outperformed the other experimental groups at the beginning, but as the interventions proceeded, G2 (emphasizing self-determination only) and G3 (emphasizing knowledge sharing and completely free choices) progressed steadily, and G3 made the best progress. These results partially support H2 and suggest that, although the autonomy of self-determination (free choices in this study) and knowledge sharing are critical to the enhancement of creativity, self-determination seems to carry more impact on such improvement than knowledge sharing. Notably, we designed G4 based on Langer's (2016) claim that mindfulness is characterized by the continuous creation of new categories, and we assumed such design would encourage multi-perspective thinking and, therefore, enhance creativity. The findings, however, suggest such design may enhance creativity for a short period of time, but in the long run, it may constrain creativity development. In addition, the fact that G2 had a better performance than G4 at the end may reflect that self-determination can better predict the improvement of creativity than knowledge sharing can. Nevertheless, the improvement of G3 suggests that when both self-determination and knowledge sharing are incorporated in smartphone-based intervention, participants have the best improvement in creativity. When integrated, the findings of this study support that self-determination helps individuals to become autonomous in their regulation and to engage in activities in a harmonious way (Deci & Ryan, 2004; Tóth-Király, Bőthe, Márki, Rigó & Orosz, 2019) and that the ideal creative process is unstructured, open-ended, and free of external limitations (Rosso, 2014). In addition, the findings of this study support that sharing ideas through observation, practice, and participation in communities contributes to professional development in creativity (Yeh, Huang, & Yeh, 2011).

Finally, the results revealed that the experimental groups (G2, G3, and G4) had better improvement in creative self-efficacy than the control group. Moreover, those who had a higher level of BMD-CL improved more in creative self-efficacy than their counterparts across groups. These findings suggest that smartphone-oriented mindfulness practiced in everyday life may improve creative self-efficacy. The findings also suggest that when people have positive feelings toward using mobile devices to improve creativity, they may be more motivated to take full advantage of mobile devices and to continue to practice enhancing their creativity. As a result of such learning, they may become mindful and enjoy the learning process, which further leads to enhancement of creativity (Boyle et al., 2011; Yeh et al., 2019a). There has been an influx of research identifying personal factors that foster creativity (Wang et al., 2018). This study, however, is the first to confirm the positive relationship between BMD-CL and creativity in smartphone-based mindfulness interventions.

6. Conclusion

Smartphones have become the most popular device for learning as well as for capturing moments in life among college students. This study pioneers the development of BMD-CL as well as the integration of smartphone use, mindfulness, knowledge sharing, self-determination, and everyday creativity to design varied types of interventions to enhance college students' ability and self-efficacy of creativity. Meanwhile, college students' beliefs toward using mobile devices to improve creativity were also considered.

The major contributions of this study are as follows. First, this study develops the "Beliefs toward Mobile Devices for Creativity Learning (BMD-CL)," a reliable and valid instrument for use in further instruction and research. Second, a creativity learning and instructional approach with ecological validity—smartphone-based mindfulness learning in everyday life—is proposed and confirmed. The findings of this study suggest that, even if only practiced for a short time, mindful learning using a smartphone lens in everyday life can effectively enhance attention, sensitivity, and imagination in regard to one's surroundings, which further leads to improvement of the ability of creativity. Moreover, practicing mindfulness in everyday life by taking photos and writing imaginative narratives, especially when both self-determination and knowledge sharing are emphasized, can enhance college students' creativity. Finally, the findings suggest that beliefs toward using mobile devices to enhance creative self-efficacy play an important role, which reminds researchers of the importance of a positive belief toward mobile devices' potential for creativity learning.

Notably, since this study was conducted in an everyday life situation, it has better ecological validity than those conducted in laboratories. This study contributes to providing a very convenient and feasible approach for enhancing personal creativity through smartphones and computers, which provides insights for the instructional design of creativity learning.

7. Limitations, Implications, and further studies

The results showed that the participants spent about 3.45 hours learning and 2.75 hours on social media using their smartphones per day, suggesting that smartphones have become an essential tool for college students' learning and social life. Implementing mindfulness interventions through mobile devices to enhance creativity is a promising approach for mindfulness, and creativity is highly valued for school education and life-long learning. This study included four groups to compare the effectiveness of varied interventions. Because of the difficulty of finding enough volunteers to engage in the experiment for a longer period of time, our interventions only lasted a week. Further studies may include our intervention design as part of the course requirement and implement it for a longer period of time to examine its effects and to maximize the intervention effect.

Most of the recent studies involving self-determination and smartphones have focused on the problems brought about by the lack of control in self-determination (e.g., Gugliandolo, Costa, Kuss, Cuzzocrea, & Verrastro, 2019; Long et al., 2019). Few studies, however, focus on how to boost creativity while taking advantage of self-determination and smartphones. This study pioneers the implementation of such intervention research in everyday life. Future studies can continue to explore different intervention effects. Such studies should provide valuable information for educators who attempt to improve students' creativity through mobile devices.

Finally, this study found that beliefs toward using mobile devices are influential to the enhancement of creativity self-efficacy in our experiment. Future studies can include a bigger sample to confirm such a relationship through investigation studies, or to include other personal traits to examine their influences on interventions using smartphones. Future research can also try to replicate the experimental design using other mobile devices.

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