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## **When smartphones meet mindful learning: the cluster profiles of passion toward smartphone use, creativity mindsets, and creativity self-efficacy**

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**Abstract:** Based on the advantages of smartphones and the importance of mindful learning, we developed a smartphone-based mindfulness intervention for creativity learning that can be easily implemented in daily life, by which we examined the relationship between personality traits and self-efficacy of creativity. The concerned personal traits included four types of passion towards smartphones and four types of creativity mindsets. Eighty-four college students participated in a ten-day intervention that requested participants to take photos of their surroundings using smartphones with an emphasis on self-determination and knowledge sharing. The results of cluster analysis revealed three distinctive patterns of clusters about creativity self-efficacy, mindsets, and passion, suggesting that creativity self-efficacy can be predicted by creativity growth mindsets and harmonious passion toward smartphones. The profiles of specific traits we identified in this study shed light on how different types of mindsets and passion toward smartphones may influence self-efficacy.

**Keywords:** mindful learning; passion; mindset; self-efficacy; smartphones.

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## 1 Introduction

The rapid growth of adopting mobile technology (e.g., smartphones) as a medium in education has shifted the educational mindset. One recent report conducted by the United Nations, Educational, Scientific, and Cultural Organization (2018) indicated that, on several occasions and in several contexts, people prefer using network-enabled devices over fixed computers when retrieving information on the Internet to solve problems. Similarly, several empirical studies also indicated that the majority of college students owned a mobile device and welcomed this new trend of smartphones as a learning tool (e.g., Atwood-Blaine et al., 2019; Smith et al., 2016).

Mobile technology, such as smartphones or tablets, has been used in several classroom settings to enrich the interactive teaching context, support collaboration and engagement, and enable efficient and meaningful learning (e.g., Barrett et al., 2021; Kaceti and Klímová, 2019; Ramírez-Donoso et al., 2021). Additionally, mindful pedagogies have been employed in education for the known benefits of improved attention, cognitive flexibility, working memory and problem-solving (Zilcha-Mano and Langer, 2016; Haller et al., 2017). Mindful learning emphasises the implicit awareness of multiple perspectives, openness to new information and emotional regulation (Langer, 2016; Yeh et al., 2019). To date, very few studies have integrated mindful learning with mobile technology to conduct interventions in creativity learning. Our previous study (Yeh et al., 2020) demonstrated that even a small amount of mindful learning in everyday life using a smartphone can enhance self-efficacy of creativity in a ten-day intervention. Based on this result, we went on to explore the cluster profiles of creativity self-efficacy and two categories of personal traits (creativity mindsets and passion toward smartphones) that could be influential to creativity self-efficacy through a smartphone-based mindfulness intervention.

Past studies have suggested the existence of varied types of passion and creativity mindsets, and different types of passion and creativity mindsets carry different effects on self-efficacy (e.g., Dweck, 2016; Fleck and Asmuth, 2020; Najafi et al., 2019; Puente-Diaz and Cavazos-Arroyo, 2019; Sun, 2020). This study, therefore, aimed to identify distinctive patterns of clusters about creativity self-efficacy, creativity mindsets, and passion toward smartphones based on a smartphone-based mindfulness intervention. Hopefully, the findings would provide insights for related instruction.

## **2 When smartphones meet mindful learning in creativity learning**

### *2.1 Smartphones and mindful learning*

Mobile technology has been used in varied classroom settings. For example, some educators developed smartphone games to foster science learning as well as to support peer communication (Atwood-Blaine et al., 2019); some teachers adopted the use of smartphones to facilitate collaborative learning and higher-order thinking skills (Smith et al., 2016); some educators used smartphone apps to support authentic foreign language learning (e.g., Barrett et al., 2021; Kacetl and Klímová, 2019); and some researchers used a mobile collaboration tool to foster the use of online learning resources (Ramírez-Donoso et al., 2021). In the same vein, Hegarty and Thompson (2019) found that when smartphones were used, students showed great passion for the learning process, especially under proper guidelines. Additionally, it was found that students were mostly self-sufficient when exploring ideas using smartphones in the online environment (Gaviola, 2021). These findings suggest that students are more engaged and perform better while utilising mobile devices or smartphones in learning.

In addition, mindful learning, which derives from mindfulness, has caught the attention of researchers in education and instructional technology areas (Yeh et al., 2019, 2020). Traditionally, mindfulness refers to “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). Based on this viewpoint, Langer (1989, 2016) proposed a definition of mindfulness from a psychological perspective. She declared that mindfulness is a flexible state of mind in which people are actively engaged in the present, are sensitive to context, and notice new things. This study adopts the psychological viewpoint of mindfulness and defines mindful learning as a mindful learning process in which an individual actively and consciously pays attention to the things they are curious about, and furthermore, tries to bring about new meanings or original thoughts from these ordinary or special things. Mindful pedagogies or mindful learning are not only able to improve attention and cognitive flexibility (Zilcha-Mano and Langer, 2016; Haller et al., 2017), but are also able to positively influence self-reported pro-environmental behavioural intentions. In other words, mindful learning helps minimise the negative impact and intensify the positive impact of one’s activities on the natural environment (Tang et al., 2017).

Despite the advantages of both mindful learning and the employment of smartphones as a learning tool, few studies have tried to integrate them into creativity training to enhance the self-efficacy of creativity. In a pioneer study of such training, Yeh et al. (2020) examined varied interventions in integrating mindful learning and smartphones to enhance self-efficacy of creativity; they found the intervention that emphasises self-determination and knowledge sharing had the best effect. However, they did not identify predictive personal traits for such learning. As personal traits may interact with interventions and influence learning effects, we took this research a step further to explore influential personal traits and to identify what combinations of personal traits may bring about better learning effects through such training.

## 2.2 *Passion, creativity mindsets, and creativity self-efficacy*

Individuals show an affinity for their preferred activities in both autonomous and controlled ways, which determine the form of their passion through behavioural regulation (Kovacsik et al., 2020). Passion typically includes two types of passion, namely, harmonious passion and obsessive passion. Harmonious passion is a result of autonomous internalisation that generates an intense but controlled drive to engage in an activity; such an activity is in accordance with aspects of the integrated self (Mageau et al., 2009) and positively associated with intrinsic motivation (Amemiya and Sakairi, 2019). In contrast, obsessive passion emerges when one internalises an activity in a rigid or controlled way when participation is obligatory, which may lead to an internalisation of pressure, and which is strongly related to negative emotions (Stenseng et al., 2011; Vallerand and Miquelon, 2007). Schellenberg et al. (2016) suggest that people with a predominant obsessive passion are more likely to avoid treating themselves with kindness and compassion when faced with failure, which may lead to maladaptive outcomes. In the same vein, Bélanger et al. (2013) found that obsessive passion (but not harmonious passion) predicted the suppression of alternative goals and the progressive inhibition of unfamiliar goals.

More recently, Yeh and Chu (2018) have proposed a two-dimensional model of passion in e-learning that includes the dimensions of the locus of control (internal versus external) and internalisation drives, forming four types of passion:

- 1 harmonious-intrapersonal passion refers to the harmonious and controllable passion that is derived from self-determined enjoyment and satisfaction while undertaking individual learning
- 2 harmonious-interpersonal passion refers to the harmonious and controllable passion that is derived from self-determined enjoyment and satisfaction while interacting with others
- 3 obsessive-intrapersonal passion refers to the excessive and uncontrollable passion that is derived from internally compelled forces
- 4 obsessive-interpersonal passion refers to the excessive and uncontrollable passion that is derived from externally compelled forces while interacting with others.

Adopting Yeh and Chu's (2018) constructs of passion in e-learning, we developed the inventory of passion towards smartphones (IPS), using smartphone experiences as the context.

Another personal trait that we are interested in is the creativity mindset. Creativity mindsets involve how people perceive their creative ability. People with a growth creativity mindset believe that their creative ability can be developed through training or practice and therefore are willing to take challenges and put effort into improving self-creativity (Fleck and Asmuth, 2020; Puente-Diaz and Cavazos-Arroyo, 2019). In contrast, people who hold a fixed creativity mindset regard creativity to be innate and unchangeable (Fleck and Asmuth, 2020; Hass et al., 2016). A growth mindset toward creativity learning is therefore critical to the development of creativity (Fleck and Asmuth, 2020; Puente-Diaz and Cavazos-Arroyo, 2019; Li et al., 2020b). Recently, Yeh et al. (2023) developed a two-dimensional theory of creativity mindsets which includes four types of creativity mindsets: growth-internal (GI) control, fixed-internal

(FI) control, growth-external (GE) control and fixed-external (FE) control. GI control mindset refers to the belief that creativity can be improved through self-learning, whereas the GE control mindset refers to the belief that creativity can be improved by being in good learning environments or through others' help. In contrast, the FI control mindset regards creativity as an inborn ability that cannot be improved through self-learning. FE control mindset regards creativity as an inborn ability that cannot be improved even by being in good learning environments or through others' help.

Finally, this study is concerned with the learning outcome of creativity self-efficacy. Self-efficacy refers to the belief in one's ability to execute the essential actions for producing given outcomes (Bandura, 2001). Creativity self-efficacy is usually cultivated by overcoming related challenges (Nghia and Tai, 2019). More recently, some researchers have employed such a concept in the context of creativity learning, and they found that creativity efficacy is critical to creative performance (Huang et al., 2020; Park et al., 2020; Tierney and Farmer, 2002; Wang et al., 2018). Among the antecedents of creativity self-efficacy, we are particularly interested in creativity mindsets and passion for smartphone use. To date, no study has adopted the aforementioned four types of creativity mindsets and passion to examine their relationship with creativity self-efficacy. Most related studies have used two-type constructs, that is, growth mindset versus fixed mindset and harmonious passion versus obsessive passion. In related studies, Najafi et al. (2019) found that passion in math, positive emotions, future perspective and identification were related to self-efficacy; such passion is, in essence, harmonious passion. Sun (2020) also found that entrepreneurial passion and self-efficacy were closely related. Additionally, Dweck (2016) suggested that a growth mindset can be nurtured through passion, effort, application and experience. Empirical findings also support the notion that creativity growth mindsets influence creative self-efficacy (e.g., Hass et al., 2016; Pretz and Nelson, 2017; Puente-Diaz and Cavazos-Arroyo, 2019). Based on the aforementioned definition of the four types of creativity mindsets and passion, as well as these related findings, it is reasonable to assume that the two types of creativity growth mindsets and the two types of harmonious passion would be positively related to creativity self-efficacy, whereas the two types of fixed mindsets and the two types of obsessive passion would be negatively related to creativity self-efficacy.

### *2.3 Smartphone-based mindfulness intervention on creativity learning*

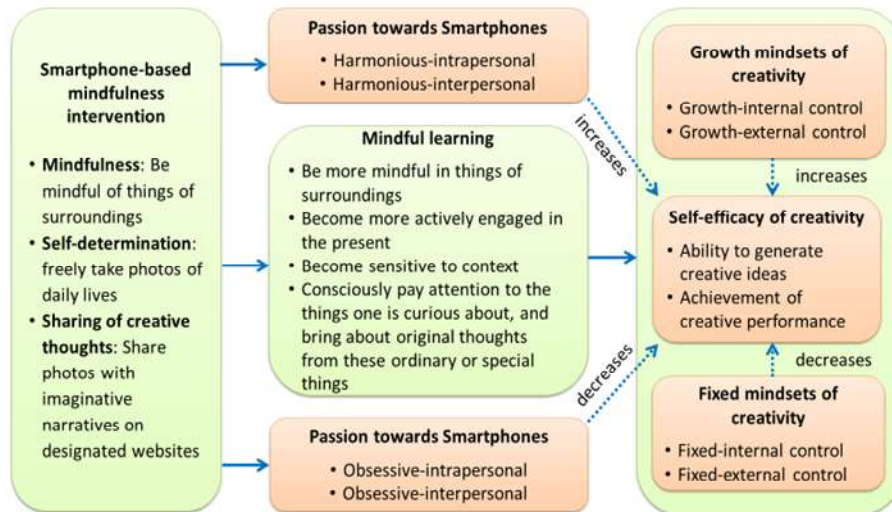
No creativity research has yet examined the relationship between different types of creativity mindsets, passion for smartphone use, and self-efficacy of creativity in a smartphone-based mindfulness intervention. Self-determination and knowledge sharing can be critical to a smartphone-based intervention (Yeh et al., 2020). Study findings have suggested that knowledge/idea-sharing enhanced the improvement of creativity and creativity self-efficacy (Kremer et al., 2019) and that self-determination, which involves self-control (Peterson et al., 2020), has an active tendency toward growth and development (Ryan and Deci, 2000). The concepts of self-determination and knowledge sharing are therefore employed in the intervention of this study.

As for the relationship between mindful learning, passion, mindsets, and self-efficacy, related studies revealed that mindfulness meditation practices or mindfulness-based relaxation courses can reduce stress and depression and increase resilience and

self-efficacy (Charoensukmongkol, 2014; Zeljka and Nicholas, 2019). In addition, a related study indicated that while harmonious passion was positively associated with intrinsic motivation, obsessive passion was negatively associated with intrinsic motivation through mindfulness (Amemiya and Sakairi, 2019). Similarly, it was found that mindfulness was associated with grit, which refers to perseverance and passion. Regarding the relationship between mindfulness and mindset, empirical studies are still very limited. Saraff et al. (2020) demonstrated the positive impact of a mindfulness-based intervention in developing a positive self-concept, self-esteem, and growth mindset in college students. These results show a positive influence of mindfulness interventions on passion, mindset and self-efficacy.

Additionally, mobile technology tools may be well suited to the learning of growth mindset and passion (Hegarty and Thompson, 2019), although related studies are still very limited. Related findings revealed that using the internet to design online growth mindset interventions facilitated students' performance and passion in the learning process (Eskreis-Winkler et al., 2016). Additionally, it was found that students showed great passion for using mobile technology in learning and showed moderate self-efficacy in learning with mobile devices (Mahat et al., 2012). Correlational studies (Li et al., 2020a) also showed that smartphone addiction is positively related to academic procrastination but negatively related to academic self-efficacy. These studies, however, did not distinguish the effects of different types of passion and mindsets. Combining these findings with the aforementioned findings regarding the influence of mindfulness interventions in non-mobile contexts, we postulate that the integration of smartphones and mindfulness interventions would bring about a significant influence on college students' learning of creativity self-efficacy; moreover, creativity growth mindset and passion in smartphone use would play important roles during such a learning process.

**Figure 1** The framework of this study (see online version for colours)



## 2.4 The present study

Based on the importance of mindful learning and the advantages of smartphones, we designed a smartphone-based mindfulness intervention to examine the relationship between different types of creativity mindsets, passion for smartphone use, and self-efficacy of creativity after the intervention. To achieve our goal, we first explore the intervention effects on changes in passion in smartphone use, mindsets of creativity, and self-efficacy of creativity (see the green parts in Figure 1). Since no control group was employed, we did not propose hypotheses regarding such changes. The only hypothesis we proposed was as follows: After the intervention, there would be distinctive profiles concerning varied types of growth mindsets, passion for smartphone use and creativity self-efficacy. In general, participants with a high level of growth mindset and harmonious passion as well as a low level of a fixed mindset and obsessive passion would have the highest level of creativity self-efficacy (see the orange parts in Figure 1).

## 3 Method

### 3.1 Participants

All participants, aged 20 to 29 years old, were recruited through an online advertisement posted on a campus website. Participants were 84 college students (17 males and 67 females,  $M_{\text{age}} = 21.21$ ,  $SD_{\text{age}} = 1.56$ ); they were rewarded with approximately \$35. This study was approved by the Institutional Review Board of the university where the research was conducted. Online written informed consent was obtained from all participants before the experiment.

### 3.2 Instruments

All three inventories employed in this study were six-point Likert-type scales, which were scored as one point to six points, representing 'strongly disagree' to 'strongly agree'. The IPS was developed by the authors using the responses of 183 college students ( $M_{\text{age}} = 20.97$ ,  $SD_{\text{age}} = 1.469$ ). The IPS was employed to measure the participants' passion for using mobile phones. With a total of 15 items, the IPS includes four types of passion: harmonious-intrapersonal (H-intra), harmonious-interpersonal (H-inter), obsessive-intrapersonal (O-intra) and obsessive-interpersonal (O-inter). The Cronbach's  $\alpha$  coefficients for the overall harmonious passion and the overall obsessive passion were .930 and .859, respectively; those of the four factors were .910, .876, .903 and .701, respectively. Confirmatory factor analysis (CFA) results indicated that IPSP has good construct validity and reliability: the goodness-of-fit index (GFI) = .922, the root mean square residual (RMR) = .072, the root mean square error of approximation (RMSEA) = .054, the normed fit index (NFI) = .905, the incremental fit index (IFI) = .965, and the comparative fit index (CFI) = .964. Moreover, values of the composite reliability ( $\rho_c$ ) of H-intra, O-intra, O-inter, and H-inter were .846, .844, .627 and .810, respectively. The average variance extracted ( $\rho_v$ ) values of the four factors were .581, .580, .380 and .517, respectively. See Appendix A for test items.

The creativity mindset inventory (CMI) (Yeh et al., 2022, 2023) was employed to measure the participants' belief in the nature of creativity. Originally developed for elementary school students, the CMI was validated by the authors using the responses of 137 college students ( $M_{\text{age}} = 21.19$ ,  $SD_{\text{age}} = 1.593$ ). The CMI included 12 test items with three items in each of the following dimensions: GI control, GE control, FI control and FE control. The Cronbach's  $\alpha$  coefficients for the overall growth creativity mindset, GI, and GE were .747, .783 and .638, respectively. The Cronbach's  $\alpha$  coefficients for the overall fixed creativity mindset, FI, and FE were .918, .831 and .829. CFA results indicated that the model had decent construct validity and reliability: the GFI, the RMR = .055, the RMSEA = .094, the NFI = .907, the IFI = .947 and the CFI = .946. The  $\rho_c$  for GI, GE, FI, and FE were .773, .655, .834 and .827, respectively. The  $\rho_v$  values of the four factors were .534, .397, .630 and .619, respectively. These results suggested that CMI has good reliability and validity. See Appendix B for test items.

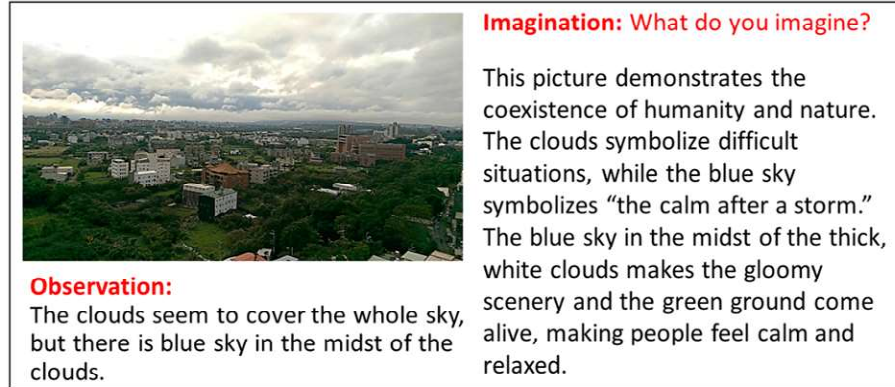
The inventory of creativity self-efficacy (ICSE) (Yeh and Lin, 2018; Yeh et al., 2020) was employed to measure the participants' level of creativity self-efficacy. With a total of nine items, the ICSE includes two factors: 'ability to generate creative ideas' (six items) and 'achievement of creative performance' (three items). The Cronbach's  $\alpha$  coefficients of the ICSE and the two factors were .927, .908 and .844, respectively. CFA results indicated that the model had good construct validity and reliability: GFI = .929, RMR = .065, RMSEA = .092, NFI = .945, IFI = .967 and CFI = .967. Finally, the  $\rho_c$  values of the two factors were .867 and .850, respectively, and the  $\rho_v$  values were .526 and .655. See Appendix C for test items.

### 3.3 *Interventions and procedures*

This study employed a smartphone-based mindfulness intervention with the features of self-determination and idea sharing in a pre-test-post-test experimental design. During the one-week experimental period, all participants were requested to use their smartphones to take photos for five days and to share the photos with imaginative narratives on a designated website. Notably, they could freely take photos of their daily lives. Through these practices, we expected the participants would be more mindful of things in their surroundings. In other words, we speculated that the participants would become more actively engaged in the present, become sensitive to context, consciously pay attention to the things they are curious about, and bring about original thoughts from these ordinary or special things. We hoped that the smartphone-based mindfulness intervention, which emphasised mindfulness in surroundings, self-determination in photo-taking, and knowledge sharing of creative thoughts online would enhance the participants' self-efficacy in creativity.

All participants completed the pre-test of creativity mindsets, passion for smartphone use, and creativity self-efficacy. In the following five days, they were requested to take two photos each day, for a total of ten photos. Finally, they took the post-test of creativity mindsets, the passion for smartphone use, and creativity self-efficacy on day 7. For each uploaded photo, we requested the participants to write an imaginative short narrative based on what they were thinking when they took the photo. Examples are shown in Figure 2.



**Figure 2** An example of the uploaded photo (see online version for colours)

## 4 Results

### 4.1 Preliminary analysis

In this study, we designed a six-point Likert-type reflection questionnaire to understand the participants’ feelings toward the interventions. The participants reported that they had become more attentive, sensitive, and imaginative about things around them. They also reported that their everyday creativity had been enhanced. These results suggest that our employed mindfulness intervention was effective (see Table 1).

**Table 1** Ms and SDs of the reflective questions

Question	<i>M</i>	<i>SD</i>
1 This smartphone activity has made me more attentive to my surroundings.	4.84	.869
2 This smartphone activity, although not lasting a long time, has enhanced my sensitivity toward my surroundings.	4.57	.850
3 This smartphone activity has enhanced my ability to view my surroundings imaginatively.	4.70	.893
4 This smartphone activity has enhanced my everyday creativity.	4.38	.906

Due to the lack of a control group, we did not try to propose hypotheses regarding learning effects on creativity mindsets, passion towards smartphones, and self-efficacy in creativity. However, repeated measure analysis of variance (repeated measure ANOVA) revealed that the participants got higher scores on GI after the intervention,  $F(1, 83) = 10.307, p = .002, \eta_p^2 = .110$ . Although there were no significant effects on FI and FE, there was a trend that these fixed mindsets were decreased in participants after the intervention. Regarding passion toward smartphones, H-intra, H-inter, and O-inter passion were increased in participants after the intervention,  $F_s(1, 83) = 8.508$  to  $13.218, p_s < .05, \eta_p^2 = .093$  to  $.137$ . Finally, the participants had higher scores on self-efficacy of

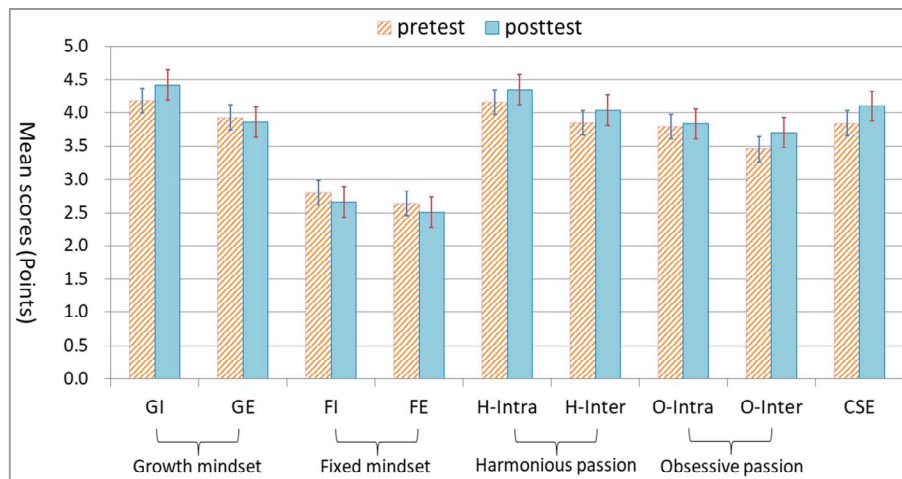
creativity after the intervention,  $F(1, 83) = 28.964, p < .001, \eta_p^2 = .259$  (see Table 2). The means and standard errors of the pre-test and post-test scores are depicted in Figure 3.

**Table 2** The effects of interventions on changes in creativity mindsets, passion toward smartphones, and self-efficacy of creativity

Source	ANOVA				Post hoc test
	MS	$F(1, 83)$	$p$	$\eta_p^2$	
Creativity mindsets					
Growth-internal control	2.461	10.307*	.002	.110	T2 > T1
Growth-external control	.239	1.186	.279	.014	
Fixed-internal control	.677	3.642	.060	.042	
Fixed-external control	.720	3.539	.063	.041	
Passion toward smartphones					
Harmonious-intrapersonal	1.572	8.508*	.005	.093	T2 > T1
Harmonious-interpersonal	1.670	13.218**	.000	.137	T2 > T1
Obsessive-intrapersonal	.073	.453	.503	.005	
Obsessive-interpersonal	2.625	12.580**	.001	.132	T2 > T1
Self-efficacy of creativity	2.766	28.964**	.000	.259	T2 > T1

Note: T1 = pre-test, T2 = post-test, \* $p < .05$ \* and \*\* $p < .001$ .

**Figure 3** The means and standard errors of creativity mindsets, passion toward smartphones, and self-efficacy of creativity in the pre-test and the post-test (see online version for colours)

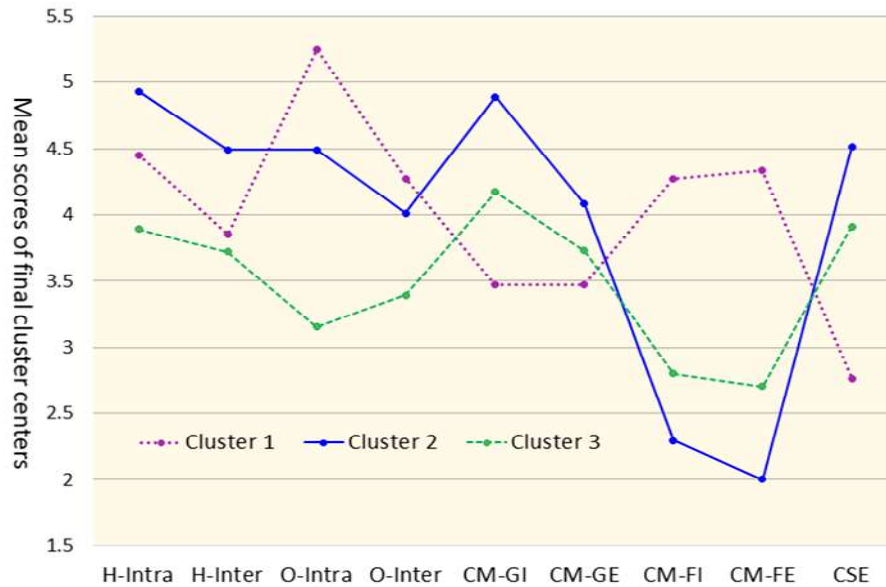


Notes: H-intra, H-inter, O-intra and O-inter are the four types of passion. GI, GE, FI and FE are the four types of mindsets. CSE: creativity self-efficacy.

#### 4.2 Profile analysis

To understand the profiles of passion in smartphone use, growth creative mindset, fixed mindset, and self-efficacy after the mindful learning intervention, we employed a k-means cluster analysis (Cutillo, 2019). The four types of passion in smartphone use, the four types of mindsets, and self-efficacy of creativity were included in the cluster analysis. Overall, the variables formed three significant clusters (C1, C2 and C3). The mean scores of the final cluster centre for each of the variables are shown in Figure 4.

**Figure 4** The final cluster centres (see online version for colours)



Notes: H-intra, H-inter, O-intra and O-inter are the four types of passion. GI, GE, FI and FE are the four types of mindsets. CSE: creativity self-efficacy.

To further compare the differences between clusters, we conducted a multivariate analysis of variance using the cluster groups (C1, C2 and C3) as between variables and all variables as dependent variables. The findings showed significant group effects on all the dependent variables, Wilks'  $\Lambda = .175$ ,  $p < .001$ ,  $\eta_p^2 = .581$  (see Table 3). The results revealed three patterns (see Table 4). The C2 cluster, which had the highest creativity self-efficacy after the intervention, showed a high level of H-intra and H-inter passion, a medium level of O-intra and O-inter passion, a high level of GI and GE mindset, and a very low level of FI and FE mindset. The C3 cluster, which had a medium level of creativity self-efficacy after the intervention, showed a medium level on all types of passion and mindsets. Finally, the C1 cluster, which had the lowest level of creativity self-efficacy after the intervention, showed a medium level of H-intra and H-inter passion, a high level of O-intra and O-inter passion, a low level of GI and GE, and a high level of FI and FE mindset.

**Table 3** The final cluster centres and ANOVA results

	<i>Cluster</i>			<i>ANOVA</i>			
	<i>1</i>	<i>2</i>	<i>3</i>	<i>F(2, 81)</i>	<i>Sig.</i>	$\eta_p^2$	<i>Scheffé</i>
H-intra	4.45	4.93	3.89	27.568	.000	.405	C2 > C3
H-inter	3.85	4.49	3.72	12.604	.000	.237	C2 > C3
O-intra	5.25	4.49	3.15	26.878	.000	.399	C1, C2 > C3
O-inter	4.27	4.01	3.39	8.889	.000	.180	C1, C2 > C3
GI	3.47	4.89	4.17	23.491	.000	.367	C2, C3 > C1; C2 > C3
GE	3.47	4.08	3.73	4.961	.009	.109	C2, C3 > C1; C2 > C3
FI	4.27	2.29	2.80	21.444	.000	.346	C1 > C2, C3; C3 > C2
FE	4.33	2.00	2.70	32.582	.000	.446	C1 > C2, C3; C3 > C2
CSE	2.76	4.51	3.91	15.442	.000	.276	C2, C3 > C1; C2 > C3

Notes: H-intra, H-inter, O-intra and O-inter are the four types of passion. GI, GE, FI and FE are the four types of mindsets. CSE: creativity self-efficacy.

**Table 4** Profiles of cluster analysis

<i>Variable</i>	<i>Cluster 2</i>	<i>Cluster 3</i>	<i>Cluster 1</i>
	<i>High self-efficacy, harmonious passion, and growth mindset, but low fixed mindset group</i>	<i>Medium self-efficacy, harmonious passion, obsessive passion, growth mindset, and fixed mindset group</i>	<i>Low self-efficacy and growth mindset, but high obsessive passion and fixed mindset group</i>
Creativity self-efficacy	High	Medium	Low
Harmonious-intrapersonal passion	High	Medium	Medium
Harmonious-interpersonal passion	High	Medium	Medium
Obsessive-intrapersonal passion	Medium	Medium	High
Obsessive-interpersonal passion	Medium	Medium	High
Growth-internal creativity mindset	High	Medium	Low
Growth-external creativity mindset	High	Medium	Low
Fixed-internal creativity mindset	Very low	Medium	High
Fixed-external creativity mindset	Very low	Medium	High

## 5 Discussion

This study aimed to explore the cluster profiles of different types of passion in smartphone use, creativity mindsets, and creativity self-efficacy in college students. Four types of creativity mindsets (GI control, GE control, FI control and FE control)

and four types of passion (harmonious-intrapersonal, harmonious-interpersonal, obsessive-intrapersonal, and obsessive-interpersonal) were employed in this study. Although no control group was employed and the learning effects through the smartphone-based mindfulness intervention need to be replicated, the results of preliminary analysis tend to support the positive impact of smartphones or mobile devices on learning (Barrett et al., 2021; Kacetl and Klímová, 2019; Ramírez-Donoso et al., 2021). Past findings have suggested that knowledge sharing helps knowledge integration that contributes to creativity performance (Kremer et al., 2019; Men et al., 2019; Sung and Choi, 2020; Zhang et al., 2019), self-determination involves self-control (Peterson et al., 2020) and an active tendency toward growth and development (Ryan and Deci, 2000), mindfulness contributes to the generation of original thoughts from ordinary or special things (Langer, 2016), and learning through smartphones or mobile devices is an easy and efficient method for idea exploration (Gaviola, 2021). Our findings suggest that combining the advantages of smartphones, mindfulness, self-determination, and online knowledge sharing may lead to positive learning outcomes. Moreover, the results of this study are in line with the finding that using mobile technology in learning can enhance self-efficacy (Mahat et al., 2012) and that mobile technology tools facilitate growth mindset traits and passion in the learning process (Eskreis-Winkler et al., 2016; Hegarty and Thompson, 2019).

This study sought to understand the profiles of passion in smartphone use, growth creativity mindsets, fixed creativity mindsets, and self-efficacy after the intervention through cluster analysis. The results revealed three distinctive groups pertaining to creativity self-efficacy. Strong self-efficacy was found to be associated with a high level of harmonious passion and a growth mindset but a low level of a fixed mindset. In contrast, weak creativity self-efficacy was related to a low level of growth mindset but a high level of obsessive passion and fixed mindset group. Finally, a medium level of creativity self-efficacy was associated with a medium level of all the other concerned variables. These findings suggest that harmonious passion for smartphone use and a growth mindset of creativity have a positive impact on the development of creativity self-efficacy, whereas obsessive passion for smartphone use and a fixed mindset of creativity hurt the development of creativity self-efficacy. These results are in accordance with the finding that intrinsic motivation, mindfulness, and self-efficacy are positively correlated (Neace et al., 2020).

Past findings have suggested that different types of passion lead to varied subsequent self-regulated behaviour (Raphiphatthana et al., 2018), which further influences learning outcomes. This study therefore further examined four specific types of passion for smartphone use. Our results are consistent with past findings that harmonious passion brought about positive outcomes (e.g., Schellenberg et al., 2016; Yeh and Chu, 2018) and that obsessive passion inhibits the reach of alternative goals (Bélanger et al., 2013). Moreover, the results of this study lend support to the notion that the influences of harmonious and obsessive passion on players' addiction to online computer games differ significantly; while obsessive passion leads to addiction, harmonious passion normally does not. The findings of this study also support the idea that people who hold a growth mindset are more likely to thrive in the face of difficulty and continue to improve (McClendon et al., 2017), while those who hold a fixed mindset may shy away from challenges or fail to meet their potential (Dweck and Yeager, 2019). Moreover, a growth mindset is consistently active when facing obstacles and it fosters self-efficacy and

motivation (Baynard, 2021). These findings suggest that different types of passion may lead to varied subsequent self-regulated behaviour, which further influences creativity mindsets and creativity self-efficacy (Raphiphatthana et al., 2018).

## **6 Conclusions**

Past studies have suggested that smartphone-based mindfulness intervention significantly enhanced creativity self-efficacy, and different types of passion and creativity mindsets carry different effects on self-efficacy. To date, no researcher has developed a smartphone-based mindfulness intervention to examine its effects on passion in smartphone use, growth creativity mindsets, fixed creativity mindsets and self-efficacy. Moreover, little research has been conducted to understand the profiles regarding what personal traits would predict self-efficacy after a smartphone-based mindfulness intervention. The personal traits of interest to this study include four types of passion for smartphone use, two types of growth mindsets, two types of fixed mindsets, and self-efficacy of creativity. The findings suggest that integrating mindful learning into photo-taking of one's surroundings using smartphones with an emphasis on self-determination and knowledge sharing may improve college students' GI control mindset towards creativity and harmonious passion.

Most importantly, we identified three distinctive patterns of clusters about creativity self-efficacy, mindset, and passion, suggesting that creativity self-efficacy can be predicted by a creativity growth mindset and harmonious passion toward smartphones. This study contributes to the development of a smartphone-based mindfulness intervention that can be easily implemented in daily life. Moreover, the profiles of specific traits we identified in this study provide related instruction or research insights into how different types of mindsets and passion toward smartphones may influence self-efficacy.

## **7 Limitations and implications**

In this study, we did not employ a control group because our main goal was to identify patterns of self-efficacy and its influential personal traits after interventive learning, rather than verifying intervention effects. However, our experimental design was built on previous successful experiences (Yeh et al., 2020), in which a control group pre-test-post-test design was employed to enhance creativity self-efficacy. In addition to our main goal, we did an exploratory analysis on whether the smartphone-based mindfulness intervention would enhance creativity self-efficacy, harmonious passion for smartphone use, and creativity growth mindsets. The findings of this study validate the effectiveness of such a smartphone-based mindfulness intervention although the robustness of the findings needs to be replicated with a control group experimental design. Nevertheless, the findings encourage the feasibility of enhancing creativity self-efficacy, the harmonious passion for smartphone use, and the growth creativity mindsets through the mindful use of smartphones in daily life. Notably, because the participants were recruited from an online advertisement, and because the participation fee is a required consideration, the experiment only lasted ten days. If such an experiment

can be designed as part of a course requirement, a more dramatic change curve may show up.

Additionally, we found a trend that the college students' GI control mindset was increased, but their fixed creativity mindsets were only marginally decreased. The change of creativity mindsets through smartphones may require a longer period of practice. Future studies may extend the experimental period and integrate more strategies for enhancing the growth mindset of creativity to optimise the learning effects. Dweck (2016) and McClendon et al. (2017) have suggested some principles to increase learners' capacity for a growth mindset. Such principles include engaging learners in developmental activities that are indicative of the growth mindset, nurturing a strong desire to continue learning new knowledge and skills, and convincing learners to take risks, confront challenges, and continue working to improve, even when feeling distressed. Related films, videos, or resources can be provided during the interventions. Additionally, online discussions may follow photo sharing to enhance the competencies of imagination and creativity; such experiences may, in turn, fortify growth mindsets and harmonious passion.

Finally, we identified three distinctive patterns of clusters about creativity self-efficacy, mindset, and passion, suggesting that creativity self-efficacy can be predicted by creativity growth mindsets and harmonious passion toward smartphones. Past findings have suggested that harmonious passion provides access to adaptive self-processes, such as mindfulness, whereas obsessive passion limits such access (St-Louis et al., 2018); moreover, need satisfaction was negatively related to an obsessive passion for screen-based activities in various contexts (Tóth-Király et al., 2019). Further studies employing smartphones for learning may create a rich environment for practice in adaptive self-processes and need satisfaction to fortify mindfulness and harmonious passion, which may, furthermore, enhance growth creativity mindsets.

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## Appendix A

### *The test items and Cronbach's $\alpha$ of the IPS*

<i>No.</i>	<i>Test item</i>
<i>Harmonious (<math>\alpha = .930</math>)</i>	
Factor 1: harmonious-intrapersonal ( $\alpha = .910$ )	
1	I often use my smartphone for learning because it helps me stay up to date on the latest news.
5	I often use my smartphone for learning because it provides learning resources that meet my needs and ability.
9	I often use my smartphone for learning because learning is interesting.
13	I often use my smartphone for learning because it allows me to make free choices and decisions about what I want to learn.

*The test items and Cronbach's  $\alpha$  of the IPS (continued)*

<i>No.</i>	<i>Test item</i>
<i>Obsessive (<math>\alpha = .859</math>)</i>	
Factor 2: harmonious-interpersonal ( $\alpha = .876$ )	
4	I often interact with others using my smartphone for inspiration.
8	I often help others solve problems through my smartphone because it gives me feelings of achievement.
12	I often actively share my knowledge or viewpoints using my smartphone.
15	To enhance my learning efficiency, I often use my smartphone to interact and discuss with others.
<i>Obsessive (<math>\alpha = .859</math>)</i>	
Factor 3: obsessive-intrapersonal ( $\alpha = .903$ )	
2	I will feel uncomfortable if I do not use my smartphone after I get up in the morning.
6	I will feel bored if I do not use my smartphone for just one day.
10	I must use my smartphone every day, no matter how busy and tired I am, or I will feel that I have wasted my day.
14	I often cannot control the impulse to use my smartphone.
Factor 4: obsessive-interpersonal ( $\alpha = .701$ )	
3	When I use my smartphone to have discussions and interact with others, it is often because I have to complete assignments.
7	In order not to have worse performance than others, I often interact and have discussions with others using my smartphone.
11	My friends often use smartphones for learning, which inspires me to learn in the same way.

**Appendix B***The test items and Cronbach's  $\alpha$  of the CMI*

<i>No.</i>	<i>Test item</i>
<i>Growth mindset (<math>\alpha = .873</math>)</i>	
Factor 1: growth-internal locus of control (GI) ( $\alpha = .823$ )	
1	As long as I work hard, my creativity can be greatly improved.
5	I can improve my creative ability through self-learning.
9	I can be more creative as long as I am willing to learn.
Factor 2: growth-external locus of control (GE) ( $\alpha = .824$ )	
2	My creativity can be improved with the help of good teachers.
6	I am willing to learn creativity and I can become more creative when there is a good learning environment.
10	My creativity can be substantially improved when I have sufficient learning opportunities.

*The test items and Cronbach's  $\alpha$  of the CMI (continued)*

<i>No.</i>	<i>Test item</i>
<i>Fixed mindset (<math>\alpha = .947</math>)</i>	
Factor 3: fixed-internal locus of control (FI) ( $\alpha = .878$ )	
3	It is hard to improve my creativity even if I work hard to improve it through self-learning.
7	Even if I am willing to learn creativity, it is hard for me to become more creative.
11	Even if I work hard by myself, my creativity won't be substantially improved.
Factor 4: fixed-external locus of control (FE) ( $\alpha = .900$ )	
4	It is hard to improve my creativity even if I have good luck and meet good teachers.
8	Even if there is someone to tutor me, it is hard for me to become more creative.
12	Even if I have sufficient learning opportunities, my creativity would not be substantially improved.

**Appendix C***The test items and Cronbach's  $\alpha$  of the ICSE*

<i>No.</i>	<i>Test item</i>
<i>The inventory of creativity self-efficacy (<math>\alpha = .927</math>)</i>	
Factor 1: achievement of creative performance ( $\alpha = .908$ )	
2	I feel that I am more creative than most of my classmates.
1	I feel that I am a creative person.
3	I feel that 'being creative' is one of my characteristics.
Factor 2: ability to generate creative ideas ( $\alpha = .844$ )	
8	I believe that my creativity can be improved as long as I try hard to learn.
5	I believe that my creativity can be constantly improved.
6	I believe that I can come up with many creative ideas.
4	I believe that I can come up with many creative problem-solving solutions.
7	I believe that I can become a creative person.
9	I believe that I can produce creative works.