The roles of empathy and motivation in creativity in design thinking

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Abstract

Creativity is an important skill in the 21st century, and design thinking has been proposed as a methodology for fostering creativity. Design creativity involves two non-rational aspects: motivation and empathy. However, little is known about how empathy and motivation work in synergy with creativity. This study explored the underlying mechanisms of empathy and motivation in creativity in design thinking. We built an explanatory model to examine the effect of empathy on motivation and creativity and the mediating effects of four aspects of motivation (i.e., attention, relevance, confidence, and satisfaction). In the study, 220 6th-grade students participated in an integrated STEM curriculum that centered on design thinking activities that lasted one semester, and then completed a questionnaire measuring their perceptions of empathy, motivation, and creativity at the end of the design activities. Partial least squares structural equation modelling was used to analyze the collected data. The results showed that empathy positively predicted creativity. In addition, empathy had a significant impact on creativity through the effect of intrinsic motivation, but not through that of extrinsic motivation. Among the four aspects of motivation, attention, relevance, and confidence each strengthened the association between empathy and creativity. However, satisfaction had a negative effect on creativity and a non-significant mediating effect. These findings increase our understanding of the internal mechanisms of design thinking and creativity. Some practical implications of empathy and motivation in creativity are also discussed.

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Introduction

Creativity is regarded as an important skill in the 21st century (Henriksen et al., 2016; Hobbs, 2004; Ritter & Dijksterhuis, 2014). It is generally considered to be the skill or ability to produce ideas or products that are novel and appropriate (Sternberg, 2001), rather than trivial or bizarre (Silvia, 2008; Yaniv, 2012). As the essence of creativity is creative problem-solving (Casakin & Wodehouse, 2021), problem-centered instruction has become the dominant pedagogy for fostering students' creativity (Livingston, 2010). And it has proved to be effective in promoting students' creativity (Hmelo-Silver, 2004; Jeno et al., 2019). Design-based problems are a type of authentic problems that can foster creativity (Casakin & Wodehouse, 2021; Kuo et al., 2019). Design thinking is a methodology for creatively solving design-based problems and developing creativity (Carlgren et al., 2016; Dorst, 2011). Its core idea is human-centered design (Brown, 2008), in which problems are identified and defined through empathizing and then solved by generating creative ideas or solutions (Razzouk & Shute, 2012).

Empathizing is the first step in design thinking and is a core element throughout the design process (Woo et al., 2018). Empathy is the complex cognitive and emotional state of taking on the perspective of another people and experiencing their emotions and thoughts, and it involves cognitive understanding (i.e., related to thought and ideas) and affective responses (i.e., related to emotions and feelings) (Davis, 1983; Jaber, 2021; Kouprie & Visser, 2009). Empathy is considered to be a necessary qualification and ability in design because being empathetic is the key to discovering or defining the design problem or real needs and to inspiring creativity and innovation (Kouprie & Visser, 2009). Some studies have found that empathy contributes mainly to the usefulness or appropriateness aspect of creativity (Grant & Berry, 2011; Li & Bai, 2015).

Other studies have found that motivation is also essential to creativity (Csikszentmihalyi, 1988). Motivation generally refers to "what people desire, what they choose to do, and what they commit to do" (Keller, 2010, p. 3). People who are more intrinsically motivated will have higher degrees of involvement, cognitive effort, and willingness to take risks, and less interference from external conditions when completing tasks, so their creative performance will be greater (Amabile, 1979; Hennessey & Amabile, 1998). It has been suggested that intrinsic motivation positively predicts creativity (Grant & Berry, 2011). Individuals who are more intrinsically motivated are more likely to persist with challenging and complex problem-solving tasks (Gagné & Deci, 2005). However, some research has found weak, mixed, or even no prediction by motivation for creativity, especially when the tasks involve providing service to others (Amabile & Pratt, 2016; Grant & Berry, 2011; Shalley & Perry-Smith, 2001). A possible interpretation of this phenomenon is that intrinsic motivation leads people to focus on the novelty aspect of creativity to pursue their interests and satisfying their curiosity (Grant & Berry, 2011). However, usefulness must also be considered in the generation of creative ideas (Grant & Berry, 2011).

Thus, individuals' empathy and motivation are two important factors that influence creativity, as creative design problem-solving involves not only rational or logical thinking but also non-rational dimensions of creative thinking such as empathy and motivation (Csikszentmihalyi, 1988; Li et al., 2007). However, the relationship between these factors has rarely been investigated (Yaniv, 2012). The synergistic effect of empathy and motivation with creativity has also received little attention. Most previous studies have found direct

effects of empathy and motivation on individuals' creativity, respectively (de Jesus et al., 2013; Lee & Park, 2021; Woo et al., 2018; Zhang et al., 2021). Empathy and motivation may work in synergy with creativity because novelty and usefulness are both indispensable components of creativity (Sternberg, 2001). Therefore, the current research explored the mechanisms underlying the relationships between empathy and motivation on individuals' creativity in design thinking.

Literature review and research hypotheses

Improving creativity through design thinking in technology and design education

Design thinking is not only a methodology for creatively solving design-based problems but also an approach to developing individuals' creativity (Brown, 2008; Carlgren et al., 2016; Dorst, 2011). Design activity is an indispensable part of technology education because it is considered the core problem-solving process of technological development (Fleer, 2000; Lewis, 2006). Design thinking has been considered an approach or methodology for solving problems in technology education (Lewis, 2006). In design-based problem-solving, design fields include software design (Kao et al., 2017), product manufacturing (Li et al., 2007), engineering design (Huang et al., 2020), architectural design (Casakin & Wodehouse, 2021), and business management (Yannou, 2013). Research has indicated that design thinking is important for designers to solve real-world problems in creative and meaningful ways (Balakrishnan, 2022; Guaman-Quintanilla et al., 2023). For instance, Balakrishnan (2022) found that design thinking helped student designers to become more creative, thus enabling them to develop practical and innovative designs. Both systematic reviews and meta-analyses have revealed that design thinking can be an effective method of promoting creativity (Mardiah et al., 2023; Micheli et al., 2019).

Previous research has mainly focused on logical problem-solving in creativity and rational thinking strategies in design thinking, such as analyzing and synthesizing (Csikszentmihalyi, 1988). However, in the solving of design problems, some logical or systematic thinking strategies such as lateral thinking may be inefficient because the design process is usually associated with a non-logical thinking method, i.e., the non-rational dimensions of creative thinking (Li et al., 2007). These non-rational aspects of creativity, which include motivation and empathy, and should be given equal attention because they also determine the outcomes of creativity (Csikszentmihalyi, 1988; Form & Kaernbach, 2018; Chen et al., 2018; Zhang et al., 2021).

The role of empathy in creativity

Empathy has been considered to be the core value and ability in user-centered design (Rusmann & Ejsing-Duun, 2022). Some empirical studies have indicated a positive association between empathy and creativity (Chang et al., 2022; Genco et al., 2011; Johnson et al., 2014). Johnson et al. (2014) and Gerco et al. (2011), for example, conducted design projects using empathic experience design to improve user-centered creative idea generation. Their results showed that empathic design led to higher originality and lower design fixation. Moreover, experience-driven empathy can immerse designers in users' real environments,

thus promoting designers' creativity (Chang et al., 2022; Hu et al., 2021). Other studies have suggested that incorporating empathy into the design thinking process can promote students' creativity and design sensibility (Chen et al., 2023; Lee & Park, 2021). Overall, previous studies have provided strong evidence of the positive relationship between empathy and creativity. In user-centered design, designers need to develop empathy with the potential users for whom they are designing the products or services (Cardoso et al., 2016; Hashim et al., 2019). Better empathy will increase the likelihood that the designed product or service will meet users' needs or requirements (Kouprie & Visser, 2009) and will thus improve the applicability, acceptance, and adoption of the end design (Wilkinson & De Angeli, 2014). In summary, empathetic design thinkers notice problems or needs that others do not and use their insight to inspire design creativity (Cardoso et al., 2016).

Based on the aforementioned evidence, we hypothesize a positive relationship between empathy and creativity (see Fig. 1):

Hypothesis 1 Empathy positively predicts creativity.

The mediating role of motivation

Motivation is identified as the direction and magnitude of behavior, or as "what goals people choose to pursue and how actively or intensely they pursue them" (Keller, 2010, p. 22). Keller (2010) proposed the ARCS model, which features four motivational aspects: attention, relevance, confidence, and satisfaction. Motivation can be generated when the learning activities attract students' attention, are relevant to their learning goals, and make them feel confident and satisfied when accomplishing their learning tasks (Keller, 2010).

The literature has shown that motivation is a well-established contributor to creativity (Amabile, 1985; Benedek et al., 2020; Zhang & Bartol, 2010). When individuals are motivated, especially intrinsically, their curiosity and interest will extend their scope of attention and the cognitive information available. This encourages their cognitive flexibility and persistence with complex and challenging tasks or problems, thus stimulating greater creativity (Grant & Berry, 2011; Paramitha & Indarti, 2014). A meta-analysis by Liu et al. (2016) revealed that different elements of motivation functioned differently as predictors of creativity and suggested the need for a more fine-grained theory to explain the complex relationship between motivation and creativity.

Some empirical studies have proved that there is a positive association between empathy and motivation (Longobardi et al., 2020; Pavey et al., 2012). This may be because individuals have higher altruistic motivation when they are empathizing (Pavey et al., 2012). That is, empathic individuals will be motivated to alleviate the suffering of others and meet the needs of others (Pavey et al., 2012; Van Lange, 2008). Therefore, we posit that motivation mediates the relationship between empathy and creativity, and we explore the deeper mediating effects of motivation in terms of attention, relevance, creative confidence, and satisfaction.

Attention in motivation

As an aspect of motivation, attention refers to capturing the interest of learners and stimulating their curiosity to learn (Keller, 2010). Learners will be more curious about a task if they devote more attention to it (Keller, 2010). Curiosity has been widely confirmed as a positive predictor of creativity (Hagtvedt et al., 2019; Schutte & Malouff, 2020). For example, Schutte et al. (2020) found that more attention to tasks was significantly associated with greater creativity. Csikszentmihalyi (1997) found that learners who devote sufficient time and effort or who focus a large amount of attention on their tasks are more likely to be creative and original. Besides, Keller (2010) stated that deeper levels of curiosity and attention can be stimulated by more complex problem-solving situations. As is known, design tasks usually involve solving ill-structured problems (Stewart, 2011). Such challenging design problems can stimulate learners' interest and attract their attention (Keller, 2010; Stewart, 2011). Therefore, in this study, learners' attention to design tasks may be a positive predictor of their creativity.

Considerable empirical evidence has been found that learners tend to lack attention when their needs and feelings are not considered or when they are taught in a monotonous delivery style (Rana et al., 2019; Zhang et al., 2022). Instead, empathy may be an appropriate way to stimulate and maintain learners' interest and attention by asking them to take on the perspective of other people and to try to experience their emotions and thoughts (Håkansson & Montgomery, 2003; Jaber, 2021). Specifically, the empathizing process during design practice includes discovery, immersion, connection and detachment (Kouprie & Visser, 2009). In the discovery phase of empathizing, stepping into users' worlds can increase designers' curiosity as well as their willingness and motivation to understand users (Kouprie & Visser, 2009). In this way, learners will become immersed in the tasks and materials, thus improving their creativity (Klapwijk & Van Doorn, 2015). Therefore, the following hypothesis is formulated (see Fig. 1):

Hypothesis 2 Attention in motivation has a mediating effect on the relationship between empathy and creativity.

H2a. Empathy is positively related to attention.
H2b. Attention is positively related to creativity.

Relevance in motivation

A sense of relevance in motivation occurs when the content to be learned is perceived to be useful or meaningful to one's work or life (Keller, 2010). Theoretically, using the ARCS model, Keller (2010) found that learners will perform better when the learning task is related to their lives or local communities (Keller, 2010). Many recent studies have sought to improve learners' creativity by using design tasks that are related to learners' real-life experiences and are meaningful or significant to them (Kao et al., 2017; Klapwijk & Van Doorn, 2015; Kreitler & Casakin, 2009; Voigt et al., 2019). For instance, in Klapwijk and Van Doorn (2015), students designed a playground, based on their experience of themselves and those of elderly people close to them. In Kreitler and Casakin (2009), learners designed

a small museum to promote the cultural life in a little town. Their findings confirmed the positive relationship between the relevance of the task and creativity in these design tasks (Kreitler & Casakin, 2009).

In addition, Klapwijk and Van Doorn (2015) further indicated that designing relevant and meaningful tasks not only stimulates student designers' creativity but also positively relates to their empathic ability by allowing them to immerse themselves in and experience the context for which the products were designed in the early phases of the design process. In particular, this immersion would enable learners to make connections with users and recall their own similar experiences, which is an indispensable component of empathy (Kouprie & Visser, 2009). For example, when learners were asked to design a playground for elderly people, they collected and analyzed information on the lives and needs of elderly people (Klapwijk & Van Doorn, 2015); in the process, the learners' empathic abilities were improved as they understood the relevance and meaning of the design task.

Therefore, this study proposes the following hypothesis (see Fig. 1):

Hypothesis 3 Relevance in motivation has a mediating effect on the relationship between empathy and creativity.

H3a. Empathy is positively related to relevance.
H3b. Relevance is positively related to creativity.

Creative confidence in motivation

Confidence in the creativity context is called creative confidence, which has been identified as learners' perceptions of their confidence or belief that they can generate creative ideas or produce creative outcomes (Beghetto & Karwowski, 2017; Liu et al., 2017). Some studies have found that creative confidence is significantly related to creative performance or creative idea/product generation (Huang et al., 2020; Liu et al., 2017; Puente-Díaz & Cavazos-Arroyo, 2017). Individuals with higher creative confidence will be more likely to engage in creative tasks, perform creatively, make sustained efforts to address challenging or difficult tasks, and achieve a higher level of creative performance (Beghetto & Karwowski, 2017).

One of the main goals of design thinking is to develop designers' creative confidence (Carroll et al., 2010; Rauth et al., 2010), in which empathy plays an important role (Voigt et al., 2019). Design thinking as a framework in design education is conducive to creative confidence (Rauth et al., 2010). That is, the design thinking framework allows learners to transfer the process of design into their own mindsets (Rauth et al., 2010). With iteration process, design thinking can help learners to complete creative design tasks more easily. As such, their creative confidence can be improved by this process (Voigt et al., 2019). Moreover, empathy, as the essential step in design thinking is helpful to stimulate learners' attention and interest and maintain their engagement; thus, it should be a positive predictor of creative confidence. Therefore, we formulate the fourth research hypothesis (see Fig. 1):

Hypothesis 4 Confidence in motivation has a mediating effect on the relationship between empathy and creativity.

H4a. Empathy is positively related to confidence.

H4b. Confidence is positively related to creativity.

Satisfaction in motivation

Keller (2010) indicated in the ARCS model that learners will be motivated to learn in the initial stage when the task is interesting and captures their attention and the context is related to their lives. However, learners usually need to make a sustained effort to achieve success in solving complex design tasks. In this case, satisfaction plays an important role in maintaining motivation (Hasegawa et al., 2015; Keller, 2010). Previous research has confirmed that satisfaction is significantly correlated with creativity (Amabile et al., 1986; Robinson & Beesley, 2010). Amabile et al. (1986) indicated that intrinsic interest was correlated with creativity because of individuals' enjoyment and satisfaction (Amabile et al., 1986).

A significant correlation has been found between empathy and satisfaction (Silva & Figueiredo-Braga, 2019; Supervía et al., 2023). Some studies have suggested that empathy increases compassion satisfaction for leading individuals to feel "strengthened by having been able to help, satisfied with one's situation, and developed as a person" (Hansen et al., 2018, p. 632). Hence, the mediating role of satisfaction is hypothesized (see Fig. 1):

Hypothesis 5 Satisfaction in motivation has a mediating effect on the relationship between empathy and creativity.

H5a. Empathy is positively related to satisfaction.
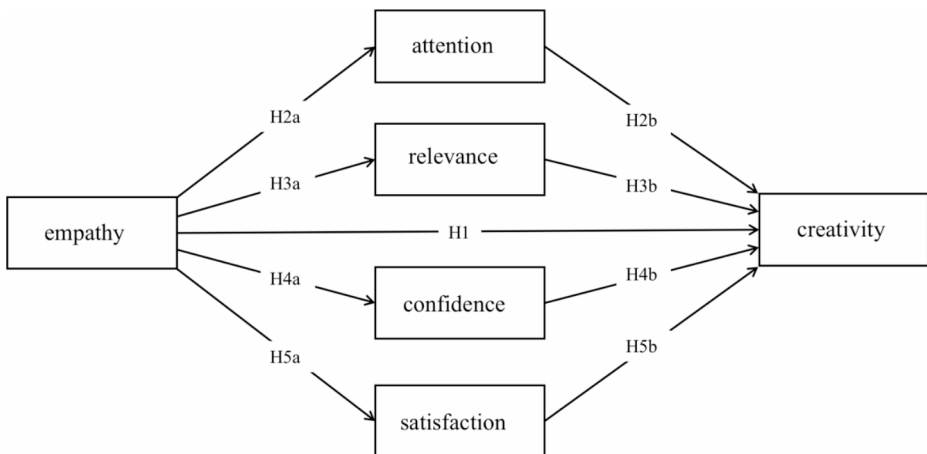
H5b. Satisfaction is positively related to creativity.

Fig. 1 Proposed research model

The current study

The current study investigates the mechanisms underlying the relationships between empathy, motivation, and creativity. An explanatory model (Fig. 1) is proposed to investigate the mediating effects of motivation in terms of attention, relevance, confidence, and satisfaction. A 27-item questionnaire was used to collect data, and partial least squares structural equation modeling (PLS-SEM) was used to test the explanatory model. Therefore, the creativity measured using a questionnaire in our study focused on the creative person or personality.

Method

Participants

The data reported in this study were collected in a 9-year education school in Hangzhou, China. The participants were 257 students from six 6th-grade classes, including 137 male (53.3%) and 120 female (46.7%) students. Their average age was 12.65 (SD_{age} = 1.17). This research was approved by the Human Research Ethics Committee of the researchers' university. The participants signed a consent form before the commencement of the study. Before data collection, the students had no relevant experience in design thinking.

Procedure

A pretest questionnaire was administered to collect the students' age and gender information. The students were asked to complete a design task, i.e., designing a creative playground facility or game that is useful and novel for younger children in grades 1 and 2. They first received instruction on integrated STEM education and then engaged in design thinking activities. They experienced a semester-long period of design activities. At the end of the semester, we administered the questionnaire to collect the students' perceptions of their empathic ability, motivation and creativity throughout the design task.

Measurements

Students' perceptions of their empathic ability

The students' perceptions of their empathic ability was measured by three items from the Toronto Empathy Questionnaire (TEQ) (Spreng et al., 2009). The participants responded to each statement on a 5-point Likert-type scale, ranging from 1=*totally disagree* to 5=*totally agree*. An example item is "If I were a designer, I would be very concerned about the user's preferences and feelings when designing a product." The reliability of the scale was acceptable (Cronbach's α=0.724). The TEQ has been widely used to test participants' empathy (Harley et al., 2020; Wu et al., 2021). Harley et al. (2020) found that the general empathic tendency measured by the TEQ was positively and significantly correlated with participants' task empathy.

Motivation in design tasks

Motivation was measured by 10 items adapted from the Course Interest Survey developed by Keller (2010), which has high reliability and validity. An example item for attention is "My curiosity is stimulated by the questions asked or the problems given in this class." An example item for relevance is "The things I am learning in this course will be useful to me." The items for confidence were adopted from the Competency-Based Creative Agency Scale by Leifer et al. (2014), which includes items such as "Share your work with others before it is finished". An example item for satisfaction is "I enjoy working for this course." Responses were scored on a 5-point Likert scale ranging from 1=*Not True* to 5=*Very True*. In the current study, the Cronbach's α values for attention, relevance, confidence and satisfaction were 0.91, 0.77, 0.38 and 0.82, respectively.

Self-perceived creativity

The Williams Creativity Assessment Packet was used to measure the participants' creativity (Williams, 1980). We selected 10 items that are appropriate for young children. However, only five items met the loading factor criterion. Each statement was scored on a 5-point Likert scale, ranging from 1=*definitively disagree* to 5=*definitively agree*. A sample item is "There are many things I'd like to try by myself." Cronbach's α for the creativity scale was 0.77.

Note that although assessment scales for creative products or creative activities have been widely used to measure creativity, they are group-level measures rather than individual-level measures.

Data analysis

To test the proposed model and aforementioned hypotheses, we applied PLS-SEM using Smart PLS software version 3 (Ringle, 2015), which is suitable for predictive analyses in complex models (Hair & Alamer, 2022). Specifically, we tested the hypothesized model in two steps. First, we built a measurement model to examine its reliability and validity. Second, we built a structural model to measure the path coefficients. To further reveal the mediating effects of attention, relevance, confidence, and satisfaction in motivation, bootstrap analysis, a rigorous and powerful mediation test, was used, with a resample of n=5,000 and a 95% confidence interval (Preacher & Hayes, 2008).

Result

Descriptive statistics and correlations between the variables

Table 1 shows the descriptive statistics and correlation coefficients for all of the variables. As expected, all six variables were correlated.

Table 1 Descriptive statistics, including the means, standard deviations and correlations between empathy, confidence, reference, attention, satisfaction and creativity

	1	2	3	4	5	6	Mean	SD
1. empathy	1.00						4.17	0.71
2. attention	0.44**						4.29	0.85
3. reference	0.40**	0.81**					4.25	0.84
4. confidence	0.44**	0.40**	0.38**				3.78	0.85
5. satisfaction	0.38**	0.75**	0.69**	0.42**			4.38	0.81
6. creativity	0.45**	0.53**	0.54**	0.51**	0.42**	1.00	3.42	0.50

Note. *p<.05; **p<.01

Table 2 The convergent validity and reliability of the measures

Measure	Item	Loadings	Cronbach α	CR	AVE
Empathy	3	0.76–0.86	0.72	0.84	0.64
Attention	3	0.91–0.93	0.91	0.94	0.85
Relevance	2	0.90–0.904	0.77	0.90	0.81
Confidence	5	0.66–0.84	0.83	0.88	0.59
Satisfaction	2	0.91–0.93	0.82	0.92	0.85
Creativity	5	0.62–0.79	0.77	0.85	0.53

Note. CR=the composite reliability; AVE=average variance extracted

Table 3 Discriminant validity using the Fornell–Larcker matrix

Measure	Empathy	Attention	Relevance	Confidence	Satisfaction	Creativity
Empathy	0.80					
Attention	0.44	0.92				
Relevance	0.41	0.81	0.90			
Confidence	0.45	0.40	0.38	0.77		
Satisfaction	0.39	0.75	0.69	0.42	0.92	
Creativity	0.46	0.53	0.54	0.53	0.43	0.73

Note. Highlighted values are squared inter-construct correlations for the Fornell–Larcker criterion

Assessment of the structural model

The convergent validity of the measurement model was evaluated using the reliability of each item, the composite reliability (CR) of the measured constructs, and the average variance extracted (AVE) (Fornell & Larker, 1981). When Cronbach's α and CR values are greater than 0.7 and the AVE is greater than 0.5, convergent validity is sufficient (Cheng & Yuen, 2018). As shown in Table 2, all of the constructs met these requirements, suggesting that measurement model had good convergent validity at the construct level. The factor loadings were all acceptable, thus indicating adequate validity according to the threshold value of 0.5 by Hair et al. (2006).

Additionally, the discriminant validity of this model was assessed using the Fornell–Larcker matrix. A research model would have sufficient divergent validity if the parameter indicates that each variable explains more of the variance of its indicators than the indicators of the other constructs (Fornell & Larcker, 1981; Yakubu et al., 2020). The results in Table 3 show that for all six variables, the matrix diameter was larger than the other arrays of each variable.
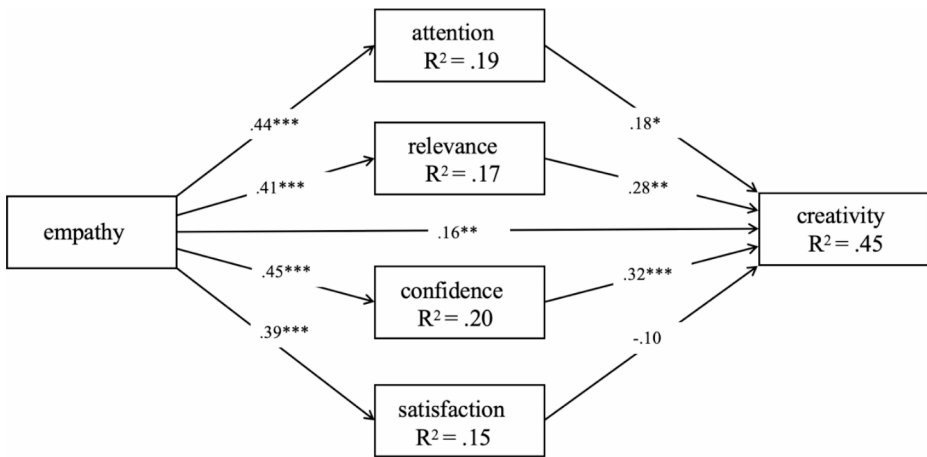
Fig. 2 Proposed research model. Note. *p<.05; **p<.01; ***p<.001

Table 4 Results for the direct effects

Hypothesis	Path	Standardized β	SE	p-value	Decision
H1	empathy → Creativity	0.16**	0.06	0.008	Supported
H2a	Empathy → Attention	0.44***	0.07	<0.001	Supported
H2b	Attention → Creativity	0.18*	0.11	0.044	Supported
H3a	Empathy → Relevance	0.41***	0.07	<0.001	Supported
H3b	Relevance → Creativity	0.28**	0.09	0.002	Supported
H4a	Empathy→ Confidence	0.45***	0.07	<0.001	Supported
H4b	Confidence → Creativity	0.32***	0.09	<0.001	Supported
H5a	Empathy → Satisfaction	0.39***	0.08	<0.001	Supported
H5b	Satisfaction → Creativity	−0.10	0.10	0.174	Not supported

*Note. *p<.05; **p<.01; ***p<.001*

Structural model and hypothesis testing

Direct effects

In light of the direct effects posited in the model, H1, "empathy is the predictor of creativity" was corroborated. The participants with higher levels of empathy also showed higher levels of creativity (β=0.16. p=.008). Moreover, as shown in Fig. 2; Table 4, H2, H3, and H4 were supported. Learners with higher levels of empathy also reported higher attention (β=0.44, p<.001, H2a), relevance (β=0.41, p<.001, H3a) and confidence (β=0.45, p<.001, H4a). In addition, their creativity was predicted by attention (β=0.18, p=.044, H2b), relevance (β=0.28, p=.002, H3b), and confidence (β=0.32, p<.001, H4b). H5 was partially supported. Although higher empathy was found to predict higher satisfaction (β=0.39, p<.001, H5a), a higher satisfaction level was found to be negatively related to creativity (β = −0.10, p=.174, H5b).

Indirect effects and mediating effects

As shown in Fig. 2, the explained variances (R^2) of attention, relevance, confidence, and satisfaction were 0.19, 0.17, 0.20, and 0.15, respectively. In general, the R^2 of creativity was 0.45, revealing that all of the variables of the research model explained 45% of creativity.

As Table 5 shows, the 95% confidence intervals of the indirect paths for attention (95% CI = [0.002, 0.16], β=0.08, p=.048), relevance (95% CI = [0.05, 0.18], β=0.11, p=.003), and confidence (95% CI = [0.08, 0.22], β=0.14, p<.001) did not include 0, suggesting significant mediating effects. However, the p-value for the indirect path from empathy to creativity through satisfaction (95% CI = [-0.11, 0.03], β = −0.04, p=.186) was greater than 0.05, implying that the mediating effect of satisfaction was not supported. Therefore, H2, H3, and H4 were supported and H5 was rejected. In other words, attention, relevance, and confidence had significant mediating effects on the relationship between empathy and creativity, and satisfaction did not. Moreover, confidence was found to have the greatest explanatory power in the mediating effects between empathy and creativity. The total effect of empathy on creativity was also significant and positive (95% CI = [0.23, 0.38], β=0.30, p<.001).

Discussion

The study explored the mechanisms by which empathy and motivation affect creativity in design and the mediating effects of the four aspects of motivation on empathy and creativity based on Keller's ARCS model. The results indicate that learners with higher level of empathy are more likely to be motivated and to achieve a higher level of creativity in the design thinking process.

The effect of empathy on creativity

The results confirm that empathy is a significant predictor of creativity, directly or indirectly, consistent with previous research (Demetriou & Nicholl, 2022; Lee & Park, 2021). Demetriou and Nicholl (2022) showed that learners who received empathy instruction in design tasks showed higher levels of emotional and cognitive creativity. Empathic individuals usually have high environment sensitivity, which is the ability to notice and identify others' feelings accurately (Carlozzi et al., 1995). In addition, more empathic people are more open-minded and less dogmatic, so they can more easily accept incoming messages

Table 5 Results for the indirect effects and mediating effects

Path	Standardized β	SE	Bias-corrected 95%CI		
			Lower	Upper	p-value
Empathy → Attention → Creativity	0.08*	0.05	0.002	0.16	0.048
Empathy → Relevance → Creativity	0.11**	0.04	0.05	0.18	0.003
Empathy → Confidence → Creativity	0.14***	0.04	0.08	0.22	<0.001
Empathy → Satisfaction → Creativity	−0.04	0.04	-0.11	0.03	0.186
Total	0.30***	0.05	0.23	0.38	<0.001

Note. CI=bias-corrected bootstrap confidence interval

*p<.05; **p<.01; ***p<.001

and then discover the real problem or user needs (Carlozzi et al., 1995). Thus, they are more likely to produce more creative products with greater usefulness (Demetriou & Nicholl, 2022).

The mediating effect of motivation

The results for the significant indirect effects and mediating effects indicate that motivation plays an important role in the relationship between learners' empathy and creativity. First, the findings reveal that both empathy and motivation are significantly positively related to creativity, which is in line with previous research (Csikszentmihalyi, 1988; de Jesus et al., 2013; Grant & Berry, 2011; Lee & Park, 2021). Second, motivation was shown to strengthen the relationship between empathy and creativity. A plausible explanation for these findings could be Deci and Ryan's (2000b) self-determination theory, which states that intrinsic motivation can be catalyzed. Empathy may be an important stimulator of intrinsic motivation, which may promote creativity because motivated people are more open and more willing to exert sustained effort on new ideas and challenges.

The mediating effect of attention in motivation

The results show that attention in motivation is a significant mediator of the relationship between empathy and creativity, which is consistent with previous research (e.g., Li et al., 2022). Empathy in the design thinking process is beneficial for maintaining learners' attention in solving design tasks (Håkansson & Montgomery, 2003; Kouprie & Visser, 2009). That is, keeping users' needs in mind, learners will put sustained effort into addressing design challenges. Then, sustained attention and effort will stimulate new idea generation and creativity (Demetriou & Nicholl, 2022).

The mediating effect of relevance in motivation

The mediating effect of relevance in motivation on the relationship between empathy and creativity is supported. This indicates that learners with higher levels of empathy are more likely to perceive the relevance of tasks or consider them to be more meaningful and useful. Perceived relevance or usefulness will stimulate learners' creativity during the design thinking process (Klapwijk & Van Doorn, 2015; Kreitler & Casakin, 2009; Voigt et al., 2019). Empathy and creativity can be improved when the design task is relevant to learners' real lives. Therefore, to promote creativity in design thinking, it is necessary to enable learners to perceive the relevance of the tasks to their lives.

The mediating effect of creative confidence in motivation

This study shows that of the four aspects of motivation, confidence is the greatest contributor to creativity and the mediating variable with the greatest effect on the relationship between empathy and creativity. Therefore, creative confidence in motivation is the essential psychological mechanism behind empathy and creativity. This finding is consistent with self-determination theory and previous research, which suggests that learners with higher levels of confidence perform better in learning and creativity (Gong, 2009; Liu et

al., 2017; Ryan & Deci, 2000b). In other words, creative confidence may promote creativity (Leifer et al., 2014;Rauth et al., 2010). Moreover, learners become more confident after they experience design and empathy activities in design thinking (Leifer et al., 2014). Because learners' empathy experiences will enable them to feel more competent in completing the design tasks for users and more confident in the design solution to meet user need (Rauth et al., 2010). Therefore, when designers develop better empathy with users or a deeper understanding of user needs, they become more confident with their creations (Demetriou & Nicholl, 2022; Voigt et al., 2019).

The nonsignificant mediating effect of satisfaction in motivation

Although empathy has been confirmed as a positive precursor of satisfaction in motivation, the mediating effect of satisfaction on creativity is not significant. However, our results indicate that learners with higher levels of empathy are more likely to be satisfied with the task process, which is in line with previous research (Hansen et al., 2018; Wagaman et al., 2015). Satisfaction is a feeling and attitude generated after comparing learning outcomes with those of others or the expectations of the learner or other people (Keller, 2010). Motivation includes intrinsic motivation and extrinsic motivation. The generally accepted viewpoint is that intrinsic motivation is conducive to creativity but that extrinsic motivation has a detrimental and undermining effect on intrinsic motivation and creativity (Amabile, 1985; Ceci & Kumar, 2016). Therefore, the finding of the non-significant effect of satisfaction on creativity may be because the extrinsic factors of satisfaction in Keller's ARCS model are detrimental to creativity, e.g., making comparisons against teachers' expectations or peers' performance. This result is in line with previous research. learners' intrinsic motivation and creativity would be undermined when the task is regarded as a means to achieve the extrinsic motivation such as expected reward, expected evaluation, competition, surveillance, and restricted choice (Amabile et al., 1986; Hennessey et al., 2010).

Conclusions, limitations and implications

The non-rational dimensions of creativity, motivation and empathy have received increasing interest in recent years. However, most previous research has focused on the direct effects of empathy and motivation on creativity (de Jesus et al., 2013; Lee & Park, 2021; Woo et al., 2018). Little is known about how empathy and motivation work in synergy with creativity. To explore the underlying mechanisms of stimulating creativity during the design thinking process, this study took both motivation and empathy into consideration. A structural equation model including all of these variables was developed to test our hypotheses. This study further examined the mediating effects of motivation, including attention, relevance, confidence, and satisfaction. We found that attention, relevance, and confidence were confirmed to be significant mediating factors in the relationship between empathy and creativity. These explorations extend previous research on the direct effects of empathy and creativity. This research contributes to the emerging literature on design thinking and provides initial insights into the role that empathy plays in user-centered design.

The current study has several limitations. *First*, the five variables in our research model only explained 45% of the variance in creativity, suggesting that other variables that were

not included in this study may influence creativity. In light of the literature, such variables may include personal and contextual characteristics (Shalley et al., 2004) and assessment strategies (Zhou & Oldham, 2001). Therefore, more factors should be explored in the future. *Second*, this study measured students' creativity with the self-reported questionnaire, which measures personal characteristics or tendencies. More objective evaluation of students' creativity in design thinking is needed, such as of product creativity or process creativity. Therefore, future studies should examine the relationship between empathy and product or process creativity. *Finally*, this study only examined the relationships between the variables. In the future, (quasi-)experimental methods should be used to make causal inferences.

Despite these limitations, our findings have a number of practical implications. *First*, this study indicated the importance of design thinking and empathy in the development of creativity. Thus, teachers should pay more attention to the social-emotional skill of empathy. Deeper empathy with users can promote the design of more meaningful and useful products or solutions rather than trivial and useless things (Demetriou & Nicholl, 2022; Nickerson, 1999). It has been recognized that "empathy can ignite and infuse the creative process to make the product real, usable and meaningful to the user" (Demetriou & Nicholl, 2022, p. 5). *Second*, appropriate strategies are needed to stimulate learners' motivation. Ryan and Deci (2000a) suggested that teachers' autonomy support is indispensable for improving learners' motivation. As shown by the current study, empathy, attention, relevance, confidence, and satisfaction all can be referable aspects of teachers' autonomy support to ignite and sustain learners' motivation.

Author contribution Xinyu Li completed the data analysis and manuscript writing. Juanjuan Chen contributed to the design of the research, material preparation, data collection, and revision of the manuscript. Hongjie Fu commented on the manuscript and helped improve the writing and data analysis. All authors read and approved the final manuscript.

Data Availability The data that support the findings of this study are available on request from the corresponding author.

Declarations

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

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