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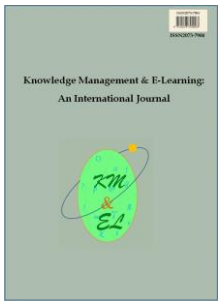

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The effects of two empathy strategies in design thinking on pre-service teachers' creativity

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Abstract: Teachers are increasingly encouraged to creatively integrate technology into their classroom instruction as designers of technology-enhanced learning (TEL). However, they are often not competent in designing TEL due to their lack of experience as participatory designers as well as the ill-structure nature of TEL design problem. Design thinking, as a methodology and a framework for the design process, can serve as a guideline for the development of pre-service teachers' creativity. However, there is a lack of research investigating whether the strategies used in the empathizing stage of the design thinking process affect pre-service teachers' creativity differently. This study explored the effects of two commonly used empathy strategies, interview and observation, on pre-service teachers' creativity through a six-week learning design activity for pre-service teachers majoring in Science and Technology Education at a first-tier university in China. The results of this quasi-experimental research showed that the pre-service teachers using the interview empathy strategy performed better in creative problem-solving performance. While there was no significant difference in the pre-service teachers' creative thinking disposition between the two empathy strategies, the pre-service teachers using the interview strategy reported more positive creative confidence in their creativity than those using the observation strategy. This study suggests future research directions for supporting design thinking–based instructional design.

Keywords: Creativity; Creative problem-solving; Creative confidence; Design thinking; Empathy; Teacher education

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1. Introduction

Information and communication technologies (ICTs) are increasingly integrated into instruction and have the potential to enhance the effectiveness and efficiency of the teaching and learning process (Backfisch et al., 2021; Chauhan, 2017; Chen et al., 2018). Moreover, the benefits of teacher involvement in designing technology-enhanced learning (TEL) are well acknowledged (Cviko et al., 2014; Kali et al., 2015). Thus, teachers are encouraged to creatively integrate technology into their classroom instruction as designers of technology-enhanced learning (Kali et al., 2015; Kirschner, 2015). However, they are often not competent in designing TEL due to their lack of experience as participatory designers as well as the ill-structure nature of TEL design problem (Cober et al., 2015; Viberg et al., 2019). Teaching is increasingly viewed as a design science that focuses on design professionals such as architects, engineers, and programmers and how they solve design problems creatively (Laurillard, 2013). Therefore, it is important to consider how teachers can be supported in the creative design of TEL (Kali et al., 2015; Koh & Chai, 2016). Design thinking, as a method and a framework for the design process, can be applied to support design engagement to prepare pre- and in-service teachers to become more competent and creative TEL designers (Henriksen et al., 2017; Högsdal & Grundmeier, 2021). It is particularly important to foster teachers' TEL design competence at the pre-service stage (Novak & Mulvey, 2021), and design thinking is increasingly proposed to foster pre-service teachers' creativity in designing TEL in the digital age and help them meet future teaching challenges (Novak & Mulvey, 2021).

Design thinking is a human-centered approach to solving design problems (Dorst, 2011). A variety of design thinking-based learning models have been developed and applied in education and teaching (Pande & Bharathi, 2020). Among them, Stanford University's five-stage model of "empathize, define, ideate, prototype, and test" has been recognized by a large number of educational researchers (Henriksen et al., 2020; Lee et al., 2019). This design-thinking model supports the development of learners' creative problem-solving and creative confidence (Rao et al., 2022). In particular, in teacher education, researchers have emphasized the importance of design thinking for pre-service teachers (Tseng et al., 2019; Wu et al., 2019). In the context of learning design, design thinking can be used as a pedagogical approach to assist pre-service teachers in designing student-centered curricula or activities (Kickbusch et al., 2020; Tseng et al., 2019). Many studies have focused on the effects of the whole design-thinking learning model.

However, they have not recognized that the various strategies used in each stage of the design thinking model can affect pre-service teachers' creativity differently.

Among these stages, the empathy stage in design thinking, as an important step in user-needs research, has yet to be explored in terms of whether empathy strategies differ in fostering pre-service teachers' creativity. Therefore, this study aimed to explore the effects of two commonly used empathy strategies, interview and observation, on pre-service teachers' creativity.

2. Literature review

2.1. Teachers' creativity and design of technology-enhanced learning

"Creativity" refers to the ability to generate novel and useful ideas to solve problems in the process of exploring and solving practical problems (Runco & Jaeger, 2012; Sternberg & Lubart, 1998). It comprises interactions between four dimensions, including process (i.e., creative problem-solving, creative thinking), creative product (e.g., creative artefact, idea, or solution), creative person (e.g., disposition, aptitude), and press or environment, also known as 4P model (Ma, 2009; Plucker et al., 2004). Research has shown that creativity can be enhanced by engaging in design experiences (Kaufman & Beghetto, 2009; Royalty et al., 2019). In education, creativity plays an important role in teachers' ability to design effective and efficient learning activities for their students, especially in integrating technology into their instructional design. Creativity is built in to instructional design (Clinton & Hokanson, 2012). Some researchers have argued that a teacher is not only a practitioner but also a designer (Bressler & Annetta, 2022; Henriksen et al., 2020; Retna, 2016). Creative teachers are more competent to deal with the complex and diverse problems of teaching practice and are more creative in targeting their instructional design to improve students' academic achievement (Henriksen et al., 2017). Laurillard (2013) argued that twenty-first century education systems need teachers who can design innovative and effective instruction. In particular, designing digital learning material is a demanding task for teachers (de Jong et al., 2021).

However, teachers are often not competent in designing TEL due to their lack of experience as participatory TEL designers as well as the ill-structure nature of TEL design problem (Cober et al., 2015; Viberg et al., 2019). "Instructional design" is defined as "the science of creating detailed specifications for the development, evaluation, and maintenance of situations, which facilitate the learning of both large and small units of subject matter" (Richey, 1988). Instructional designers seek to create new instructional materials or systems in which students learn. The design problem in instruction is usually ill-structured and lacks definitive solutions (Henriksen et al., 2017; Kelley & Knowles, 2016), as neither the conditions for design nor the desired outcomes of instruction are made available to instructional designers (Rowland, 1993). Furthermore, teachers have few opportunities to design TEL materials or systems themselves, resulting in their inadequate understanding of the affordances of technologies for learning as well as learners' real needs or requirements for TEL opportunities.

2.2. Using design thinking to promote teachers' creativity

Design thinking is increasingly proposed to foster pre-service teachers' creativity in instructional design (Novak & Mulvey, 2021). It is a methodology for developing creativity (Dorst, 2011). Its core concept is user-centered design, in which problems are

identified and defined through empathy and creative ideas or innovative solutions are generated through brainstorming, prototyping, and iterative testing to creatively solve problems (Razzouk & Shute, 2012). Such a user-centered design approach aims to create artefacts, products, or services that are applicable, appropriate, and accessible to as many users as possible within the design constraints (Dong et al., 2004). Of the various design thinking models, Stanford University's five-stage model of Empathizing, Defining, Ideation, Prototyping, and Testing (EDIPT) is the most commonly used (Henriksen et al., 2017; Lee et al., 2019; Pratomo et al., 2021). "Empathizing" in this context refers to empathizing with others' thoughts, feelings, and attitudes to investigate user-needs, while "defining" is the in-depth analysis and understanding of these user-needs to define the actual problems by translating the needs into a specification for developing solutions. "Ideation" refers to the creation of ideas and solutions, and "prototyping" is the process of visual representation of the solution by the user. Finally, "testing" refers to the process of trying new solutions, further iterating, and optimizing the prototype. Some educational researchers have advocated the application of design thinking to real-life teaching practices to enhance teachers' teaching creativity. This model aligns with the competencies of the teacher as a professional designer of education. Specifically, teachers must possess the competencies of (1) gathering information about learners, (2) defining an instructional problem or diagnosing what is best for the learners, (3) designing and determining an effective and/or efficient instruction, (4) carrying out the instruction, and (5) evaluating the effectiveness and/or efficiency of the instruction (Kirschner, 2015).

Some researchers have reported the positive effects of integrating design thinking into instructional design on teachers' creativity and creative confidence. For example, Retna (2016) used the method of case study to investigate Singapore teachers' perspectives on integrating design thinking into the classroom. The results of the study's interviews showed that design thinking has the potential to improve creativity, problem-solving, communication, and cooperation skills and to foster the empathy of learners. Rauth et al. (2010) used qualitative research methods to interview 17 teachers from Stanford University in the United States and Potsdam University in Germany. They found that design thinking can foster knowledge creation at various levels and enhance creative confidence. Design thinking provides a flexible structure to guide teachers to solve problems creatively. Henriksen et al. (2017) framed their teacher education course around the design thinking model and found that teachers learned more about the application of design thinking in education, improved their ability to integrate techniques into teaching to come up with solutions systematically and creatively, and were more willing to bear failure in creative risks.

2.3. Empathy strategies in design thinking

Throughout the design thinking process, empathizing with users is considered to be a great challenge and is at the core of the user-centered design process (Carlgren et al., 2016; Glen et al., 2015). It is imperative to develop empathy for end-users at an early stage to inform the design process. The first step of any design-thinking activity is to use empathy to discover what users need, and thus explore human-driven innovation (Efeoglu et al., 2013), that is, to think and deal with problems from the perspective of others, experience their emotions and thoughts, and understand their positions and feelings (Carroll et al., 2010; Gasparini, 2015; Kouprie & Visser, 2009; Hashim et al., 2019; Simeon et al., 2022). This involves not only the recognition of users' cognition but also an in-depth understanding of user emotion with regards to products (Hashim et al., 2019; Yoon et al., 2016). Designers must observe users in action or interview them to elicit

their needs. This process helps designers to develop empathy for the end-users. Designers' ability to precisely recognize users' needs supports their determination of the intention of their design (Yoon et al., 2016). Designers can only design novel and useful products when they truly understand the users' needs.

Accordingly, in the context of education, teachers should understand their students' learning needs and difficulties and design with the students in mind. TEL design is mostly influenced by practical concerns. In education, the empathy stage focuses on the learners' experience. Teachers can identify and understand the needs of their students, e.g., the students' difficulties in learning, to define the instructional problem in an empathetic way (Boschman et al., 2014). Teachers can use certain strategies to develop empathy for their students (Ní Shé et al., 2022; Retna, 2016). During the empathy stage, designers can empathize and understand user needs through empathy strategies such as role-playing, observation, and interview (Ní Shé et al., 2022).

In the stage of empathizing, many scaffolding strategies can be applied to capture users' needs. Among them, observation and interviews are commonly used in the empathy stage to capture the real needs of intended users (Hashim et al., 2019). Observation aims to capture the user's perspective by noting their behavior in the context of their own environments, watching how they interact with their surroundings, and capturing and recording their "actions" (Kouprie & Visser, 2009). Through the process of observation, designers can confirm who the user is; when, where, what, and how to use the acquired information and knowledge; and what the core data are for product development and problem-solving (Cotton et al., 2010).

Interviewing is a method of communication that can encourage users to describe their vision of a desired product and to express their practical needs. Interviewing can obtain a broad array of target users' views. Furthermore, considering target users' responses and requirements can stimulate designers' creativity in the design process (Wagner & Jiang, 2012; Yoon et al., 2016). Designers should formulate an interviewing outline or questionnaire in advance based on the design purpose, and then collect relevant information in a comprehensive and planned way to prepare for further analysis of the relevant requirements (Mohedas et al., 2022).

Such observations and interviews influence the efficiency and quality of the subsequent stages of design thinking of defining problems, conceptualizing solutions, and prototyping. However, there is a lack of studies investigating the effects of these two empathy strategies on teacher-designers' creativity in designing TEL.

3. Research questions

This study aimed to explore the effects of two empathy strategies, interview and observation, on pre-service teachers' creativity. We focused on the following three research questions:

1. Is there any difference in creative problem-solving performance between pre-service teachers using the interview empathy strategy and those using the observation empathy strategy?
2. Is there any difference in creative thinking dispositions between pre-service teachers using the interview empathy strategy and those using the observation empathy strategy?
3. Is there any difference in creative confidence between pre-service teachers using the interview empathy strategy and those using the observation empathy strategy?

In addition, this study surveyed pre-service teachers to further explore their perceptions of important stages in the design-thinking process and their learning gains.

4. Methods

4.1. Research design

This study used a quasi-experimental design to investigate the effects of the interview and observation empathy strategies used in the design-thinking process on pre-service teachers' creative problem-solving performance, creative thinking disposition, and creative confidence. The pre-service teacher participants' learning task in the study was to use design thinking to design a digital learning system for potential student users.

4.2. Participants

This study used a quasi-experimental approach. Pre-service teachers majoring in Science and Technology Education (N = 23) from a first-tier university in China participated in this study. They had no experience of designing a TEL system. The pre-service teachers were randomly assigned to the experimental and control conditions, with 11 in the experimental condition and 12 in the control condition. They were further randomly divided into smaller groups of three members, with one group in the experimental condition having only two members.

4.3. Procedure

To investigate the effects of the two empathy strategies, interview and observation, on pre-service teachers' creativity in terms of the teachers' creative problem-solving performance, creative thinking disposition, and creative confidence, this study was based on an authentic, classroom-based design thinking activity. The participants in the two conditions were taught face-to-face by the same teacher. The experiment lasted for six weeks, with four 45-min sessions per week. The learning task of the experiment was to collaboratively investigate the learning difficulties of primary- or secondary-school students in their science classes (physics, chemistry, biology, geography, etc.), define the problem to be solved (e.g., learning about "atmospheric pressure" in physics), and develop a prototype of a learning system or website by using Axure software (shown in Fig. 1).

The course activities were designed using the EDIPT design-thinking model as a guideline. Thus, the pre-service teachers were required to work in groups to complete the learning activities through the stages of empathy, definition, ideation, prototyping, and testing. The six-week course activities were organized as follows.

In the first week, the instruction focused mainly on the course introduction. The course teacher introduced the learning task and the design process and described how to identify user needs (approximately 45 minutes). The teacher conducted a 45-minute training session on Axure software usage. The pre-service teachers then spent 90 minutes practicing with the Axure software.

After the sessions of the first week ended, the pre-service teachers began to empathize with potential users, i.e., primary- or secondary-school students. They tried to recognize and understand the users' needs using either the interview (experimental

condition) or observation (control condition) strategies. The pre-service teachers in the experimental condition contacted several primary or secondary students and developed their interview outline. Examples of their interview items are: “In which science subject do you have learning difficulties?”, “What concepts do you have problems with within this course?”, “What is the specific problem?”, “How would you like to be helped?”, and “Which style of digital learning system do you like?” The pre-service teachers in the control condition used direct classroom observation to identify the learning difficulties of the primary or secondary students, who were in the same class as the interviewed students. In the classroom, the pre-service teachers observed these students in their learning and thought about what they might be struggling with in their learning.

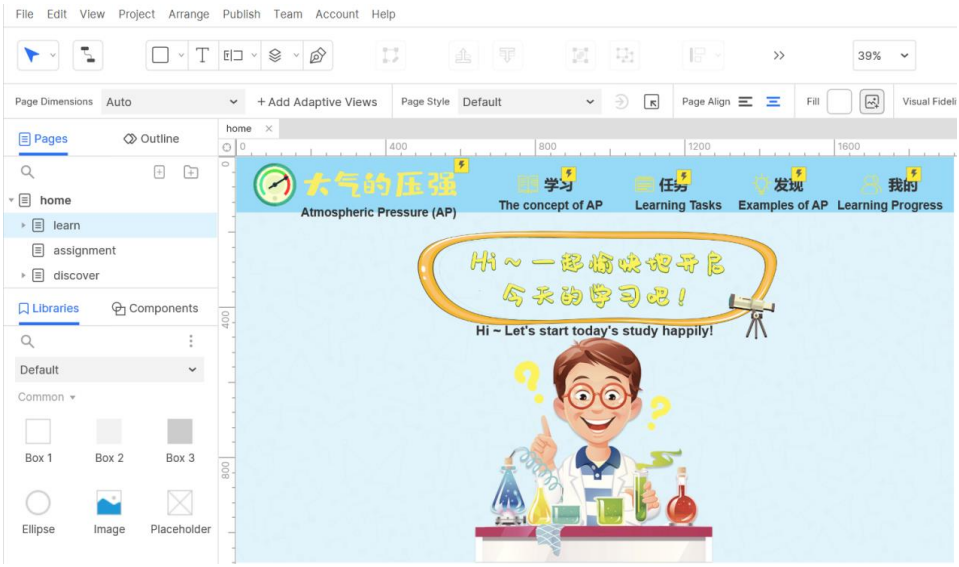

Fig. 1. “Atmospheric Pressure” prototype (website) designed by pre-service teachers

From the second week to the fifth week, the pre-service teachers were required to collaboratively define their problem of focus, brainstorm through ideation, and prototype and test the designed websites. First, the pre-service teachers applied their subject knowledge to identify and refine their understanding of the needs of the primary or secondary students and defined the design problem to be solved. Second, they generated creative solutions to the problem through their group members’ divergent thinking. Third, they developed and implemented their solution into prototypes, i.e., websites, using Axure software. Finally, they tested their prototypes on the basis of the user needs that were identified in the empathizing and problem-defining stages.

In the sixth week, the pre-service teachers were required to make a presentation to demonstrate their prototypes and conducted peer reviews of the other groups’ websites’ level of creativity based on the scoring criteria presented in Table 1. The teacher also evaluated the creativity and provided commentary on the websites’ design. Finally, all of the pre-service teachers completed a creativity proposition questionnaire. The learning activity flow is shown in Fig. 2.

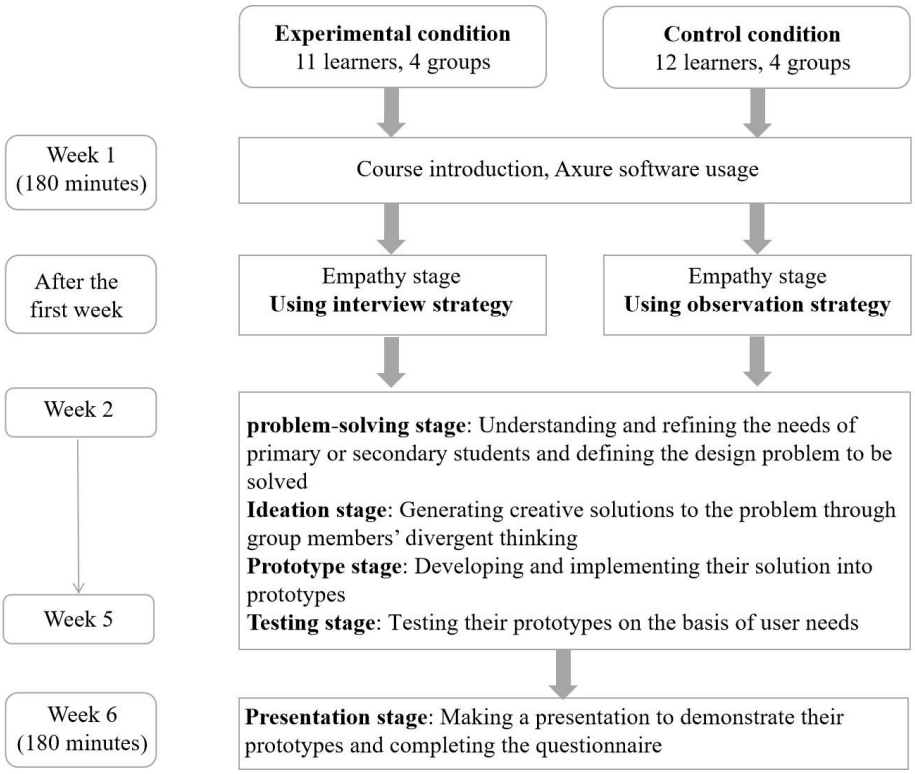

Fig. 2. Design-thinking activity flow chart

4.4. Measures

After collecting the questionnaire and survey data from the pre-service teachers during design-thinking learning activities and analyzing the data using a combination of quantitative and qualitative methods, this study evaluated the pre-service teachers' creativity from three dimensions: (1) creative problem-solving performance as displayed in the group products, (2) creative thinking disposition and (3) creative confidence as measured by the post-course questionnaire.

4.4.1. Creative problem-solving performance

The pre-service teachers' creative problem-solving performance was measured based on the creativity of the group prototype product. In the prototype presentation stage, each group elaborated on the results of their analysis of the users' needs, the problem to be solved, the conceptual design through ideation, and the final work presentation. The evaluation of their creative problem-solving performance included four aspects: empathy, problem definition, ideation, and prototype presentation. The specific elements of the evaluation are shown in Table 1. The total score was 100, with the teacher's and peer groups' evaluations each accounting for 50%.

Table 1
Scoring criteria for prototype presentation

Dimension	Description	Score
Empathy	The group recognizes and is able to give a clear summary of the users' needs.	20
Problem definition	The group is able to analyze and understand the problems of the users' learning and define the problems to be solved.	20
Ideation	The group proposes prototyping solutions (including the design of learning goals, content, and activities) that address the needs/problems of the users.	20
Prototype presentation	The group's prototype design is logically complete and clear and fits the users' needs, and the design of the learning activities is novel and innovative, in contrast to traditional teaching.	40

4.4.2. Creative thinking disposition and creative confidence

We selected the widely used Creative Thinking Disposition Scale (Runco et al., 2001) and the Creative Confidence Scale (Royalty et al., 2014) to measure the participants' self-perceptions of their creativity. Example items of the Creative Thinking Disposition Scale are "I have many wild ideas" and "I have always been an active thinker." An example item of the Creative Confidence Scale is "I can explicitly define or describe my creative process."

4.4.3. Perceptions of the pre-service teachers

The study involved a survey conducted with the participants to explore their perceptions of the design-thinking learning activities. The survey questions were: (Q1) "Which stage of this design-thinking learning activity do you think is the most important?" and (Q2) "What did you gain from this design experience?" Content analysis was applied to the survey data to generate themes in a bottom-up manner. One person's responses to a single question could be coded into multiple themes. For example, one pre-service teacher stated, "During this activity, I learned how to collaborate and divide the work with team members and learned about basic Axure operations," which was coded into two themes, software operations/system design and facilitating teamwork. The specific coding framework is shown in Table 2. The first two authors analyzed the responses in a blinded manner. Their inter-rater reliability reached 0.83. They discussed the discrepancies in the emergent themes during the coding process to reach a consensus.

5. Results and discussion

5.1. Effects of the two empathy strategies on pre-service teachers' creative problem-solving performance

To investigate the differences in creative problem-solving performance between the experimental and control conditions, this study analyzed the prototype websites. The results, presented in Table 3, show that the mean scores of each dimension were higher for the experimental condition than for the control condition. First, the experimental groups' mean score of the empathy dimension (M = 18.21) was much higher than that of the control groups (M = 14.65). This indicates that the two empathy strategies had

different effects on the pre-service teachers' empathy performance. The pre-service teachers who used the interview empathy strategy performed better in the empathy stage; as they were able to consider the users' needs more comprehensively through the interviews and were better able to meet the users' needs in the design of the prototype. In addition, the pre-service teachers in the experimental condition (M = 18.19) achieved a higher mean score on defining the problem than that of their counterparts in the control condition (M = 16.12). The pre-service teachers in the two conditions identified the users' needs using different strategies during the empathy stage, which may have led to their different definitions and understandings of the users' problems. The pre-service teachers who used the interview strategy could understand the users' needs in-depth and define the users' problems better. Moreover, they had a slightly higher mean score (M = 17.56) in the ideation dimension than did the control condition (M = 16.99). The pre-service teachers using the interview strategy may have gained a more accurate understanding of the users' information or needs; thus, they may have been able to design more creative problem solutions during the ideation stage. This phenomenon may promote participants' creative problem-solving performance (Micheli et al., 2019).

Table 2
Coding framework for pre-service teachers' interview data

Survey question	Theme	Example
Q1: Importance	Empathy	Empathy is the foundation of and prerequisite for the whole design activity, determining and influencing every step thereafter.
	Definition	We can know what the system is designed to do only when we have properly defined the problem.
	Ideation	The ideation stage helps us to quickly generate solutions to the problems.
	Prototyping	Prototyping is an important way to realize ideas.
	Testing	The testing stage allow us to make something that we are satisfied with through continuous improvement.
Q2: Learning gains	Software operations/system design	I learned the basic operation of Axure and understood the whole system design process.
	Facilitating teamwork	I thought that intragroup and intergroup communication were really important.
	Enhancing confidence	We should not be afraid of coming up with new ideas that have not been tried.
	Consolidation of subject knowledge	We reviewed what we had learned before and developed a deeper understanding.

Regarding the prototype presentation, the groups in the experimental condition performed better (M = 36.60) than the control condition (M = 35.16). The pre-service teachers' performance in the empathy stage may have further influenced their performance in the other stages of design thinking. Finally, the total score of the experimental condition (M = 90.56) was significantly higher than that of the control condition (M = 82.91). This indicates that the pre-service teachers using the interview strategy solved the design problems in a relatively targeted and creative way, as their presentation showed that they had made a clear and logical connection between users' needs and their designs. The two empathy strategies affected the pre-service teachers' problem-solving performance differently. From the perspective of developing empathy

for users, it is necessary to deepen pre-service teachers' understanding of students' needs. Problem identification and definition are the core processes in reducing complexity and identifying goal specification in creative problem-solving (Kim et al., 2022). Teachers can better solve the problems of potential users' learning situations when they reach a full understanding these problems.

Table 3
Descriptive statistics for group prototypes of the pre-service teachers using different empathy strategies

Dimension	Condition	Min.	Max.	*Mean*	*SD*
Empathy	Experimental condition (N = 4)	17.875	18.333	18.21	0.27
(Max score = 20)	Control condition (N = 4)	14.444	14.778	14.65	0.15
Defining the problem	Experimental condition (N = 4)	17.889	18.750	18.19	0.39
(Max score = 20)	Control condition (N = 4)	15.375	16.750	16.12	0.65
Ideation	Experimental condition (N = 4)	16.250	18.875	17.56	1.16
(Max score = 20)	Control condition (N = 4)	16.250	17.444	16.99	0.59
Prototype presentation	Experimental condition (N = 4)	35.667	37.75	36.60	0.95
(Max score =20)	Control condition (N = 4)	34	36	35.16	0.84
Total score	Experimental condition (N = 4)	88.125	93.875	90.56	2.60
(Max score = 100)	Control condition (N = 4)	81	84.778	82.91	1.55

5.2. Effects of empathy strategies on pre-service teachers' creative thinking disposition

To examine the differences in creative thinking disposition between the pre-service teachers in the experimental and control conditions, this study ran an independent samples *t*-test. As shown in Table 4, the results of the *t*-test show that there was no significant difference between pre-service teachers who adopted the interview strategy (M = 3.35) and those who adopted the observation strategy (M = 3.28) in terms of their creative thinking disposition (t = 0.564, p = 0.579).

Table 4
Descriptive statistics and *t*-test results for pre-service teachers' creative thinking disposition

Condition	*N*	*Mean*	*SD*	*t*(*df*)	*p*
Experimental condition	11	3.35	0.35	0.564 (21)	0.579
Control condition	12	3.28	0.23		

The results show that there was no significant difference between the two empathy strategies (i.e., interview and observation) in terms of the pre-service teachers' creative thinking disposition. As this course was guided by the same design-thinking model for both conditions, all of the pre-service teachers were required to complete the learning task in a collaborative manner following the stages of empathy, definition, ideation, prototyping, and testing. Therefore, the design-thinking learning activities did not differ significantly in terms of creative thinking disposition between the two conditions.

The participants in both conditions stated that when they encountered problems, they actively sought alternative solutions. For example, one of the pre-service teachers in

the experimental condition said, "In the prototype design, we originally wanted to set up a game of connect-the-dots, but Axure software couldn't realize this function. Later, we changed it to a drag-and-drop and button-click solution, and it worked well." Similarly, in the control condition, as one of the pre-service teachers phrased it, "When we encountered a problem, we worked together as a group, actively looked for alternative ways to solve it, and shared solutions." This further confirms that design-thinking learning activities can support pre-service teachers in solving problems creatively and developing creative thinking (O'Byrne et al., 2018). However, most of the participants reported technical problems that required a cross-disciplinary team with programming members to address.

5.3. Effects of the two empathy strategies on pre-service teachers' creative confidence

To examine the differences between the experimental and control conditions in terms of the pre-service teachers' creative confidence, this study ran an independent samples t-test. The results (shown in Table 5) show that there was a significant difference between the experimental and control conditions in terms of creative confidence ($t = 2.262$, $p < 0.05$). The pre-service teachers who used the interview strategy ($M = 3.28$) had significantly higher creative confidence than those who used the observation strategy ($M = 2.81$), indicating that these empathy strategies influenced the pre-service teachers' creative confidence differently. That is, the pre-service teachers in the experimental condition felt more confident in their creativity than those in the control condition.

Table 5
Descriptive statistics and *t*-test results for the pre-service teachers' creative confidence

Condition	*N*	*Mean*	*SD*	*t*(*df*)	*p*
Experimental condition	11	3.28	0.51	2.262 (21)	0.034*
Control condition	12	2.81	0.48		

Note. * $p < 0.05$

The positive effect of the interview empathy strategy on creative confidence can be explained as follows. In contrast to those using the observation strategy, the pre-service teachers using the interview strategy were able to directly elicit the potential users' needs (McCurdy et al., 2020). This may have allowed them to generate clearer problem definitions, take fewer detours in the design process, solve problems more efficiently, and be more confident in their creative problem solutions. Research has also found that design thinking can develop creative confidence (Balakrishnan, 2022), and our post-survey data confirms this. As stated by one of the pre-service teachers in the control condition, "When designing the general process, our group was not able to grasp the content (users' needs) well and needed to rework it many times. When I overcame some problems, I felt a small sense of accomplishment." Thus, the learners' creative confidence seems to be related to the empathy strategy adopted, which is consistent with the findings of Kelley and Kelley (2012).

5.4. Effects of the two empathy strategies on pre-service teachers' perceptions

The results of the pre-service teachers' responses to the survey questions are presented in Table 6, which includes the survey questions and themes, illustrative examples, and the frequency of each theme for each condition. The survey data were transcribed and

analyzed in Chinese. The responses from the survey quoted in the study were translated into English for presentation purposes only. The results in Table 6 indicate the pre-service teachers' perceptions of the important empathy stage of design thinking and their perceived learning gains.

Table 6
Interview results

Survey questions	Themes	Experimental condition	Control condition
Q1: Importance	Empathy	6 (54.54%)	1 (8.33%)
	Definition	1 (9.09%)	2 (16.67%)
	Ideation	3 (27.27%)	6 (50%)
	Prototyping	0 (0%)	2 (16.67%)
	Testing	1 (9.09%)	1 (8.33%)
Q2: Gains in learning	Software operations/system design	8 (50%)	9 (60%)
	Facilitating teamwork	6 (37.50%)	4 (26.67%)
	Enhancing confidence	1 (6.25%)	0 (0%)
	Consolidating subject knowledge	1 (6.25%)	2 (13.33%)

Regarding the importance of the five stages of design thinking, the majority of the pre-service teachers in the experimental condition considered empathy to be the most important stage, and none of them considered prototyping to be the most important. However, in the control condition, half of the pre-service teachers considered the ideation stage to be the most important. Another 16.67% of them considered the problem-definition or prototyping stages to be the most important stages. The reason for the difference between the two conditions is that the pre-service teachers in the experimental condition used the interview strategy in the empathy stage, thereby becoming more aware that empathy is the key to capturing user needs and is essential to the human-centered design process (Hashim et al., 2019). In contrast, the pre-service teachers using the observation strategy did not seem to fully understand user needs. Like most novice designers, they preferred to analyze the problem through discussion from their own point of view during the ideation stage. In addition, they spent more time in the definition and prototyping stages attempting to understand the users' needs.

Regarding the pre-service teachers' learning gains, four emergent themes were reported by the participants. The two main learning gains reported by the participants in both conditions were software operations/system design and teamwork skill development. Because the design-thinking activity involved designing and developing websites through group work, the pre-service teachers in both of the conditions were able to learn how to work in groups and how to develop the learning system with Axure software. Moreover, they reported gains in the consolidation of subject knowledge due to the requirement that they collaboratively investigate the learning difficulties encountered by primary or secondary students and then use their knowledge about instructional design to solve the instructional dilemma. It should be noted that 6.25% of the responses from the pre-service teachers in the experimental condition reported that the design thinking enhanced their confidence. The pre-service teachers using the interview empathy strategy were more willing to bear failure from their creative risks, which was likely to increase their confidence. In contrast, the pre-service teachers in the control condition did not report such positive perceptions.

6. Limitations and future work

This study has several limitations. First, this study only explored the effects of two empathy strategies, interview and observation, on pre-service teachers' creativity. However, there are other strategies, such as role-playing, which can also be used during the empathy stage. Second, designing a digital learning system can be challenging for pre-service teachers, who may encounter many problems with the use of technology. Insufficiency of information literacy may hinder the generation and implementation of creative idea. Therefore, in future research, online tutorial resources could be provided to pre-service teachers to facilitate their learning of the software operation. Third, design thinking has attracted an increasing amount of scholarly interest in the field of education (Henriksen et al., 2020). Teachers should take design-thinking curriculum to develop their design thinking and to use design thinking in creative TEL design.

7. Conclusion and implications

7.1. Conclusions

The design-thinking model serves as a guideline for the development of pre-service teachers' creativity. In the design-thinking model, empathy plays an important role in discovering user needs and exploring human-driven creativity. Empathizing with users during the design problem-solving process involves considering and dealing with problems from the perspective of users, attempting to understand their emotions and thoughts. In instructional design, teachers must be empathetic to potential students' needs so that they can better define the learning situation and creatively solve instructional problems.

This study used a quasi-experimental research method to investigate the effects of the empathy strategies of interview and observation, used during the design-thinking process, on pre-service teachers' creativity. The findings show that the pre-service teachers using the interview empathy strategy performed better in solving problems and reported higher levels of creative confidence, suggesting the benefits of applying the interview empathy strategy to support design thinking and complex problem-solving. Specifically, the interview empathy strategy provided the pre-service teachers with an opportunity to more deeply understand user needs and identify design problems. With a full understanding of user needs, the pre-service teachers using the interview strategy were better equipped to solve the TEL design problems. In addition, these participants had clearer definitions of the problems and took fewer detours in the design process.

7.2. Implications

The findings of this study have implications for design thinking based educational practices. First, design thinking involves supporting real-life design problem-solving, emphasizing creative solutions. Instructional designers should first identify the learning difficulties encountered by their learners so as to design learning activities that promote the learners' deep learning. They should interview their students to elicit the students' needs, thereby developing empathy for the students. Second, instructional designers must follow the "human-centered" design process, which is conducive to highlighting students' unique characteristics and giving them more thinking and learning space. Third,

design-thinking activities involve iterative processes; therefore, instructional designers must identify problems and design, modify, and improve their products iteratively.

Author Statement

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