

The Effect of Preservice English Teachers' Design Thinking on Their ICT Competencies in Hebei: The Mediating Role of ICT Integration Self-Efficacy Beliefs

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Abstract

This study explored the relationship between design thinking, self-efficacy beliefs for integrating information and communication technology (ICT), and ICT competencies of pre-service English teachers (PSETs) in Hebei Province, China. The convenience sampling is used, and participants included 350 PSETs enrolled in four teacher-training colleges in Hebei. Questionnaires were administered to the study participants using the Design Thinking Scale, ICT Integration Self-Efficacy Scale, and ICT Competencies Scale. SPSS25 and AMOS25 were used to analyze the data, and the conclusion of this study was that design thinking has a significant positive effect on ICT competencies, and ICT integration self-efficacy plays a mediating role in the effect of design thinking on ICT competencies. Based on the results of the study, a teaching reform model framework is proposed in conjunction with the English teacher-training program in Hebei Province, China, with a view to providing a reference for future English teacher-training program teaching reform.

Keywords: Pre-service English teachers, design thinking, ICT integration self-efficacy, ICT competencies

1. Introduction

In the global context of "Internet Plus", Big Data and Artificial Intelligence, teachers must be equipped with ICT competencies in order to adapt to the needs of modern education and to better guide and facilitate student learning. UNESCO's ICT Competency Standards for Teachers emphasizes that teachers need knowledge to use ICT to support constructivist learning. Effective integration of information technology into teaching and learning is an essential competency for teachers in the 21st century (Ottenbreit-Leftwich et al., 2018; Fraillon et al., 2020). Teaching with integrated technology promotes students' interest in learning and facilitates their motivation. And, English, as the second foreign language in Chinese education, some students will hold resistance and will find it boring, in today's digital age environment, English teachers' teaching has been transformed. Teachers are no longer satisfied with simply putting multimedia and pedagogy together, but are actively exploring ways to innovatively integrate technology with teaching to cope with more complex learning environments, and this integrative and innovative pedagogical approach can be better adapted to the needs of modern learning (Neal & Miller, 2006). In order to adapt to this innovative pedagogical integration, teachers need to possess the ICT competencies. However, most pre-service English teachers in China still do not have enough skills and confidence to create technology-integrated learning environments for their students.

Two important factors affecting pre-service teachers' ICT competencies are the design thinking and the self-efficacy (Abbitt, 2011; Tsai, 2015; Aslan & Zhu, 2016; Toudour et al., 2018; Alsharief, 2018). As the design thinking continues to gain popularity, the field of teacher education has attempted to use design thinking to develop teacher trainees' ICT competencies, encouraging the improvement of their own ICT competencies by designing courses, etc. Koh et al. (2015) showed through their research that design thinking is beneficial to enhancing teachers' ability to integrate technology and teaching. The University of Virginia introduced design thinking into the curriculum of teacher education students and encouraged teacher education students to use design thinking for curriculum design. It was found that ICT integration self-efficacy beliefs mediated teacher education students' ICT competencies (Wang & Zhao, 2021). Design thinking has significant and positive effects on the individuals' ICT integration self-efficacy. Researches on the relationship between ICT integration self-efficacy beliefs and ICT competencies has also found that ICT integration self-efficacy significantly and positively influences the individual's ICT competencies (Jason, 2014; Young et al., 2016). However, few studies have elaborated on the relationship between these three variables regarding pre-service English teachers; therefore, this study will explore the relationship between design thinking, ICT integration self-efficacy, and ICT competencies of pre-service English teachers.

1.1 Constructivist Learning Theory

The theoretical basis of this study is the constructivist learning theory, which emphasizes that an individual's cognitive ability and the learning process interact and promote each other. Constructivist learning theories mainly include Piaget's cognitive development theory, Vygotsky's psychological development theory, and Bruner's cognitive learning theory (Babakr et al., 2019; Stapleton & Stefaniak, 2019).

According to Bruner's cognitive learning theory, it is believed that learners construct new ideas and knowledge based on what they know, and need to make more efforts to stimulate their own motivation to learn, so that students are interested in participating in the process, and do participate in the learning actively, which in turn promotes their ability to cope with the outside world (Stapleton & Stefaniak, 2019). In other words, students construct new ideas and concepts (e.g., design thinking) by stimulating their motivation to learn (e.g., self-efficacy), which in turn affects their ability to cope with the outside world (e.g., information technology teaching and learning ability). Therefore, this study builds a relationship with the research framework that design thinking influences the ability to teach with information technology through the integration of technological self-efficacy.

1.2 Pre-service Teachers' ICT Competencies

With the advent of the digital age, the information technology capacity has become one of the 21st century skills, and the ICT competency is not only the skill of mastering information technology, but also includes problem solving, information processing, critical thinking, and creative and innovative use of information technology. Although there are some differences in the definition of ICT competency according to different researchers' perceptions and understanding perspectives, and different people or scholars have different views and perspectives on it, all of them emphasize the integration of IT technological competence into teaching and learning, and its use for teaching and learning (Koehler & Mishra, 2005; Ertmer & Ottenbreit-Leftwich, 2010; Krumsvik, 2014; Almerich et al. 2016; Farjon et al. 2019; Tondeur et al. 2018). For pre-service teachers, the development of design thinking is critical to improving their ICT competencies.

Based on the characteristics of pre-service teachers' requirements for ICT competencies, this study will adopt Almerich et al.'s (2016) two-domain model (technological competencies and pedagogical competencies) to understand pre-service teachers' ICT competencies. Where technological competencies is the need for teachers to acquire a range of knowledge and skills that will enable them to fully master the technological resources needed in their teaching practice (Almerich et al., 2016). Technological competencies further include: use of computers, basic computer applications (e.g., word processing, spreadsheet creation), multimedia applications (e.g., video editing), and information technology skills (e.g., web design, information gathering). The second aspect of pedagogical competencies is the ability of teachers to use technological resources appropriately in curriculum design and professional development and to plan their own teaching and classroom organization, which includes: planning instruction, designing learning environments that incorporate information technology, communication and innovation, and some ethical and legal issues.

1.3 The Effect of Design Thinking on ICT Competencies

Design thinking as a constructivist learning strategy enables students to be motivated to explore and solve problems, be open to ideas, and promotes their innovation and creativity (Scheer & Plattner, 2011; Scherr et al., 2012). Design thinking promotes constructivist learning in students and facilitates the development of 21st century skills, which include information technology skills (Scheer et al., 2012). Scheer et al. (2012) consider design thinking as a dynamic, non-linear framework that follows an iterative process. This process can be divided into five steps: empathise, define, ideate, prototype, and test (see Figure 1). In short, design thinking is a creative process in which problems are solved through different steps.

With the increasing popularity of design thinking in the field of education, in the field of teacher education, researchers try to use design thinking to cultivate the information technology ability of teacher trainees, and encourages the improvement of their own ICT competencies by designing courses and so on. The University of Virginia introduced design thinking into the curriculum of teacher education students and encouraged teacher education students to use design thinking for curriculum design. Koh et al. (2015) showed through their study that design thinking is beneficial to enhance teachers' ability to integrate technology and teaching. Tsai (2015) mentioned in their study that the influencing factors of ICT competencies include design thinking, which promotes teachers' use of technology. Koh et al. (2015) showed that design intention and curriculum design practices are closely related to teachers' perceptions of TPACK (Technology, Instruction, and Subject Content Knowledge Integration). Therefore, teacher educators need to actively assist teachers with intentional instructional design in order to improve their level of competency in integrating technology and instruction. It is evident that design thinking promotes ICT competencies. In Koh et al. (2015) study, it was confirmed that design thinking is used to improve teachers' instructional competence in integrating technology. Therefore, this study infers that pre-service English teachers' design thinking has a positive effect on their ICT competencies.

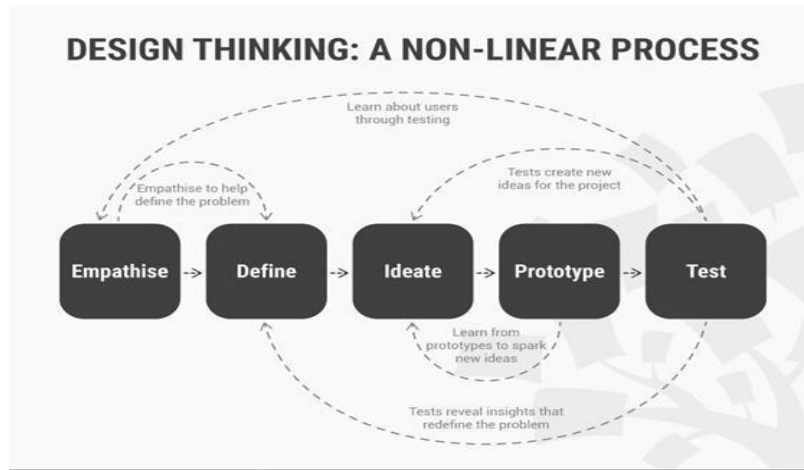


Figure 1. A model of the five stages of the design thinking process

1.4 ICT Integration Self-Efficacy Beliefs as a Mediator

The theory of ICT integration self-efficacy beliefs is derived from Bandura's (1997) theory of self-efficacy. Compeau and Higgins (1995) proposed that computer self-efficacy is a person's assessment of whether or not they can have the ability to use a computer. Kerckaert et al. (2015) suggested that communication technology self-efficacy is a person's perceived ability to use communication technology or not. Abbitt & Klett (2011) mentioned self-efficacy for integrating technology, which is mainly applied to teachers' perceptions of their ability to use technology in the classroom. Therefore, based on Abbitt & Klett's (2011), this study defines ICT integration self-efficacy beliefs as preservice English teachers' assessment of their ability to incorporate IT into their classroom instruction and to use IT effectively. The ICT integration self-efficacy beliefs has been found to be used as a mediating variable in several studies (Tsai, 2021) and mediating role in teacher trainees' ICT competencies.

1.5 Purpose of the Study

Through the literature combing, it is found that design thinking and ICT integration self-efficacy beliefs are important influencing factors of ICT competencies. However, previous literature focuses on the relationship between design thinking and ICT integration self-efficacy beliefs, or design thinking and ICT competencies, and there is no detailed research to explain how the three of them interact and influence each other. The researcher works in an English teacher education major in a local university of Hebei Province in China. As China increases the training of teacher trainees and teacher certification, the English teacher education major in which the researcher works is also facing corresponding reforms and thinking about how to train high-quality future English teachers. Through classroom lectures and extracurricular exchanges, the researcher has found that some pre-service English teachers are not innovative in classroom teaching and trial lectures, are not student-centered, and cannot calmly respond to emergencies in the class, so it is evident that there is a need to cultivate the design thinking of pre-service English teachers, which can help to enhance their ICT competencies. Through this study, practical guidance and training can be provided to English teacher trainees to help them better apply design thinking in informative teaching. At the same time, the study can also help provide students, teachers and school some related recommendations to optimize the delivery of English education and improve students' learning outcomes and proficiency in English. The following research questions guided the investigation of this study:

1. How pre-service English teachers' design thinking affects their ICT competencies.
2. How pre-service English teachers' design thinking affects their ICT integration self-efficacy beliefs.
3. How pre-service English teachers' ICT integration self-efficacy beliefs affects their ICT competencies.
4. How pre-service English teachers' ICT integration self-efficacy beliefs mediates the relationship between design thinking and ICT competencies.

2. Method

2.1 Participants and Data Collection

This study collected data from four local universities in Hebei Province, and the researcher recruited 350 senior students majoring in English teacher education. Data were collected through a questionnaire sent through the online platform "Wenjuanxing" (<https://www.wjx.cn>), which included contextual variables as well as scales for design thinking, ICT integration self-efficacy beliefs, and ICT competencies, and the questionnaire included the content informing the participants of the purpose of the study, the content of the questionnaire, the guarantee of confidentiality, and the time needed to finish the questionnaire. Therefore, pres-ervice teachers who completed this survey were considered to have consented to the data collection.

2.2 Instruments

2.2.1 ICT Competencies

A variety of scales for ICT competencies are now available, with varying emphases, and can be broadly categorized into two types: self-reported measures (Tondeur et al., 2017) and performance-based measures (Aesaert et al., 2015). Taking into account the characteristics of the object of this study (pre-service English teachers), Tondeur et al.'s (2015) scale developed for pre-service teachers to measure ICT competencies will be used. The scale consists of 19 items, each of which is scored on a 5-point Likert scale ranging from 1 for "Strongly Disagree" to 5 for "Strongly Agree". The overall Cronbach's alpha reliability coefficient for the scale is 0.89, which indicates that the scale has the good reliability (Tondeur et al., 2015), and is categorized into two dimensions: the ability to use ICT for facilitating student learning competencies in using ICT (ICTC-PU) and the ability to manage ICT for their own teaching purposes (ICTC-ID). The items are shown in Appendix A.

2.2.2 Design Thinking

This study utilized the Design Thinking Instrument developed by Cai and Yang (2023) to measure teachers' design thinking based on the five stages of the design thinking process. The scale consists of 17 items, each of which is scored on a 5-point Likert scale from 1 for "never" to 5 for "always". The scale is organized into four dimensions: empathise and define, ideate, prototype, and test. The Cronbach's alpha reliability coefficient for each dimension of the scale ranges from 0.86 to 0.88, indicating good reliability. The items are shown in Appendix B.

2.2.3 ICT Integration Self-Efficacy Beliefs

The ICT integration self-efficacy beliefs scale was utilized as developed by Wang et al. (2004) to measure pre-service teachers' perceptions of their confidence in being able to integrate technology in the class. The scale consists of 16 items on a 5-point scale, with participants indicating that they agree with each statement on a scale of (1-strongly disagree, 5-strongly agree). Item scores were summed to form a total score for ICT integration self-efficacy beliefs, with higher scores indicating stronger beliefs. According to Wang et al. (2004), the internal consistency reliability coefficient of the scale reached 0.96, indicating that the scale is highly reliable. The items are shown in Appendix C.

3. Results

3.1 Descriptive Analysis

In the 350 samples of this study, the two background variables of gender and places of origin were examined, and the results showed that, in terms of gender, 173 male pre-service teachers, was the 49.4% of the sample, and 177 female teachers, was the 50.6% of the sample; in terms of places of origin, 187 pre-service teachers, 53.4% of the sample, came from the rural areas, and 163 from the urban areas, was the 46.6% of the sample; the above data showed that in this sample, the proportion of male and female students is equal, and there are more pre-service English teachers from rural areas than from urban areas. As shown in Table 4.1:

Table 4.1 Statistical tables on demographic variables

Demographic Variables	Categorization	Frequency	Percentage
Gender	male	173	49.4%
	female	177	50.6%
Places of Origin	urban areas	163	46.6%
	rural areas	187	53.4%

The analysis shows that all three variables and their dimensions are in the medium to high range, as shown in Table 4.2:

Table 4.2. Descriptive Statistics

Dimensions	Items	M	SD
Empathise & Define	6	3.318	.946
Ideate	4	3.331	.971
prototype	3	3.443	1.012
Test	4	3.343	.989
Design Thinking	17	3.349	.717
ICT Integration	16	3.295	.994
Self-efficacy			
ICTC-PU	11	3.344	.963
ICTC-ID	8	3.356	.995
ICT Competencies	19	3.349	.841

3.2 Variance Analysis

The Independent Samples T-test was used to analyze the differences in design thinking, ICT integration self-efficacy, and ICT competencies among pre-service English teachers of different genders and places of origin. It showed design thinking, ICT integration self-efficacy, and ICT competencies were significantly different across gender and places of origin.

3.3 Correlation Analysis

In this study, Person correlation analysis was used to analyze whether there was a correlation and the degree of correlation among the three variables.

Analyzing the Person correlation coefficients, the results showed that design thinking was moderately positively and significantly correlated with ICT integration self-efficacy, design thinking was moderately positively and significantly correlated with ICT competencies; and ICT integration self-efficacy was moderately positively and significantly correlated with ICT competencies. As shown in Table 4.3:

Table 4.3. Correlation Analysis

Variables	1	2	3
Design Thinking	1		
ICT Integration Self-efficacy	.600***	1	
ICT Competencies	.678***	.607***	1

Note: *p<0.05 **p<0.01 ***p<0.001.

3.4 Regression Analysis

Regression analysis comes further to explore the explanatory and predictive relationships among variables on the basis of linear relationships. In this part, linear regression and multiple regression analyses were used to understand the effects of pre-service English teachers' design thinking and ICT integration self-efficacy on ICT competencies and the mediating role of ICT integration self-efficacy between design thinking and ICT competencies, respectively.

3.4.1 Regression Analysis of Design Thinking on ICT Competencies

Regression analysis was used to test the effect of English preservice teachers' design thinking on ICT competencies. In the regression model, the regression model of design thinking on ICT competencies was established with ICT competencies as the dependent variable and design thinking as the independent variable, and in the regression, each demographic variable (gender, places of origin) was rearranged into a dummy variable, and female students and rural areas were used as the reference groups respectively. This is shown in Table 4.4:

Table 4.4. Regression Analysis of Design Thinking on ICT competencies

Controlled Variable	Dependent Variable:ICT Competencies				
	B	SE	β	p	VIF
male	.212***	.049	.126***	.000	1.241
urban	- 1.015***	.053	- .602***	.000	1.432
Independent Variable					
Design Thinking	.372***	.037	.317***	.000	1.459
R ²			.765		
Adj R ²			.763		
F			375.055***		
df			(3)		

Note 1: *p<0.05 **p<0.01 ***p<0.001;

Note 2: “female”、 “rural areas”as the reference group.

After controlling for demographic variables, the results showed that the design thinking of pre-service English teachers in Hebei Province, China, significantly and positively affects ICT competencies in this study.

3.4.2 Regression Analysis of Design Thinking on ICT Integration Self-Efficacy

Regression analysis was used to test the effect of design thinking on the ICT integration self-efficacy of English pre-service teachers. Through these analyses, design thinking significantly and positively influenced ICT integration self-efficacy among English pre-service teachers in Hebei Province, China in this study. This is shown in Table 4.5:

Table 4.5. Regression Analysis of Design Thinking on ICT integration self-efficacy

Controlled Variable	Dependent Variable:ICT integration self-efficacy				
	B	SE	β	p	VIF
male	1.041***	.073	.524***	.000	1.241
urban	- .213***	.079	- .107***	.000	1.432
Independent Variable					
Design Thinking	.469***	.055	.339***	.000	1.459
R ²			.620		
Adj R ²			.617		
F			188.345***		
df			(3)		

Note 1: *p<0.05 **p<0.01 ***p<0.001;

Note 2: “female”、 “rural areas”as the reference group.

3.4.3 Regression Analysis of ICT Integration Self-Efficacy on ICT Competencies

Regression analysis was used to test the effect of pre-service English teachers' ICT integration self-efficacy on ICT competencies. Through the analysis, the ICT integration self-efficacy of English pre-service teachers in Hebei Province, China, in this study significantly and positively affected ICT competencies. This is shown in Table 4.6:

Table 4.6. Regression Analysis of ICT integration self-efficacy on ICT competencies

Dependent Variable:ICT Competencies					
Controlled Variable	B	SE	β	p	VIF
male	.081***	.066	.048***	.000	1.955
urban	- 1.138***	.054	- .675***	.000	1.301
Independent Variable					
ICT integration self-efficacy	.213***	.035	.251***	.000	2.181
R ²			.725		
Adj R ²			.722		
F			303.633***		
df			(3)		

Note 1: *p<0.05 **p<0.01 ***p<0.001;

Note 2: “female”、 “rural areas”as the reference group.

3.4.4 The Mediating Role of ICT Integration Self-Efficacy between Design Thinking and ICT Competencies

This study refers to Baron and Kenny (1986) to propose the mediation effect test, the mediation effect should meet three conditions: A. the independent variable has a significant predictive effect on the dependent variable; B. the independent variable has a significant predictive effect on the mediator; C. the independent variable and the mediator are added into the regression model at the same time to predict the dependent variable, the mediator has a significant predictive effect, and the independent variable will have a significant predictive effect. The predictive effect will decrease significantly, if after the decrease, the independent variable has no significant predictive effect on the dependent variable, then it is called fully mediation; if after the decrease, the independent variable still has significant predictive effect on the dependent variable, then it is called partial mediation.

Since there were significant differences in the ICT integration self-efficacy and ICT competencies among pre-service English teachers of different genders, as well as significant differences in the self-efficacy of ICT integration self-efficacy and ICT competencies among pre-service English teachers of different places of origin, the contextual variables (gender and places of origin) were used as control variables in the regression model of the present study. The results showed that ICT integration self-efficacy had a significant effect on ICT competencies, while the Design Thinking standardized coefficient decreased but still had a predictive effect, suggesting that ICT integration self-efficacy partially mediated the effect of Design Thinking on ICT competencies, as shown in Table 4.7:

Table 4.7. The Mediating Role of ICT Integration Self-Efficacy between Design Thinking and ICT Competencies

Item	Model	Mode2	Mode3
	ICT Competencies	ICT Integration Self-efficacy	ICT Competencies
Controlled Variable	Beta	Beta	Beta
male	.126	.524	.069
urban	- .602	- .107	- .590
Independent Variable			
Design Thinking	.317	.339	.280
Intermediate Variable			
ICT Integration Self-efficacy	-	-	.109
R ²	.765	.620	.769
Adj R ²	.763	.617	.767
F	375.055	188.345	287.663
df	(3)	(3)	(4)

Note 1: *p<0.05 **p<0.01 ***p<0.001;

Note 2: “female”、 “rural areas”as the reference group.

The mediation test was further conducted using Bootstrap test, which refers to whether the 95% confidence interval of the product term (a*b) of the regression coefficient a and regression coefficient b includes the number 0; if the 95% confidence interval does not include the number 0, it means that there is the mediation; if it is said that the 95% confidence interval includes the number 0, it means that there is no mediation. In this study, the mediating effect was further validated. As shown in Table 4.8:

Table 4.8. Bootstrap Analysis

Name	Effect	BoostSE	Bootstrap's 95%CI	
			LLCI	ULCI
Total Effect	.371	.036	.0001	.299
Direct Effect	.328	.040	.0001	.249
Indirect Effect	.043	.014	.015	.072

Through the above analysis, the ICT integration self-efficacy of Chinese pre-service English teachers in Hebei Province in this study had a mediating role in design thinking on ICT competencies.

4. Discussion

4.1 Discussion of Results

The purpose of this study was to explore the relationships among design thinking, ICT integration self-efficacy, and ICT competencies. It was found that: (1) design thinking had a significant positive effect on ICT competencies; (2) design thinking had a significant positive effect on ICT integration self-efficacy; (3) ICT integration self-efficacy had a significant positive effect on ICT competencies; and (4) ICT integration self-efficacy partially mediated the relationship between design thinking and ICT competencies.

Through the descriptive analysis of the three variables, the design thinking, ICT integration self-efficacy, and ICT competencies of pre-service English teachers in Hebei Province, China, were at a moderately high level. Data analysis of differences in design thinking, ICT integration self-efficacy, and ICT competencies of pre-service English teachers by different background variables (gender, places of origin) showed that male students were at higher levels than female students on all three variables, which is in line with the findings of previous studies (Fackme et al., 2001; Isabel & Cristina, 2021; Ozdal, 2021; Muhsin, 2022). Pre-service English teachers from rural areas were significantly higher than those from urban areas on all three variables, in line with the findings of other researchers (Conceicao et al., 2016; Elmedina, 2022).

4.2 Suggestion

In response to the above findings, the design thinking, ICT integration self-efficacy, and ICT competencies of pre-service English teachers in Hebei Province, China, were at a medium-high level, but ICT integration self-efficacy was the lowest among the three variables, and empathise and definition were lower in design thinking relative to the three design thinking processes of ideate, prototype, and test, which means that the pre-service English teachers were still relatively poor in terms of their ability to introduce design thinking into the curriculum. In addition, pre-service English teachers' ability to use information technology for their own teaching is lower relative to their ability to support students' use of it, and pre-service English teachers should also improve their own ICT competencies so that they can better integrate information technology in the class and better promote students' application of information technology.

Based on the above analysis, this study makes the following recommendations for pre-service English teacher in Hebei Province, China, in the hope of promoting their design thinking, ICT integration self-efficacy, and ICT competencies.

As a full-time teacher of English teacher training major, pre-service English teachers' learning during school is very important for their later entry into the workplace, so design thinking should be appropriately integrated into the curriculum of English majors to cultivate students' design thinking skills. According to Carroll et al.'s (2010) design thinking process model (Figure 1), in which empathise is understanding and observing, define is to form the content by oneself, ideate and prototype is to conceptualize the problem, and finally testing. A curriculum model based on design thinking was created to develop students' design thinking skills by taking *Comprehensive English* for example, a basic course for English teacher trainees, as shown in Figure 2. *Comprehensive English* is a basic compulsory course for English teacher trainees and a necessary course for pre-service English teachers to build up their basic skills, and a text will be selected for each lesson, through which students have to master the corresponding language knowledge as well as fulfill the relevant emotional objectives.

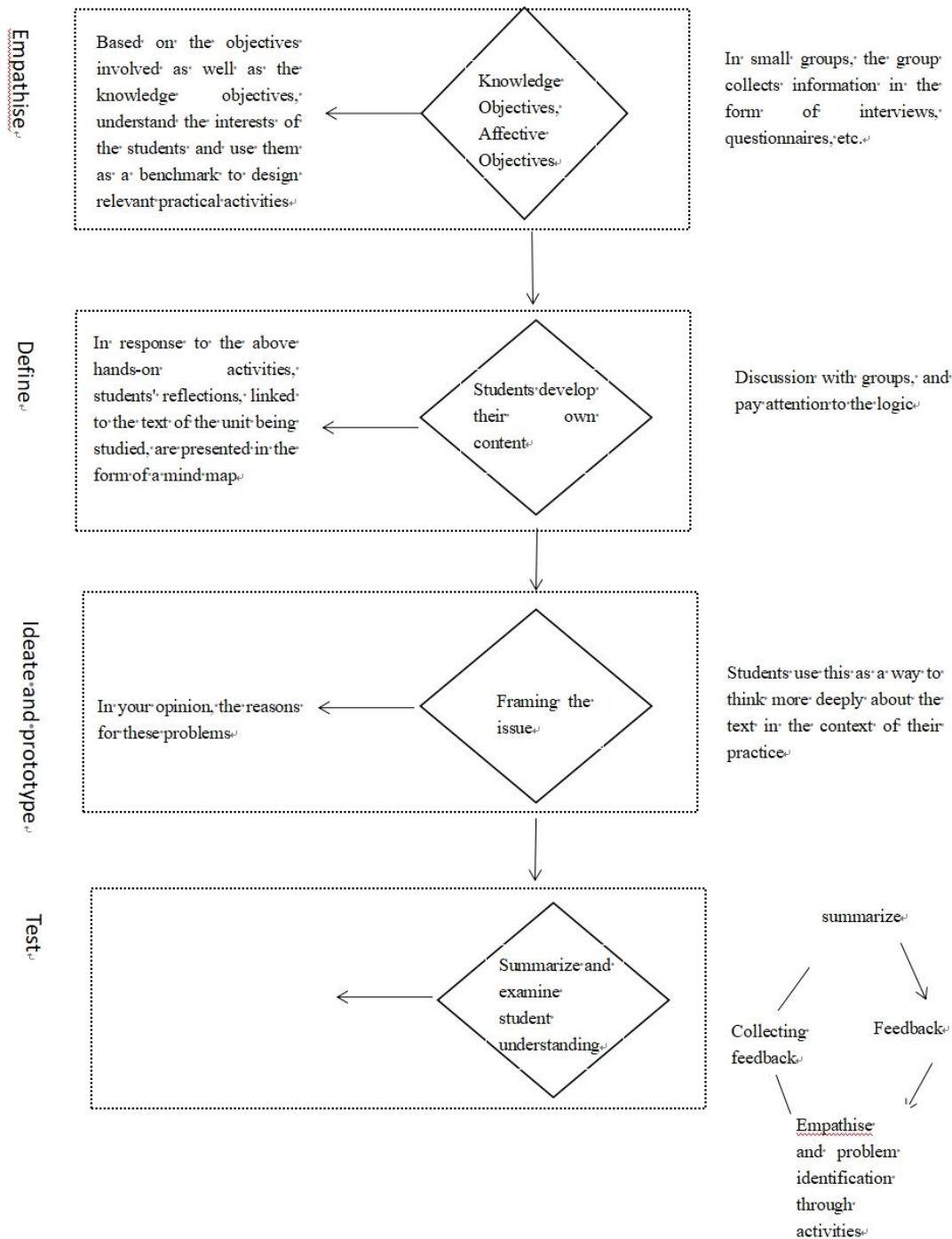


Figure 2. Curriculum Design

In the part of empathise, to be student-centered, increase students' interest in learning, teachers in the introduction part of the course, analysis of students' interest points, arranged in small groups as a unit of the relevant activities, to promote students' understanding of the text and observation; Definition of the part of the students according to the relevant activities, summarize the knowledge related to the text as well as the emotional point of view, through the form of a mind map, clearly organized in the class to carry out. In this process, students focus on the cultivation of logical ability; conceptualization and prototype are put together, the prototype is the formation of the framework, then students after the above two processes, have a clear understanding of the content of the article, the knowledge learned and the expression of emotions, then this step requires students to think deeply about the content and the article, to find the problem and summarize the problem; and finally, according to the problems found and summarized, combined with the content obtained in the previous three processes, the students will be able to make a clear understanding of the content of the text and the emotions. Finally, based on the problems identified and summarized, combined with the content gained in the previous three processes, a textual description is formed. In these processes, teachers should

combine the characteristics of the students to design and do activities that can arouse students' interest, so that students are interested in participating in the learning activities, collect students' feedback and provide timely feedback on the students' content, so as to achieve mutual understanding between the two sides. In the ideation step, students are encouraged to increase their creativity through brainstorming, conscious collaboration and acceptance of all contributions. All of the steps require students to integrate information technology, which improves their information technology skills, and through these activities, students' self-confidence is increased, which is conducive to their self-efficacy in integrating technology.

In addition, teacher training colleges should carry out corresponding teaching reforms, encourage teachers to integrate ICT competencies supported by design thinking into teaching; provide relevant hardware facilities and related training, so as to carry out reforms from the ground up, so that English teacher trainees can integrate design thinking and ICT competencies from the basic courses, and lay a good foundation for their future teaching work.

4.3 Limitations and Direction for the Future Studies

Although this study has achieved some expected results, there are still some shortcomings due to the limitations of the researcher's research capacity and capability. In terms of sampling, due to the researcher's time and ability, the sample of this study was limited to pre-service English teachers in four teacher training colleges in Hebei Province, China, and it was not possible to take into account pre-service English teachers in other provinces, thus limiting the interpretation of the findings and the inferences. In future studies, it would be useful to extend the scope of the study to include pre-service English teachers in other provinces of China in order to expand the sample size and collect more comprehensive information. Moreover, it would be more meaningful if more pre-service English teachers could be comprehensively examined.

5. Conclusion

This study shows that design thinking influences pre-service English teachers' ICT competencies, so it is necessary to integrate design thinking into the curriculum in order to develop their design thinking skills. In addition, as the demand for online or hybrid courses continues to grow, especially in language teaching and learning environments, where the difficulty of planning and implementation is often underestimated, design thinking can also serve as a framework for evaluating best practices (Kelly & Emma, 2020). Therefore, further research into the integration of design thinking into English language programs for teacher education is necessary.

Encourage schools as well as teachers to integrate design thinking into English teacher training courses, form a specialized course design team composed of teachers, and carry out teaching reforms, which can not only cultivate the design thinking ability of teachers, but also cultivate the design thinking ability of students from the basis, which is conducive to the improvement of their future teaching ability.

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Appendix A

ICT Competencies

Dimension	No.	Content
	ICT1	1.I am able to motivate pupils to use ICT in a positive way.
	ICT2	2.I am able to stimulate pupils to use ICT in a critical manner.
	ICT3	3.I am able to provide pupils with activities to exercise knowledge/skills by means of ICT.
	ICT4	4.I am able to provide pupils with activities on subject matters to learn with ICT.
	ICT5	5.I am able to offer pupils opportunities to express ideas in a creative way by means of ICT.
	ICT6	6.I am able to support pupils in searching information by means of ICT.
	ICT7	7.I am able to support pupils in processing and managing information by means of ICT.
	ICT8	8.I am able to support pupils to present information by means of ICT.
	ICT9	9.I am able to support pupils to communicate with ICT in a safe, responsible and effective way.
	ICT10	10.I am able to support pupils to work together with ICT.
	ICT11	11.I am able to educate pupils to use ICT in a conscious way (respecting ergonomics, intellectual property , etc).
ICTC-ID	ICT12	12.I am able to select ICT applications in view of a specific educational setting.
	ICT13	13.I am able to (re)design ICT applications in view of a specific educational setting.
	ICT14	14.I am able to use ICT to differentiate learning and instruction.
	ICT15	15.I am able to track the learning progress of pupils in a digital way.
	ICT16	16.I am able to evaluate pupils with the help of ICT.
	ICT17	17.I am able to use ICT appropriately to communicate with pupils.
	ICT18	18.I am able to design a learning environment with the available infrastructure.
	ICT19	19.I am able to select ICT applications effectively in creating a learning environment (eg, in view of the group size).

Appendix B

Design Thinking

Dimension	No.	Content
Empathise and Ideate	DT1	1.I try to know about the students' learning needs
	DT2	2.I encourage students to talk about how they feel during conversations.
	DT3	3.I observe students to understand them better.
	DT4	4.I try to understand students in multiple ways.
	DT5	5.I specify the difficulties in classroom instruction.
	DT6	6.I constantly summarize the characteristics of quality teaching.
	DT7	7.I generate new teaching ideas by brainstorming.
	DT8	8.I explore new ideas by reflecting on my teaching practice.
	DT9	9.I learn about teaching approaches from experienced colleagues.
Prototype	DT10	10.I get new teaching ideas by observing other teachers' classes.
	DT11	11.I go over a teaching idea with examples.
	DT12	12.I generate flow charts or outlines to visualize the instruction procedure.
	DT13	13.I draft a teaching plan to better understand a teaching approach.
	DT14	14.I test the teaching plan in an actual classroom setting.
	DT15	15.I pay attention to students' responses when I test a teaching plan.
	DT16	16.I modify a teaching plan according to students' feedback.
	DT17	17.I reflect on teaching practice to improve the teaching plan.

Appendix C

ICT Integration Self-efficacy

Dimension	No.	Content
测试 原设想	ICT Integration Self-efficacy	TIS1 1. I feel confident that I understand computer capabilities well enough to maximize them in my classroom.
		TIS2 2. I feel confident I can help students when they have difficulty with the computer.
		TIS3 3. I feel confident that I have the skills necessary to use the computer for instruction.
		TIS4 4. I feel confident that I can use the correct computer terminology when directing students' computer use.
		TIS5 5. I feel confident in my ability to evaluate software for teaching and learning.
		TIS6 6. I feel confident that I can successfully teach relevant subject content with appropriate use of technology.
		TIS7 7. I feel confident I can mentor students in appropriate uses of technology.
		TIS8 8. I feel confident I can effectively monitor students' computer use for project development in my classroom.
		TIS9 9. I feel confident I can provide individual feedback to students during technology use.
		TIS10 10. I feel confident I can consistently use educational technology in effective ways.
		TIS11 11. I feel confident I can be responsive to students' needs during technology use.
		TIS12 12. I feel confident about assigning and grading technology-based projects.
		TIS13 13. I feel confident I can regularly incorporate technology into my lessons, when appropriate to student Learning.
		TIS14 14. I feel confident about selecting the appropriate technology for instruction based on curriculum standards.
		TIS15 15. I feel confident about using technology resources (e.g, XueXiTong, Quizlet) to collect and analyze data from student tests and products to improve instructional practices.
		TIS16 16. I feel confident that I can motivate my students to participate in technology-based projects.

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