The Development of Instructional Model Based on Design Thinking and Brainstorming to Enhance Undergraduate Students' Creative Thinking Ability

Zhou Chaozheng[1,2], Bung-on Sereerat[2,*], Saifon Songsiengchai[3] & Phenporn Thongkamsuk[2]

[1]Graduate School, Bansomdejchaopraya Rajabhat University, Bangkok, Thailand

[2]Faculty of Education, Bansomdejchaopraya Rajabhat University, Bangkok, Thailand

[3]Institute of Science Innovation and Culture, Rajamangala University of Technology Krungthep, Thailand

*Correspondence: Faculty of Education, Bansomdejchaopraya Rajabhat University, Bangkok, Thailand. E-mail: bungon.se@bsru.ac.th

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Abstract

This research aimed to 1) study the factors that affect third-year undergraduate students' creative thinking ability at Baise University, 2) develop an instructional model based on design thinking and brainstorming, 3) compare third-year undergraduate students' creative thinking ability before and after using the instructional model based on design thinking and brainstorming. The sample group was 45 third-year undergraduate students at Baise University. The research Instruments were 1) an interview form about factors that affect the development of third-year undergraduate students' creative thinking ability, 2) a questionnaire about factors that affect the development of third-year undergraduate students' creative thinking ability, 3) lesson plans, 4) a creative thinking ability test 5) an interview form about opinions on teaching 6) an observation form about students' behavior. This study analyzed quantitative data through descriptive statistics, frequency, percentage, means, and standard deviation. For dependent samples, t-tests were used to analyze the different scores of undergraduate students before and after using the instructional model. Qualitative data were analyzed through content analysis. The research results were 1) the factors affecting undergraduate students' creative thinking ability include environmental factors (family, school, and society) and personal factors (personality traits, motivation, attitude, and emotional state), 2) the four components of the instructional model are principle, objective, learning process, and result, 3) after implementing the instructional model, the post-test scores of undergraduate students' creative thinking ability significantly increased, with a statistical significance of 0.01.

Keywords: instructional model, design thinking, brainstorming, creative thinking ability

1. Introduction

1.1 Rationale

Enhancing students' creative thinking ability is a primary objective of education. In its narrow sense, creativity denotes the ability most emblematic of creative individuals (Guilford, 1950). Creativity includes the dimensions of creative thinking and creative performance. Creative thinking is an internal mental state-like expression of creativity (Abbott, 2010). Creative thinking involves creating ideas, procedures, experiences, and objects (Fouladi & Shahidi, 2016). Creative thinking ability includes fluency, flexibility, elaboration, and originality, enabling an individual to produce novel, original, and appropriate thoughts (Florida, 2002; Pink, 2005, cited in Scherer, 2018). Originality is one of the most apparent creative abilities of divergent-thinking abilities, which belong to productive-thinking abilities (Guilford, 1957). This research focuses on creative thinking ability, especially originality, to produce novel, unusual, clever, remote associations, or connections ideas.

Promoting and enhancing creativity is essential for physical and mental survival (Fouladi & Shahidi, 2016). According to Battelle for Kids (2019), a national nonprofit organization, creativity is one of the learning and

innovation skills, two 21st-century skills at the center of learning. Creative thinking is considered an essential commodity of human capital (Florida, 2002; Pink, 2005, cited in Scherer, 2018), and it has many significant benefits for healthy social and emotional well-being (Skiba et al., 2010, cited in Aish, 2014). Encouraging students to engage in creative thinking ability is consistently identified as a primary objective of education (Steinbeck, 2011). So, based on socioeconomic requirements or learning theory of learning theories of Bruner, Dewey, Piaget, and Vygotsky, enhancing students' creative thinking ability is a key goal of education. In many countries such as China, Australia, Finland, Greece, Hong Kong, and the United Kingdom, enhancing students' creative thinking ability has become an essential goal of their education systems, although it is challenging (Vong, 2008; Wong, 2008; MCEETYA, 2008; Saarilahti et al., 1999; GPI, 2003; QCA, 2005, cited in Kampylis, 2010).

China attaches great importance to fostering creative talents. China insists that innovation is the primary driving force for development. Creative talent is the primary resource and the foundation of national innovation. It is the primary goal of the Ministry of Education to list “Cultivating a group of high-level talents with innovative ability” as the “Educational Revitalization Plan for the 21st Century”. In 2019, the CPC Central Committee and The State Council jointly issued “Chinese Education Modernization 2035” again, requiring strengthening and cultivating creative talents, especially first-class ones.

Chinese undergraduate students lack the consciousness and motivation for creativity. Chinese higher education students do not get enough support from their families and society to enhance their creativity (Gao et al., 2018). It is a recognized fact that Chinese university students have low creative thinking ability (Li et al., 2013). A survey on the creativity of Chinese university students shows that only 3.2% of university students think that their creativity is extreme, only 18.7% of university students think that their creativity is relatively strong, and most university students think that their creativity is average (Zhu & Liu, 2007). These researchers suggest that more educational initiatives that promote creative thinking ability among Chinese undergraduate students are necessary.

Undergraduate students’ creative thinking ability can be enhanced by using design thinking. Design Thinking is often employed to address challenging, multi-dimensional "wicked problems" that defy clear requirements and solutions (Rittel & Webber, 1973, cited in Fabri, 2015). It was used as a human-centered methodology in a design innovation program at Stanford University and at one successful design consultancy (Steinbeck, 2011). By blending empathy, creativity, and analytical processes within the design thinking framework, genuine innovation can emerge during problem-solving (Brown,2010, cited in Fabri, 2015). Steinbeck (2011) implemented design thinking as an innovation pedagogy in a university in Colombia, explored its elements, and found its potential for enhancing students' creative ability. Lima (2022) conducted a study of the effects of metacognition and design thinking on preservice teachers' creative problem-solving in a Teacher Preparation Course, and the finding indicated that the application of design thinking in the curriculum had a positive impact on creative thinking (divergent thinking), particularly in elements of originality. To enhance students' creative ability in nursing, Ekthamasuth et al. (2022) developed an instructional model named the DGR model, which was based on design thinking and reflective practice approaches. DGR model consists of the following five steps: preparation and inspiration——data discovery and problem identification——information retrieval and verification solutions——development and inspection of innovation prototypes——dissemination and reflection on learning. Implementing the DGR model enhanced nursing students' creative ability in nursing with a statistically significant level of 0.05.

Undergraduate students’ creative thinking ability can be enhanced by using brainstorming. Alex Faickney Osborn popularized the term "brainstorming." In 1939, he developed techniques for fostering creative problem-solving to bolster employees' capacity to generate inventive ideas individually for advertising campaigns. Consequently, he commenced hosting group-thinking sessions and observed a notable enhancement in the quality and quantity of ideas generated by employees. Initially labeled as “organized ideation” by Osborn, participants later coined the term "brainstorm sessions" (Parker & Begnaud, 2004). A synthesis of Wikipedia (n.d.) and the Interaction Design Foundation (n.d.) definition of brainstorming shows that brainstorming is a collaborative creativity method employed by design teams to seek solutions for specific problems. Participants find themselves in an uninhibited environment, enabling them to think more freely, generate a wide range of ideas, and establish connections between them to lay the groundwork for potential solutions. During the session, all ideas are recorded without criticism. Following the brainstorming session, the ideas are evaluated for further consideration.

In summary, creative thinking ability is essential to students, and it can be exercised and enhanced by using design thinking and brainstorming in instruction. Therefore, this research is interested in developing an instructional model based on design thinking and brainstorming to enhance the creative thinking ability of third-year undergraduate students at Baise University.

1.2 Research Questions

1) What factors affect the development of third-year undergraduate students' creative thinking ability at Baise University?

2) What are the elements of the model based on design thinking and brainstorming to enhance the creative thinking ability of third-year undergraduate students at Baise University?

3) What are the results of implementing the instructional model based on design thinking and brainstorming to enhance third-year undergraduate students' creative thinking ability at Baise University?

1.3 Objectives

1) To study the factors that affect third-year undergraduate students' creative thinking ability at Baise University.

2) To develop an instructional model based on design thinking and brainstorming.

3) To compare third-year undergraduate students' creative thinking ability before and after using the instructional model based on design thinking and brainstorming.

1.4 Research Hypothesis/Hypotheses

Undergraduate students had higher creative thinking ability after using the instructional model based on design thinking and brainstorming.

1.5 The Variables

Independent Variable*:* The instructional model based on design thinking and brainstorming.

Dependent Variable*:* Creative thinking ability.

2. Method

2.1 Population and Sample Group

2.1.1 The Population

90 third-year undergraduate students who major in pre-service primary school teachers at Baise University.

2.1.2 The Sample Group

The cluster random sampling method selected 45 third-year undergraduate students majoring in pre-service primary school teachers at Baise University in one class.

2.2 Research Instruments

1) Interview form about factors that affect the development of third-year undergraduate students' creative thinking ability;

2) Questionnaire about factors that affect the development of third-year undergraduate students' creative thinking ability;

3) Four lesson plans;

4) Creative thinking ability test;

5) Interview form about opinions on teaching;

6)Observation form about Student behavior.

2.3 Research Process

This study was conducted in three steps.

2.3.1 The process of studying factors that affect the development of third-year undergraduate students' creative thinking ability is as follows:

1) The researcher collected data on the factors that affect the development of third-year undergraduate students' creative thinking ability from 10 academic scholars or professional experts who are expert in creative thinking ability development through the interview and the questionnaire.

2) The researcher analyzed data about factors affecting undergraduate students' creative thinking ability.

2.3.2 The process of developing the instructional model

1) The researcher studied the process of developing an instructional model, the theory of design thinking and brainstorming, and the research result in step 1.

2) The researcher determined the components of the instructional model.

3) The researcher drafted the details of the instructional model based on design thinking and brainstorming: principles, objectives, learning process, and results.

4) Advisers verified details of the instructional model based on design thinking and brainstorming.

5) The researcher modified the details of the instructional model based on design thinking and brainstorming, following advisers' suggestions.

6) Five experts verified the details of the instructional model based on design thinking and brainstorming. Three were from Thailand, and the other two were from China.

7) The researcher modified the details of the instructional model based on design thinking and brainstorming, following experts' suggestions.

2.3.3 The process of experimental and improvement of the instructional model

1) 45 third-year undergraduate students who were pre-service primary school teachers in 1 class and who were enrolling in the *Primary School Mathematics Instruction Design and Implementation course* at Baise University were selected through cluster random sampling and were organized to take pretest before using the instructional model through the creative thinking ability test.

2) These 45 third-year undergraduate students learned 4 units of the Primary School Mathematics Instruction Design and Implementation course through 4 lesson plans designed according to the instructional models based on design thinking and brainstorming. They learned 8 hours per week and 16 hours in total through 2 weeks.

3) The researcher observed these third-year undergraduate students' behavior during learning and interviewed them about their opinions on teaching.

4) These 45 third-year undergraduate students were organized to take a posttest after using the instructional model through the creative thinking ability test.

5)Analyzed data and improved instructional model according to suggestions.

2.4 Data Analysis

This study analyzed quantitative data through descriptive statistics, frequency, percentage, means, and standard deviation. For dependent samples, t-tests were used to analyze the different scores of undergraduate students before and after using the instructional model. Qualitative data were analyzed through content analysis.

3. Result

Research results are presented as follows.

3.1 Results on Factors That Affect the Development of Third-Year Undergraduate Students' Creative Thinking Ability

Table 1. Summary Table of Influencing Factors

(n=10)

Factors	Ranking within sub-factors	$\overline{X}$	SD.
Environmental Factors		**4.53**	**.12237**
F1 Family	6	4.40	.14055
F2 School	4	4.59	.21628
F3 Society	5	4.50	.20412
Personal factors		**4.68**	**.17999**
F4 Personality traits	3	4.61	.19939
F5 Motivation	1	4.87	.17213
F6 Attitude and emotional state	2	4.68	.31292

Table 1 indicates that factors affecting undergraduate students' creative thinking ability include environmental factors ($\overline{X}$ =4.53) and personal factors ($\overline{X}$ =4.68). The environmental factors comprise three sub-factors: family, school, and society. Personal factors comprise three sub-factors: personality traits, motivation, attitude and emotional state. All of these factors affect the development of undergraduate students' creative thinking ability. Levels of sub-factors' affection ranks as following: motivation($\overline{X}$ =4.87), attitude and emotional state($\overline{X}$ =4.68), personality traits($\overline{X}$ =4.61), school($\overline{X}$ =4.59), society ($\overline{X}$ =4.50), family ($\overline{X}$ =4.40).

3.2 Results on the Development of an Instructional Model Based on Design Thinking and Brainstorming

The Instructional model consists of 4 components, as follows:

3.2.1 Principle

Creative thinking ability is essential to individuals and society (Florida, 2002; Pink, 2005, quoted by Scherer, 2018; Skiba et al., 2010, cited in Aish, 2014). Enhancing students' creative thinking ability is a primary objective of education (Steinbeck, 2011; Kampylis, 2010; Vong, 2008, cited in Kampylis, 2010). Originality is one of the most obvious creative abilities (Guilford, 1957). The Cambridge Dictionary defines it as the quality of being special and interesting and not the same as anything or anyone else (n.d.). This research focuses on creative thinking ability, especially originality, to produce novel, unusual, clever, remote associations, or connections ideas.

Design Thinking was used as a human-centered innovation methodology in a design innovation program (Steinbeck, 2011). One of the most renowned design thinking frameworks is Stanford University's 5-step approach: empathize, define, ideate, prototype, and test (Fabri, 2015). Undergraduate students' creative thinking ability can be enhanced by using design thinking in pedagogy (Brown,2010, cited in Fabri, 2015; Steinbeck, 2011; Lima, 2022; Ekthamasuth et al., 2022; Dam, 2023).

Brainstorming is a collaborative creativity method. Participants find themselves in an uninhibited environment, can think freely, and generate a wide range of ideas; all ideas are recorded without criticism (Wikipedia, n.d.). Brainstorming is employed in the ideation phase of design thinking (Interaction Design Foundation, n.d.). Undergraduate students' creative thinking ability can be enhanced by brainstorming (Guilford, 1981, cited in Sisk, 2021; Grieseb, 2016).

Learning the instructional model based on design thinking and brainstorming can enhance undergraduate students' creative thinking ability, especially originality.

3.2.2 Objective

Through learning based on the instructional model based on design thinking and brainstorming, undergraduate students can enhance their creative thinking ability, especially originality, to produce novel, unusual, clever, remote associations, or connections ideas.

3.2.3 Learning Process

Step 1: Empathizing

(a) The teacher introduces the learning objectives and activities, especially how to brainstorm together.

(b) The teacher teaches the undergraduate students new theoretical knowledge.

(c) The teacher provides undergraduate students with videos or case texts of scenarios of working or learning of their target groups or real users.

(d) Undergraduate students watch the videos or read the case texts. Each student analyzes the problems, wants, needs, emotions, and actions that arise when their target groups or real users work or learn.

(e) Undergraduate students share their analysis of the problems, wants, needs, emotions, and actions that arise when their target groups or real users work or learn.

(f) Undergraduate students discuss and conclude the problems, wants, needs, emotions, and actions that arise when their target groups or real users work or learn.

Step 2: Defining

(a) Each undergraduate student identifies the problems that need to be solved to provide better service guidance or support to their target groups or real users.

(b) Each undergraduate student shares the problems that they identified.

(c) Undergraduate students discuss and conclude the problems that need to be solved to provide better service

guidance or support to their target groups or real users.

Step 3: Ideate

(a) The teacher presents brainstorming rules.

(b) Undergraduate students began brainstorming and calling for ideas to solve the problems identified in step 2.

(c) Undergraduate students and their teacher work together to select the most associated ideas to solve the problems identified in step 2 and wrap up.

Step 4: Prototype

(a) Each undergraduate student designs a solution to solve the problems identified in step 2.

(b) Undergraduate students within the learning team share and help modify the solution they have designed with each other.

(c) Each undergraduate student modifies their solution texts.

(d) Undergraduate students share and test their modified solutions within the team.

(e) Each undergraduate student modifies the solution again to solve the problems identified in step 2 and identifies the best solutions.

Step 5: Test

(a) Undergraduate students implement the best solutions identified in step 4 to solve the problems identified in step 2.

(b) Undergraduate students evaluate the complete process of implementing the best solution to solve the problems identified in step 2.

(c) Undergraduate students use the results generated during evaluation to redefine one or more further problems.

3.2.4 Results

Through learning based on the instructional model based on design thinking and brainstorming, undergraduate students enhance their creative thinking ability, especially originality, to produce novel, unusual, clever, remote associations, or connections ideas.

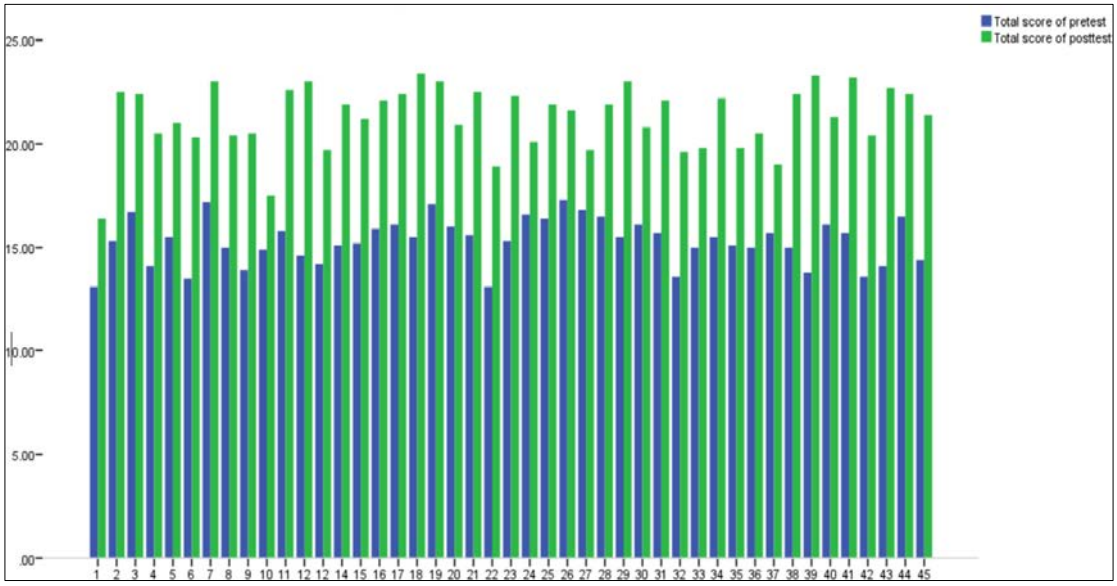
3.3 Results on the Improvement of Undergraduate Students' Creative Thinking Ability

Table 2. Comparison of Pre-Test and Post-Test

Creative thinking ability	X	**N**	**SD**	**t**	**df**	**P**
Posttest	21.28	45	1.565	27.073**	44	.000
Pretest	15.30	45	1.103			

**Statistically significant at the level. 01 ($p < .01$)

Based on Table 2, it was clear that the students' post-test score ($\bar{x}$ = 21.28, SD=1.565) was significantly higher than the pre-test score ($\bar{x}$ =15.30, SD=1.103) at a level of 0.01, t = 27.073, $p < 0.001$. This indicates that the instructional model based on design thinking and brainstorming can enhance undergraduate students' creative thinking ability.



Figures 1. Changes in Undergraduate Students' Creative Thinking Ability

Figure 1 indicates that all 45 undergraduate students enhanced their creative thinking ability by learning through the instructional model based on design thinking and brainstorming. This indicates that the instructional model based on design thinking and brainstorming is effective for all students from the sample group.

4. Discussion

The study's analytical discussion is segmented into three parts, each explored sequentially in this section.

4.1 Discussion on the Factors That Affect the Development of Third-Year Undergraduate Students' Creative Thinking Ability

The factors affecting undergraduate students' creative thinking ability include environmental and personal factors. The environmental factors include three sub-factors: family, school, and society. Personal factors comprise three sub-factors: personality traits, motivation, attitude, and emotional state. This is consistent with a study by Guilford (1950), who pointed out that environmental and individual factors influence individual creativity.

The ranking of sub-factors and their impact on undergraduate students' creative thinking ability are as follows:

4.1.1 Motivation

In the ranking of sub-factors, the first factor is motivation. This indicates that good motivation positively impacts the development of creative thinking among undergraduate students. This is supported by research from Guilford, who presented that the actual production of results of a creative nature by an individual with the necessary abilities depends on their motivational and temperamental traits (Guilford, 1950). A person may have a high level of creativity in the intellectual structure most relevant to creative production but not be motivated to utilize these abilities. In this way, the creative output may be very little. A highly creative person must be driven by curiosity; if he has this attitude, he will be more sensitive to problems (Guilford, 1986).

4.1.2 Attitude and Emotional State

Regarding sub-factors, the second factor is attitude and emotional state. This indicates that attitude and emotional state impact the development of creative thinking ability among undergraduate students. This is consistent with the results of a study from Guilford (1986), who presented: in terms of attitudes, taking gender roles too seriously, focusing too much on other norms, respecting authority figures, trying to be happy for the success of others, and lack of self-confidence can hinder creative development; in terms of emotions, prejudice, worry, anxiety, jealousy, disobedience, apathy and complacency can hinder creative development.

4.1.3 Personality Traits

In the ranking of sub-factors, the third factor is personality traits. This indicates that good personality traits positively

impact the development of creative thinking among undergraduate students. This is supported by research from Guilford, who presented that the actual production of results of a creative nature by an individual with the necessary abilities depends on their motivational and temperamental traits (Guilford, 1950); creative people must be flexible, not rigid (Guilford, 1986).

4.1.4 School

In the ranking of sub-factors, the fourth factor is school. This indicates that schools positively impact the development of creative thinking ability among undergraduate students. The following research supports this: 1) The research from Hong et al. (2009, cited in Chan & Yuen, 2014), who presented that teacher's characteristics, such as clear learning goal orientation, influence the cultivation of student creativity. 2) The research from Bramwell et al. (2011, cited in Chan & Yuen, 2014) presented that teachers' attributes, including intelligence (both intrapersonal and interpersonal), motivation, values, diligence, nonconformity, knowledge, intuition, confidence, flexibility, and energy, significantly influence their strategies for fostering creativity in students. 3) The research from Chan & Yuen (2014), who presented that school and teachers exhibiting creativity-related personality traits such as curiosity, independence, open-mindedness, persistence, unconventionality, creativity, enjoyment of experimentation, knowledgeability, strong enthusiasm and motivation for teaching and learning are more effective at fostering student creativity.

4.1.5 Society

In the ranking of sub-factors, the fifth factor is society. This indicates that society positively impacts the development of creative thinking among undergraduate students. This is supported by research from Chan and Yuen (2014), who identified community as one of two environmental factors. This is also similar to the research result from Guilford (1986), who stated that being born in a rural or urban area affects a person's creative development. However, all ten scholars or professional experts in this study doubted Guilford's (1986) research result that rural children are more creative than urban children. This may be because the gap between urban and rural areas in China has narrowed in recent years, and rural students do not necessarily face and participate in more societal problems that need to be solved than urban students.

4.1.6 Family

In the ranking of sub-factors, the sixth factor is family. This indicates that family positively impacts the development of creative thinking ability among undergraduate students. This is similar to the research result from Guilford (1986), who presented that family influence's creative ability development.

4.2 Discussion on the Development of Instructional Models

In this study, we developed an instructional model based on design thinking and brainstorming. The instructional model consists of four components: principle, objective, learning process, and result. This instructional model's learning process consists of five steps: empathizing, defining, ideating, prototyping, and testing. This learning process is consistent with Stanford University's d. school 5-step approach of empathize-define-ideate-prototype-test (Fabri, 2015; Dam,2023). This learning process is also supported by research from Ekthamasuth et al. (2022), who developed an instructional DGR model based on design thinking and reflective practice approaches. DGR model consists of the following five steps: preparation and inspiration—data discovery and problem identification—information retrieval and verification solutions—development and inspection of innovation prototypes—dissemination and reflection on learning.

4.3 Discussion on the Effectiveness of the Instructional Model in Enhancing Undergraduates' Creative Thinking Ability

Results indicate that the instructional model based on design thinking and brainstorming effectively enhances undergraduate students' creative thinking ability. The following researches support these: 1) The research from Steinbeck (2011), who implemented design thinking as an innovation pedagogy in a university in Colombia, explored its elements and found its potential for enhancing students' creative ability. 2) The research from Lima (2022), who conducted a study of the effects of metacognition and design thinking on preservice teachers' creative problem-solving in a Teacher Preparation Course, and the finding indicated that the application of design thinking in the curriculum had a positive impact on creative thinking (divergent thinking), particularly in elements of originality. 3) The research from Ekthamasuth et al. (2022), who developed an instructional DGR model based on design thinking and reflective practice approaches. Implementing the DGR model enhanced nursing students' creative ability in nursing with a statistically significant level of 0.05.

5. Conclusion

The factors affecting undergraduate students' creative thinking ability include environmental and personal factors. The environmental factors comprise three sub-factors: family, school, and society. Personal factors comprise three sub-factors: personality traits, motivation, attitude, and emotional state.

The instructional model based on design thinking and brainstorming consists of four components: principle, objective, learning process, and result. Its learning process consists of five steps: empathizing, defining, ideate, prototype, and test.

Undergraduate students' creative thinking ability was enhanced after implementing an instructional model based on design thinking and brainstorming.

6. Future Research

In the future, research can continue in the following aspects:

1) This study explored the factors influencing undergraduate students' creative thinking ability through questionnaires and interviews with 10 academic scholars or professional experts in creative thinking ability development. In the future, more experts and scholars in creative thinking ability development can be surveyed through questionnaires and interviews. Testing, questionnaires, and interviews can be conducted on undergraduate students to explore the factors influencing the development of their creative thinking ability.

2) In this study, Unit 6, Unit 7, Unit 8, and Unit 9 (four lessons and 16 hours in total) of the *Primary School Mathematics Curriculum Instruction Design and Implementation Course* were selected as the carrier and referred to the general framework of the instructional model. In the future, attempts can be made to apply this instructional model in more courses to explore and improve it.

3) This study investigated whether this instructional model could enhance undergraduate students' creative thinking ability. In the future, research can also explore whether this instructional model can enhance the development of undergraduate students' other abilities, such as critical thinking ability and design ability, reflective ability, etc.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.