THE DEVELOPMENT OF INSTRUCTIONAL MODEL BASED ON DESIGN THINKING AND BRAINSTORMING TO ENHANCE UNDERGRADUATE STUDENTS' CREATIVE THINKING ABILITY

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

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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 was conducted in three steps: studying factors that affect the development of third-year undergraduate students' creative thinking ability, developing an instructional model based on design thinking and brainstorming, and experimenting and improving the instructional model. 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 , the learning process of the instructional model is five steps: empathizing, defining, ideate, prototype, and test, 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, Enhance, Creative Thinking Ability

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Zhou Chaozheng

Contents

Contents (Continued)

List of Figures

List of Tables

Chapter 1
Introduction

Rationale

Creative thinking ability is an internal mental state-like expression of creativity. 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 (Almeida, 2008; Abbott, 2010). Creativity is the demonstrated ability to show evidence of fluency, flexibility, originality, and elaboration (Guilford, 1967). 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, quoted in Scherer, 2018). Originality is one of the most obvious 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.

Enhancing students' creative thinking ability is a primary objective of education in the word. 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, and innovation are one of 4C (creativity and innovation, critical thinking and problem-solving, communication, and collaboration), and it belongs to learning & innovation skills, which are two of the 21st-century skills at the center of learning. Creative thing is considered an essential commodity of human capital (Florida, 2002; Pink, 2005, quoted in Scherer, 2018), and it has many significant benefits for healthy social and emotional well-being (Skiba et al., 2010, quoted 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 (Kampylis, 2010), enhancing students' creative thinking ability has become an essential goal of their education systems, although it is challenging.

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”. “Mass innovation and entrepreneurship” is the call of Premier Li Keqiang in the 2015 government report. Put the training of Creative talents on a new agenda to promote the source of “Made in China 2025.” In addition, to cultivate and train a world-class contingent of scientific talents, the Ministry of Science and Technology jointly issued and implemented the Outline of the National Medium - and Long-Term Program for the Development of Human Resources (2010-2020), to provide a strong guarantee for the scientific development and construction of the country. In 2016, the Outline of the National Innovation-Driven Development Strategy, released by the Central Committee of the Communist Party of China and The State Council, unequivocally outlined China's aspirations: by 2020, China aimed to emerge as an innovative nation; by 2030, it aimed to establish itself among the leading innovative nations; and by 2050, China aimed to ascend as a global force in scientific and technological innovation. In 2019, the CPC Central Committee and The State Council jointly issued “Chinese Education Modernization 2035” again, requiring strengthening cultivating creative talents, exceedingly first-class creative talents.

Chinese undergraduate students lack the consciousness and motivation for creativity. Currently, 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 believe 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.

The researcher of this study is a teacher at Baise University who primarily teaches the course Primary School Mathematics Curriculum Instruction Design and Implementation to third-year undergraduate students majoring in primary school preservice teacher education. The course focuses on instructing undergraduates on how to become qualified primary school math teachers, specifically by teaching them how to design lesson plan and implement in Primary School Mathematics Curriculum.

During many years of teaching this course, the researcher has found that the lesson plans for Primary School Mathematics Curriculum designed by Baise University undergraduates lack innovation, and their creative thinking skills need to be improved.

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, quoted in Fabri, 2015). It was used as a human-centered innovation 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 the problem-solving process (Brown, 2010, quoted 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 is essential to students, and it can be exercised and enhanced through design thinking and brainstorming. Therefore, this research is interested in developing an instructional model based on design thinking and brainstorming to enhance the creative thinking of third-year undergraduate students at Baise University.

Research Questions

1. What factors affect third-year undergraduate students’ creative thinking ability development at Baise University?

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

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

Objectives

1. To study the factors that affect the 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 the third-year undergraduate students' creative thinking ability before and after using the instructional model based on design thinking and brainstorming.

Research Hypothesis/Hypotheses

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

Scope of the Research

Population and the Sample Group

Population:

The population of this study was 90 third-year undergraduate students who enrolled in the Primary School Mathematics Instructional Design and Implementation course in the fall semester of 2023 from Baise University. They were randomly divided into 2 classes, 45 third-year students per class.

The Sample Group:

The sample group for this study was 45 third-year undergraduate students in 1 class who were by clusters random sampling method selected from a mix of good, medium, and weak abilities and enrolled in the Primary School Mathematics Instruction Design and Implementation course at Baise University in the fall semester of 2023.

The Variables

Independent Variable:

The instructional model based on design thinking and brainstorming.

Dependent Variable:

Creative thinking ability.

Contents

In the fall semester of 2023, the researcher of this study taught the course of Primary School Mathematics Curriculum Instruction Design and Implementation to third-year undergraduate students at Baise university. In the Primary School Mathematics Curriculum Instruction Design and Implementation course, unit 6 is "lesson plan design and implementation of numbers and algebra areas in Primary School Mathematics Curriculum", unit 7 is "Lesson plan design and implementation of geometry area in Primary School Mathematics Curriculum", unit 8 is "Lesson plan design and implementation of statistics and probability areas in Primary School Mathematics Curriculum", unit 9 is "Lesson plan design and implementation of synthesis and practice areas in Primary School Mathematics Curriculum". The contents of units 6, 7, 8 and 9 of the Primary School Mathematics Instructional Design and Implementation course are suitable for using the instructional model based on design thinking and brainstorming. So based on exploring the factors that affect the third-year undergraduate students' creative thinking ability and developing an instructional model based on design thinking and brainstorming, this study carried experimentation with the instructional model in these four units to improve it and to test its influence on the development of undergraduate students' creative thinking ability. The contents of these four units are as follows:

Unit 6: Content analysis, lesson plan design, and implementation of numbers and algebra areas in the Primary School Mathematics Curriculum. In this unit, undergraduate students will analyze the content of numbers and algebra areas in the Primary School Mathematics Curriculum and learn lesson plan design and implementation, with one class and four hours.

Unit 7: Content analysis, lesson plan design, and implementation of geometry areas in Primary School Mathematics Curriculum. In this unit, undergraduate students will analyze the content analysis of geometry areas in the Primary School Mathematics Curriculum. They will learn lesson plan design and implementation of geometry areas in the Primary School Mathematics Curriculum, with a total of 1 class and 4 hours.

Unit 8: Content analysis, lesson plan design and implementation of statistics and probability areas in Primary School Mathematics Curriculum. In this unit,

undergraduate students will analyze content analysis of statistics and probability areas in the Primary School Mathematics Curriculum. They will learn lesson plan design and implementation of statistics and probability areas in the Primary School Mathematics Curriculum, with a total of 1 class and 4 hours.

Unit 9: Content analysis, lesson plan design, and implementation of synthesis and practice areas in Primary School Mathematics Curriculum. In this unit, undergraduate students will analyze the content analysis of synthesis and practice areas in the Primary School Mathematics Curriculum. They will learn lesson plan design and implementation of synthesis and practice areas in the Primary School Mathematics Curriculum, with a total of 1 class and 4 hours.

Table 1.1 Table of contents

Units	Lessons	Contents	Hours
Unit 6 lesson plan design and implementation of numbers and algebra areas in *Primary School Mathematics Curriculum*	Lesson 1	(1) Content analysis of numbers and algebra areas in *Primary School Mathematics Curriculum*. (2) Lesson plan design of numbers and algebra areas in *Primary School Mathematics Curriculum*. (3) Lesson plan implementation of numbers and algebra areas in *Primary School Mathematics Curriculum*.	4
Unit 7 Lesson plan design and implementation of geometry area in *Primary School Mathematics Curriculum*	Lesson 2	(1) Content analysis of geometry areas in *Primary School Mathematics Curriculum*. (2) Lesson plan design of geometry areas in *Primary School Mathematics Curriculum*. (3) Lesson plan implementation of geometry areas in *Primary School Mathematics Curriculum*.	4

Table 1.1 (Continued)

Units	Lessons	Contents	Hours
Unit 8 Lesson plan design and implementation of statistics and probability areas in *Primary School Mathematics Curriculum*	Lesson 3	(1) Content analysis of statistics and probability areas in *Primary School Mathematics Curriculum*. (2) Lesson plan design of statistics and probability areas in *Primary School Mathematics Curriculum*. (3) Lesson plan implementation of statistics and probability areas in *Primary School Mathematics Curriculum*.	4
Unit 9 Lesson plan design and implementation of synthesis and practice areas in *Primary School Mathematics Curriculum*	Lesson 4	(1) Content analysis of synthesis and practice areas in *Primary School Mathematics Curriculum*. (2) Lesson plan design of synthesis and practice areas in *Primary School Mathematics Curriculum*. (3) Lesson plan implementation of synthesis and practice areas in *Primary School Mathematics Curriculum*.	4

Time

From March 2023 to April 2023: Completion of the first three chapters of defense sessions.

From April 2023 to August 2023: Design of testing tools and evaluation by experts.

From September 2023 to January 2024: Conduct research

From January 2023 to February 2024: Completion and publication of research article

Advantages

1. Through learning based on the instructional model based on design thinking and brainstorming, undergraduate students can enhance their creative thinking ability. Creative thinking ability is one of the core qualities of students. After the development of students' creative thinking ability, they can benefit from their study, life, and even future work. For example, it can improve their academic performance, their competitiveness in employment, and even their quality of life.

2. The development of the instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability in this study can serve as a reference and guide for other researchers.

3. Teachers and personnel involved in instructional work in universities can use the research results as instruction guidance to enhance undergraduate students' creative thinking ability.

4. Universities can use the instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability and promote instructional reform.

Definition of Terms

The instructional model based on design thinking and brainstorming.

The instructional model based on design thinking and brainstorming refers to a systematic design process based on design thinking and brainstorming, which aims at enhancing students' creative thinking ability, especially originality. It includes four elements: principles, objectives, learning processes, and results. It focuses on a human-centered methodology through a 5 steps approach of step 1 empathizing, step 2 defining, step 3 ideates, step 4 prototype, and step 5 test.

Step 1 empathizing

Undergraduate students observe and research the problems, wants, needs, emotions, feelings, and actions that come out when target groups or real users are working or learning.

Step 2: Defining

Undergraduate students identify the problem that needs to be solved to provide better service, guidance, and support to their target groups or real users.

Step 3: Ideate

Undergraduate students began to brainstorm to call for ideas to solve the problems identified in Step 2.

Step 4: Prototype

Undergraduate students design and modify solutions to solve the problems identified in Step 2.

Step 5: Test

Undergraduate students implement the best solutions identified in step 4 to solve the problems of target groups or real users.

Creative thinking ability

Creative thinking refers to a mental step that leads to an invention, solution, or new combination, and it has to do with creativity and creating ideas, procedures, experiences, and objects. Creative thinking ability includes fluency, flexibility, elaboration, and originality. Originality is one of the most apparent creative abilities of divergent-thinking abilities, which belong to productive-thinking abilities. originality is the quality of being unique and interesting and not the same as anything or anyone else. This research focuses on originality: to produce novel, unusual, clever, remote associations or connections ideas.

Students

In this study, the third-year undergraduate students refer to the third-year pre-service primary school teachers (undergraduate students majoring in Primary Education) from Baise University in Chian.

Research Framework

The concepts used in this study mainly include construction of instructional model method (Wan, 2015)/creative thinking ability (Guilford, 1957, 1959; Guilford, 1982; Abbott, 2010; Fouladi & Shahidi, 2016; Florida, 2002; Pink, 2005, quoted in Scherer, 2018)/design thinking (Rittel & Webber, 1973, quoted in Fabri, 2015; Brown, 2010, quoted by Fabri, 2015; Steinbeck, 2011; Lima, 2022; Ekthamasuth et al.,2022) and brainstorming (Osborn,1963; Parker & Begnaud, 2004). The instructional model developed in this research contains four elements: Principle, Objective, Learning Process, and Result. The instructional model was implemented in One Group Pretest - Posttest Design to enhance undergraduate students' creative thinking ability.

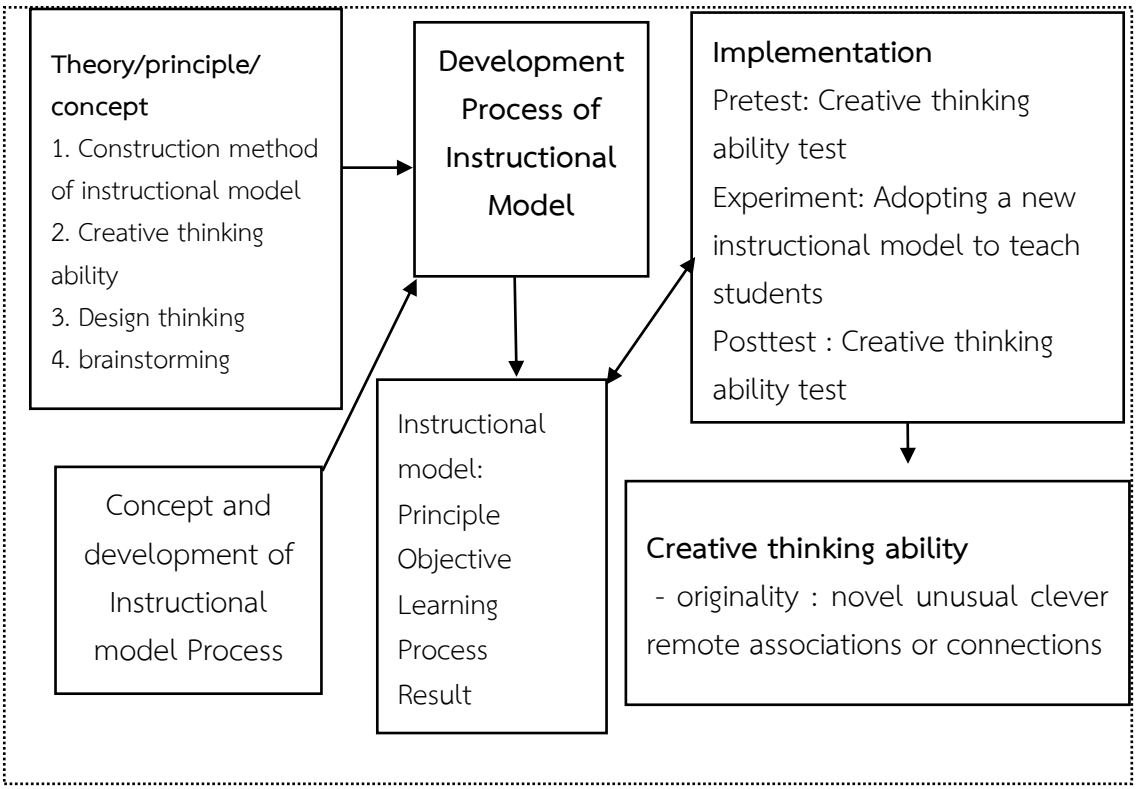

Figure 1.1 Research Framework

Chapter 2
Literature Review

This study aims to develop an instructional model based on design thinking and brainstorming to improve the creative thinking ability of undergraduate students. Therefore, the relevant literature is retrieved and reviewed in databases such as ProQuest, Web of Science/SCI, Google Scholar, China National Knowledge Infrastructure, Baidu Scholar, and other websites with the themes of design thinking, brainstorming, instructional model, and creative thinking ability.

1. Creative thinking ability
2. Instructional model
3. Design thinking
4. Brainstorming
5. Related Research

The details are as follows.

Creative thinking ability

Definition of creative thinking ability

In its narrow sense, creativity denotes the ability most emblematic of creative individuals (Guilford, 1950). It is most clearly indicated in divergent thinking (Guilford, 1957). Creativity is a stable, continuously distributed trait; It enables one to generate novel, original, and appropriate solutions (Brown, 1989; Guilford, 1950; quoted in Abbott, 2010). Creativity includes the dimensions of creative thinking and creative performance. Creative thinking is an internal mental state-like expression of creativity (Almeida et al., 2008; Abbott, 2010). By abstracting factors from activities, Guilford (1957) found that fluency, flexibility, and originality are more creative than others. Creativity is the demonstrated ability to show evidence of fluency, flexibility, originality, and elaboration (Guilford, 1967).

Some researchers believe that creative thinking transcends rationality (Guilford, 1982). Creative thinking is an internal mental state-like expression of creativity (Abbott, 2010). Creative thinking is a mental step that leads to an invention, solution, or new combination, and it has to do with creativity and 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, quoted in Scherer, 2018).

Originality is one of the most obvious creative abilities of divergent-thinking abilities, which belong to productive-thinking abilities. It refers to an individual ability to give unusual or un-common responses, remote associations or connections, or ingenious responses (Guilford, 1957). Originality was recognized as adaptive flexibility with semantic material; Individuals with originality can produce shifts or changes in meaning and come up with novel, unusual, clever, or farfetched ideas (Guilford, 1959). The Cambridge Dictionary defines originality as the quality of being unique and interesting and not the same as anything or anyone else. Originality seems to be general (Guilford, 1957).

Importance of creative thinking ability

The results of an aptitude project at the University of Southern California gained the most attention for creative thinking ability (Guilford, 1961).

Promoting and enhancing creativity are essential mysteries for both physical and mental survival (Fouladi & Shahidi, 2016).

According to Guilford's (1950) research, since 1950, there has been a broad acknowledgment, especially among individuals outside academia, of the importance of seeking knowledge about creative disposition.

Our intellectual abilities, especially our creative capacity, are our most important national resources for our way of life and our security (Guilford, 1959).

Whether based on socioeconomic requirements or the 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 (Kampylis, 2010).

It is known from the Hong Kong Curriculum Development Council (2000, 2001, quoted in Chan & Yuen, 2014) and the Education Bureau (2007a, 2007b, quoted in Chan & Yuen, 2014) that the education reform in Hong Kong at the beginning of the 21st century included creativity as an important major goal in the general school curriculum for the first time (Chan & Yuen, 2014).

Factors affecting the development of students' creative thinking ability

This review of research aims to identify and analyze the various factors that affect the development of students' creative thinking abilities. Studies have found that the factors that are most often explored in the research include intrinsic motivation, parental support, teacher support, and classroom environment.

Intrinsic motivation is the internal desire to learn that is independent of external rewards or punishments. Research has shown that students with higher levels of intrinsic motivation are more likely to engage in creative problem-solving and creative thinking. Furthermore, these students are also more likely to take risks and explore new ideas.

Parental support plays an important role in the development of students' creative thinking ability. Parents can provide a supportive environment that encourages students to think creatively. Research has shown that parents who provide positive reinforcement for creative thinking and problem-solving, as well as those who provide a positive home atmosphere, are more likely to have children who are more creative and open to new ideas.

Teacher support is also an important factor in the development of students' creative thinking ability. Teachers can provide an environment that encourages creativity by giving students the freedom to explore and take risks. Furthermore, teachers can provide feedback and guidance to help students develop their creative thinking abilities.

Finally, the classroom environment also plays an important role.

Both environmental and individual factors influence individual creativity (Guilford, 1950; Chan & Yuen, 2014).

Family influences the development of creative ability. Children from disadvantaged families were often more creative (Guilford, 1986).

School is a factor affecting the development of students' creative thinking ability. Research has found that teacher characteristics, such as clear learning goal orientation, influence the cultivation of student creativity (Hong et al., 2009, quoted in Chan & Yuen, 2014). 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 (Bramwell et al., 2011, quoted in Chan & Yuen, 2014). Teachers

exhibiting creativity-related personality traits such as curiosity, independence, open-mindedness, persistence, unconventionality, creativity, enjoyment of experimentation, knowledgeability, and strong enthusiasm and motivation for teaching and learning are more effective at fostering student creativity (Chan & Yuen, 2014).

Being born in a rural or urban area will affect a person's creative development. Rural children are more creative than urban children Guilford (1986). Community is one of two environmental factors (Chan & Yuen, 2014).

Attitude and emotional state affect the development of students' creative thinking ability. 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. Emotions such as prejudice, worry, anxiety, jealousy, disobedience, apathy, and complacency can hinder creative development (Guilford, 1986).

Motivation is a factor affecting the development of individual creative thinking ability. 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).

Personality traits including temperamental traits, and flexibility affect the development of individual creative thinking ability. 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).

Assessment of creative thinking ability

The Torrance Test of Creative Thinking (TTCT), devised by E. Paul Torrance (1962, 1974) stands out as a prominent assessment method. It Extended Guilford's idea. Its purpose is to gauge an individual's creative thinking prowess through evaluation across four distinct domains: fluency, adaptability, originality, and elaboration. Widely embraced, the TTCT finds application in both educational environments and scholarly investigations.

Additional assessment techniques have emerged, including the Creativity Assessment Procedure (CAP) and the Ideational Fluency Test (IFT). The CAP assesses individuals' capacity to generate innovative ideas and tackle problems, while the IFT

concentrates on quantifying the volume of ideas a person can generate. Both the CAP and IFT are employed to assess creative thinking skills in educational contexts and research endeavors.

In his study, Psaltis utilized Paul Torrance's Tests of Creative Thinking as the quantitative data collection instrument, demonstrating its validity for his research. Psaltis highlighted that Torrance's Tests of Creative Thinking represents the latest iteration of his assessment tool, aiming to examine intelligence through a more creative lens compared to conventional methods. Spanning over 60 years, Torrance's contributions, including his tools and concepts, hold significant prominence in creativity and gifted research. The TTCT is extensively employed for gathering quantitative data in arts programs (Almeida et al., 2008).

Instructional model

Definition of the instructional model

An instructional model serves as a structured framework guiding the organization and delivery of instruction, typically comprising a coherent sequence of activities and strategies. Key components of instructional models encompass instructional objectives, content, assessment, evaluation, and feedback. These models aid educators in designing and implementing effective instruction tailored to their students' needs. Research about instructional models has centered on their capacity to enhance student learning outcomes, including academic performance and motivation. For instance, Hwang and Tsai (2020) demonstrated that employing an instructional model emphasizing student engagement, clear objectives, and effective assessment strategies notably enhances student learning outcomes. Similarly, Chen et al. (2019) found that a model integrating collaborative learning, creative thinking, and problem-solving activities leads to improved student learning outcomes.

Classification of instructional models

Research indicates that instructional modes can be categorized into four primary types: formal, informal, blended, and self-directed. Formal instructional modes entail structured, instructor-led activities like lectures, seminars, and tutorials. Informal instructional modes, on the other hand, encompass less structured, learner-driven activities such as online learning, mentoring, and self-directed study. Blended

instructional modes amalgamate features of both formal and informal instruction, exemplified by scenarios like lectures followed by discussions or online courses with mentoring components. Lastly, self-directed instructional modes revolve around autonomous learning approaches like independent study or self-guided courses.

The first instructional model examined is the Behaviorism model, rooted in the notion that reinforcement can shape behavior. It emphasizes observable behaviors and utilizes rewards and punishments to modify behavior, proving effective for teaching fundamental skills and knowledge. However, critics argue it overlooks the learner's internal states and motivation (Gagné, 1985). The second instructional model explored is the Cognitive Model, founded on the concept that learners construct meaning from experiences and knowledge through cognitive processes. It underscores understanding how learners think and learn, fostering higher order thinking skills and recognizing the significance of internal states and motivation (Brow, et al., 1989). The third instructional model examined is the Constructivism model, which posits that learners actively construct knowledge through interactions with their environment. While effective in nurturing higher-order thinking skills, it has been faulted for its lack of structure and reliance on learner initiative (Duffy & Jonassen, 2013). The fourth instructional model explored is the Social Cognitive Model, premised on the idea that learners excel when engaged in social interactions. It underscores collaborative activities and dialogue, fostering higher-order thinking skills while accentuating the social dimension of learning.

In general, researchers have observed that various instructional modes correlate with diverse levels of student engagement, learning outcomes, and satisfaction. For instance, formal instruction excels in delivering structured learning content but may benefit from the flexibility and interactivity inherent in more informal modes. Conversely, informal instruction tends to be more engaging and interactive but may require additional structure and guidance. Blended instructional modes represent a synthesis of both approaches, offering the structured framework of formal instruction alongside the interactive elements of informal instruction. Lastly, self-directed instruction can be highly effective for motivated and disciplined learners, yet it can pose challenges in terms of monitoring and assessment.

Research trend of the instructional model

Research indicates that instructional models serve as effective tools for enhancing learning outcomes, each presenting its distinct advantages and drawbacks. While no model is flawless, each can effectively deliver instruction within the classroom. Instructional models ought to be tailored to suit the requirements of specific learning environments, incorporating active learning strategies and opportunities for students to engage in practice and receive feedback. Moreover, these models should foster student engagement, collaboration, and the cultivation of higher-order thinking skills.

In summary, extensive research has been conducted on the meaning, types, and trends in instructional models. Studies have demonstrated that instructional models can enhance learning outcomes, boost student motivation, and improve teacher efficacy and job satisfaction. Various instructional modes correlate with different levels of student engagement, learning outcomes, and satisfaction.

Design Thinking

Research on the definition of design thinking. Creative personality encompasses the patterns of traits that are typical of creative individuals. These creative patterns manifest in behaviors such as inventing, designing, contriving, composing, and planning (Guilford, 1950). According to Wikipedia's definition of design thinking, design thinking encompasses the cognitive, strategic, and practical methods employed by designers during the design process. It also encapsulates the accumulated knowledge about how individual reason while tackling design challenges. Design thinking is often employed to address challenging, multi-dimensional "wicked problems" that defy clear requirements and solutions (Rittel & Webber, 1973, quoted by Fabri, 2015). It was used as a human-centered innovation methodology in a design innovation program at Stanford University and at one successful design consultancy (Meinel, 2011). By blending empathy, creativity, and analytical processes within the framework of design thinking, genuine innovation can emerge during the problem-solving process (Brown, 2010, quoted by Fabri, 2015).

Research on steps of design thinking as a process for innovation. Meinel et al. propose a five-phase framework to describe the design innovation process: (1) (Re)defining the problem, (2) Need finding and benchmarking, (3) Ideating, (4) Building,

and (5) Testing (Meinel et al., 2011). According to them, the stages themselves may seem straightforward, but the ability to discern the appropriate inflection points and determine the next stage requires adaptive expertise. This capability represents a high-order intellectual activity that demands practice and is acquired through learning. Brown (2008) suggests viewing the process not as a linear sequence but as a system of intersecting spaces: inspiration, ideation, and implementation. Additionally, projects may iterate through these spaces multiple times as teams refine ideas and explore new directions. 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. One of the most renowned frameworks of design thinking is Stanford University's d. school 5-step approach: empathize, define, ideate, prototype, and test (Fabri, 2015).

Brainstorming

Alex Faickney Osborn popularized the term "brainstorming." In 1939, he initiated the development of 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 both 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, especially 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. Brainstorming is the most common technique that is used to encourage groups to produce creative ideas (McFadzean, 1998).

Guilford (1975) employed brainstorming to develop creative giftedness. Alex Osborn proposed brainstorming to generate creative ideas (Guilford, 1984). Brainstorming is employed in the ideation phase of design thinking (Interaction Design Foundation, n.d.).

Related Research

Study on using design thinking to enhance students' creative thinking ability

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. The implementation of the DGR model enhanced nursing students' creative ability in nursing with a statistically significant level of 0.05.

Design thinking was used as a human-centered innovation methodology in a design innovation program at Stanford University and at one successful design consultancy (Steinbeck, 2011). It is often employed to address challenging, multi-dimensional "wicked problems" that defy clear requirements and solutions (Rittel & Webber, 1973, quoted 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. The implementation of the DGR model enhanced nursing students' creative ability in nursing with a statistically significant level of 0.05.

Study on using brainstorming to enhance students' creative thinking ability

Creative thinking ability requires brainstorming (Guilford, 1981, quoted by Sisk, 2021). Creative products can be generated through brainstorming (Algarni, 2022). Through analysis of relevant research, Grieseb (2016) found that brainstorming can promote people's creative development.

Conclusion

Research shows that the appropriate instructional model can effectively improve the learning quality of students. Different instructional modes are associated with different levels of student engagement, learning outcomes, and satisfaction. Design thinking and brainstorming can promote the development of students' creative thinking ability. Chinese undergraduate students' creative thinking ability needs to be improved. At present, there is no research on the development of instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability. Therefore, it is necessary to develop an instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability. This study explored the factors that affect the third-year undergraduate students' creative thinking ability at Baise University to develop an instructional model based on design thinking and brainstorming and to compare the third-year undergraduate students' creative thinking ability before and after using the instructional model based on design thinking and brainstorming.

Concluding ideas about design thinking, brainstorming, creative thinking ability, instructional model, and learning process are shown as follows.

Table 2.1 Concluding ideas about design thinking, brainstorming, creative thinking ability, instructional model, and learning process.

Design thinking	Brainstorming	Creative thinking ability	Instructional model	Learning Process
Design thinking is a human-centered methodology that uses co-design and intuitive problem-solving techniques to match people's needs with what is technologically feasible and organizationally viable. One of the most popular frameworks of design thinking is Stanford University's d. school 5-step approach of empathize-define-ideate-prototype-test.	Brainstorming is part of design thinking. It is a method design teams use to generate ideas to solve clearly defined design problems. In controlled conditions and a free-thinking environment, teams approach a problem by such means as “How Might We” questions.	Creative thinking ability refers to the ability of internal mental which consists of four elements: fluency, flexibility, elaboration, originality This research focuses on originality, to produce novel, unusual, clever, remote associations or connections ideas.	An instructional model is a framework or structure that provides a framework for instruction, typically consisting of a logical sequence of activities and strategies. It consists of four components: principle, objective, learning process, and result.	Step 1: Empathizing Undergraduate students observe and research the problems, wants, needs, emotions, feelings, and actions that come out when target groups or real users are working or learning. Step 2: Defining Undergraduate students identify the problem that needs to be solved in order to provide better service or, guidance or support to their target groups or real users. Step 3: Ideate Undergraduate students began to brainstorm to call for ideas to solve the problems identified in Step 2. Step 4: Prototype Undergraduate students design and modify solutions to solve the problems

Table 2.1 (Continued)

Design thinking	Brainstorming	Creative thinking ability	Instructional model	Learning Process
				identified in Step 2. Step 5: Test Undergraduate students implement the best solutions identified in step 4 to solve the problems of target groups or real users.

Chapter 3
Research Methodology

The methodology of this research was research and development (R&D). The research objectives were 1) to study the factors that affect the development of the third-year undergraduate students' creative thinking ability at Baise University, 2) to develop an instructional model based on design thinking and brainstorming, and 3) to compare the third-year undergraduate students' creative thinking ability before and after use the instructional model based on design thinking and brainstorming. This research was a multi-sequenced design and equivalent status design: qualitative research and quantitative research. Research design, research processes, and data analysis were presented as follows.

Step 1 The study on the factors that affect the development of third-year undergraduate students' creative thinking ability.

The Population/The Sample Group

The Population

Academic scholars and professional experts in creative thinking ability development.

The Sample Group

10 academic scholars or professional experts in creative thinking ability development were drawn from purposive sampling. The selected scholar or experts have the following characteristics: a Doctor of Education degree and at least 5 years of teaching experience in a university.

Research Instruments

1. Instruments

1) Interview form about factors that affect the development of the third-year undergraduate students' creative thinking ability. The structured interview form has 8 questions.

2) Questionnaire about factors that affect the development of the third-year undergraduate students' creative thinking ability. The questionnaire consists of

31 questions at 5 levels of Likert scale: strongly disagree, disagree, unsure, agree, strongly agree.

3) Assessment form for validity of factors affecting the development of creative thinking ability interview.

4) Assessment form for validity of factors affecting the development of creative thinking ability questionnaire.

2. The development process of research tools

2.1 The development process of interview form about factors that affect the development of the third-year undergraduate students' creative thinking ability.

1) Study the concept and formulation process of the interview form about factors that affect the development of the third-year undergraduate students' creative thinking ability at Baise University: The structured interview form has 8 questions

2) Drafted the interview form

3) Verified interview form by advisers

4) Modified the interview form as suggested

5) Five experts verified the validity of the interview form. Three were from Thailand, and the other two were from China. The test consistency index of congruency for all of its items is 1.00, which is from the second part Appendix D.

6) Modify the interview form according to the suggestions.

2.2 The process of developing the questionnaire about factors that affect the development of third-year undergraduate students' creative thinking ability

1) The questionnaire's concept and development process were studied, and the factors that affect the development of third-year undergraduate students' creative thinking abilities were discussed.

2) Draft questionnaire: Adopt a five-level Likert scoring method, including 31 questions, including strongly disagree, disagree, unsure, agree, and strongly agree.

3) The advisers verified the questionnaire.

4) Modify the questionnaire as suggested.

5) 5 experts verified the validity of the questionnaire. Three were from Thailand, and the other two were from China. The test consistency index of

congruency for all of its items is 1.00. All of its items' test consistency index of congruency is no less than 0.80, which is from the second part Appendix D.

6) Modify the questionnaire according to suggestions.

2.3 The development process of the assessment form for the validity of the interview form about factors that affect the development of the third year

1) Study the concept and development process of the assessment form for the validity of the interview form.

2) Drafted an assessment form for validity of the interview form about factors that affect the development of third-year undergraduate students' creative thinking ability. The following are the criteria for consideration:

The rating is +1. There is an opinion that "Corresponds to definition."

The rating is 0. There is an opinion that "Not sure it corresponds to definition."

The rating is -1. There is an opinion that "Inconsistent with definition."

The test consistency index of congruency for all of its items is 1.00. At the end of each section, there is a space for experts to write suggestions to help improve the interview form about factors that affect the development of third-year undergraduate students' creative thinking ability.

3) The advisers verified the validity of the assessment form for the validity of the interview form about factors that affect the development of third-year undergraduate students' creative thinking ability.

4) Modify the effectiveness evaluation form of the interview form as suggested.

2.4 The development process of the assessment form for the validity of the questionnaire about factors that affect the development of third-year undergraduate students' creative thinking ability

1) Study the concept and development process of the questionnaire validity assessment form.

2) Draft an assessment form for the validity of the questionnaire about factors that affect the development of third-year undergraduate students' creative thinking ability. The following are the criteria for consideration:

The rating is +1. There is an opinion that “Corresponds to definition.”

The rating is 0. There is an opinion that “Not sure it corresponds to definition.”

The rating is -1. There is an opinion that “Inconsistent with definition.”

The test consistency index of congruency for all of its items is 1.00. There is a space at the end of each section for experts to write down suggestions for improving it.

3) Advisers verified the assessment form for the validity of factors affecting the development of the creative thinking ability questionnaire.

4) Modify the assessment form for the validity of factors affecting the development of the creative thinking ability questionnaire according to suggestion.

Data collection

1) The researchers coordinated with 10 experts by issuing official documents from Bansomdejchaopraya Rajabhat University to inform them of the research tools and data collection process to collect data on the quality of all instruments used in this step.

2) The researchers 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 experts in creative thinking ability development through the interview and the questionnaire.

Data Analysis

The data was analyzed as follows:

1) Quantitative data on instrument quality were analyzed using the Index of Item Objective Consistency (IOC).

2) Quantitative data from the questionnaire about factors that affect the development of third-year undergraduate students’ creative thinking ability was analyzed through frequency, percentage, means, and standard deviation. The mean score was compared with the criteria as follows:

The mean score is in the interval (4.50 - 5.00) means “strongly agree”.

The mean score is in the interval (3.50 - 4.50) means “agree”.

The mean score is in the interval (2.50 - 3.50) means “unsure”.

The mean score is in the interval (1.50 - 2.50) means “disagree”.

The mean score is in the interval [1.00 - 1.50) means “strongly disagree.”

3) Qualitative data were analyzed through the content analysis method. Concluding idea about research process step 1 shown as follows:

Table 3.1 Research process step 1

Research objective	**To study the factors that affect the development of third-year undergraduate students’ creative thinking ability.**
Research Process	1. Determined the research instruments to be used 2. Developed research instruments and check validity 3. Collected data 4. Analyzed data
Research Target group	10 academic scholars or professional experts in creative thinking ability development.
Research instrument	1) Interview form about factors that affect the development of the third-year undergraduate students’ creative thinking ability. 2) Questionnaire about factors that affect the development of the third-year undergraduate students’ creative thinking ability. 3) Assessment form for validity of factors affecting the development of creative thinking ability interview. 4) Assessment form for validity of factors affecting the development of creative thinking ability questionnaire.
Data collection	1) Coordinated with 5 experts by issuing official documents from Bansomdejchaopraya Rajabhat University and informed them of research tools and data collection process to collect data on the quality of all instruments used in this step. 2) Collected data on the factors that affect the development of the 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.

Table 3.1 (Continued)

Research objective	**To study the factors that affect the development of third-year undergraduate students' creative thinking ability.**
Data Analysis	1) Quantitative data on instrument quality were analyzed using the Index of Item Objective Consistency (IOC). 2) Quantitative data from the questionnaire about factors that affect the development of third-year undergraduate students' creative thinking ability was analyzed through frequency, percentage, means, and standard deviation. 3) Qualitative data were analyzed through the content analysis method.

Step 2: The development of an instructional model based on design thinking and brainstorming.

The process of the instructional model development

1) Studied the instructional model development process and the details from the first step. The study of the first step found the factors affecting undergraduate students' creative thinking ability include environmental factors and personal factors. The environmental factors consist of three sub-factors family, school, and society. Personal factors consist of three sub-factors personality traits, motivation, attitude, and emotional state.

2) The instructional model components were determined: principle, objective, learning process, and result.

3) Drafted the details of the instructional model.

4) Details of the instructional model based on design thinking and brainstorming verified by advisers.

5) Details of the instructional model were modified based on design thinking and brainstorming according to the suggestions.

6) Details of the instructional model based on design thinking and brainstorming were verified by 5 experts. Three of them were from Thailand, and the other two were from China. All of its items' test consistency index of congruency is 1.00, which is from the second part in Appendix D.

7) Details of the instructional model based on design thinking and brainstorming were modified according to the suggestions.

The process of the assessment form for the validity of the instructional model development

1) Studied the concept and development process of the validity of instructional model development

2) Drafted the assessment form for the validity of the instructional model. At the end of each section, there is a space for experts to write recommendations that will help improve it. The following are the criteria for consideration:

The rating is +1. There is an opinion that "Corresponds to definition."

The rating is 0. There is an opinion that "Not sure it corresponds to definition."

The rating is -1. There is an opinion that "Inconsistent with definition."

The test consistency index of congruency for all of its items is 1.00.

3) Advisers verified the assessment form for the validity of the instructional model.

4) Modified the assessment form for the validity of the instructional model according to the recommendations.

Data collection

The researchers coordinated with 5 experts by issuing official documents from Bansomdejchaopraya Rajabhat University to them and informed them of research tools and data collection process and collected data on the quality of instruments.

Data Analysis

1) Quantitative data on the quality of the instructional model based on design thinking and brainstorming was analyzed through the analysis of the Index of Item Objective Consistency (IOC).

2) Qualitative data were analyzed through content analysis method

Concluding idea about research process step 2 shown as follows:

Table 3.2 Research Process Step 2

Research objective	**To develop an instructional model based on design thinking and brainstorming**
Research process	1) Studied an instructional model development process, theory of design thinking and brainstorming, and research results in step 1. 2) Determined an instructional model component. 3) Drafted the instructional model based on design thinking and brainstorming: principles, objectives, learning process, and results. 4) Verified the details of the instructional model based on design thinking and brainstorming.
Research Target group	5 experts
Research instrument	Assessment form for validity of the instructional model based on design thinking and brainstorming.
Data collection	The researchers coordinated with 5 experts by issuing official documents from Bansomdejchaopraya Rajabhat University to them and informed them research tools and data collection process and collected data on quality of instruments.
Data Analysis	Quantitative data on the quality of the instructional model based on design thinking and brainstorming was analyzed through analysis of the Index of Item Objective Consistency (IOC)

Step 3 The experimental and improvement of the instructional model

This research is experimental. One Group Pretest–Posttest Design was used with the following experimental design:

Table 3.3 Experimental design

Group	**Pretest**	**Experimental**	**Posttest**
R	O1	X	O2

The meaning of the symbols used in the experimental design.

R	means	Random Sampling
X	means	experimental
O1	means	Pretest
O2	means	Posttest

The Population / The Sample Group

The Population

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

The Sample Group

The sample group for this study was 45 third-year undergraduate students in 1 class who were selected by clusters random sampling method from a mix of good, medium, and weak abilities, and enrolled in the Primary School Mathematics Instruction Design and Implementation course at Baise University in the fall semester of 2023.

Research Instruments

1. Instruments

1) Lesson plans which were designed according to the instructional model based on design thinking and brainstorming.

2) Creative thinking ability test.

3) Interview form about opinions on teaching.

4) Observation form about students' behavior.

5) Assessment forms for validity of lesson plan I-IV.

6) Assessment form for validity of creative thinking ability test.

7) Assessment form for validity of interview form about opinions on teaching.

8) Assessment form for validity of observation form about students' behavior.

2. The development process of the Research Tools

2.1 The process of developing lesson plans based on the instructional model based on design thinking and brainstorming

1) Study the concept and development process of lesson plans.

2) Identified elements of the lesson plan: 1) Concept, 2) Content, 3) Objectives, 4) Learning process, 5) Learning resources, 6) Evaluation.

3) Studied the details of the instructional model based on design thinking and brainstorming.

4) Drafted lesson plans based on the instructional model based on design thinking and brainstorming. In this study, 4lessons in 4 units (16 hours in total) were mainly selected for experimental study.

5) Advisers validated the details of the lesson plans.

6) Modify the details of the instructional model according to the suggestions.

7) Verified the details of the lesson plan by 5 professional scholars consistent with the research objectives and concepts to the following criteria.

The rating is +1. There is an opinion that “Corresponds to definition”.

The rating is 0. There is an opinion that “Not sure it corresponds to definition”.

The rating is -1. There is an opinion that “Inconsistent with the definition”.

All of its items’ test consistency index of congruency is 1.00, which is from the second part in Appendix D.

8) Modified lesson plan according to the recommendations.

2.2 The development process of the creative thinking ability test

1) Investigated the conceptualization and development process of the creative thinking ability test.

2) Drafted a creative thinking ability test, which consisted of 5 situations from the Primary School Mathematics Curriculum for undergraduate students to design lesson plans that should be new, unique, accurate, and consistent with other parts. The following are the criteria for Scoring:

If the learning process and learning media are new, unique, accurate, and consistent with other parts, you will get 5 points.

If the learning process and learning media are new, unique, and accurate, but not consistent with other parts, you will get 4 points.

If the learning process or learning media are new, unique, and accurate, but not consistent with other parts, you will get 3 points.

If the learning process and learning media are new and unique, but not accurate and not consistent with other parts, you will get 2 points.

If the learning process or learning media are new and unique, but not accurate and not consistent with other parts, you will get 1 point.

If the learning process and learning media are not new, not unique, not accurate, or not consistent with other parts, you will get 0 point.

3) The details of the creative thinking ability test validated by advisers.

4) Revise the details of the creative thinking ability test according to the suggestions.

5) Details of the creative thinking ability test were validated by 5 experts. Three of them were from Thailand, and the other two were from China. All of its items' test consistency index of congruency is 1.00, which is from the second part in Appendix D.

6) Details of the creative thinking ability test were modified according to the suggestions.

7) A pre-test of the creative thinking ability test was conducted on 45 undergraduate students who come from a class similar to the class of the sample group, and the reliability of Cronbach's α value of 0.89. It has a value higher than 0.70, which can be considered a good research tool that can be used in further research experiments.

8) Modification of the creative thinking ability test based on according to the recommendations

2.3 The development process of interview form about opinions on teaching

1) Studied the concept and development process of interview form about opinions on teaching.

2) Drafted an interview form about opinions on teaching.

3) Verified the details of the interview form about opinions on teaching by advisers.

4) Modified the details of the interview form about opinions on teaching according to suggestions.

5) Verified the details of the interview form about opinions on teaching by 5 experts. Three of them were from Thailand, and the other two were from China. All of its items' test consistency index of congruency is 1.00, which is from the second part in Appendix D.

6) Modified the interview form about opinions on teaching according to the recommendations.

2.4 The development process of observation form about students' behavior

1) Researching the concept and process of developing an observation form about students' behavior.

2) Drafting an observation form about students' behavior.

3) Details of the observation form about students' behavior were verified by the advisers.

4) Revising the details of the observation form about students' behavior based on the suggestions.

5) The details of the observation form about students' behavior were validated by 5 experts. Three of them were from Thailand, and the other two were from China. All of its items' test consistency index of congruency is 1.00, which is from the second part in Appendix D.

6) Revised the observation form about students' behavior as per suggestions.

2.5 The development process of assessment forms for validity of lesson plans according to the instructional model

1) I studied the concept and development process of the assessment form for the validity of the lesson plan.

2) Drafted four assessment forms for the validity of lesson plans I-IV. The following are the criteria for consideration:

The rating is +1. There is an opinion that "Corresponds to definition."

The rating is 0. There is an opinion that "Not sure it corresponds to definition."

The rating is -1. There is an opinion that "Inconsistent with definition."

At the end of each section, there is a space for experts to write suggestions that can help improve.

3) Verified four assessment forms for validity of lesson plans by advisers

4) Modified assessment forms for the validity of lesson plans according to suggestion

2.6 The development process of the assessment form for the validity of the creative thinking ability test

1) Studied the concept and development process of assessment form for validity of creative thinking ability test.

2) Draft an assessment form for the validity of the creative thinking ability test.

3) The assessment form for the validity of the creative thinking ability test was verified by advisers

4) Revised the assessment form for the validity of the creative thinking ability test based on suggestions

2.7 The development process of the assessment form for the validity of the interview form about opinions on teaching

1) Studied the concept and development process of the assessment form for the validity of the interview form and opinions on teaching.

2) Drafted an assessment form for the validity of the interview form about opinions on teaching.

3) Verified the assessment form for the validity of the Interview form about opinions on teaching by advisers.

4) Modified the assessment form for the validity of the Interview form about opinions on teaching according to advisers' suggestions.

2.8 The development process of the assessment form for validity of observation form about students' behavior

1) Studied about concept and development process of assessment form for validity of observation form about students' behavior.

2) Drafted an assessment form to validate the observation form about students' behavior.

3) Verify the assessment form for the validity of the observation form about students' behavior by advisers.

4) Modified the assessment form for validity of the observation form about students' behavior according to advisers' suggestions.

Experimental and improvement process

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 Curriculum Instruction Design and Implementation course at Baise University were selected by clusters random sampling methods from a mix of good, medium, and weak abilities 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 Curriculum Instruction Design and Implementation course through 4 lesson plans that were designed according to 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.

Data Analysis

The data were analyzed as follows.

1) Quantitative data on the quality of all instruments used in this step was analyzed through the analysis of the Index of Item Objective Consistency (IOC). Quantitative data on the creative thinking ability of the third-year undergraduate students who came from a class similar to the class as the sample group and who were tested to test the creative thinking ability test was analyzed through reliability Cronbach's α, difficulty (p), discriminant power (r).

2) Quantitative data on the creative thinking ability of the third-year undergraduate students as the sample group analyzed through frequency, percentage, means, standard deviation, t–test for dependent.

3) Qualitative data were analyzed through content analysis based on the content obtained from observations and experimental interviews.

Concluding idea about research process step 3 shown as follows:

Table 3.4 Research Process Step 3

Research objective	To compare the third-year undergraduate students' creative thinking ability before and after using the instructional model based on design thinking and brainstorming.
Research process	1) The sample group was organized to take a pretest. 2) The sample group was experimented with. 3) The researcher observed and interviewed the sample group. 4) The sample group was organized to take the post-test. 5) Analyzed data and improved instructional model according to suggestions.
Research target group	45 third-year undergraduate students who were pre-service primary school teachers in 1 class and who were enrolling in the *Primary School Mathematics Curriculum Instruction Design and Implementation* course at Baise University.
Research instrument	1) Lesson plans which were designed according to the instructional model based on design thinking and brainstorming. 2) Creative thinking ability test. 3) Interview form about opinions on teaching. 4) Observation form about students' behavior. 5) Assessment forms for validity of lesson plan I-IV. 6) Assessment form for validity of creative thinking ability test. 7) Assessment form for validity of interview form about opinions on teaching. 8) Assessment form for validity of observation form about students' behavior.
Data collection	1) To collect data on creative thinking ability from the sample group through pretest and posttest. 2) Collected data on undergraduate students' opinions on teaching through interviews. 3) Collected data on students' behavior during learning through observation.

Table 3.4 (Continued)

Data analysis	1) Quantitative data on the quality of all instruments was analyzed through IOC. Quantitative data on the creative thinking ability of the third-year undergraduate students from a class similar to the class of the sample group and tested on the creative thinking ability test was analyzed through reliability Cronbach's α, difficulty (p), discriminant power (r). 2) Quantitative data on the creative thinking ability of the third-year undergraduate students, who were the sample group, was analyzed through frequency, percentage, means, standard deviation, and a t–test for dependent variables. 3) Qualitative data were content analyzed.

Chapter 4
Results of Analysis

The methodology of this research was research and development (R&D). The research objectives were 1) To study the factors that affect the third-year undergraduate students' creative thinking ability at Baise University, 2) to develop an instructional model based on design thinking and brainstorming, and 3) to compare the third-year undergraduate students' creative thinking ability before and after using the instructional model based on design thinking and brainstorming.

Therefore, this chapter is divided into three parts:

Result of Part 1: The study on the factors that affect the development of third-year undergraduate students' creative thinking ability (OB1);

Result of Part 2: The development of an instructional model based on design thinking and brainstorming (OB2);

Result of Part 3: The experimental and improvement of the instructional model (OB3);

Symbol and abbreviations

$\overline{X}$	means the average value
SD.	means standard deviation
n	means the number of students
f	means frequency
df	means the degree of freedom
t	means statistical data for the t-test value
p	means the p-value for the dependent sample
**	means statistical significance at level .01

The details are as follows:

Results of Data Analysis

In this study, the statistical software IBM SPSS Statistics 20 was used to perform statistical tests on the respondents' general data to reveal the respondents' basic data characteristics and analyze the influencing factors and the test results of the instructional experiment. Tests of reliability, validity, difficulty, and discrimination were done for the tests, and descriptive statistics such as mean, standard deviation, and percentage were covered in the analysis while a t-test was utilized, and the corresponding p-value was calculated to present the statistical results of the basic data of the respondents, analysis of the influencing factors and the testing of the teaching experiments in a rigorous manner.

Result of Part 1: The study on the factors that affect the development of the third-year undergraduate students' creative thinking ability (OB1)

1. Present study participants data

10 academic scholars or professional experts in creative thinking ability development participated in the interview and the questionnaire about factors that affect the development of third-year undergraduate students' creative thinking ability. All of these 10 scholars or experts have the following characteristics: a doctor of education degree and at least 5 years of teaching experience in a university.

Table 4.1 Frequency and percentage of respondents' common data

Respondents' common data	Frequency	Percent
1. Gender		
Male	6	60.00
Female	4	40.00
Total	**10**	**100.00**
2. Age		
35-40 years old	5	50.00
41-45 years old	4	40.00
46-50 years old	1	10.00
Total	**10**	**100.00**

Table 4.1 (Continued)

Respondents' common data	Frequency	Percent
3. Job title		
Professor	1	10.00
Associate professor	6	60.00
Assistant professor	3	30.00
Total	**10**	**100.00**
4. Experience working in universities		
5-10 years	5	50.00
More than 10 years	5	50.00
Total	**10**	**100.00**

From Table 4.1, it can be seen that in terms of gender, 6 respondents were male, which accounted for the highest percentage of 60%. In terms of age, there were 5 respondents aged 30-40 years old, accounting for 50%, 4 respondents aged 40-50 years old, accounting for 40%, and 1 respondent aged 50-60 years old, accounting for 10%. In terms of job title, 1 respondent was a professor accounting for 10%, 6 respondents were Associate professors accounting for 60%, and 3 respondents were assistant professors accounting for 10%.

2. The results of the questionnaire on the factors influencing third-year undergraduate students' creative thinking ability

To evaluate the factors affecting the third-year undergraduate students' creative thinking ability, we need to analyze the results of the questionnaire about factors that affect the development of the third-year undergraduate students' creative thinking ability.

Table 4.2 Summary table of information factors

(n=10)

Factors	Ranking within sub-factors	$\overline{X}$	SD.
Environmental Factors		**4.53**	**0.12**
F1 Family	6	4.40	**0**.14
F2 School	4	4.59	**0**.22
F3 Society	5	4.50	**0**.20
Personal factors		**4.68**	**0.18**
F4 Personality traits	3	4.61	0.20
F5 Motivation	1	4.87	0.17
F6 Attitude and emotional state	2	4.68	0.31

Table 4.2 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 abilities. Levels of sub-factors affection rank as follows: 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).

Table 4.3 Family factors' affecting third-year undergraduate students' creative thinking ability.

Factors	Ranking	$\overline{X}$	SD.
1.1 The eldest son or daughter in a family, or among siblings in the same family, tends to have a greater creative thinking ability	3	4.20	0.42
1.2 If a student often faces a large number of problems that need to be solved in the family, then he or she will tend to have higher creative thinking skills.	2	4.40	0.70
1.3 If undergraduates can feel that their parents are interested in and support to their creative thinking, their creative thinking ability will be well developed.	1	4.60	0.52

Table 4.3 indicates the following:

1) The first influencing factor in the ranking of family factors is parents' interest and in supporting for undergraduates' creative thinking ($\overline{X}$ =4.60).

2) The second influencing factor in the ranking of family factors is the number of problems undergraduates face in their families that need to be solved ($\overline{X}$ =4.40).

3) The third influencing factor in the ranking of family factors is an undergraduates' order among family children ($\overline{X}$ =4.20).

Table 4.4 School factors' affecting third-year undergraduate students' creative thinking ability

(n=10)

Factors	Ranking	$\overline{X}$	SD.
2.1 Good time management is necessary to enhance undergraduates' creative thinking ability.	3	4.70	0.48
2.2 Having enough time is necessary to enhance undergraduates' creative thinking ability in class and outside of class.	2	4.80	0.42
2.3 Too many undergraduates in the classroom is not conducive to enhance their creative thinking ability	5	4.50	0.53
2.4 Atmosphere of opening to new ideas and allowing take risks and make mistakes is necessary to enhance undergraduates' creative thinking ability	5	4.50	0.53
2.5 Interaction that is fun, appreciating, acceptance, and giving opportunities to do things in the classroom is necessary to enhance undergraduates' creative thinking ability	1	4.90	0.32
2.6 An atmosphere of allowing to think and reflect without rushing is necessary to enhance undergraduates' creative thinking ability	4	4.60	0.52
2.7 Collective problem-solving is effective in enhancing undergraduates' creative thinking ability	4	4.60	0.52
2.8 Using project work and challenging problems in curriculum and subjects is useful to enhance their creative thinking ability	3	4.70	0.48
2.9 Too much assessment is not conducive to enhance their creative thinking ability in curriculum and subjects.	6	4.00	0.47

Table 4.4 indicates the following:

1) The first influencing factor in the ranking of school factors is interaction, which is fun, appreciation, acceptance, and giving opportunities to do things in the classroom ($\overline{X}$ =4.90).

2) The second influencing factor in the ranking of school factors is interaction, which is giving enough time to enhance undergraduates' creative thinking ability in class and outside of class ($\overline{X}$ =4.80).

3) The third influencing factor in the ranking of school factors is good time management ($\overline{X}$ =4.70) and using projects and challenging problems in curriculum and subjects ($\overline{X}$ =4.70).

4) The fourth influencing factor in the ranking of school factors is interaction which is an atmosphere of allows to think and reflect without rush ($\overline{X}$ =4.60) and collective problem-solving ($\overline{X}$ =4.60).

5) The fifth influencing factor in the ranking of school factors is the class size ($\overline{X}$ =4.50) and atmosphere of opening to new ideas and allowing take risks and make mistakes ($\overline{X}$ =4.50).

6) The sixth influencing factor in the ranking of school factors is an appropriate assessment within the curriculum and subjects ($\overline{X}$ =4.00).

Table 4.5 Society factors' affecting third-year undergraduate students' creative thinking ability

(n=10)

Factors	Ranking	$\overline{X}$	SD.
3.1 If a student often faces a large number of problems that need to be solved in society, then he or she will tend to have higher creative thinking skills.	3	3.20	0.92
3.2 A societal atmosphere that is open to new ideas and safe for students to take risks and make mistakes is necessary to enhance undergraduate students' creative thinking ability.	2	4.80	0.42
3.3 The societal atmosphere places a lot of emphasis on examinations, which contradicts enhancing undergraduate students' creative thinking ability.	1	5.00	0.00
3.4 The high societal expectation of creative thinking ability enhancement is conducive to enhancing undergraduate students' creative thinking ability.	1	5.00	0.00

Table 4.5 indicates the following:

1) The first factors influencing the ranking of society are the social atmosphere of focusing on exams ($\overline{X}$=5.00) and the high societal expectation of creative thinking ability ($\overline{X}$=5.00).

2) The second influencing factor in the ranking of society factors is a societal atmosphere that is open to new ideas and safe for students to take risks and make mistakes ($\overline{X}$=4.80).

3) The third influencing factor in the ranking of society factors is the number of problems students usually face in society that need to be solved ($\overline{X}$=3.20).

Table 4.6 Personality traits factors affecting third-year undergraduate students' creative thinking ability

(n=10)

Factors	Ranking	$\overline{X}$	SD.
4.1 Undergraduate students with curious personality traits usually have more creative thinking ability.	2	4.90	0.32
4.2 Undergraduate students with independent personality traits usually have more creative thinking ability.	2	4.90	0.32
4.3 Undergraduate students with open-minded personality traits usually have more creative thinking ability.	1	5.00	0.00
4.4 A flexible personality is conducive to enhancing undergraduates' creative thinking ability, and a rigid personality is not conducive to enhancing undergraduates' creative thinking ability.	1	5.00	0.00
4.5 It is advantageous for the development of creative thinking for an undergraduate student if he/she has the flexibility to switch from one discipline to another at any time.	4	4.30	0.82
4.6 Undergraduate students with persistent personality traits usually have more creative thinking ability.	3	4.70	0.48
4.7 Undergraduate students with unconventional personality traits usually have more creative thinking ability.	4	4.30	0.82
4.8 Men (women) who often exhibit a bit more femininity (masculinity) in their personality traits usually have better creative thinking ability than other males(females).	5	3.80	0.92

Table 4.6 indicates the following:

1) The first influencing factors in the ranking of personality traits factors are undergraduate students with open-minded personality traits ($\overline{X}$=5.00) and flexible or rigid personalities ($\overline{X}$=5.00).

2) The second influencing factors in the ranking of personality traits factors are undergraduate students' curious personality traits ($\overline{X}$=4.90) and independent personality traits ($\overline{X}$=4.90).

3) The third influencing factor in the ranking of personality traits factors is undergraduate students' persistent personality traits ($\overline{X}$=4.70).

4) The fourth influencing factor in the ranking of personality traits is undergraduates' flexibility to switch from one discipline to another at any time ($\overline{X}$=4.30) and unconventional personality traits ($\overline{X}$=4.30).

5) The fifth influencing factor in the ranking of personality traits factors is undergraduate students exhibiting the characteristics of the opposite sex ($\overline{X}$=3.80).

Table 4.7 Motivation factors' affecting on third-year undergraduate students' creative thinking ability.

(n=10)

Factors	Ranking	$\overline{X}$	SD.
5.1 If an undergraduate student lacks the motivation to utilize certain abilities related to creative production within their intellectual structure, their creative output may be limited.	3	4.70	0.48
5.2 Curiosity-driven undergraduate students tend to have higher creative thinking abilities.	1	5.00	0.00
5.3 If undergraduate students have a clear purpose in mind for what they are going to do, they are willing to spend time on creative thinking.	2	4.90	0.32

Table 4.7 indicates the following:

The first influencing factor in the ranking of motivation factors is undergraduates' curiosity drive ($\overline{X}$=5.00).

The second influencing factor in the ranking of motivation factors is undergraduates' clear purpose in mind ($\overline{X}$ =4.90).

The third influencing factor in the ranking of motivation factors is undergraduates' motivation to utilize creativity ($\overline{X}$ =4.70).

Table 4.8 Attitude and emotional state factors' affecting on third-year undergraduate students' creative thinking ability

Factors	Ranking	$\overline{X}$	SD.
6.1 Having a positive attitude about creativity is certainly necessary for undergraduate students to enhance their creative thinking ability.	2	4.90	0.31
6.2 If undergraduates are focused too much on following rules and guidelines, it is not conducive to enhance their creative thinking ability.	1	5.00	0.00
6.3 Attitudes such as respect for authority figures, being pleased with others' success, and a lack of self-confidence can suppress creative thinking in undergraduate students.	4	4.00	0.94
6.4 Emotional states such as bias, worry, anxiety, jealousy, defiance, indifference, and complacency can hinder the development of creative thinking abilities in undergraduate students.	3	4.80	0.42

Table 4.8 indicates the following:

The first influencing factor in the ranking of attitude and emotional state factors is undergraduates' too much on following rules and guidelines ($\overline{X}$ =5.00).

The second influencing factor in the ranking of attitude and emotional state factors is undergraduates' having a positive attitude about creativity ($\overline{X}$ =4.90).

The third influencing factor in the ranking of attitude and emotional state factors is undergraduates' emotional states, such as bias, worry, anxiety, jealousy, defiance, indifference, and complacency ($\overline{X}$ =4.80). These can hinder the development of creative thinking abilities in undergraduate students.

The fourth influencing factor in the ranking of attitude and emotional state factors are undergraduates' attitudes, such as respect for authority figures, being pleased with others' success, and a lack of self-confidence ($\overline{X}$=4.00). These can suppress creative thinking in undergraduate students.

3. The results of the interviews on the factors that affect the development of the third-year undergraduate students' creative thinking ability

To explore the factors that affect third-year undergraduate students' creative thinking ability, we interviewed 10 academic scholars or professional experts in creative thinking ability development. They had the following characteristics: a Doctor of Education degree and at least 5 years of teaching experience in university.

The following are the responses from the respondents. The numbers and percentages in parentheses indicate the number of respondents who commented.

Table 4.9 Interviewees' opinion

Question	Interviewees' opinion
T1: Will family affect the development of undergraduate students' creative thinking ability? If so, discuss how this factor influences undergraduate students' creative thinking ability development.	100 % (10/10) of the interviewees believe that family impacts the development of undergraduate students' creative thinking ability. Synthesizing the interviewees' responses revealed that family affects the development of undergraduate students' creative thinking abilities. Family education type, family atmosphere, and the knowledge and experience of family members all have a particular impact on the formation and development of undergraduate students' creative thinking ability: 1) Family education type: Democratic family education helps cultivate children with independent thinking, courage to express and try new ideas, thereby promoting the development of creative thinking. In contrast, authoritarian family environments may limit a child's independent thinking, leading to a slower development of creative thinking ability.2) Family atmosphere: Harmonious family relationships and positive communication contribute to students' psychological well-being, providing a conducive environment for cultivating creative thinking. 3) Knowledge and experience of family members: Parents with rich knowledge and experience, through conscious verbal and behavioral guidance, play a positive role in fostering the creative thinking ability of undergraduate students.

Table 4.9 (Continued)

Question	Interviewees' opinion
	Examples of responses from selected interviewees: Interviewee 1: Family affects the development of students' creative thinking skills. Family education is democratic, allowing children to have their ideas, the courage to express their ideas, and do what they want to do; the child's creative thinking develops better because the children raised in such a family are more courageous to try new things, even if the attempt fails, will not be devastated, and authoritative family, requiring children to listen, obey, then the children do not dare to have their ideas, the development of creative thinking will be slow. Creative thinking is slow to develop. Interviewee 5: A family atmosphere that allows for boldness and expressing opinions helps students develop creative thinking skills.
T2: Will school impact the development of undergraduate students' creative thinking ability? If so, discuss how this factor influences undergraduate students' creative thinking ability development.	100 % (10/10) of the interviewees believe that school impacts the development of undergraduate students' creative thinking ability. Synthesizing the interviewees' responses revealed that the school environment, encompassing teaching philosophy, methods, atmosphere, and institutional factors, is seen to have a substantial impact on this development. 1) University is considered a crucial ground for individual growth and development. Factors such as geographic location, educational goals, curriculum, teaching methods, and student management directly influence the platform, direction, and level of development of undergraduate students' creative thinking ability. 2) The school's teaching philosophy and educators' teaching methods significantly impact students' creative thinking. Courses designed to foster student development and a relaxed, enjoyable learning atmosphere contribute to developing creative thinking. 3) A school environment that encourages bold expression and diverse opinions contributes to developing students' creative thinking. 4) University life, free from the constraints of entrance exams, allows students to develop their thinking ability freely and comprehensively, including creative thinking. The university phase is considered a critical period for developing innovative thinking. 5) The values guiding talent cultivation, the school's teaching model, and the evaluation system all play critical roles in determining the level and effectiveness of developing students' creative thinking abilities. Examples of responses from selected interviewees: Interviewee 1: Schools can affect the development of creative thinking ability in undergraduate students. The school's teaching philosophy and the

Table 4.9 (Continued)

Question	Interviewees' opinion
	teachers' teaching style will affect the students' creative thinking. A school curriculum that is oriented towards the development of the student promotes creativity, and a teacher who creates a relaxed and enjoyable learning environment also encourages the development of creative thinking. Interviewee 8: Schools can affect the development of creative thinking ability in undergraduate students. A school climate that allows for bold speech and the expression of opinions contributes to students' creative thinking development.
T3: Will society impact the development of undergraduate students' creative thinking ability? If so, discuss how this factor influences undergraduate students' creative thinking ability development.	100 % (10/10) of the interviewees believe that society impacts the development of undergraduate students' creative thinking ability. Synthesizing the interviewees' responses revealed that the societal environment, encompassing values, attitudes, trends, and practical opportunities, is a significant factor influencing the development of undergraduate students' creative thinking ability. Examples of responses from selected interviewees: Interviewee 2: Society affects undergraduate students' creative thinking development. Strictly speaking, undergraduates' creative thinking ability has to be practiced and tested in society, and the values, attitudes towards undergraduates, prevailing social trends, and platforms or conditions provided for undergraduates in society directly or indirectly constrain the development of undergraduates' creative thinking ability to a certain extent. Interviewee 4: Society affects undergraduate students' creative thinking development. I feel that society equally affects the development of creative thinking ability in undergraduate students. Life is a marathon, and people's thinking abilities are constantly developing, improving, and perfecting on the long road of life. Anytime undergraduates have more and more contact with society, they are bound to be influenced by society, including developing creative thinking abilities. Even when undergraduates regard entering and integrating into society as an essential life goal, the influence of society on undergraduates is unquestionable.
T4: Will personality traits influence the development of undergraduate students' creative thinking ability? If so, discuss how	100 % (10/10) of the interviewees believe that personality traits impact the development of undergraduate students' creative thinking abilities. Synthesizing the interviewees' responses revealed that personality traits, particularly those related to courage, openness to new experiences, self-confidence, and critical thinking, significantly influence the development of undergraduate students' creative thinking ability. 1) Influence of Blood and Choleric Temperaments: Individuals with sanguine and choleric personality traits are believed to promote the

Table 4.9 (Continued)

Question	Interviewees' opinion
this factor influences undergraduate students' creative thinking ability development.	development of creative thinking ability. These traits are characterized by courage and a willingness to try new things, fostering an interest in experimentation. Creativity often emerges through trial and error, continuous improvement, and the generation of new ideas. 2) Impact of Personality Traits on Various Dimensions: Personality traits manifest in aspects like character, cognition, behavior, and emotions, influencing the development of undergraduate students' creative thinking ability. For example, introverted personalities may hinder deep exploration of external stimuli, while an independent cognitive style is more favorable for creative thinking development. Reckless and impulsive behavior might lead to missed opportunities, and emotional characteristics like anxiety and low self-awareness may hinder creative thinking development. 3) Interconnection between Personality Traits and Innovation: A close relationship between personality traits and innovation significantly affects an individual's thinking and behavior. Different personality traits may result in varying levels of innovation. For instance, extroverted individuals are more open to new ideas and willing to try innovative problem-solving methods, enhancing their creativity. 4) Significance of confidence and critical thinking: High self-confidence encourages individuals to face challenges and take risks, fostering a positive attitude that can significantly contribute to developing creative thinking ability. Additionally, possessing critical thinking skills aids in rational evaluation and examination of the feasibility of creative ideas, enhancing overall creative ability. Examples of responses from selected interviewees: Interviewee 1: Personality traits affect the development of creative thinking ability in undergraduate students. The personality traits of polycythemia and choleric promote the development of creative thinking ability because these two types of personality traits are bold enough to try new things and are interested in new things. Creativity often starts with trial and error, and through trial and error, it is constantly improved to come up with new things. Interviewee 4: Personality traits affect the development of creative thinking ability in undergraduate students. People are different. Some students are active and innovative, so their creative thinking ability develops relatively well. Some students are conservative and not good at innovation, so their creative thinking ability is relatively slower to develop.

Table 4.9 (Continued)

Question	Interviewees' opinion
T5: Will undergraduate students' motivation influence their development of creative thinking ability? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.	100 % (10/10) of the interviewees believe that undergraduate students' motivation has an impact on the development of undergraduate students' creative thinking ability. Their answers show that the motivation of undergraduate students plays a pivotal role in influencing the development of their creative thinking ability, impacting their attitude, direction, persistence, and the level of innovation they exhibit. 1) Clear learning motivation and goals: learning motivation influences the development of creative thinking ability. With clear learning motives and goals, students are inclined to explore and delve into areas they find interesting. For example, students motivated by a sense of contributing to the nation's rejuvenation may passionately engage in researching emerging fields, thereby enhancing their creative thinking ability. 2) Impact of motivation on attitude, direction, and persistence: motivation significantly affects the attitude, direction, intensity, and persistence of undergraduate students' engagement in activities. It plays a crucial role in determining whether students approach tasks with a positive attitude, choose the right direction, invest wholeheartedly, and persist in the face of difficulties or setbacks, ultimately influencing the development of their creative thinking ability. 3) Motivation as a driving force for innovation: motivation serves as a driving force for creativity. When students are passionate and interested in a particular subject, they are more likely to consciously explore and understand that field. Additionally, motivation propels students to seek self-development and growth, accumulating knowledge and experience that enhances their skill set, making it easier to generate creative ideas and solutions. 4) Motivation influencing effort and innovation willingness: Undergraduate students' motivation affects the direction and intensity of their efforts. The willingness to innovate, or the intensity of this willingness, contributes to varying outcomes in the development of creative thinking ability. 5) Motivation's role in inspiring creativity and innovative behavior: motivation inspires creativity by fueling students' enthusiasm and interest, leading to a more conscious exploration of a particular field and the dedicated application of creative thinking. Moreover, motivation prompts students to seek self-development, accumulating knowledge and experience, thereby fostering unique and valuable creative ideas and solutions.

Table 4.9 (Continued)

Question	Interviewees' opinion
	Examples of responses from selected interviewees: Interviewee 7: Motivation affects the development of the creative thinking ability of undergraduate students. Simply put, motivation is the idea that prompts a person to engage in an activity, which is reflected in the beginning, direction, intensity, and persistence of people's behavior in a certain activity. In the development of the creative thinking ability of undergraduates, motivation affects the correctness of the attitude of undergraduates in engaging in a certain thing or activity, the correctness or deviation of the direction, the degree of physical and mental devotion, and whether they can persist or give up when they encounter difficulties or setbacks, etc. All these are important influences that weaken or strengthen the development of undergraduates' creative thinking abilities. Interviewee 9: Motivation affects the development of creative thinking ability of undergraduate students. Motivation affects the direction and extent of students' efforts. Whether or not students are willing to innovate, or whether or not they are willing to innovate strongly, can lead to different results to some extent in the development of creative thinking ability.
T6: Will undergraduate students' attitudes about creativity, authority figures, norms affect their development of creative thinking ability? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.	Synthesizing the responses of the interviewees revealed that undergraduate students' attitudes toward creativity, authority figures, and norms have a significant impact on the development of their creative thinking ability. Emphasizing a mindset of learning, challenging norms, and seeking inspiration from exemplary figures contributes positively to fostering creative thinking among students. 1) Attitude toward authority and norms: students' attitudes of blind obedience and strict adherence to norms can hinder the development of creative thinking. Embracing a mindset of learning from authority figures, challenging outdated norms, and freeing one's thoughts fosters the development of creative thinking. 2) Role of exemplary figures: exemplary figures in a field, characterized by strong creativity, positive attitudes, and adherence to norms, serve as role models for undergraduate students. Their achievements inspire students to emulate them, contributing to the enhancement of creative thinking ability through dedicated efforts and positive outcomes in various activities. 3) Impact of attitude on freedom of thought: negative attitudes, such as excessive rigidity, blind admiration, or strict adherence to norms, can lead to self-anxiety, blind conformity, and timidity, restricting the free development of undergraduate students' creative thinking ability. Educators should

Table 4.9 (Continued)

Question	Interviewees' opinion
	provide opportunities for independent thinking, encourage challenging traditions, and value diverse perspectives to elevate students' creative thinking. Examples of responses from selected interviewees: Interviewee 6: Students' attitudes about creativity, authority figures, and norms affect the development of undergraduate students' creative thinking ability. Students' attitudes about authority figures and norms are obedient and are not conducive to the development of creative thinking ability. Standing on the shoulders of authority figures, continuous learning, emancipation, and breaking stereotypical rules will promote the development of their creative thinking ability. Interviewee 10: Students' attitudes about creativity, authority figures, and norms affect the development of undergraduate students' creative thinking ability. Undergraduates' bad attitudes about creativity, authority figures, and institutional norms, such as too much constraint, blind worship, and conformity, will make undergraduates fall into the bad mentality of self-anxiety, self-blindness, and timidity, thus limiting the free development of undergraduates' creative thinking ability. Teachers should provide undergraduates with more space for independent thinking and problem solving, pay attention to cultivating the spirit of students to dare to challenge traditions, habits, and authority, value students' distinctive insights and opinions, and try to take various forms to support students to understand things and analyze things in different ways, so as to enhance the level of undergraduates' undergraduate creative thinking ability.
T7: Will undergraduate students' emotional state, such as bias, worry, anxiety, jealousy, defiance, indifference, and complacency, affect their development of creative thinking ability? If so, discuss how this.	Overall, the interviewees unanimously believe that the negative emotional states of undergraduate students have a negative impact on creative thinking ability, manifested in limited cognition, restricted development opportunities, and hindered interpersonal relationships. 1) Obstacles of negative emotions to creative thinking: negative emotions such as bias, concern, anxiety, jealousy, resistance, indifference, complacency, etc., among undergraduate students can impede the development of creative thinking ability. These emotions may lead to a one-sided view of problems or overlook their essence, thereby affecting the ability to grasp the essence of things. 2) Impact of emotional states on development opportunities, perseverance, and cognition: negative emotional states may cause undergraduates to miss opportunities for the development of creative thinking ability, weaken perseverance, or lead to distorted perceptions of

Table 4.9 (Continued)

Question	Interviewees' opinion
factor influences the development of undergraduate students' creative thinking ability	the development of creative thinking ability, thereby constraining further progress in this area. 3) Constraints on interpersonal relationships and communication: negative emotions exacerbate interpersonal conflicts between undergraduate students and others, resulting in tense relationships and a lack of communication, restricting the development and cultivation of creative thinking ability. Examples of responses from selected interviewees: Interviewee 1: Undergraduate students' emotional state such as bias, worry, anxiety, jealousy, defiance, indifference, and complacency can hinder the development of their creative thinking ability because they may look at a problem one-sidedly or lose sight of the problem and fail to grasp the essence of the matter. Interviewee 9: Undergraduate students' emotional states, such as bias, worry, anxiety, jealousy, defiance, indifference, and complacency, to some extent, affect the development of their creative thinking ability. The psychological state of undergraduates plays an influential role in all aspects of their growth and development. If undergraduates have some negative and negative psychological problems, the development of their creative thinking ability will certainly be inhibited.
T8: Will a sense of purpose affect the development of undergraduate students' creative thinking ability? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.	100% of interviewees believe that the sense of purpose in undergraduate students has a positive impact on creative thinking ability. Having a clear goal can encourage students to delve into relevant knowledge, identify gaps in their field, and fill these gaps through independent learning, thereby promoting the development of creative thinking. At the same time, appropriate goals can stimulate students' learning motivation, while excessively high or low goals may lead to negative emotions, affecting the healthy development of creative thinking. The scientific setting of goals should fully consider factors such as students' physical fitness, knowledge structure, psychological qualities, and school teaching conditions to ensure the optimal development of creative thinking ability. Examples of responses from selected interviewees: Interviewee 6: Sense of purpose will promote the development of creative thinking ability of undergraduate students. For example, if a student wants to become a life scientist, he has to keep exploring knowledge related to life sciences, searching for the current gaps in life sciences, and filling the gaps through what he has learned and what he thinks, in which

Table 4.9 (Continued)

Question	Interviewees' opinion
	the student's creative thinking is developed and practiced. Interviewee 9: A sense of purpose can affect the development of creative thinking ability in undergraduate students. More similar to the motivation mentioned earlier, a sense of purpose will have an influential role.

Result of Part 2: The development of an instructional model based on design thinking and brainstorming (OB2)

The details of the instructional model are as follows:

Principle

Creative thinking ability is the ability of the internal mental state to express creativity. It is important because it is regarded as a key commodity of human capital (Florida, 2002; Pink, 2005, quoted by Scherer, 2018), and it has many significant benefits for healthy social and emotional well-being (Skiba et al., 2010 quoted by Aish, 2014). In many countries, enhancing students' creative thinking ability has become an important goal of their education systems, Although it is challenging (Vong, 2008; Wong, 2008; MCEETYA, 2008; Saarilahti et al., 1999; GPI, 2003; QCA, 2005; quoted in Kampylis, 2010). Creative thinking ability consists of four elements: fluency, flexibility, originality, and refinement (Guilford, 1982). Originality is the power of independent thought or constructive imagination. The Cambridge Dictionary defines originality as the quality of being special and interesting and not the same as anything or anyone else. This research focuses on creative thinking ability, especially on originality, to produce novel, unusual, clever, remote associations, or connections ideas.

Undergraduate students' creative thinking ability can be enhanced by using design thinking. Design Thinking was used as a human-centered innovation 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 framework of design thinking, genuine innovation can emerge during the problem-solving process (Brown, 2010, quoted in Fabri, 2015). Some studies found that the employment of design thinking in pedagogy has a

positive impact on enhancing university students' creative thinking ability (Steinbeck, 2011; Lima, 2022; Ekthamasuth et al., 2022). Several frameworks exist to facilitate the implementation of a design thinking approach, with one of the most renowned being Stanford University's 5-step approach: empathize, define, ideate, prototype, and test. This method closely aligns with IDEO's educator's toolkit (Fabri, 2015). In the empathize step, designers will research their users' needs; In the define step, designers will state their users' needs and problems; In the ideate step, designers will challenge assumptions and create ideas; In the prototype step, designers will Start to Create Solutions; In test step, designers will try their solutions out (Dam, 2023).

Undergraduate students' creative thinking ability can be enhanced by using brainstorming. In 1939, Alex Faickney Osborn initiated the development of techniques for fostering creative problem-solving to bolster employees' capacity to generate inventive ideas individually for advertising campaigns. 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, especially 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. Brainstorming is employed in the ideation phase of design thinking. Creative thinking ability requires brainstorming (Guilford, 1981, quoted in Sisk, 2021). It can be generated through brainstorming (Griese, 2016; Algarni, 2022).

Through learning based on the instructional model based on design thinking and brainstorming, undergraduate students can enhance their creative thinking ability especially originality.

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.

Learning process

Step 1: Empathizing

1.1 The teacher introduces the learning objectives and learning activities, especially the way to brainstorm together.

1.2 The teacher teaches the undergraduate students new theoretical knowledge.

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

1.4 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.

1.5 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.

1.6 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

2.1 Each undergraduate student identifies the problem that needs to be solved to provide better service, guidance, or support to their target groups or real users.

2.2 Undergraduate students share the problems identified by them.

2.3 Undergraduate students discuss and conclude the problems that need to be solved for their target groups or real users to work or learn more effectively.

Step 3: Ideate

3.1 The teacher presents brainstorming rules.

3.2 Undergraduate students began to brainstorm and call for ideas to solve the problems identified in step 2.

3.3 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

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

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

4.3 Each undergraduate student modifies their solution texts.

4.4 Undergraduate students share and test their modified solution within the team itself.

4.5 Each undergraduate student modifies the solution to solve the problems identified in Step 2 and identifies the best solutions.

Step 5: Test

5.1 Undergraduate students implement the best solutions identified in the prototype solution step to solve the problems of target groups or real users.

5.2 Undergraduate students evaluate the complete process of implementing the best solution to solve the problems of target groups or real users.

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

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.

Result of Part 3: The experimental and improvement of the instructional model (OB3)

1. Data analysis of pre-and post-test

This section compares undergraduate students' creative thinking ability before and after the experiment through a comparative samples t-test, which provides information on whether the differences are significant before and after using the instructional model based on design thinking and brainstorming.

Table 4.10 Comparison of pre-test and post-test of creative thinking ability

creative thinking ability	Score	n	$\bar{X}$	SD.	t	df	p
Posttest	25	45	21.28	1.57	27.07**	44	0.00
Pretest	25	45	15.30	1.10			

**Statistically significant at the level 0.01 (p <0.01)

Table 4.10 indicates that the difference in undergraduate students' creative thinking ability before and after the experiment is statistically significant through the paired samples t-test. There is a significant difference in their creative thinking ability (t = 27.07, p<0.001). The mean of the pretest ($\bar{X}$ =15.30) was significantly lower than the mean of the posttest ($\bar{X}$ = 21.28), with statistical significance at the level of 0.01. This indicates that the instructional model based on design thinking and brainstorming can enhance undergraduate students' creative thinking abilities.

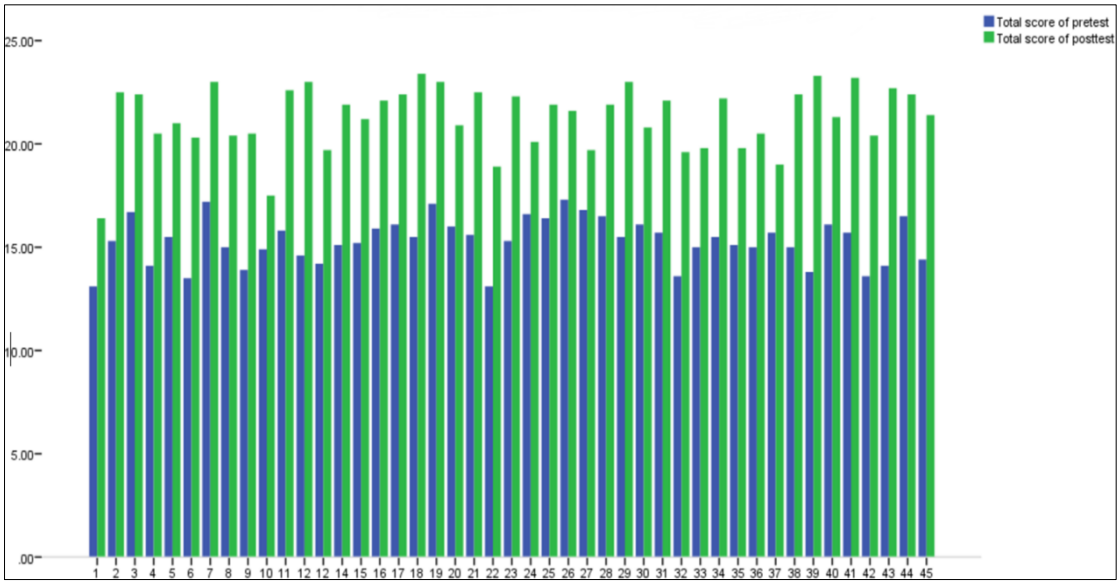

Figure 4.1 Changes in undergraduate students' creative thinking ability

Figure 4.1 shows that all 45 undergraduate students had enhanced their creative thinking ability through learning based on the instructional based on design thinking and brainstorming. This indicates that the instructional model based on

design thinking and brainstorming is effective for all undergraduate students from the sample group in enhancing their creative thinking ability.

2. Findings from the undergraduate students' behavior observations

To support the statistical results of the pre-test and post-test, undergraduate student behavioral observations were also conducted in this study. During the teaching experiment, the researcher recorded undergraduate students' learning, activities, and tasks. The researcher observed the undergraduate students at each learning session in the classroom to study their learning behaviors during the class.

Table 4.11 Summary of student's behavior observation form

Lessons	Steps	Observation Notes
Lesson 1: Lesson plan design and implementation of numbers and algebra areas in *Primary School Mathematics Curriculum*	Step 1: Empathizing	Undergraduate students attentively watched instructional videos about numbers and algebra areas in the *Primary School Mathematics Curriculum*. After observation, they actively engaged in personal analysis, sharing, and discussions about the primary school students' needs, wants, emotions, feelings, actions, and problems when they were learning in the lesson of numbers and algebra areas in the *Primary School Mathematics Curriculum*. However, undergraduates were not yet proficient in the analysis process, and they may require reminders from the teacher. Some undergraduates' analyses were not comprehensive and not sufficiently deep.
	Step 2: Defining	Undergraduate students actively engaged in personal analysis, sharing, discussion, and identification of the problems in the *Primary School Mathematics Curriculum* teacher's teaching that need to be solved in order for primary school students to learn more effectively in the lessons of numbers and algebra areas. However, they are not very proficient in the defined process yet, and they may require reminders from the teacher. Some undergraduate students lack depth and comprehensiveness in problem analysis, and there are also some who do not yet accurately identify the issues.
	Step 3: Ideate	Undergraduate students actively participate in brainstorming and boldly express their ideas. However, they were not very familiar with the rules and procedures of brainstorming; And their ideas lacked novelty, uniqueness, accuracy, consistency with problems identified in step 2.

Table 4.11 (Continued)

Lessons	Steps	Observation Notes
	Step 4: Prototype	Undergraduate students can actively participate in designing a lesson plan for the number and algebra areas in *the Primary School Mathematics Curriculum, and* they were able to actively share and mutually evaluate the lesson plans they have designed. However, their lesson plans' learning process and learning media were not new, unique, or accurate, and not consistent with other parts.
	Step 5: Test	Undergraduate students could actively participate in microteaching. However, they were not yet proficient in the process of microteaching; Their teaching manner appeared unnatural and less confident; And primary school students' learning process and learning media in their microteaching were not new, not unique, not accurate and not did not consistent with other parts.
Lesson 2: Lesson plan design and implementation of geometry area in *Primary School Mathematics Curriculum*	Step 1: Empathizing	Undergraduate students attentively watched instructional videos about geometry areas in the *Primary School Mathematics Curriculum*. After observation, they actively engaged in personal analysis, sharing, and discussions about the primary school students' needs, wants, emotions, feelings, actions, and problems when they were learning the lessons in geometry area areas in the *Primary School Mathematics Curriculum*. Undergraduates were proficient in the analysis process; However, some undergraduates' analyses were not comprehensive and not sufficiently deep.
	Step 2: Defining	Undergraduate students actively engaged in personal analysis, sharing, discussion, and identification of the problems in the *Primary School Mathematics Curriculum* teacher's teaching that need to be solved in order for primary school students to learn more effectively in the lessons of geometry areas. They were proficient in the defined process; However, some undergraduate students' analyses were not very deep, and their identification of problems was not completely accurate.
	Step 3: Ideate	Undergraduate students actively participated in brainstorming and boldly expressed their ideas, and they were familiar with the rules and procedures of brainstorming. However, their ideas lacked novelty, uniqueness, accuracy, or consistency with problems identified in step 2.
	Step 4: Prototype	Undergraduate students can actively participate in designing a lesson plan for the number and algebra areas in *Primary School Mathematics Curriculum*; And they were able to actively share and mutually evaluate the lesson plans they have designed. However, their

Table 4.11 (Continued)

Lessons	Steps	Observation Notes
		lesson plans' learning process and learning media were not new or not unique or not accurate or not did not consistent with other parts.
	Step 5: Test	Undergraduate students could actively participate in microteaching; They were proficient in the process of microteaching. However, their teaching style was not yet natural and confident enough; And primary school students' learning process and learning media in their microteaching were not new or not unique or not accurate or or not did not consistent with other parts.
Lesson 3: Lesson plan design and implementation of statistics and probability areas in *Primary School Mathematics Curriculum*	Step 1: Empathizing	Undergraduate students attentively watched instructional videos about statistics and probability areas in the *Primary School Mathematics Curriculum*. After observation, they actively engaged in personal analysis, sharing, and discussions about the primary school students' needs, wants, emotions, feelings, actions, and problems when they were learning in the lessons of statistics and probability areas in the *Primary School Mathematics Curriculum*. Undergraduates were very proficient in the analysis process; Their analyses were comprehensive. However, some undergraduates' analyses were not sufficiently deep.
	Step 2: Defining	Undergraduate students actively engaged in personal analysis, sharing, discussion, and identification of the problems in *Primary School Mathematics Curriculum* teacher's teaching that need to be solved in order for primary school students to learn more effectively in the lessons of statistics and probability areas. They were proficient in the defined process. Most of the undergraduate students' analyses were deeper, and their identification of problems was more accurate.
	Step 3: Ideate	Undergraduate students actively participate in brainstorming and boldly express their ideas; And they were familiar with the rules and procedures of brainstorming; However, their ideas were new, unique, accurate and consistent with problems identified in step 2.
	Step 4: Prototype	Undergraduate students can actively participate in designing a lesson plan for the number and algebra areas in *Primary School Mathematics Curriculum*; They were able to actively share and mutually evaluate the lesson plans they have designed; And their lesson plans' learning process and learning media were new, unique, accurate and consistent with other parts.
	Step 5: Test	Undergraduate students could actively participate in microteaching; They were proficient in the process of microteaching. Their teaching style was natural and confident. However, primary

Table 4.11 (Continued)

Lessons	Steps	Observation Notes
		school students' learning process and learning media in their microteaching were not new or not unique enough or not accurate enough or not did not consistent with other parts enough.
Lesson 4: Lesson plan design and implementation of synthesis and practice areas in *Primary School Mathematics Curriculum*	Step 1: Empathizing	Undergraduate students attentively watched instructional videos about synthesis and practice areas in the *Primary School Mathematics Curriculum*. After observation, they actively engaged in personal analysis, sharing, and discussions about the primary school students' needs, wants, emotions, feelings, actions, and problems when they were learning in the lessons of statistics and probability areas in the *Primary School Mathematics Curriculum*. Undergraduates were very proficient in the analysis process; Their analyses were comprehensive. However, some undergraduates' analyses were not sufficiently deep.
	Step 2: Defining	Undergraduate students actively engaged in personal analysis, sharing, discussion and identification about the problems in *Primary School Mathematics Curriculum* teacher's teaching that needs to be solved in order for primary school students to learn more effectively in the lessons of synthesis and practice areas; They were proficient in the define process; Their analyses were deep and their identification of problems were accurate.
	Step 3: Ideate	Undergraduate students actively participated in brainstorming and boldly expressed their ideas, and they were familiar with the rules and procedures of brainstorming. However, their ideas were new, unique, accurate, and consistent with the problems identified in Step 2.
	Step 4: Prototype	Undergraduate students can actively participate in designing a lesson plan for the number and algebra areas in the *Primary School Mathematics Curriculum*. They were able to actively share and mutually evaluate the lesson plans they had designed, and their lesson plans' learning process and learning media were more new, unique, accurate, and consistent with other parts.
	Step 5: Test	Undergraduate students could actively participate in microteaching; they were proficient in the process. Their teaching style was natural and confident. Primary school students learning process and learning media in their microteaching were new, unique, accurate, and consistent with other parts.

Step 5: Test Undergraduate students could actively participate in microteaching; they were proficient in the process. Their teaching style was natural and confident. Primary school students learning process and learning media in their microteaching were new, unique, accurate, and consistent with other parts.

Table 4.11 shows that the implementation of the instructional model based on design thinking and brainstorming in the "Primary School Mathematics Curriculum Instruction Design and Implementation course" effectively promoted the learning of undergraduate students, and it also enhanced the development of their creative thinking ability. Through learning, students can improve the following abilities:

1) Undergraduate students can empathize more deeply with the needs and emotions of primary school students' needs, wants, emotions, feelings, actions, and problems during learning before designing a lesson plan for primary school students in the Primary School Mathematics Curriculum.

2) Undergraduate students can analyze more deeply the existing problems in Primary School Mathematics Curriculum teacher's teaching that needs to be solved for primary school students to learn more effectively. And they can define the problems more accurately.

3) Undergraduate students can brainstorm more effectively and generate a greater number of ideas that were new, unique, accurate and consistent.

4) Undergraduates can design new, unique, accurate, and consistent lesson plans for primary school students in the Primary School Mathematics Curriculum.

5) Undergraduates' teaching styles are more natural and confident. Primary school students learning process and learning media in their microteaching were new, unique, accurate, and consistent with other parts.

2. Findings from the Interview Form for Teaching Opinions

The findings of this part of the study focused on interviewing the participants through semi-structured interviews to find out the students' perspectives on the instructional model based on design thinking and brainstorming. A total of 10 participants were interviewed.

Table 4.12 Students' opinions on teaching

Items	Students' opinions
1. Can you skillfully apply design thinking in your learning?	90% (9/10) of the interviewees responded that they can proficiently apply design thinking in their learning, while 10% (1/10) of the interviewees stated that they can use design thinking but are not yet proficient.
2. What problems do you have when using design thinking?	Based on the responses from the interviewees, undergraduate students face the following challenges when using design thinking in their learning: 1) Time constraints in teaching, limited opportunities to deeply observe elementary mathematics in the field, leading to difficulties in empathy and problem definition. 2) Difficulty in designing innovative lesson plans due to limitations in foundational theoretical knowledge and teaching experience. 3) Lack of in-depth experience in teaching at primary schools, resulting in less depth when providing suggestions for modifying primary school mathematics lesson plans to each other.
3. Can you skillfully apply brainstorming in your learning?	90% (9/10) of the interviewees responded that they can proficiently apply brainstorming in their learning, while 10% (1/10) of the interviewees stated that they can use design thinking but are not yet proficient.
4. What problems do you have when using brainstorming?	Considering the responses from the interviewees, undergraduate students encounter the following challenges when using brainstorming in their learning: 1) Limited teaching time affecting the effectiveness of brainstorming; 2) A minority of group members not actively participating, impacting the effectiveness of brainstorming; 3) Difficulty in presenting original ideas; 4) Uncertainty in handling opposing viewpoints when they arise.

Table 4.12 (Continued)

Items	Students' opinions
5. Is the instructional model based on design thinking and brainstorming useful in enhancing your creative thinking ability?	100% (10/10) of the interviewees responded that the implementation of the instructional model based on design thinking and brainstorming is useful in enhancing their creative thinking ability. It enhances the development of creative thinking among undergraduate students through the following aspects: 1) Design thinking emphasizes starting from the user's perspective, challenging traditional limitations, encouraging multi-perspective thinking, and seeking unique solutions. 2) Brainstorming encourages the free expression of ideas, collective discussions to stimulate creativity, and the expansion of perspectives. 3) Leveraging collective intelligence to inspire more creativity. 4) Enhancing observational skills and cultivating divergent thinking, encouraging association and leaps of thought.
6. How do you think teachers should help undergraduate students improve their creative thinking ability(originality)?	Summing up the responses from the interviewees, they can be summarized as follows: 1) Encourage independent exploration and provide students with sufficient freedom and space; 2) Create an open and inclusive teaching environment to encourage students to freely express their opinions; 3) Introduce design thinking and brainstorming, allowing students to experience the process of innovative thinking through practical exercises; 4) Utilize diverse teaching methods, such as group discussions and case analyses; 5) Guide students in reflection and summarization, and provide opportunities for practical application;6)Encourage diverse perspectives and ways of thinking.
7. What learning strategies do you think are the most effective?	Summing up the responses from the interviewees, they can be summarized as follows: 1) Practice and practical training; 2) Heuristic teaching strategies; 3) Create open, diverse, and challenging tasks; 4) Emphasize interdisciplinary thinking; 5) Brainstorming; 6) Encourage independent learning and research; 7) Group discussion and collaboration;8)Practice and

Table 4.12 (Continued)

Items	Students' opinions
	project-based learning; 9) Provide diverse learning resources; 10) Emphasize feedback and evaluation; 11) Cultivate critical thinking; 12) reate exploratory problems; 13) Offer courses and activities to foster innovative thinking; 14) Encourage students with individualized teaching.
8. Finally, is there anything else you would like to add about your views on teaching?	Summing up the responses from the interviewees, they can be summarized as follows: 1) Brainstorming; 2) Use the brainstorming method; 3) Start from the level that students can accept; 4) Reform teaching methods, adopt heuristic, discussion-based, problem-based, independent learning, and research-based teaching methods; 5) Stimulate students' thinking development; 6) Offer specific creative courses, teach creative strategies and techniques; 7) Provide diverse teaching resources, reference case analysis, and integrate with practical experience; 8) Strengthen interdisciplinary learning; 9) Utilize technological means to assist teaching; 10) Establish a good teacher-student relationship; 11) Create an innovative environment, encourage students, and motivate them to participate in innovative activities; 12) Regularly evaluate and adjust teaching strategies; 13) Spark students' interest and provide them with a platform; 14) Provide innovative platforms and practical opportunities, combining practice with reflection.

Table 4.12 shows that the implementation of the instructional model based on design thinking and brainstorming has enhanced undergraduate students’ creative thinking abilities. However, through in-depth interviews, we found that there are still some issues that need to be addressed in the implementation of this teaching model.

Chapter 5
Conclusion Discussion and Recommendations

The research objectives were 1) to study the factors that affect the development of the third-year undergraduate students' creative thinking ability in Baise University 2) to develop an instructional model based on design thinking and brainstorming and 3) to compare the third-year undergraduate students' creative thinking ability before and after use the instructional model based on design thinking and brainstorming.

The population of this study was 90 third-year undergraduate students. The sample group for this study was 45 third-year undergraduate students in 1 class who were selected by clusters random sampling method from a mix of good, medium, and weak abilities and enrolled in the Primary School Mathematics Instruction Design and Implementation course at Baise University in the fall semester of 2023.

The research tools 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.

This study was conducted in three steps: a study on the factors that affect the development of third-year undergraduate students' creative thinking ability, The development of an instructional model based on design thinking and brainstorming, and an experimental improvement of the instructional model.

Conclusion

The results of the study show that:

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, the learning process of the instructional model is five steps: empathizing, defining, ideate, prototype, and test

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.

Discussion

The analytical discussion of the study is segmented into three parts, each of which is sequentially explored in this section.

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 factors and personal factors. The environmental factor consists of three sub-factors: family, school, and society. Personal factors consist of three sub-factors: personality traits, motivation, attitude, and emotional state. This is consistent with the results of a study by Guilford (1950), who pointed out that both environmental and individual factors influence individual creativity.

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

1.1 Motivation

In the ranking of sub-factors, the first factor is motivation. This indicates that good motivation has a positive impact on 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 that is 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, and if he has this attitude, he will be more sensitive to problems (Guilford, 1986).

The impact of motivation on undergraduate students' creative thinking ability is as follows: 1) If an undergraduate student lacks the motivation to utilize certain abilities related to creative production within their intellectual structure, their creative output may be limited. 2) Curiosity-driven undergraduate students tend to have higher creative thinking abilities. 3) If undergraduate students have a clear

purpose in mind for what they are going to do, they are willing to spend time on creative thinking.

1.2 Attitude and emotional state

In the ranking of sub-factors, the second factor is attitude and emotional state. This indicates that attitude and emotional state have an impact on the development of creative thinking 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. Emotions such as prejudice, worry, anxiety, jealousy, disobedience, apathy, and complacency can hinder creative development.

The impact of attitude and emotional state on undergraduate students' creative thinking ability are as follows: 1) Having a positive attitude about creativity is certainly necessary for undergraduate students to enhance their creative thinking ability. 2) If undergraduates are focused too much on following rules and guidelines, it is not conducive to enhance their creative thinking ability. 3) Attitudes such as respect for authority figures, being pleased with others' success, and a lack of self-confidence can suppress creative thinking in undergraduate students. 4) Emotional states such as bias, worry, anxiety, jealousy, defiance, indifference, and complacency can hinder the development of creative thinking abilities in undergraduate students.

1.3 Personality traits

In the ranking of sub-factors, the third factor is personality traits. This indicates that good personality traits have a positive impact on 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).

The impact of personality traits on undergraduate students' creative thinking ability is as follows: 1) Undergraduate students with curious personality traits usually have more creative thinking ability. 2) Undergraduate students with independent personality traits usually have more creative thinking ability. 3)

Undergraduate students with open-minded personality traits usually have more creative thinking ability. 4) A flexible personality is conducive to enhancing undergraduates' creative thinking ability, and a rigid personality is not conducive to enhancing undergraduates' creative thinking ability. 5) It is advantageous for the development of creative thinking for an undergraduate student if he/she has the flexibility to switch from one discipline to another at any time. 6) Undergraduate students with persistent personality traits usually have more creative thinking abilities. 7) Undergraduate students with unconventional personality traits usually have more creative thinking abilities. 8) Men (women) who often exhibit a bit more femininity (masculinity) in their personality traits usually have better creative thinking abilities than other males(females).

1.4 School

In the ranking of sub-factors, the fourth factor is school. This indicates that schools have a positive impact on the development of creative thinking among undergraduate students. This is supported by the following research: 1) The research from Hong et al. (2009, quoted 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, quoted 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.

The impact of the school on undergraduate students' creative thinking ability is as follows: 1) Good time management is necessary to enhance undergraduates' creative thinking ability. 2) Having enough time is necessary to enhance undergraduates' creative thinking ability in class and outside of class. 3) Too many undergraduates in the classroom is not conducive to enhancing their creative thinking ability. 4) An atmosphere of opening to new ideas and allowing students to

take risks and make mistakes is necessary to enhance undergraduates' creative thinking ability. 5) Interaction that is fun, appreciating, accepting, and giving opportunities to do things in the classroom is necessary to enhance undergraduates' creative thinking ability. 6) An atmosphere that allows them to think and reflect without rushing is necessary to enhance undergraduates' creative thinking ability. 7) Collective problem-solving is effective in enhancing undergraduates' creative thinking ability. 8) Using project work and challenging problems in curriculum and subjects is useful to enhance their creative thinking ability. 9) Too much assessment is not conducive to enhancing their creative thinking ability in curriculum and subjects.

1.5 Society

In the ranking of sub-factors, the fifth factor is society. This indicates that society has a positive impact on the development of creative thinking among undergraduate students. This is supported by research from Chan & Yuen (2014), who identified that community is one of two environmental factors. This is also similar to the research result from Guilford (1986), who stated that factors related to being born in a rural or urban area affect a person's creative development. However, not all academics agreed with it. However, all the ten scholars or professional experts in this study expressed doubts about 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.

The impact of society on undergraduate students' creative thinking ability is as follows: 1) If a student often faces a large number of problems that need to be solved in society, then he or she will tend to have higher creative thinking skills. 2) A societal atmosphere that is open to new ideas and safe for students to take risks and make mistakes is necessary to enhance undergraduate students' creative thinking ability. 3) The Societal atmosphere places a lot of emphasis on examinations, which contradicts enhancing undergraduate students' creative thinking ability. 4) The high societal expectation of creative thinking ability enhancement is conducive to enhancing undergraduate students' creative thinking ability.

1.6 Family

In the ranking of sub-factors, the sixth factor is family. This indicates that family has a positive impact on the development of creative thinking among undergraduate students. This is similar to the research result from Guilford (1986), who presented that family influences the development of creative ability.

The impact of the family on undergraduate students' creative thinking ability is as follows: 1) The eldest son or daughter in a family, or among siblings in the same family, tends to have greater creative thinking ability. 2) If a student often faces a large number of problems that need to be solved in the family, then he or she will tend to have higher creative thinking skills. 3) If undergraduates feel that their parents are interested and supportive, this is a source of additional motivation for them to think creatively.

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 consisted of four components: principle, objective, learning process, and result. This instructional model's learning process consists of five steps: empathizing, defining, ideate, prototype, and test. 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 model named the DGR model, which was based on design thinking and reflective practice approaches. DGR model conrisists 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.

3. Discussion on the effectiveness of the implementation of the instructional model

Results indicate that the instructional model based on design thinking and brainstorming is effective for undergraduate students in enhancing their creative thinking ability. This is supported by the following researchers: 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) 1) The research from Ekthamasuth et al. (2022), who developed an instructional model named the DGR model based on design thinking and reflective practice approaches. The implementation of the DGR model enhanced nursing students' creative ability in nursing with a statistically significant level of 0.05.

Based on the above, it can be found that: Creative patterns manifest in behaviors such as designing and planning (Guilford, 1950). Design thinking is a human-centered innovation methodology in a design innovation program (Meinel, 2011). Within the framework of design thinking, genuine innovation can emerge during the problem-solving process (Brown, 2010, quoted by Fabri, 2015). Brainstorming is a collaborative creativity method employed, especially by design teams (McFadzean, 1998) and is a common technique that is used to encourage groups to produce creative ideas (McFadzean,1998). It can be employed to develop creative giftedness (Guilford, 1975). Brainstorming is employed in the ideation phase of design thinking (Interaction Design Foundation, n.d.).

Recommendations

1. Applicability of results

The results of this study can be applied in the following aspects:

The instructional model based on design thinking and brainstorming can be applied to other undergraduate design courses to enhance undergraduate students' creative thinking ability.

The instructional model based on design thinking and brainstorming can be applied to other undergraduate design courses to enhance undergraduate students' design capabilities.

The instructional model based on design thinking and brainstorming can be applied to elementary, middle, and high school-related courses to cultivate students' creative thinking abilities.

2. Future Researches

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

1) Further research can be conducted on the factors influencing the development of undergraduate students' creative thinking ability. 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 can be surveyed through questionnaires and interviews to investigate the factors influencing the development of undergraduate students' creative thinking abilities. Test, questionnaires, and interviews can be conducted on undergraduate students to explore the factors influencing the development of their creative thinking abilities.

2) In this study, Unit 6, Unit7, Unit8, Unit9 (4 lessons and 16 hours in total) of Primary School Mathematics Curriculum Instruction Design and Implementation course were selected as the carrier and refer to the general framework of instructional model. In the future, attempts can be made to apply this instructional model in more courses to explore and improve the model.

3) Research can be conducted on the promotion of the instructional model based on design thinking and brainstorming of aspects other than creative thinking ability. This study primarily 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 such as reflective ability, design ability, etc.

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Appendices

Appendix A

List of Specialists and Letters of Specialists Invitation for IOC Verification

List of Specialists and Letters of Specialists Invitation for IOC Verification

Name of Experts	Position/Office
Asst. Prof. Dr. Supanee Sirisawatchai	Bansomdejchaopraya Rajabhat University
Asst. Prof. Dr. Patchareephorn Bangkeaw	Bansomdejchaopraya Rajabhat University
Asst. Prof. Dr. Chalermsup Karanjakwut	Head of the English Program / Bansomdejchaopraya Rajabhat University
Prof. Dr.Huang Jianxiong	Baise University
Assoc. Prof. Dr. Wang Chunhua	Mongolia Normal University

Appendix B

Official Letter

Ref. No. MHESI 0643.14/1537

Graduate School
Bansomdejchaopraya Rajabhat University
1061 Itsarapap 15 Itsarapap Rd.
Thonburi Bangkok 10600

20 December 2023

Subject Request for Research Tool Validation

Dear Assistant Professor Dr.Supranee Sirisawatchai

Attachment Validation sheets

Regarding the thesis entitled "The development of instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability"of **Mr. Zhou Chaozheng**, a Ph.D. student majoring in the Curriculum and Instruction Programme at Bansomejchaopraya Rajabhat University code number code number 6373103101, Thailand, under the supervision of Prof. Dr. Bung - on Sereerat, Dr.Penporn Thongkamsuk, and Assistant Professor Dr.Saifon Songsiengchai will use the written instruments in the said research. Given the researcher would like your expertise to validate the attached instruments to qualify for conduction. Knowing your experience in the field of education, I would like to ask for your help validating the instrument before administering it to the study participants.

The thesis introduction, research objective, questionnaire, and interview are hereby attached. I will gladly hear your suggestions and comments for improving the instrument. Your positive response is highly appreciated. Please check IOC processing and return all files to the researcher after 30 days of your finishing validation sheets.

Sincerely,

(Assistant Professor Dr.Kanakorn Sawangcharoen)
Dean of Graduate School
Bansomejchaopraya Rajabhat University

Tel. (662) 4737000 Ext.
Fax. (662) 4737000

Ref. No. MHESI 0643.14/1538

Graduate School
Bansomdejchaopraya Rajabhat University
1061 Itsarapap 15 Itsarapap Rd.
Thonburi Bangkok 10600

20 December 2023

Subject Request for Research Tool Validation

Dear Assistant Professor Dr. Patchareeporn Bangkeaw

Attachment Validation sheets

Regarding the thesis entitled "The development of instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability"of **Mr. Zhou Chaozheng**, a Ph.D. student majoring in the Curriculum and Instruction Programme at Bansomejchaopraya Rajabhat University code number code number 6373103101, Thailand, under the supervision of Prof. Dr. Bung - on Sereerat, Dr. Penporn Thongkamsuk, and Assistant Professor Dr. Saifon Songsiengchai will use the written instruments in the said research. Given the researcher would like your expertise to validate the attached instruments to qualify for conduction. Knowing your experience in the field of education, I would like to ask for your help validating the instrument before administering it to the study participants.

The thesis introduction, research objective, questionnaire, and interview are hereby attached. I will gladly hear your suggestions and comments for improving the instrument. Your positive response is highly appreciated. Please check IOC processing and return all files to the researcher after 30 days of your finishing validation sheets.

Sincerely,

(Assistant Professor Dr.Kanakorn Sawangcharoen)
Dean of Graduate School
Bansomejchaopraya Rajabhat University

Tel. (662) 4737000 Ext.
Fax. (662) 4737000

Ref. No. MHESI 0643.14/1539

Graduate School
Bansomdejchaopraya Rajabhat University
1061 Itsarapap 15 Itsarapap Rd.
Thonburi Bangkok 10600

20 December 2023

Subject Request for Research Tool Validation

Dear Assistant Professor Dr.Chalermsup Karanjakwut

Attachment Validation sheets

Regarding the thesis entitled "The development of instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability"of **Mr. Zhou Chaozheng**, a Ph.D. student majoring in the Curriculum and Instruction Programme at Bansomejchaopraya Rajabhat University code number code number 6373103101, Thailand, under the supervision of Prof. Dr. Bung - on Sereerat, Dr. Penporn Thongkamsuk, and Assistant Professor Dr. Saifon Songsiengchai will use the written instruments in the said research. Given the researcher would like your expertise to validate the attached instruments to qualify for conduction. Knowing your experience in the field of education, I would like to ask for your help validating the instrument before administering it to the study participants.

The thesis introduction, research objective, questionnaire, and interview are hereby attached. I will gladly hear your suggestions and comments for improving the instrument. Your positive response is highly appreciated. Please check IOC processing and return all files to the researcher after 30 days of your finishing validation sheets.

Sincerely,

(Assistant Professor Dr.Kanakorn Sawangcharoen)
Dean of Graduate School
Bansomejchaopraya Rajabhat University

Tel. (662) 4737000 Ext.
Fax. (662) 4737000

Ref. No. MHESI 0643.14/1540

Graduate School
Bansomdejchaopraya Rajabhat University
1061 Itsarapap 15 Itsarapap Rd.
Thonburi Bangkok 10600

20 December 2023

Subject Request for Research Tool Validation

Dear **Prof. Dr. Huang Jianxiong**

Attachment Validation sheets

Regarding the thesis entitled "The development of instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability"of **Mr. Zhou Chaozheng**, a Ph.D. student majoring in the Curriculum and Instruction Programme at Bansomejchaopraya Rajabhat University code number code number 6373103101, Thailand, under the supervision of Prof. Dr. Bung - on Sereerat, Dr.Penporn Thongkamsuk, and Assistant Professor Dr.Saifon Songsiengchai will use the written instruments in the said research. Given the researcher would like your expertise to validate the attached instruments to qualify for conduction. Knowing your experience in the field of education, I would like to ask for your help validating the instrument before administering it to the study participants.

The thesis introduction, research objective, questionnaire, and interview are hereby attached. I will gladly hear your suggestions and comments for improving the instrument. Your positive response is highly appreciated. Please check IOC processing and return all files to the researcher after 30 days of your finishing validation sheets.

Sincerely,

(Assistant Professor Dr.Kanakorn Sawangcharoen)
Dean of Graduate School
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Tel. (662) 4737000 Ext.
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Ref. No. MHESI 0643.14/ 1541

Graduate School
Bansomdejchaopraya Rajabhat University
1061 Itsarapap 15 Itsarapap Rd.
Thonburi Bangkok 10600

20 December 2023

Subject Request for Research Tool Validation

Dear **Assoc. Prof. Dr. Wang Chunhua**

Attachment Validation sheets

Regarding the thesis entitled "The development of instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability"of **Mr. Zhou Chaozheng**, a Ph.D. student majoring in the Curriculum and Instruction Programme at Bansomejchaopraya Rajabhat University code number code number 6373103101, Thailand, under the supervision of Prof. Dr. Bung - on Sereerat, Dr.Penporn Thongkamsuk, and Assistant Professor Dr.Saifon Songsiengchai will use the written instruments in the said research. Given the researcher would like your expertise to validate the attached instruments to qualify for conduction. Knowing your experience in the field of education, I would like to ask for your help validating the instrument before administering it to the study participants.

The thesis introduction, research objective, questionnaire, and interview are hereby attached. I will gladly hear your suggestions and comments for improving the instrument. Your positive response is highly appreciated. Please check IOC processing and return all files to the researcher after 30 days of your finishing validation sheets.

Sincerely,

(Assistant Professor Dr.Kanakorn Sawangcharoen)
Dean of Graduate School
Bansomejchaopraya Rajabhat University

Tel. (662) 4737000 Ext.
Fax. (662) 4737000

Appendix C

Research Instrument

C.1 Assessment form for validity of the_instructional model based on design thinking and brainstorming

Research Title: The development of an instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability

Research Objectives:

1. To explore the factors that affect the 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 the third-year undergraduate students' creative thinking ability before and after using the instructional model based on design thinking and brainstorming.

Assessor: .....Position: .....

Workplace: .....

Directions:

Please assess the item objective congruence (IOC) for the instructional model based on design thinking and brainstorming by putting √ it in the box according to the following criteria:

Give +1 to an item that is congruent with a clear understanding of this study

Give 0 to an item that is uncertain or not sure whether it is related to the study

Give -1 to an item that is not understood or is not congruent or related to this study

No.	Items	Assessment result			Remarks
		-1	0	+1	
1	Principle				
2	Objective				
3	Learning processes				
4	Result				

Suggestions

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

Sign..... Assessor

(.....)

Date...../...../.....

B.2 Interview form about factors that affect the development of third-year undergraduate students' creative thinking ability

Dear Professor/Associate Professor/ Assistant Professor:

This interview is part of the research on the development of an instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability, which aims to explore the factors that affect the development of third-year undergraduate students' creative thinking ability.

The information obtained from each respondent, the researcher guarantees that your answers are confidential and will have no impact on your institution or you.

There are 8 questions in the interview, please answer truthfully according to your actual situation and teaching experience. This interview will last 15-20 minutes.

Thank you very much for your response to the interview.

Name: ..... Gender: .....

Position/Role: ..... School/Institution Name: .....

1. Will family affect the development of undergraduate students' creative thinking ability? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.

2. Will school impact the development of undergraduate students' creative thinking ability? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.

3. Will society impact the development of undergraduate students' creative thinking ability? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.

4. Will personality traits influence the development of undergraduate students' creative thinking ability? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.

5. Will undergraduate students' motivation influence their development of creative thinking ability? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.

6. Will undergraduate students' attitude toward creativity, attitude toward authority figures, and attitude toward norms affect their development of creative thinking ability? If so, discuss how these factors influence the development of undergraduate students' creative thinking ability.

7.Will undergraduate students' emotional state such as bias, worry, anxiety, jealousy, defiance, indifference, and complacency affect their development of crea-

tive thinking ability? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.

8. Will a sense of purpose affect the development of undergraduate students' creative thinking ability? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.

C2 Assessment form for validity of the interview form about factors that affect the development of third-year undergraduate students' creative thinking ability

Research Title: The development of an instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability

Research Objectives:

1. To explore the factors that affect the 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 the third-year undergraduate students' creative thinking ability before and after using the instructional model based on design thinking and brainstorming.

Assessor: .....Position: .....

Workplace: .....

Directions:

Please assess the item objective congruence (IOC) for the interview form about factors that affect the development of third-year undergraduate students' creative thinking ability by putting √ in the box according to the following criteria:

Give +1 to an item that is congruent with a clear understanding of this study

Give 0 to an item that is uncertain or not sure whether it is related to the study

Give -1 to an item that is not understand or is not congruent or related to this study

No.	Questions	Assessment result			Remarks
		-1	0	+1	
1	Will family affect the development of undergraduate students' creative thinking ability abilities? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.				
2	Will school impact the development of undergraduate students' creative thinking ability abilities? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.				
3	Will society impact the development of undergraduate students' creative thinking ability abilities? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.				
4	Will personality traits influence the development of undergraduate students' creative thinking ability abilities? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.				
5	Will undergraduate students' motivation influence their development of creative thinking ability abilities? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.				
6	Will undergraduate students' attitudes about creativity, authority figures, norms affect their development of creative thinking ability abilities? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.				
7	Will undergraduate students' emotional state such as bias, worry, anxiety, jealousy, defiance, indiffer-				

No.	Questions	Assessment result			Remarks
		-1	0	+1	
	ence, and complacency can affect their development of creative thinking ability abilities? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.				
8	Will a sense of purpose_affect the development of undergraduate students' creative thinking ability abilities? If so, discuss how this factor influences the development of undergraduate students' creative thinking ability.				

Suggestions

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. . . . . .

. . . . . .

. . . . . .

. . . . . .

Sign..... Assessor

(.....)

Date...../...../.....

B.3 Questionnaire about factors that affect the development of third-year undergraduate students' creative thinking ability

Dear Professor/Associate Professor/ Assistant Professor:

This questionnaire is part of the research on "The Development of Instructional Model Based on Design Thinking and Brainstorming to Enhance Undergraduate Students' Creative Thinking Ability," which aims to explore the factors that affect the development of third-year undergraduate students' creative thinking ability.

The information obtained from each respondent, the researcher guarantees that your answers are confidential and will have no impact on the institution or you.

There are 37 questions in the questionnaire, please answer truthfully according to your actual situation and teaching experience. This interview will last 15-20 minutes.

Thank you very much for your response to the questionnaire.

Part I: Information on the identity of the interviewees

1. Gender

1) Male 2) Female

2. Age

1) 30-40 years old 2) 40-50 years old 3) 50-60 years old 4) 61 years old or above

3. Highest education

1) Bachelor's degree 2) Master's degree 3) Doctoral degree

4. Job title

1) Professor 2) Associate professor 3) Assistant professor 4) Instructor

5. Experience in working at universities

1) Less than 5 years 2) 5-10 years 3) More than 10 years

6. Main research areas:

Part II: Factors that affect the development of the third-year undergraduate students' creative thinking ability

Direction: please read the following 31 items carefully and select the extent to which factors affect factors that affect the development of the undergraduate students' creative thinking ability based on your actual situation and teaching experience.

Rating Scale of Likert Scale 5 level:

1=strongly disagree, 2= disagree r, 3= unsure, 4=Larger agree, 5= strongly agree

Factors			Question	Level					Remarks
				1	2	3	4	5	
Environmental Factors	Family		1.1 The eldest son or daughter in a family, or among siblings in the same family, tends to have a greater creative thinking ability.						
			1.2 If a student often faces a large number of problems that need to be solved in the family, then he or she will tend to have higher creative thinking skills.						
			1.3 If undergraduates can feel that their parents are interested in and support to their creative thinking, their creative thinking ability will be well developed.						
	School	Time and space	2.1 Good time management is necessary to enhance undergraduates' creative thinking ability.						
			2.2 Having enough time is necessary to enhance undergraduates' creative thinking ability in class and outside of class.						
			2.3 Too many undergraduates in the classroom is not conducive to enhance their creative thinking ability.						
		Atmosphere	2.4 The Atmosphere of opening to new ideas and allowing students to take risks and make mistakes is necessary to enhance undergraduates' creative						

Factors			Question	Level					Remarks
				1	2	3	4	5	
			thinking ability.						
			2.5 Interaction that is fun, appreciating, accepting, and giving opportunities to do things in the classroom is necessary to enhance undergraduates' creative thinking ability.						
			2.6 An atmosphere that allows them to think and reflect without rushing is necessary to enhance undergraduates' creative thinking ability.						
			2.7 Collective problem-solving is effective in enhancing undergraduates' creative thinking ability.						
		Curriculum and subjects	2.8 Using project work and challenging problems in curriculum and subjects is useful to enhance their creative thinking ability.						
			2.9 Too much assessment is not conducive to enhance their creative thinking ability in curriculum and subjects.						
	Society		3.1 If a student often faces a large number of problems that need to be solved in society, then he or she will tend to have higher creative thinking skills.						
			3.2 A societal atmosphere that is open to new ideas and safe for students to take risks and make mis-						

Factors		Question	Level					Remarks
			1	2	3	4	5	
		takes is necessary to enhance undergraduate students' creative thinking ability.						
		3.3 Societal atmosphere places a lot of emphasis on examinations is contradicts with enhancing undergraduate students' creative thinking ability.						
		3.4 The high societal expectation of creative thinking ability enhancement is conducive to enhancing undergraduate students' creative thinking ability.						
Personal factors	personality traits	4.1 Undergraduate students with curious personality traits usually have more creative thinking ability						
		4.2 Undergraduate students with independent personality traits usually have more creative thinking ability						
		4.3 Undergraduate students with open-minded personality traits usually have more creative thinking ability						
		4.4 Flexible personality is conducive to enhance undergraduates' creative thinking ability, and rigid personality is not conducive to enhance undergraduates' creative thinking ability.						

Factors		Question	Level					Remarks
			1	2	3	4	5	
		4.5 It is advantageous for the development of creative thinking for an undergraduate student if he/she has the flexibility to switch from one discipline to another at any time.						
		4.6 Undergraduate students with persistent personality traits usually have more creative thinking ability						
		4.7 Undergraduate students with unconventional personality traits usually have more creative thinking ability						
		4.8 Men (women) who often exhibit a bit more femininity(masculinity) in their personality traits usually have better creative thinking abilities than other males(females).						
	Motivation	5.1 If an undergraduate student lacks the motivation to utilize certain abilities related to creative production within their intellectual structure, their creative output may be limited.						
		5.2 Curiosity-driven undergraduate students tend to have higher creative thinking abilities.						
		5.3 If undergraduate students have a clear purpose in mind for what they						

Factors		Question	Level					Remarks
			1	2	3	4	5	
		are going to do, they are willing to spend time on creative thinking.						
	Attitude and emotional state	6.1 Having a positive attitude about creativity is certainly necessary for undergraduate students to enhance their creative thinking ability.						
		6.2 If undergraduates are focused too much on following rules and guidelines, it is not conducive to enhance their creative thinking ability.						
		6.3 Attitudes such as respect for authority figures, being pleased with others' success, and a lack of self-confidence can suppress creative thinking in undergraduate students.						
		6.4 Emotional states such as bias, worry, anxiety, jealousy, defiance, indifference, and complacency can hinder the development of creative thinking abilities in undergraduate students.						

C.3 Assessment form for the validity of the questionnaire about factors that affect_the development of third-year undergraduate students' creative thinking ability

Research Title:

The development of instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability.

Research Objectives:

1. To explore the factors that affect the third-year undergraduate students' creative thinking ability in Baise University.

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

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

Assessor: .....Position: .....

Workplace: .....

Directions:

Please assess the item objective congruence (IOC) for the questionnaire about factors that affect the development of third-year undergraduate students' creative thinking ability by putting √ in the box according to the following criteria:

Give +1 to an item that is congruent with a clear understanding of this study

Give 0 to an item that is uncertain or not sure whether it is related to the study

Give -1 to an item that is not understand or is not congruent or related to this study

Factors			Questions	Remarks			Remarks
				+1	0	-1	
Environment Factors	Family		1.1 The eldest son or daughter in a family, or among siblings in the same family, tends to have a greater creative thinking ability.				
			1.2 If a student often faces a large number of problems that need to be solved in the family, then he or she will tend to have higher creative thinking skills.				
			1.3 If undergraduates can feel that their parents are interested in and support to their creative thinking, their creative thinking ability will be well developed.				
	School	Time and space	2.1 Good time management is necessary to enhance undergraduates' creative thinking ability.				
			2.2 Having enough time is necessary to enhance undergraduates' creative thinking ability in class and outside of class.				
			2.3 Too many undergraduates in the classroom is not conducive to enhance their creative thinking ability.				
		Atmosphere	2.4 The Atmosphere of opening to new ideas and allowing students to take risks and make mistakes is necessary to enhance undergraduates' creative thinking ability.				
			2.5 Interaction that is fun, appreciating, accepting, and giving opportunities to do things in the classroom is necessary to enhance undergraduates' creative thinking ability.				
			2.6 An atmosphere that allows them to think and reflect without rushing is necessary to enhance undergraduates' creative thinking ability.				
			2.7 Collective problem-solving is effective in enhancing undergraduates' creative thinking ability.				
		Curriculum	2.8 Using project work and challenging problems in curriculum and subjects is useful to enhance their creative thinking ability.				

Factors		Questions	Remarks			Remarks
			+1	0	-1	
	and subjects	2.9 Too much assessment is not conducive to enhance their creative thinking ability in curriculum and subjects.				
	Society	3.1 If a student often faces a large number of problems that need to be solved in society, then he or she will tend to have higher creative thinking skills.				
		3.2 A societal atmosphere that is open to new ideas and safe for students to take risks and make mistakes is necessary to enhance undergraduate students' creative thinking ability.				
		3.3 Societal atmosphere places a lot of emphasis on examinations is contradicts with enhancing undergraduate students' creative thinking ability.				
		3.4 The high societal expectation of creative thinking ability enhancement is conducive to enhancing undergraduate students' creative thinking ability.				
Personal factors	personality traits	4.1 Undergraduate students with curious personality traits usually have more creative thinking ability				
		4.2 Undergraduate students with independent personality traits usually have more creative thinking ability				
		4.3 Undergraduate students with open-minded personality traits usually have more creative thinking ability				
		4.4 Flexible personality is conducive to enhance undergraduates' creative thinking ability, and rigid personality is not conducive to enhance undergraduates' creative thinking ability.				
		4.5 It is advantageous for the development of creative thinking for an undergraduate student if he/she has the flexibility to switch from one discipline to another at any time.				

Factors	Questions	Remarks			Re-marks
		+1	0	-1	
	4.6 Undergraduate students with persistent personality traits usually have more creative thinking ability				
	4.7 Undergraduate students with unconventional personality traits usually have more creative thinking ability				
	4.8 Men (women) who often exhibit a bit more femininity(masculinity) in their personality traits usually have better creative thinking abilities than other males(females).				
Motivation	5.1 If an undergraduate student lacks the motivation to utilize certain abilities related to creative production within their intellectual structure, their creative output may be limited.				
	5.2 Curiosity-driven undergraduate students tend to have higher creative thinking abilities.				
	5.3 If undergraduate students have a clear purpose in mind for what they are going to do, they are willing to spend time on creative thinking.				
Attitude and emotional state	6.1 Having a positive attitude about creativity is certainly necessary for undergraduate students to enhance their creative thinking ability.				
	6.2 If undergraduates are focused too much on following rules and guidelines, it is not conducive to enhance their creative thinking ability.				
	6.3 Attitudes such as respect for authority figures, being pleased with others' success, and a lack of self-confidence can suppress creative thinking in undergraduate students.				
	6.4 Emotional states such as bias, worry, anxiety, jealousy, defiance, indifference, and complacency can hinder the development of creative thinking abilities in undergraduate students.				

Suggestions

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Sign.. Assessor

(..)

Date........../................../.............

B.4 Lesson plans I

Lesson topic: Lesson plan design and implementation of numbers and algebra areas in *Primary School Mathematics Curriculum*

Time: 4 hours

1. Concept

A lesson plan of numbers and algebra areas in *the Primary School Mathematics Curriculum is a teacher's detailed description of numbers and algebra areas in the Primary School Mathematics Curriculum* of instruction or "learning trajectory" for a numbers and algebra areas lesson. A numbers and algebra areas lesson plan is the teacher's guide for running a particular numbers and algebra areas lesson, and it includes the goal (what the students are supposed to learn), how the goal will be reached (the method, procedure) and a way of measuring how well the goal was reached.

2. Contents

2.1 Numbers and Algebra areas

2.2 Lesson plan design and implementation

3. Objective

1) Students can design lesson plans for numbers and algebra areas in the *Primary School Mathematics Curriculum* that are special and not the same as anyone else

2) Students can implement lesson plans for numbers and algebra areas

4. Learning processes

Step 1: Empathizing

1.1 Introduce the learning objectives and learning activities of a unit “Content analysis, lesson plan design and implementation of numbers and algebra areas in Primary School Mathematics Curriculum, especially introduce the way to brainstorm together when learning.

1.2 The teacher teaches the students new theoretical knowledge

1.2.1 Content requirements of Numbers and algebra areas in *Primary School Mathematics Curriculum* from Chinese Mathematics Curriculum Standards for Compulsory Education.

1.2.2 Academic requirements of numbers and algebra areas in *Primary School Mathematics Curriculum* from Chinese Mathematics Curriculum Standards for Compulsory Education.

1.2.3 Tips for teaching numbers and algebra areas from Chinese Mathematics Curriculum Standards for Compulsory Education.

1.3 The teacher provides students with primary school mathematics teacher's videos on the area of numbers and algebra in the *Primary School Mathematics Curriculum*.

1.4 Students watch the videos, observe, and analyze individually the needs, wants, emotions, feelings, actions, and problems of primary school students when they are learning the lesson numbers and algebra areas in the *Primary School Mathematics Curriculum*.

1.5 Students share about primary school students' needs, wants, emotions, feelings, actions, and problems when they are learning in the lesson of numbers and algebra areas in the *Primary School Mathematics Curriculum*.

1.6 Students discuss and conclude primary school students' needs, wants, emotions, feelings, actions, and problems when they are learning the lesson of numbers and algebra areas in the *Primary School Mathematics Curriculum*.

Step 2: Defining

2.1 Each student identifies the problem in the primary school mathematics teacher's teaching that needs to be solved in order for primary school students to learn more effectively in the lesson on numbers and algebra areas in the *Primary School Mathematics Curriculum*.

2.2 Students share with each other the problems identified by them.

2.3 Students discuss and conclude the problems in primary school mathematics teachers' teaching that need to be solved in order for primary school students to learn more effectively in the lesson on numbers and algebra areas in the *Primary School Mathematics Curriculum*.

Step 3: Ideate

3.1 Teacher presents brainstorming rules

3.1.1 Set a time limit – Depending on the problem's complexity, 15–60 minutes is normal.

3.1.2 Begin with a target problem/brief – Members should approach this sharply defined question, plan, or goal and stay on topic.

3.1.3 Refrain from judgment/criticism – No-one should be negative (including via body language) about any idea.

3.1.4 Encourage weird and wacky ideas – Further to the ban on killer phrases like "too expensive", keep the floodgates open so everyone feels free to blurt out ideas (provided they're on topic).

3.1.5 Aim for quantity – Remember, "quantity breeds quality." The sifting-and-sorting process comes later.

3.1.6 Build on others' ideas – It's a process of association where members expand on others' notions and reach new insights, allowing these ideas to trigger their own. Say “and”—rather than discourage with “but”—to get ideas closer to the problem.

3.1.7 Stay visual – Diagrams and Post-Its help bring ideas to life and help others see things in different ways.

3.1.8 Allow one conversation at a time – To arrive at concrete results, it’s essential to keep on track this way and show respect for everyone’s ideas.

3.2 Students began to brainstorm to call for ideas to solve the problems in primary school mathematics teachers’ teaching that were identified in step 2 in order for primary school students to learn more effectively in numbers and algebra areas.

3.3 Students and teachers work together to select most associated idea to solve the problems in primary school mathematics teachers’ teaching that identified in step 2 in order for primary school students to learn more effectively in numbers and algebra areas.

Step 4: Prototype

4.1 Each student designs a primary school mathematics lesson plan of numbers and algebra areas to solve the problems identified in step 2 in order for primary school students to learn more effectively.

4.2 Students within learning team share and help modify with each other their primary school mathematics lesson plan of numbers and algebra areas they have designed.

4.3 Each student modifies their primary school mathematics lesson plan of numbers and algebra areas.

4.4 Students share and test their modified primary school mathematics lesson plan of numbers and algebra areas within the team itself.

4.5 Each student modifies again primary school mathematics lesson plan of numbers and algebra areas to solve the problems identified in step 2 in order for primary school students to learn more effectively.

Step 5: Test

5.1 Students implement the best primary school mathematics lesson plan for numbers and algebra areas through microteaching.

5.2 Students evaluate the complete process of implementing the best primary school mathematics lesson plan of numbers and algebra areas in order for primary school students to learn more effectively.

5.3 Students use the results generated during evaluation to redefine one or more further problems in primary school mathematics teachers' teaching.

5. Learning resources

Teaching videos of a primary school mathematics teaching on the area of numbers and algebra/Textbook/Chaoxing/PPT/mobile/ references

6. Evaluation

Observe whether undergraduate students can think independently thought independently, have constructive imagination, are special and interesting, and are not the same as anything or anyone else when they are designing lesson plans of numbers and algebra areas in the *Primary School Mathematics Curriculum*.

C.4 Assessment form for Validity of the lesson plan I

Research Title:

The development of an instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability.

Research Objectives:

1. To explore the factors that affect the third-year undergraduate students' creative thinking ability in Baise University.

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

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

Assessor: .....Position: .....

Workplace: .....

Directions:

Please assess the item objective congruence (IOC) for lesson plan I by putting √ it in the box according to the following criteria:

Give +1 to an item that is congruent with a clear understanding of this study

Give 0 to an item that is uncertain or not sure whether it is related to the study

Give -1 to an item that is not understood or is not congruent or related to this study

No.	Items		Assessment result			Remarks
			-1	0	+1	
1	Concept					
2	Contents					
3	Objectives					
4	Learning processes	Step 1: Empathizing				
		Step 2: Defining				
		Step 3: Ideate				
		Step 4: Prototype				
		Step 5: Test				
5	Learning resources					
6	Evaluation					

Suggestions

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Sign..... Assessor

(.....)

Date...../...../.....

B.5 Lesson Plans II

Lesson topic: Lesson plan design and implementation of geometry area in *Primary School Mathematics Curriculum*

Time: 4 hours

1. Concept

A lesson plan for the geometry area in the *Primary School Mathematics Curriculum* is a teacher's detailed description of the geometry area in the *Primary School Mathematics Curriculum* of instruction or "learning trajectory" for a geometry area lesson. A geometry area lesson plan is the teacher's guide for running a particular geometry area lesson, and it includes the goal (what the students are supposed to learn), how the goal will be reached (the method and procedure), and a way of measuring how well the goal was reached.

2. Contents

2.1 geometry area

2.2 Lesson plan design and implementation

3. Objective

3.1 Students can design lesson plans for the geometry area in the *Primary School Mathematics Curriculum* that are special and not the same as anyone else

3.2 Students can implement lesson plans for the geometry area

4. Learning process

Step 1: Empathizing

1.1 Introduce the learning objectives and learning activities of the unit “Content analysis, lesson plan design and implementation of geometry area in *Primary School Mathematics Curriculum*, especially introduce the way to brainstorm together when learning.

1.2 The teacher teaches the students new theoretical knowledge

1.2.1 Content requirements of geometry area in *Primary School Mathematics Curriculum* from Chinese Mathematics Curriculum Standards for Compulsory Education.

1.2.2 Academic requirements of Geometry area in *Primary School Mathematics Curriculum* from Chinese Mathematics Curriculum Standards for Compulsory Education.

1.2.3 Tips for teaching geometry area from Chinese Mathematics Curriculum Standards for Compulsory Education.

1.3 Teacher provides students with primary school mathematics teacher's teaching videos on the area of geometry in the *Primary School Mathematics Curriculum*.

1.4 Students watch the videos, observe, and individually analyze about primary school students' needs, wants, emotions, feelings, actions, and problems when they are learning in the lesson geometry area in the *Primary School Mathematics Curriculum*.

1.5 Students share with each other about primary school students' needs, wants, emotions, feelings, actions and problems when they are learning in the lesson of geometry area in *Primary School Mathematics Curriculum*.

1.6 Students discuss and conclude primary school students' needs, wants, emotions, feelings, actions, and problems when they are learning in the lesson geometry area in the *Primary School Mathematics Curriculum*.

Step 2: Defining

2.1 Each student identifies the problem in the primary school mathematics teacher's teaching that needs to be solved in order for primary school students to learn more effectively in the lesson geometry area in the *Primary School Mathematics Curriculum*.

2.2 Students share with each other the problems identified by them.

2.3 Students discuss and conclude the problems in primary school mathematics teachers' teaching that need to be solved in order for primary school students to learn more effectively in the lesson geometry area in the *Primary School Mathematics Curriculum*.

Step 3: Ideate

3.1 Teacher review brainstorming rules.

3.2 Students began to brainstorm to call for ideas to solve the problems in primary school mathematics teachers' teaching that were identified in step 2 in order for primary school students to learn more effectively in the geometry area.

3.3 Students and teachers work together to select most associated idea to solve the problems in primary school mathematics teachers' teaching that identified in step 2 in order for primary school students to learn more effectively in geometry area.

Step 4: Prototype

4.1 Each student designs a primary school mathematics lesson plan for the geometry area to solve the problems identified in step 2 in order for primary school students to learn more effectively.

4.2 Students within the learning team share and help modify with each other their primary school mathematics lesson plan for the geometry area they have designed.

4.3 Each student modifies their primary school mathematics lesson plan for the geometry area.

4.4 Students share and test their modified primary school mathematics lesson plan of geometry area within the team itself.

4.5 Each student modifies the primary school mathematics lesson plan of the geometry area to solve the problems identified in step 2 in order for primary school students to learn more effectively.

Step 5: Test

5.1 Students implement the best primary school mathematics lesson plan for the geometry area through microteaching.

5.2 Students evaluate the complete process of implementing the best primary school mathematics lesson plan for the geometry area in order for primary school students to learn more effectively.

5.3 Students use the results generated during evaluation to redefine one or more further problems in primary school mathematics teachers' teaching.

5. Learning resources

Teaching videos of a primary school mathematics teacher in the area of geometry/Textbook/Chaoxing /PPT/mobile/ references

6. Evaluation

Observe whether undergraduate students can think independently thought independently, have constructive imagination, being special and interesting and not the same as anything or anyone else when they are designing lesson plans of geometry area in *Primary School Mathematics Curriculum*.

C.5 Assessment form for Validity of the lesson plan II

Research Title:

The development of an instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability.

Research Objectives:

1. To explore the factors that affect the third-year undergraduate students' creative thinking ability in Baise University.

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

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

Assessor: .....Position: .....

Workplace: .....

Directions:

Please assess the item objective congruence (IOC) for lesson plan II by putting √ it in the box according to the following criteria:

Give +1 to an item that is congruent with a clear understanding of this study

Give 0 to an item that is uncertain or not sure whether it is related to the study

Give -1 to an item that is not understood or is not congruent or related to this study.

No.	Items		Assessment result			Remarks
			-1	0	+1	
1	Concept					
2	Contents					
3	Objectives					
4	Learning processes	Step 1: Empathizing,				
		Step 2: Defining				
		Step 3: Ideate				
		Step 4: Prototype				
		Step 5: Test				
5	Learning resources					
6	Evaluation					

Suggestions

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Sign..... Assessor

(.....)

Date...../...../.....

B.6 Lesson Plans III

Lesson topic: Lesson plan design and implementation of statistics and probability areas in *Primary School Mathematics Curriculum*

Time: 4 hours

1. Concept

A lesson plan of statistics and probability areas in *the Primary School Mathematics Curriculum is a teacher's detailed description of statistics and probability areas in the Primary School Mathematics Curriculum* of instruction or "learning trajectory" for a statistics and probability areas lesson. A statistics and probability areas lesson plan is the teacher's guide for running a particular statistics and probability areas lesson, and it includes the goal (what the students are supposed to learn), how the goal will be reached (the method, procedure) and a way of measuring how well the goal was reached.

2. Contents

2.1 statistics and probability areas

2.2 Lesson plan design and implementation

3. Objective

3.1 Students can design lesson plans for statistics and probability areas in the *Primary School Mathematics Curriculum* that are special and not the same as anyone else

3.2 Students can implement lesson plans in statistics and probability areas

4. Learning process

Step 1: Empathizing

1.1 Introduce the learning objectives and learning activities of a unit “Content analysis, lesson plan Design and implementation of statistics and probability areas in *Primary School Mathematics Curriculum*, especially introduce the way to brainstorm together when learning.

1.2 The teacher teaches the students new theoretical knowledge

1.2.1 Content requirements of statistics and probability areas in *Primary School Mathematics Curriculum* from Chinese Mathematics Curriculum Standards for Compulsory Education.

1.2.2 Academic requirements of statistics and probability areas in *Primary School Mathematics Curriculum* from Chinese Mathematics Curriculum Standards for Compulsory Education.

1.2.3 Tips for teaching statistics and probability areas from Chinese Mathematics Curriculum Standards for Compulsory Education.

1.3 Teacher provides students with primary school mathematics teacher's teaching videos on the area of statistics and probability in *Primary School Mathematics Curriculum*.

1.4 Students watch the videos, observe, and analyze individual primary school students' needs, wants, emotions, feelings, actions, and problems when they are learning in the lesson of statistics and probability areas in the *Primary School Mathematics Curriculum*.

1.5 Students share with each other about primary school students' needs, wants, emotions, feelings, actions, and problems when they are learning in the

lesson of statistics and probability areas in the *Primary School Mathematics Curriculum*.

1.6 Students discuss and conclude primary school students' needs, wants, emotions, feelings, actions and problems when they are learning in the lesson of statistics and probability areas in *Primary School Mathematics Curriculum*.

Step 2: Defining

2.1 Each student identifies the problem in the primary school mathematics teacher's teaching that needs to be solved in order for primary school students to learn more effectively in the lesson on statistics and probability areas in the *Primary School Mathematics Curriculum*.

2.2 Students share with each other the problems identified by them.

2.3 Students discuss and conclude the problems in primary school mathematics teachers' teaching that need to be solved in order for primary school students to learn more effectively in the lesson on statistics and probability areas in the *Primary School Mathematics Curriculum*.

Step 3: Ideate

3.1 Teacher review brainstorming rules.

3.2 Students began to brainstorming to call for ideas to solve the problems in primary school mathematics teachers' teaching that identified in step 2 in order for primary school students to learn more effectively in statistics and probability areas.

3.3 Students and teachers work together to select most associated idea to solve the problems in primary school mathematics teachers' teaching that identified in step 2 in order for primary school students to learn more effectively in statistics and probability areas.

Step 4: Prototype

4.1 Each student designs a primary school mathematics lesson plan of statistics and probability areas to solve the problems identified in step 2 in order for primary school students to learn more effectively.

4.2 Students within the learning team share and help modify with each other their primary school mathematics lesson plan of statistics and probability areas they have designed.

4.3 Each student modifies their primary school mathematics lesson plan of statistics and probability areas.

4.4 Students share and test their modified primary school mathematics lesson plan of statistics and probability areas within the team itself.

4.5 Each student modifies the primary school mathematics lesson plan of statistics and probability areas to solve the problems identified in step 2 in order for primary school students to learn more effectively.

Step 5: Test

5.1 Students implement the best primary school mathematics lesson plan for statistics and probability areas through microteaching.

5.2 Students evaluate the complete process of implementing the best primary school mathematics lesson plan of statistics and probability areas in order for primary school students to learn more effectively.

5.3 Students use the results generated during evaluation to redefine one or more further problems in primary school mathematics teachers' teaching.

5. Learning resources

Teaching videos of a primary school mathematics teacher on the area of statistics and probability/Textbook/Chaoxing/PPT/mobile/ references

6. Evaluation

Observe whether undergraduate students can think independently thought independently, have constructive imagination, being special and interesting and not the same as anything or anyone else when they are designing lesson plans of statistics and probability areas in *Primary School Mathematics Curriculum*.

C.6 Assessment form for Validity of the Lesson Plan III

Research Title:

The development of instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability.

Research Objectives:

1. To explore the factors that affect the third-year undergraduate students' creative thinking ability in Baise University.

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

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

Assessor: .....Position: .....

Workplace: .....

Directions:

Please assess the item objective congruence (IOC) for lesson plan III by putting √ it in the box according to the following criteria:

Give +1 to an item that is congruent with a clear understanding of this study

Give 0 to an item that is uncertain or not sure whether it is related to the study

Give -1 to an item that is not understood or is not congruent or related to this study.

No.	Items		Assessment result			Remarks
			-1	0	+1	
1	Concept					
2	Contents					
3	Objectives					
4	Learning processes	Step 1: Empathizing				
		Step 2: Defining				
		Step 3: Ideate				
		Step 4: Prototype				
		Step 5: Test				
5	Learning resources					
6	Evaluation					

Suggestions

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Sign..... Assessor

(.....)

Date...../...../.....

B.7 Lesson Plans IV

Lesson topic: Lesson plan design and implementation of synthesis and practice areas in *Primary School Mathematics Curriculum*

Time: 4 hours

1. Concept

A lesson plan of synthesis and practice areas in the *Primary School Mathematics Curriculum* is a teacher's detailed description of synthesis and practice areas in the *Primary School Mathematics Curriculum* of instruction or "learning trajectory" for a synthesis and practice areas lesson. A synthesis and practice areas lesson plan is the teacher's guide for running a particular synthesis and practice areas lesson, and it includes the goal (what the students are supposed to learn), how the goal will be reached (the method, procedure) and a way of measuring how well the goal was reached.

2. Contents

2.1 Synthesis and practice areas

2.2 Lesson plan design and implementation

3. Objective

3.1 Students can design lesson plans of synthesis and practice areas in the *Primary School Mathematics Curriculum* that are special and not the same as anyone else

3.2 Students can implement lesson plans in synthesis and practice areas

4. Learning process

Step 1: Empathizing

1.1 Introduce the learning objectives and activities of the unit “Lesson plan design and implementation of synthesis and practice areas in *Primary School Mathematics Curriculum*, especially introduce brainstorming together when learning.

1.2 The teacher teaches the students new theoretical knowledge

1.2.1 The content requirements for synthesis and practice areas in the *Primary School Mathematics Curriculum* are based on the Chinese Mathematics Curriculum Standards for Compulsory Education.

1.2.2 Academic requirements of synthesis and practice areas in *Primary School Mathematics Curriculum* from Chinese Mathematics Curriculum Standards for Compulsory Education.

1.2.3 Tips for teaching synthesis and practice areas from Chinese Mathematics Curriculum Standards for Compulsory Education.

1.3 The teacher provides students with primary school mathematics teacher's videos on synthesis and practice in the *Primary School Mathematics Curriculum*.

1.4 Students watch the videos, observe, and analyze individual primary school students' needs, wants, emotions, actions, and problems when they are learning in the lesson on synthesis and practice areas in the *Primary School Mathematics Curriculum*.

1.5 Students share about primary school students' needs, wants, emotions, feelings, actions, and problems when they are learning in the lesson of synthesis and practice areas in the *Primary School Mathematics Curriculum*.

1.6 Students discuss and conclude primary school students' needs, wants, emotions, feelings, actions, and problems when they are learning in the lesson of synthesis and practice areas in the *Primary School Mathematics Curriculum*.

Step 2: Defining

2.1 Each student identifies the problem in the primary school mathematics teacher's teaching that needs to be solved for primary school students to learn more effectively in the lesson of synthesis and practice areas in the *Primary School Mathematics Curriculum*.

2.2 Students share the problems they identified.

2.3 Students discuss and conclude the problems in primary school mathematics teachers' teaching that need to be solved for primary school students to learn more effectively in the lesson of synthesis and practice areas in the *Primary School Mathematics Curriculum*.

Step 3: Ideate

3.1 Teacher review brainstorming rules.

3.2 Students began brainstorming to solicit ideas for solving the problems identified in step 2 in primary school mathematics teachers' teaching so that primary school students could learn more effectively in synthesis and practice areas.

3.3 Students and teachers work together to select the most associated ideas to solve the problems in primary school mathematics teachers' teaching that are identified in step 2 so that primary school students learn more effectively in synthesis and practice areas.

Step 4: Prototype

4.1 Each student will design a primary school mathematics lesson plan with synthesis and practice areas to solve the problems identified in step 2 so that primary school students learn more effectively.

4.2 Students within the learning team share and help modify their primary school mathematics lesson plan of synthesis and practice areas they have designed with each other.

4.3 Students modified their primary school mathematics lesson plan for synthesis and practice areas.

4.4 Students share and test their modified primary school mathematics lesson plan of synthesis and practice areas within the team.

4.5 Each student will modify the primary school mathematics lesson plan of synthesis and practice areas again to solve the problems identified in step 2 in order for primary school students to learn more effectively.

Step 5: Test

5.1 Students implement the best primary school mathematics lesson plan of synthesis and practice areas through microteaching.

5.2 Students evaluate the complete process of implementing the best primary school mathematics lesson plan of synthesis and practice areas so that primary school students learn more effectively.

5.3 Students use the results generated during evaluation to redefine one or more further problems in primary school mathematics teachers' teaching.

5. Learning resources

Teaching videos of a primary school mathematics teacher on the area of synthesis and practice/Textbook/Chaoxing/PPT/mobile/ references

6. Evaluation

Observe whether undergraduate students can think independently, have constructive imagination, and be special and interesting, not the same as anything or anyone else, when they are designing lesson plans for synthesis and practice areas in the *Primary School Mathematics Curriculum*.

C.7 Assessment form for Validity of the lesson plan IV

Research Title:

The development of an instructional model based on design thinking and brainstorming to enhance_undergraduate students' creative thinking ability.

Research Objectives:

1. To explore the factors that affect the third-year undergraduate students' creative thinking ability in Baise University.

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

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

Assessor: .....Position: .....

Workplace: .....

Directions:

Please assess the item objective congruence (IOC) for lesson plan IV by putting √ it in the box according to the following criteria:

Give +1 to an item that is congruent with a clear understanding of this study

Give 0 to an item that is uncertain or not sure whether it is related to the study

Give -1 to an item that is not understood, congruent, or related to this study.

No.	Items		Assessment result			Remarks
			-1	0	+1	
1	Concept					
2	Contents					
3	Objectives					
4	Learning processes	Step 1: Empathizing				
		Step 2: Defining				
		Step 3: Ideate				
		Step 4: Prototype				
		Step 5: Test				
5	Learning resources					
6	Evaluation					

Suggestions

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Sign..... Assessor

(.....)

Date...../...../.....

B.8 Creative thinking ability test

Direction:

1. This Creative Thinking Ability test is part of the research on "The development of instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability." It aims to study the level of creative thinking ability (originality).

2. Please read and analyze situations carefully and then design lesson plans.

3. The learning process and media you designed should be new, unique, accurate, and consistent with other parts to test your creative thinking ability.

Thank you very much for your response to the questionnaire.

Scoring criteria:

Evaluation criteria	Scoring criteria
If the learning process and learning media are new, unique, accurate and consistent with other parts.	5
If the learning process and learning media are new, unique and accurate, but not consistent with other parts.	4
If the learning process or learning media are new, unique and accurate, but not consistent with other parts.	3
If the learning process and learning media are new and unique, but not accurate and not consistent with other parts.	2
If the learning process or learning media are new and unique, but not accurate and not consistent with other parts.	1
If the learning process and learning media are not new, not unique, not accurate, not consistent with other parts.	0

Situation 1:

If you are a fifth-grade mathematics teacher in primary school and are preparing to teach "Multiplying Decimals by a whole number," which belongs to numbers and algebra areas, please design a lesson plan for students with average math scores who have learned the addition of decimals and the multiplication of whole numbers, and know that in real life there are problems of multiplying decimals by whole numbers, but don't know how to multiply decimals by whole numbers yet. Approximately 40 primary school students per class. Each classroom has desks and chairs, an intelligent blackboard, and a scanner that can scan and project students' homework onto the blackboard and other traditional teaching tools. Your lesson

plan should include the lesson topic, learning time, contents, learning objective, learning media, learning process, and blackboard writing. Your learning process and learning media should be new, unique, accurate, consistent with other parts, and appropriate for students.

Situation 2:

If you are a first-grade mathematics teacher in primary school and are preparing to teach "number sense of whole number within 100," which belongs to numbers and algebra areas, please design a lesson plan for students with higher math scores who have learned number sense of whole number within 20 and have a particular understanding of numbers within 100 in daily life, but lack systematic learning. Approximately 40 primary school students per class. Each classroom has desks and chairs, a smart blackboard, and a scanner that can scan and project students' homework onto the blackboard and other traditional teaching tools. Your lesson plan should include the lesson topic, learning time, contents, learning objective, learning media, learning process, and blackboard writing. Your learning process and media should be new, unique, accurate, consistent with other parts, and appropriate for students.

Situation 3:

If you are a fifth-grade mathematics teacher in primary school and are preparing to teach the "area of parallelogram," which belongs to geometry areas, please design a lesson plan for students with poor math scores who have learned the concept and structure of parallelograms and the formula for calculating the area of a rectangle, but don't know the formula for calculating the area of a parallelogram. Approximately 40 primary school students per class. Each classroom has desks and chairs, a smart blackboard, and a scanner that can scan and project students' homework onto the blackboard and other traditional teaching tools. Your lesson plan should include the lesson topic, learning time, contents, learning objective, learning media, learning process, and blackboard writing. Your learning process and media should be new, unique, accurate, consistent with other parts, and appropriate for students.

Situation 4:

If you are a fifth-grade mathematics teacher in primary school and are preparing to teach "single bar graphs," which belong to statistics and probability areas, please design a lesson plan for students with average math scores who have learned about single-form statistical tables and know that in real life there are problems of single bar graphs, but lack systematic learning. Approximately 40 primary school students per class. Each classroom has desks and chairs, a smart blackboard, and a scanner that can scan and project students' homework onto the blackboard and other traditional teaching tools. Your lesson plan should include the lesson topic, learning time, contents, learning objective, learning media, learning process, and blackboard writing. Your learning process and media should be new, unique, accurate, consistent with other parts, and appropriate for students.

Situation 5:

If you are a fifth-grade mathematics teacher in primary school and are preparing to teach "problems of tree planting," which belongs to synthesis and practice areas, please design a lesson plan for students with poor math scores who know that in real life, there are problems of tree planting, but lack systematic learning. Approximately 40 primary school students per class. Each classroom has desks and chairs, a smart blackboard, and a scanner that can scan and project students' homework onto the blackboard and other traditional teaching tools. Your lesson plan should include the lesson topic, learning time, contents, learning objective, learning media, learning process, and blackboard writing. Your learning process and learning media should be new, unique, accurate, consistent with other parts, and appropriate for students.

C.8 Assessment form for the validity of the creative thinking ability test

Research Title:

The development of an instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability.

Research Objectives:

1. To explore the factors that affect the third-year undergraduate students' creative thinking ability in Baise University.

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

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

Assessor: .....Position: .....

Workplace: .....

Directions:

Please assess the item objective congruence (IOC) for the creative thinking ability test by puttingvit in the box according to the following criteria:

Give +1 to an item that is congruent with a clear understanding of this study

Give 0 to an item that is uncertain or not sure whether it is related to the study

Give -1 to an item that is not understood, congruent, or related to this study.

No.	Situations	Assessment result			Re-marks
		-1	0	+1	
1	Situation 1: If you are a fifth-grade mathematics teacher in primary school and are preparing to teach "Multiplying Decimals by Whole Numbers," which belongs to the numbers and algebra areas, please design a lesson plan for the teaching. Your design work should be new, unique, accurate, and appropriate for the job.				
2	Situation 2: If you are a first-grade mathematics teacher in primary school and are preparing to teach "number sense of whole number within 100," which belongs to numbers and algebra areas, please design a lesson plan for the teaching. Your design work should be new, unique, accurate, and appropriate.				
3	Situation 3: If you are a fifth-grade mathematics teacher in primary school and are preparing to teach the "area of parallelogram," which belongs to geometry areas, please design a lesson plan. Your design work should be new, unique, accurate, and appropriate.				
4	Situation 4: If you are a fifth-grade mathematics teacher in primary school and are preparing to teach "single bar graphs," which belong to the statistics and probability areas, please design a lesson plan for the teaching. Your design work should be new, unique, accurate, and appropriate for the job.				
5	Situation 5: If you are a fifth-grade mathematics teacher in primary school and are preparing to teach "problems of tree planting," which belongs to synthesis and practice areas, please design a lesson plan for the teaching. Your design work should be new, unique, accurate, and appropriate.				
	Scoring criteria	+1	0	-1	
1	If the learning process and learning media are new, unique, accurate and consistent with other parts, you will get 5 points.				
2	If the learning process and learning media are new, unique and accurate, but not consistent with other parts, you will get 4 points.				
3	If the learning process or learning media are new, unique and accurate, but not consistent with other				

No.	Situations	Assessment result			Re-marks
		-1	0	+1	
	parts, you will get 3 points.				
4	If the learning process and learning media are new and unique, but not accurate and not consistent with other parts, you will get 2 points.				
5	If the learning process or learning media are new and unique, but not accurate and not consistent with other parts, you will get 1 point.				
6	If the learning process and learning media are not new, not unique, not accurate, not consistent with other parts, you will get 0 point.				

Suggestions

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Sign..... Assessor

(.....)

Date...../...../.....

B.9 Interview form about opinions on teaching

1. Basical Information

Name: Gender:

Class: Interview time:

2. Interview Content

(1) Can you skillfully apply design thinking in your learning?

(2) What problems do you have when using design thinking?

(3) Can you skillfully apply brainstorming in your learning?

(4) What problems do you have when using brainstorming?

(5) Is the instructional model based on design thinking and brainstorming useful in enhancing your creative thinking ability?

(6) How should teachers help undergraduate students improve their creative thinking ability(originality)?

(7) What learning strategies do you think are the most effective?

(8) Finally, is there anything else you want to add about your views on teaching?

C.9 Assessment form for validity of the interview form about opinions on teaching

Research Title:

The development of an instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability.

Research Objectives:

1. To explore the factors that affect the third-year undergraduate students' creative thinking ability in Baise University.

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

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

Assessor: .....Position: .....

Workplace: .....

Directions:

Please assess the item objective congruence (IOC) for the interview form about opinions on teaching by putting√in the box according to the following criteria:

Give +1 to an item that is congruent with a clear understanding of this study

Give 0 to an item that is uncertain or not sure whether it is related to the study

Give -1 to an item that is not understood, congruent, or related to this study.

No.	Items	Assessment result			Re-marks
		-1	0	+1	
1	Can you skillfully apply design thinking in your learning?				
2	What problems do you have when using design thinking?				
3	Can you skillfully apply brainstorming in your learning?				
4	What problems do you have when using brainstorming?				
5	Is the instructional model based on design thinking and brainstorming helpful in enhancing your creative thinking ability?				
6	How should teachers help undergraduate students improve their creative thinking ability(originality)?				
7	What learning strategies do you think are the most effective?				
8	Finally, is there anything else you want to add about your views on teaching?				

Suggestions

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Sign..... Assessor

(.....)

Date...../...../.....

B.10 Observation form about students' behavior

Course Title: ..... Instructor: .....

Duration: .....Classroom location: .....

Total number of students: .....Observer: .....

Lesson I: Lesson plan design and implementation of numbers and algebra areas in *Primary School Mathematics Curriculum*

Learning Process	Learning Observation
Step 1: Empathizing	
Step 2: Defining	
Step 3: Ideate	
Step 4: Prototype	
Step 5: Test	

Lesson II: Lesson plan design and implementation of geometry area in *Primary School Mathematics Curriculum*

Learning Process	Learning Observation
Step 1: Empathizing	
Step 2: Defining	
Step 3: Ideate	
Step 4: Prototype	
Step 5: Test	

Lesson III: Lesson plan design and implementation of statistics and probability areas in *Primary School Mathematics Curriculum*

Learning Process	Learning Observation
Step 1: Empathizing	
Step 2: Defining	
Step 3: Ideate	
Step 4: Prototype	
Step 5: Test	

Lesson IV: Lesson plan design and implementation of synthesis and practice areas in *Primary School Mathematics Curriculum*

Learning Process	Learning Observation
Step 1: Empathizing	
Step 2: Defining	
Step 3: Ideate	
Step 4: Prototype	
Step 5: Test	

Comments/Observations:

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Sign..... Observer

(.....)

Date...../...../.....

C.10 Assessment form for validity of the observation form about students' behavior

Research Title:

The development of an instructional model based on design thinking and brainstorming to enhance undergraduate students' creative thinking ability.

Research Objectives:

1. To explore the factors that affect the third-year undergraduate students' creative thinking ability in Baise University.

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

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

Assessor: .....Position: ....

Workplace: .....

Directions:

Please assess the item objective congruence (IOC) for the observation form about students' behavior by putting √ it in the box according to the following criteria:

Give +1 to an item that is congruent with a clear understanding of this study

Give 0 to an item that is uncertain or not sure whether it is related to the study

Give -1 to an item that is not understood, congruent, or related to this study.

Course Title: ..... Instructor: .....

Duration: ..... Classroom location: .....

Total number of students: .....Observer: .....

Lesson I: Lesson plan design and implementation of numbers and algebra areas in *Primary School Mathematics Curriculum*

Learning Process	Learning Observation	Assessment result			Remarks
		-1	0	+1	
Step 1: Empathizing					
Step 2: Defining					
Step 3: Ideate					
Step 4: Prototype					
Step 5: Test					

Lesson II: Lesson plan design and implementation of geometry area in *Primary School Mathematics Curriculum*

Learning Process	Learning Observation	Assessment result			Remarks
		-1	0	+1	
Step 1: Empathizing					
Step 2: Defining					
Step 3: Ideate					
Step 4: Prototype					
Step 5: Test					

Lesson III: Lesson plan design and implementation of statistics and probability areas in *Primary School Mathematics Curriculum*

Learning Process	Learning Observation	Assessment result			Remarks
		-1	0	+1	
Step 1: Empathizing					
Step 2: Defining					
Step 3: Ideate					
Step 4: Prototype					
Step 5: Test					

Lesson IV: Lesson plan design and implementation of synthesis and practice areas in *Primary School Mathematics Curriculum*

Learning Process	Learning Observation	Assessment result			Remarks
		-1	0	+1	
Step 1: Empathizing					
Step 2: Defining					
Step 3: Ideate					
Step 4: Prototype					
Step 5: Test					

Suggestions

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Sign..... Assessor

(.....)

Date...../...../.....

Appendix D

The Results of the Quality Analysis of Research Instruments

D.1 Index of Item Objective Consistency (IOC) statistics of the instructional model based on design thinking and brainstorming

No.	Items	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
1	Principle	1	1	1	1	1	1. 00	Valid
2	Objective	1	1	1	1	1	1. 00	Valid
3	Learning processes	1	1	1	1	1	1. 00	Valid
4	Result	1	1	1	1	1	1. 00	Valid

D.2 Index of Item Objective Consistency (IOC) statistics of the interview form about factors that affect the development of third-year undergraduate students' creative thinking ability

No.	Questions	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
1	Will family affect the development of undergraduate students' creative thinking ability abilities? If so, discuss how this factor influences undergraduate students' creative thinking ability development.	1	1	1	1	1	1. 00	Valid
2	Will school impact the development of undergraduate students' creative thinking ability abilities? If so, discuss how this factor influences undergraduate students' creative thinking ability development.	1	1	1	1	1	1. 00	Valid
3	Will society impact the development of undergraduate students' creative thinking ability abilities? If so, discuss how this factor influences undergraduate students' creative thinking ability development.	1	1	1	1	1	1. 00	Valid
4	Will personality traits influence the development of undergraduate students' creative thinking ability abilities? If so, discuss how this factor influences undergraduate students' creative thinking ability development.	1	1	1	1	1	1. 00	Valid
5	Will undergraduate students' motivation influence their development of creative thinking ability abilities? If so, discuss how this factor influences undergraduate students' creative thinking ability development.	1	1	1	1	1	1. 00	Valid
6	Will undergraduate students' attitudes about creativity, authority figures, and norms affect their development of	1	1	1	1	1	1. 00	Valid

No.	Questions	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
	creative thinking ability abilities? If so, discuss how this factor influences undergraduate students' creative thinking ability development.							
7	Will undergraduate students' emotional state, such as bias, worry, anxiety, jealousy, defiance, indifference, and complacency, affect their development of creative thinking ability abilities? If so, discuss how this factor influences undergraduate students' creative thinking ability development.	1	1	1	1	1	1. 00	Valid
8	Will a sense of purpose affect the development of undergraduate students' creative thinking ability abilities? If so, discuss how this factor influences undergraduate students' creative thinking ability development.	1	1	1	1	1	1. 00	Valid

D.3 Index of Item Objective Consistency (IOC) statistics of the questionnaire about factors that affect the development of third-year undergraduate students' creative thinking ability

No.	Questions	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
	Family							
1	The eldest son or daughter in a family, or among siblings in the same family, tends to have a more extraordinary creative thinking ability.	0	1	1	1	1	0. 80	Valid
2	If students often face many problems that need to be solved in the family, they will tend to have higher creative thinking skills.	1	1	1	1	1	1. 00	Valid
3	If undergraduates can feel that their parents are interested in and support to their creative thinking, their creative thinking ability will be well developed.	1	1	1	1	1	1. 00	Valid
	School							
1	Good time management is necessary to enhance undergraduates' creative thinking ability.	1	1	1	1	1	1. 00	Valid
2	Enough time is necessary to enhance undergraduates' creative thinking abilities in and outside of class.	1	1	1	1	1	1. 00	Valid
3	Too many undergraduates in the classroom is not conducive to enhance their creative thinking ability.	1	1	1	1	1	1. 00	Valid
4	The atmosphere of opening to new ideas and allowing students to take risks and make mistakes is necessary to enhance undergraduates' creative thinking ability.	1	1	1	1	1	1. 00	Valid
5	Fun interaction, as well as appreciation, acceptance, and giving opportu-	1	1	1	1	1	1. 00	Valid

No.	Questions	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
	nities to do things in the classroom, is necessary to enhance undergraduates' creative thinking ability.							
6	An atmosphere that allows them to think and reflect without rushing is necessary to enhance undergraduates' creative thinking ability.	1	1	1	1	1	1. 00	Valid
7	Collective problem-solving is effective in enhancing undergraduates' creative thinking ability.	1	1	1	1	1	1. 00	Valid
8	Using project work and challenging problems in curriculum and subjects is helpful to enhance their creative thinking ability.	1	1	1	1	1	1. 00	Valid
9	Too much assessment does not e hance their creative thinking ability in curriculum and subjects.	1	1	1	1	1	1. 00	Valid
	Society							
1	If students often face many problems that need to be solved in society, they will tend to have higher creative thinking skills.	1	1	1	1	1	1. 00	Valid
2	A societal atmosphere open to new ideas and safe for students to take risks and make mistakes is necessary to enhance undergraduate students' creative thinking ability.	1	1	1	1	1	1. 00	Valid
3	The societal atmosphere places much emphasis on examinations, which contradicts enhancing undergraduate students' creative thinking ability.	1	1	1	1	1	1. 00	Valid
4	The high societal expectation of creative thinking ability enhancement is conducive to enhancing undergraduate students' creative thinking ability.	1	1	1	1	1	1. 00	Valid

No.	Questions	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
	personality traits							
1	Undergraduate students with curious personality traits usually have more creative thinking ability	1	1	1	1	1	1. 00	Valid
2	Undergraduate students with independent personality traits usually have more creative thinking ability	1	1	1	1	1	1. 00	Valid
3	Undergraduate students with open-minded personality traits usually have more creative thinking ability	1	1	1	1	1	1. 00	Valid
4	A flexible personality is conducive to enhancing undergraduates' creative thinking ability, and a rigid personality is not conducive to enhancing undergraduates' creative thinking ability.	1	1	1	1	1	1. 00	Valid
5	It is advantageous for the development of creative thinking for an undergraduate student if they have the flexibility to switch from one discipline to another at any time.	1	1	1	1	1	1. 00	Valid
6	Undergraduate students with persistent personality traits usually have more creative thinking ability	1	1	1	1	1	1. 00	Valid
7	Undergraduate students with unconventional personality traits usually have more creative thinking ability	1	1	1	1	1	1. 00	Valid
8	Men (women) who often exhibit a bit more femininity(masculinity) in their personality traits usually have better creative thinking abilities than other males(females).	1	1	1	1	1	1. 00	Valid
	Motivation							
1	If an undergraduate student lacks the motivation to utilize specific abilities related to creative production within their intellectual structure, their crea-	1	1	1	1	1	1. 00	Valid

No.	Questions	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
	tive output may be limited.							
2	Curiosity-driven undergraduate students tend to have higher creative thinking abilities.	1	1	1	1	1	1. 00	Valid
3	If undergraduate students have a clear purpose in mind for what they will do, they are willing to spend time on creative thinking.	1	1	1	1	1	1. 00	Valid
	Attitude and emotional state							
1	A positive attitude about creativity is necessary for undergraduate students to enhance their creative thinking ability.	1	1	1	1	1	1. 00	Valid
2	6.2 If undergraduates are focused too much on following rules and guidelines, it is not conducive to enhance their creative thinking ability.	1	1	1	1	1	1. 00	Valid
3	Attitudes such as respect for authorityfigures, being pleased with others' success, and lacking self-confidence can suppress creative thinking in undergraduate students.	1	1	1	1	1	1. 00	Valid
4	Emotional states such as bias, worry, anxiety, jealousy, defiance, indifference, and complacency can hinder the development of creative thinking abilities in undergraduate students.	1	1	1	1	1	1. 00	Valid

D.4 Index of Item Objective Consistency (IOC) statistics of the lesson plan I

No.	Items	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
1	Concept	1	1	1	1	1	1. 00	Valid
2	Contents	1	1	1	1	1	1. 00	Valid
3	Objectives	1	1	1	1	1	1. 00	Valid
4	Learning processes							
	Step 1: Empathizing	1	1	1	1	1	1. 00	Valid
	Step 2: Defining	1	1	1	1	1	1. 00	Valid
	Step 3: Ideate	1	1	1	1	1	1. 00	Valid
	Step 4: Prototype	1	1	1	1	1	1. 00	Valid
	Step 5: Test	1	1	1	1	1	1. 00	Valid
5	Learning resources	1	1	1	1	1	1. 00	Valid
6	Evaluation	1	1	1	1	1	1. 00	Valid

D.5 Index of Item Objective Consistency (IOC) statistics of the lesson plan II

No.	Items	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
1	Concept	1	1	1	1	1	1. 00	Valid
2	Contents	1	1	1	1	1	1. 00	Valid
3	Objectives	1	1	1	1	1	1. 00	Valid
4	Learning processes							
	Step 1: Empathizing	1	1	1	1	1	1. 00	Valid
	Step 2: Defining	1	1	1	1	1	1. 00	Valid
	Step 3: Ideate	1	1	1	1	1	1. 00	Valid
	Step 4: Prototype	1	1	1	1	1	1. 00	Valid
	Step 5: Test	1	1	1	1	1	1. 00	Valid
5	Learning resources	1	1	1	1	1	1. 00	Valid
6	Evaluation	1	1	1	1	1	1. 00	Valid

D.6 Index of Item Objective Consistency (IOC) statistics of the lesson plan III

No.	Items	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
1	Concept	1	1	1	1	1	1. 00	Valid
2	Contents	1	1	1	1	1	1. 00	Valid
3	Objectives	1	1	1	1	1	1. 00	Valid
4	Learning processes							
	Step 1: Empathizing	1	1	1	1	1	1. 00	Valid
	Step 2: Defining	1	1	1	1	1	1. 00	Valid
	Step 3: Ideate	1	1	1	1	1	1. 00	Valid
	Step 4: Prototype	1	1	1	1	1	1. 00	Valid
	Step 5: Test	1	1	1	1	1	1. 00	Valid
5	Learning resources	1	1	1	1	1	1. 00	Valid
6	Evaluation	1	1	1	1	1	1. 00	Valid

D.7 Index of Item Objective Consistency (IOC) statistics of the lesson plan IV

No.	Items	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
1	Concept	1	1	1	1	1	1. 00	Valid
2	Contents	1	1	1	1	1	1. 00	Valid
3	Objectives	1	1	1	1	1	1. 00	Valid
4	Learning processes							
	Step 1: Empathizing	1	1	1	1	1	1. 00	Valid
	Step 2: Defining	1	1	1	1	1	1. 00	Valid
	Step 3: Ideate	1	1	1	1	1	1. 00	Valid
	Step 4: Prototype	1	1	1	1	1	1. 00	Valid
	Step 5: Test	1	1	1	1	1	1. 00	Valid
5	Learning resources	1	1	1	1	1	1. 00	Valid
6	Evaluation	1	1	1	1	1	1. 00	Valid

D.8 Index of Item Objective Consistency (IOC) statistics of the creative thinking ability test

No.	Situations	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
1	Situation 1: If you are a fifth-grade mathematics teacher in primary school and are preparing to teach "Multiplying Decimals by whole numbers," which belongs to numbers and algebra areas, please design a lesson plan. Your design work should be new, unique, accurate, and appropriate.	1	1	1	1	1	1. 00	Valid
2	Situation 2: If you are a first-grade mathematics teacher in primary school and are preparing to teach "number sense of whole number within 100," which belongs to numbers and algebra areas, please design a lesson plan for the teaching. Your design work should be new, unique, accurate, and appropriate.	1	1	1	1	1	1. 00	Valid
3	Situation 3: If you are a fifth-grade mathematics teacher in primary school and are preparing to teach the "area of parallelogram," which belongs to geometry areas, please design a lesson plan. Your design work should be new, unique, accurate, and appropriate.	1	1	1	1	1	1. 00	Valid
4	Situation 4: If you are a fifth-grade mathematics teacher in primary school and are preparing to teach "single bar graphs," which belong to statistics and probability areas, please design a lesson plan for the teaching. Your design work should be new, unique, accurate, and appropriate.	1	1	1	1	1	1. 00	Valid
5	Situation 5: If you are a fifth-grade mathematics teacher in primary school and are preparing to teach "problems of tree planting," which belongs to synthesis and practice areas, please design a lesson plan for	1	1	1	1	1	1. 00	Valid

No.	Situations	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
	the teaching. Your design work should be new, unique, accurate, and appropriate.							
	Scoring criteria							
1	If the learning process and learning media are new, unique, accurate and consistent with other parts, you will get 5 points.	1	1	1	1	1	1. 00	Valid
2	If the learning process and learning media are new, unique and accurate, but not consistent with other parts, you will get 4 points.	1	1	1	1	1	1. 00	Valid
3	If the learning process or learning media are new, unique and accurate, but not consistent with other parts, you will get 3 points.	1	1	1	1	1	1. 00	Valid
4	If the learning process and learning media are new and unique, but not accurate and not consistent with other parts, you will get 2 points.	1	1	1	1	1	1. 00	Valid
5	If the learning process or learning media are new and unique, but not accurate and not consistent with other parts, you will get 1 point.	1	1	1	1	1	1. 00	Valid
6	If the learning process and learning media are not new, not unique, not accurate, not consistent with other parts, you will get 0 point.	1	1	1	1	1	1. 00	Valid

D.9 Index of Item Objective Consistency (IOC) statistics of the interview form about opinions on teaching

No.	Items	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
1	Can you skillfully apply design thinking in your learning?	1	1	1	1	1	1. 00	Valid
2	What problems do you have when using design thinking?	1	1	1	1	1	1. 00	Valid
3	Can you skillfully apply brainstorming in your learning?	1	1	1	1	1	1. 00	Valid
4	What problems do you have when using brainstorming?	1	1	1	1	1	1. 00	Valid
5	Is the instructional model based on design thinking and brainstorming helpful in enhancing your creative thinking ability?	1	1	1	1	1	1. 00	Valid
6	How should teachers help undergraduate students improve their creative thinking ability(originality)?	1	1	1	1	1	1. 00	Valid
7	What learning strategies do you think are the most effective?	1	1	1	1	1	1. 00	Valid
8	Finally, is there anything else you want to add about your views on teaching?	1	1	1	1	1	1. 00	Valid

D.10 Index of Item Objective Consistency (IOC) statistics of the observation form about students' behavior

No.	Items	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
	Lesson I							
1	Step 1: Empathizing	1	1	1	1	1	1. 00	Valid
2	Step 2: Defining	1	1	1	1	1	1. 00	Valid
3	Step 3: Ideate	1	1	1	1	1	1. 00	Valid
4	Step 4: Prototype	1	1	1	1	1	1. 00	Valid
5	Step 5: Test	1	1	1	1	1	1. 00	Valid
	Lesson II							
1	Step 1: Empathizing	1	1	1	1	1	1. 00	Valid
2	Step 2: Defining	1	1	1	1	1	1. 00	Valid
3	Step 3: Ideate	1	1	1	1	1	1. 00	Valid
4	Step 4: Prototype	1	1	1	1	1	1. 00	Valid
5	Step 5: Test	1	1	1	1	1	1. 00	Valid
	Lesson III							
1	Step 1: Empathizing	1	1	1	1	1	1. 00	Valid
2	Step 2: Defining	1	1	1	1	1	1. 00	Valid
3	Step 3: Ideate	1	1	1	1	1	1. 00	Valid
4	Step 4: Prototype	1	1	1	1	1	1. 00	Valid
5	Step 5: Test	1	1	1	1	1	1. 00	Valid
	Lesson IV							

No.	Items	Experts					IOC	Validity
		No. 1	No. 2	No. 3	No. 4	No. 5		
1	Step 1: Empathizing	1	1	1	1	1	1. 00	Valid
2	Step 2: Defining	1	1	1	1	1	1. 00	Valid
3	Step 3: Ideate	1	1	1	1	1	1. 00	Valid
4	Step 4: Prototype	1	1	1	1	1	1. 00	Valid
5	Step 5: Test	1	1	1	1	1	1. 00	Valid

D.11 Test Quality Verification

The creative thinking ability test offered 5 Situations for undergraduate students to design primary school mathematics lesson plans, which should be new, unique, accurate, and consistent with other parts.

To ensure the quality of the test, a pre-test of the creative thinking ability test was conducted on 45 undergraduate students who come from a class similar to the class of the sample group, and the reliability Cronbach's α, difficulty (p), discriminant power (r) of the creative thinking ability test were verified.

Tests were selected with Cronbach's α values of 0.7 or higher, difficulty in the range of [0.20 - 0.80], and discriminating power of 0.20 or higher.

1) Reliability

Cronbach's alpha (Cronbach's α), also known as tauequivalent reliability (ρT) or coefficient alpha (Coefficient α), is a reliability coefficient and a measure of the internal consistency of tests and measures. (Cronbach,1951; Cho, 2016). It can be calculated through the following formula (Goforth,2015; Raykov & Marcoulides,2019):

$$\alpha = (\frac{k}{k-1})(1-\frac{\sum_{i=1}^{k}\sigma_{y_i}^2}{\sigma_x^2})$$

Where:

k refers to the number of scale items.

$\sigma_{y_i}^2$ refers to the variance associated with item i.

σ_x^2 refers to the variance associated with the observed total scores.

Through IBM SPSS Statistics 20 software analysis the Cronbach's α , mean scores and variances. The results of the analysis are shown below:

Table 6. 1 Mean scores and variances statistics

(n=45)

Situation	$\bar{X}$	σ^2
Situation 1	2.95	.250
Situation 2	3.02	.269
Situation 3	3.06	.255
Situation 4	3.08	.259
Situation 5	3.10	.228
Total	15.21	4.394

Based on the above, We can calculate the P of the test as follows:

$$\alpha = (\frac{k}{k-1})(1-\frac{\sum_{i=1}^{k}\sigma_{y_i}^2}{\sigma_x^2})$$
$$= (\frac{5}{5-1})[1-\frac{(0.25+0.269+0.255+0.259+0.228)}{4.394}]$$
$$= 0.89$$

The Cronbach's α (0.89) is higher than 0.7. It means that the creative thinking ability test has good reliability.

2） Difficulty

For objective questions, when the total marks of the test are the same, then the mean score $\bar{X}$ reflects the difficulty level of the whole test; the test with the lower mean score is more difficult, and the test with a higher mean score is more difficult, so the following formula can be used to calculate the difficulty of a test:

$$P = \frac{\bar{X}}{W}$$

Where:

$\bar{X}$ is the total average score of all candidates (Mean)

W is the full score (25 points) (Liu & Chen, 2003)

The difficulty coefficient ranges from 0. 3 to 0. 7, with a coefficient lower than 0. 3 indicating that a question is difficult and higher than 0. 7 indicating that a question is easy.

As shown in Table 4.3, the mean score of the total is 15.32. We can calculate the P of the test as follows:

$$P = \frac{15.32}{25} = 0.61$$

0.61 is in the range of [0.20 - 0.80]. It means that the difficulty of the creative thinking ability test is appropriate.

3) Discrimination

Discrimination is the size of a test question's ability to discriminate between subjects' situations.

In this study, the scores of undergraduate students in the top 27% and bottom 27% of the rankings were used as thresholds for high and low subgroups according to the discriminant formula:

$$D = \frac{(\bar{X}_H - \bar{X}_L)}{W}$$

Where:

$\bar{X}_H$ is the average score for the high subgroup,

$\bar{X}_L$ is the average score for the low subgroup, and

W is the full score (25 points).

The means of total score for low and high subgroups obtained using IBM SPSS Statistics 20 software are as follows:

Table 6. 2 Means of the total score for low and high subgroup

Total score	N	$\bar{X}$
Low subgroup <= 13.79	12	12.78
High subgroup15.61+	12	18.18

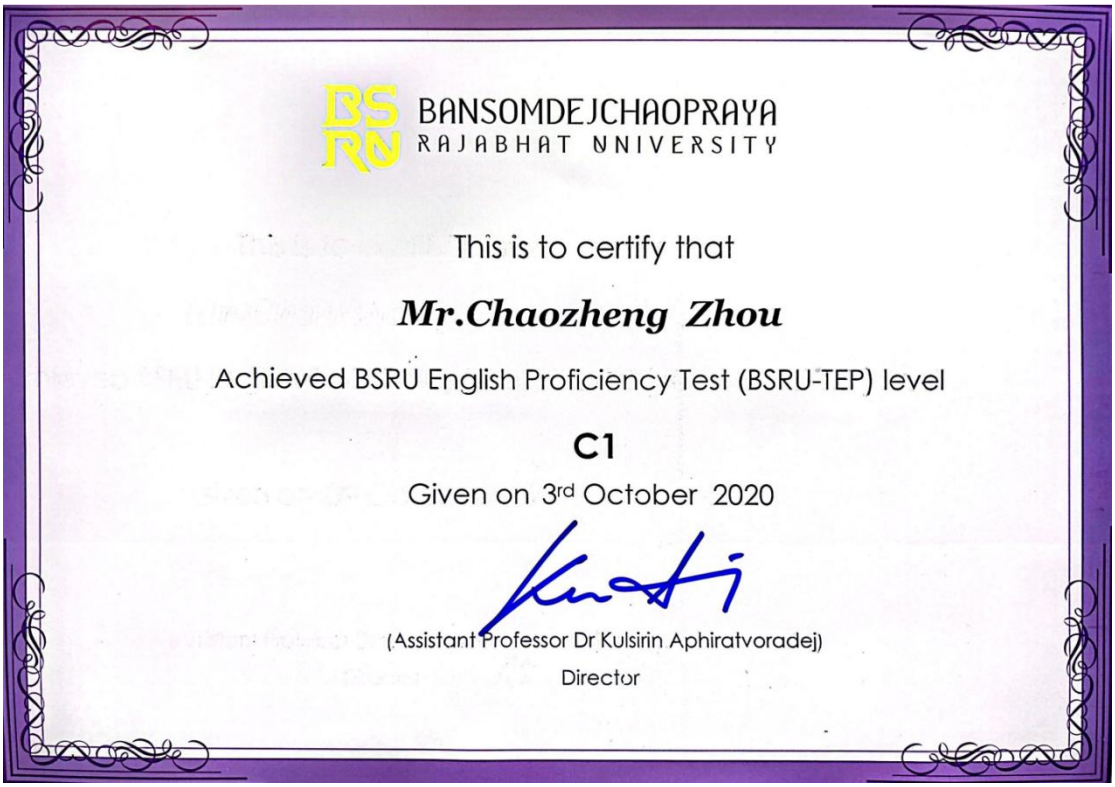
Based on the data in Table 4.5, we calculate the discrimination(D) of the test as follows:

$$D = \frac{(18.18 - 12.78)}{25} = 0.22$$

0.23 is in the range of [0.20 - 0.80]. It means that the difficulty of the creative thinking ability test is appropriate.

Appendix E

Certificate of English



BANSOMDEJCHAOPRAYA
RAJABHAT UNIVERSITY

This is to certify that

Mr.Chaozheng Zhou

Achieved BSRU English Proficiency Test (BSRU-TEP) level

C1

Given on 3rd October 2020

(Assistant Professor Dr Kulsirin Aphiratvoradej)
Director

Appendix F

The Document for Acceptance Research

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

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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 ($\bar{X}$ =4.53) and personal factors ($\bar{X}$ =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($\bar{X}$ =4.87), attitude and emotional state($\bar{X}$ =4.68), personality traits($\bar{X}$ =4.61), school($\bar{X}$ =4.59), society ($\bar{X}$ =4.50), family ($\bar{X}$ =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.

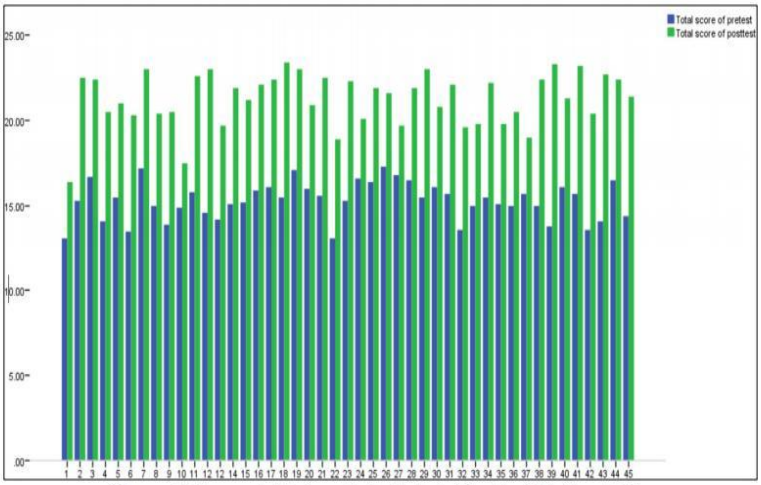
3.3 Results on the Improvement of Undergraduate Students' Creative Thinking Ability

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

Creative thinking ability	$\bar{X}$	**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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