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Developing a Project-Based Learning Course Model Combined with the Think–Pair–Share Strategy to Enhance Creative Thinking Skills in Education Students

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Abstract: The aim of this research was to produce a project-based learning (PjBL) course model that combines with the Think–Pair–Share (TPS) strategy and to determine its effectiveness in improving the creative thinking skills of education students. The sample of participants comprised 100 students from a university in Bangkok, Thailand. Five main elements comprised the PjBL-TPS course: 1. Project Preparation (including an introduction, pairs formation, and an understanding of the project); 2. Project Pair Cooperation (including discussion, knowledge framework development in pairs, practice analysis, brainstorming, and pair feedback); 3. Project Production (including its development, testing, refinement, and presentation); 4. Project Evaluation (including giving feedback on the work of the other pairs); and 5. Project Conclusion (including reflecting on the overall experience of the project). The results show that, in their post-course exercises, the students displayed enhanced creativity in all areas of creative skills (involving fluency, flexibility, originality, and elaboration). The experimental group demonstrated significantly higher creativity levels compared to the control group. In addition, the post-course assessments of the self-perceived creativity improvements of the students revealed that, post-course, most of the students perceived improvements in every aspect of their creativity.

Keywords: project-based learning; Think–Pair–Share strategy; creative thinking skills; education students

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1. Introduction

Creative thinking is an important skill for teachers, enabling them to adapt to the curriculum, solve problems, design engaging lessons, manage the classroom, and develop a positive learning environment [1]. To achieve educational objectives, it is important to incorporate creative thinking into classroom activities; however, student teachers in many Asian countries and regions have received limited exposure to creative teaching practices during their training. This may be because traditional educational approaches prioritize a structured curriculum and academic outcomes, reducing the scope for originality and creative thinking. Consequently, some may lack confidence in their ability to think creatively, restricting their ability to effectively integrate creative thinking into their classroom activities. Thus, student teachers could benefit from continuous professional development, training programs, workshops, mentoring, and guidance from experienced teachers to increase their creativity in designing and managing classroom activities [2,3].

Project-based learning (PjBL) is an instructional model for students to learn new skills and knowledge by working on a project [4]. A main aspect of PjBL is that students are required to take an active role in their own learning, meaning that students can identify and explore problems and questions, conduct research, and develop their own solutions [4,5].

The Think–Pair–Share (TPS) strategy is a useful strategy by which to promote teamwork and active, student-centered learning collaboration [6]. It encourages students to

think independently and come up with their own ideas (Think), share and discuss their ideas with a partner (Pair), and then present their ideas to the class (Share) [6,7]. When students are encouraged to generate diverse ideas, engage in creative thinking, and receive feedback from their peers, creativity is fostered through active engagement, collaboration, and reflection on their own and others' ideas [7].

There is evidence that project-based learning (PjBL) and Think–Pair–Share (TPS) strategies foster creative thinking in general education [8–11]. However, to address unanswered questions, some areas require further exploration. For example, more in-depth research is needed on how to adapt and implement these strategies across various academic subjects, in addition to how to more effectively assess the development of creative thinking. We acknowledge the need to better support education majors in boosting their creative thinking for their future teaching.

This study is important in that it combines a project-based learning (PjBL) model with the Think–Pair–Share (TPS) strategy to create a practical course model for fostering creative thinking by education majors. By exploring the implementation of this model, our objective is to better understand how to adjust and apply these strategies across different subjects and teaching situations. This will subsequently empower teachers with innovative tools with which to improve their ability to nurture students' creative thinking skills.

2. Objectives

1. To enhance the creative thinking skills of student teachers by developing a PjBL-TPS course model.
2. To assess the impact of the PjBL-TPS course model on the creative thinking skills of student teachers.

3. Literature Review

3.1. Project-Based Learning Model

Project-based learning (PjBL) is an instructional approach that helps students to learn by actively engaging with real-world issues and challenges [5,12]. PjBL is very versatile and can be used in various settings and implemented through different models. It has become apparent through previous investigations that project-based learning approaches share similar trends, comprising several stages. Although there are several models of PjBL with different stages, some of the stages can be combined and adapted based on the specific issues or topics [4,13,14], as shown in Table 1.

Table 1. Model of project-based learning.

Combined Stages	Similar Issues or Topics	Lou, S. J. et al. [15]	Wajdi, F. [16]	Hanif, S. [17]	Alotaibi, M. G. [18]	Zulyusri, Z. et al. [19]
Preparation	Motivation/questioning/introduction	√	√			√
	Schedule a plan (i.e., setting the scope, goals, process, and calendar)	√	√	√	√	√
Implementation	Carry out tasks and problem solving	√	√	√	√	√
Monitoring	Supervising the project implementation process	√	√	√	√	√
Production	Report/present/publish product	√	√	√	√	√
Evaluation	Assessment/feedback	√	√	√	√	√

Table 1 shows that the various project-based learning (PjBL) models, each with different stages, can be combined into five key stages: preparation, implementation, monitoring, production, and evaluation. However, although the monitoring element has been included in many similar models, in this study it was not. This was because monitoring would have assigned a fundamental responsibility to the teachers throughout the process.

3.2. Think–Pair–Share Strategy

Think–Pair–Share is a classroom strategy that encourages active learning and participation [7,20]. It is an effective way to engage students in critical thinking and problem solving and can be used across different subject areas. Operating as a three-step model, it comprises the following [6]:

Think: The students independently think about the questions or problems posed by the teacher. This stage allows the students to process the information and form their own ideas and opinions.

Pair: The students are then paired up with a partner to discuss their thoughts and ideas. This encourages them to share their understanding, explain their reasoning, and learn from their partner as well as hear different perspectives, which can deepen understanding and critical thinking.

Share: The students share their discussions with the larger group, which can lead to a deeper understanding of the material and a broader range of perspectives. It also allows the teacher to assess student understanding and address any misconceptions.

Kagan, S. and Kagan, M. [6] stated that the Think–Pair–Share strategy includes several considerations. Its effective implementation can significantly improve its strategic efficacy. These include the following:

1. Effective Grouping

To ensure fair and balanced pairs, students must be carefully grouped by considering their diverse backgrounds. To enhance collaboration and a comprehensive discussion, the match pairs should be based on interests or learning styles.

2. Effective Questioning

Choose challenging topics according to the course goals to spark curiosity and prompt deeper thinking and discussion.

3. Provide Time for Thinking

Allow enough time for students to think so that they can foster their creative thinking and unique insights while minimizing restricted thought.

4. Encourage Discussion and Sharing

Encourage active listening and participation in partner discussions, with defined collaboration rules, to allow for efficient communication and diverse perspectives.

5. Inviting Student Sharing with the Class

Motivate students to clearly communicate their ideas, creating an inclusive environment. During whole class sharing, teacher guidance stimulates deeper discussions.

TPS is often used across educational fields, including science, mathematics, language arts, social studies, and education. TPS is also easy to implement and can be tailored to different learning contexts; it is, therefore, a valuable strategy to promote collaborative and reflective classroom learning [9,20].

3.3. Creative Thinking

Creative thinking is a mental process whereby people produce new and unconventional ideas and imaginative solutions to complex challenges and problems. It involves generating concepts that eschew the conventional, fostering innovation and inventive problem solving [21].

The main factors comprising creative thinking skills include several approaches [21–23]:

Fluency: Rapidly generate different concepts, which involves quickly producing various potential solutions or perspectives. This broadens thinking, enhancing the potential for innovation.

Flexibility: Adapting to different viewpoints or methods. This involves the ability to examine problems from various angles and the accepting and integrating of diverse thought processes, fostering innovation and adaptability.

Originality: Generating unique and distinctive ideas or solutions involves expanding upon traditional thinking patterns to find unique perspectives, driving innovation.

Elaboration: Deeper insight into the development and expansion of ideas includes considering viewpoints or solutions as well as how to make them more comprehensive, specific, and feasible. This ensures the practical applicability of creative thinking.

The widespread recognition of the significance of creative thinking in education has led to its prominent role in school curricula. In Scotland, creativity is 'very clearly at the heart of the philosophy of Curriculum for Excellence and is fundamental to the definition of what it means to be a "successful learner" in the Scottish education system' [24]. Recently, critical and creative thinking have been integrated as general capabilities into the Australian Creative Thinking: Skill Development Framework 3 curriculum, and the Gonski report noted the need to 'equip every child to be a creative, connected and engaged learner in a rapidly changing world' was a priority [25].

ACER's framework, constructed via a comprehensive review of the literature and empirical research on creative thinking, strongly emphasizes creative thinking, distinguishing it from creativity. It also asserts that the strategies for fostering creative thinking can be effectively taught and applied in the classroom, supporting teachers in developing and evaluating the creative thinking skills of their students [22].

To cultivate creative thinking, individuals can participate in practices such as brainstorming, discussions, using mind maps, and participating in problem-solving exercises. Embracing diverse perspectives and ideas is crucial for fostering a more creative mindset [21–23].

Quasi-experimental research has investigated the impact of integrating project-based learning on creative thinking in various scenarios. Yustina et al. [6] focused on pre-service biology teachers and found that blended learning (BL) and project-based learning (PjBL) significantly enhanced creative thinking, as demonstrated by higher average scores (91) and the N-gain index (0.62) for the experimental class compared to the control class (N-gain index 0.51). Likewise, Chen et al. [7] focused on engineering courses and found that project-based learning promoted creative thinking, particularly in fluency and flexibility. These findings emphasize the significance of incorporating the appropriate tools with which to enhance creative thinking.

Quasi-experimental research has investigated the efficacy of the Think–Pair–Share (TPS) learning model for fostering creativity and critical thinking skills. Utami and Rusdarti [10] compared TPS to expository learning, revealing that the experimental group, by utilizing TPS, demonstrated significantly higher average final test scores, with 86.00% of students classified as "Very Creative". Likewise, Chandra and Ety [11] conducted a study within a seventh-grade class, employing an open-ended approach coupled with the Think–Pair–Share (TPS) strategy. The findings revealed that incorporating individual tasks, paired discussions, and group presentations, resulted in enhanced creative thinking skills among students. The outcome revealed that 84.5% of the students were labeled as "Good" concerning their creative thinking abilities.

Therefore, the following hypotheses for this study were determined as follows:

Null Hypothesis (H0). *There is no significant difference in the level of creative thinking skills among student teachers before and after the implementation of the PjBL-TPS course model.*

Alternative Hypothesis (H1). *After the implementation of the PjBL-TPS course model, there is a significant improvement in the creative thinking skills of student teachers.*

4. Methodology

4.1. Ethical Approval

The design of this project was reviewed and approved by the Academic Committee of the International College, Krirk University, on 1 February 2022 (Reference No. 2022-0201). The review prioritized ethics, ensuring participant rights and adherence to standards, so that high ethical standards were maintained in the research.

4.2. Approach

This study used a pre-test–post-test design for the control and experimental groups, focused on the research and development (R&D) of a project-based learning (PjBL) course model coupled with the Think–Pair–Share (TPS) strategy to improve students' creative thinking skills.

The R&D research design focuses on a systematic approach for innovating, enhancing, or creating new methods, products, or processes, especially in education [26]. This method follows the R&D cycle, which includes studying the research findings related to the product, developing these findings, testing in a relevant setting, and making revisions to address any identified deficiencies found during the testing. In more rigorous R&D programs, this cycle is repeated until the test datasets confirm that the product conforms with the defined behavioral objectives [27].

Like the quasi-experimental methods, the R&D experimental approach facilitates experimentation in classroom environments. This aligns with real-world conditions to improve a study's applicability to educational settings [26,27]. Researchers implement measures to control variables, ensuring the accuracy and reliability of their findings.

Two stages were involved in controlling the variables. First, two classes with comparable learning performances were chosen for the experimental and control groups, ensuring a balanced distribution of the key factors. This increased the initial similarity between the groups and also minimized the potential bias from grouping differences. Second, a pre-test assessing the creative thinking skills of the students was conducted before the experiment, enabling the researchers to control for potential initial differences. Table 2 concisely illustrates the research process employed in this study as follows.

Table 2. Research process.

Step 1: Analysis	Identify the research problem and conduct a literature review to establish this study's theoretical framework and objectives.
Step 2: Design	Determine the sample size and develop the lesson plans and instructional materials for the experimental group.
Step 3: Development and Pilot Testing	After designing the course, five experts in relevant fields evaluated its appropriateness and accuracy using the Index of Item Objective Congruence (ICO) evaluation method. A pilot intervention, which included 30 education students not involved in the main experiment, was conducted to confirm its effectiveness during a preliminary analysis before the actual study. After this pilot phase, the lesson plans and materials were revised based on the feedback received.
Step 4: Experiment	Recruit participants, obtain informed consent, and conduct pre-test–post-test assessments to measure the creative thinking skills of the experimental and control groups.
Step 5: Evaluation	Analyze the pre-test and post-test assessment data using appropriate statistical techniques, analyze the qualitative data from the surveys, summarize the findings, draw conclusions, and make recommendations for further research.

4.3. Participants

This study included participants from two fourth-year classes majoring in early childhood education at a university in Bangkok, Thailand. The students were enrolled in the course 'Innovation in Education' and had limited relevant work experience.

One class was the control group (N = 50) and the other class the experimental group (N = 50). The experimental group received 5 lessons on innovative classroom games, using

the project-based learning (PjBL) course. The control group received 5 lessons using a traditional teaching approach.

4.4. The PjBL Course

This course was designed for preschool teachers and focuses on creative approaches to classroom games.

Classroom games are very useful in early childhood education. Well-designed games can promote active learning, socialization, problem solving, and creativity, creating a stimulating and enjoyable environment to improve children's engagement and motivation [28]. Understanding how to organize classroom games and develop game-related skills in early childhood education is essential for pre-service kindergarten teachers, as these skills significantly impact a child's overall development and future academic and social success. Once pre-service students become practicing preschool teachers, it may be necessary for them to continue creating effective classroom games in the actual classroom.

4.4.1. Lesson Plans

Five lesson plans were designed for the experimental group, and included activities such as group discussions, brainstorming, and tasks that involved analysis and creativity (Table 3).

Table 3. Five lesson plans incorporating the PjBL-TPS model and theory.

Lessons	Objectives	Content/Instruction	Desirable Characteristics: Enhance Creative Thinking
Lesson 0	Introduction and pairs formation (30 min)	1. Introduction to the project. 2. Overview of creative thinking, project-based learning, and the Think–Pair–Share strategy. 3. Formation of pairs.	-
Lesson 1	Understanding, discussion and developing knowledge frameworks in pairs (90 min)	1. Understand the key principles of game design and game design elements. 2. Group discussion on game design elements and game implementation. 3. Create knowledge frameworks in pairs: employ mind maps to create knowledge frameworks and combine them to illustrate and reinforce understanding of the learned material.	Elaboration: Providing further explanations of observations and insights.
Lesson 2	Analyze practices and discussion in pairs (90 min)	1. In pairs, analyze a list of given games to identify the game design elements. 2. Paired discussion of the findings of the game analysis; make a report.	Fluency: Learning more games and exchanging multiple game ideas with peers. Elaboration: Offering additional explanations of observations and insights.
Lesson 3	Brainstorming ideas, and their development and presentation (90 min)	1. Introduction to brainstorming techniques. 2. Conduct a brainstorming session to generate a variety of game ideas. 3. Collaboratively select and refine the most feasible and interesting game ideas. 4. Game concept development. 5. Presentation and feedback from instructor.	Originality: Generating as many game ideas as possible and identifying unique game design elements. Elaboration: Exchanging multiple game ideas with peers and providing further explanations of their own game concepts.

Table 3. *Cont.*

Lessons	Objectives	Content/Instruction	Desirable Characteristics: Enhance Creative Thinking
Lesson 4	Testing and evaluation (120 min)	1. Students exchange and playtest the other pairs' game concepts. 2. Refinement of game concept. 3. Presentation and reflection.	Fluency: Learning more games and exchanging multiple game ideas with peers. Flexibility: Considering different ways in which game design elements can be combined or modified. Elaboration: Providing specific and detailed feedback.
Lesson 5	Final project implementation (120 min)	1. Students implement the refined game concept. 2. Instructor's observations and reflections on the gameplay; identify any areas for improvement. 3. Reflection and conclusions on their overall experience in the project.	Flexibility: Being open to reflections on the gameplays' game concepts. Elaboration: Adding details and refining the game mechanics.

4.4.2. The PjBL-TPS Course Model

The PjBL-TPS course model, as shown by the five lesson plans shown in Section 4.4.1, comprised five stages.

Stage 1: Project Preparation

In this stage, the students were acquainted with the concept of creative thinking in the realm of early childhood education. The aims included offering a comprehensive understanding of project-based learning (PjBL) and the Think–Pair–Share (TPS) strategy, along with a thorough review of the fundamental principles of game design. Pairs were arranged to ensure a balance in learning levels. The aim was to provide the foundation for the next steps.

This stage was scheduled for Lessons 0–1.

Stage 2: Project Collaboration

In this stage, student pairs examined the games, generated game ideas, and collaboratively constructed knowledge frameworks with which to visually represent the studied content. The student pairs worked together, improving their thinking and refining the project based on feedback. This stage emphasized the development of fluency and flexibility by urging the education students to contemplate various perspectives and build on others' ideas. Through the generation and exchange of ideas, students emphasized each other's strengths.

This stage was scheduled for Lessons 2–5.

Stage 3: Project Production

In Stage 3, the pairs refined and tested their game concept. They then reflected on the process before revealing it to the class. This stage encouraged originality, asking the students to engage in creative thinking in alignment with the learning objectives. This approach helped them to design their games.

This stage was scheduled for Lessons 3–5.

Stage 4: Project Evaluation

In Stage 4, the pairs that were involved in evaluation and reflection critically analyzes the game concepts of the other pairs by determining the strengths and weaknesses, thereby promoting elaboration skills. In addition, this stage promoted originality, since the students were asked to formulate creative thought to make their games more engaging and unique. The objective was to improve fluency and flexibility by encouraging the students to participate in more games and exchange ideas with the others.

This stage was scheduled for Lessons 4–5.

Stage 5: Project Conclusion

In Stage 5, the pairs reflected on their project experience, considered their learning, and shared insights with their peers to enhance elaboration by considering how to apply new knowledge; it also promoted originality through the sharing of unique perspectives and refining ideas.

This stage was scheduled for Lessons 4–5.

4.5. Measurement Tool

The research used measurement tools to assess creative thinking skills and a questionnaire sheet. To collect the primary data for analyzing the students' creative thinking skills, the teacher instructed the students to finish a practical exercise involving creative thinking skills in class after the course. After they had finished, they completed a self-assessment questionnaire.

Sufficient time was allocated for completing both the practical exercises and the self-assessment questionnaire.

4.5.1. Practical Exercises

To fully understand the creativity of the students, the researcher emphasized open-ended as well as structured questions to provide opportunities for the students to demonstrate their creativity in different ways.

Test questions were then designed according to the four aspects of creative skills and the course content for a comprehensive evaluation.

Fluency: The questions evaluate the students' capacity to generate a substantial number of ideas or solutions related to games within a specified time frame.

Test Question 1:

List as many existing classroom games as possible that can be played indoors or outdoors, fostering learning and requiring minimal preparation.

Test Question 2:

Provide numerous existing classroom games adaptable for diverse learning objectives, such as promoting teamwork, critical thinking, and creativity.

Scoring Criteria (25 points):

1. Game Quantity Generated (10 points): Each idea receives one point, with a maximum of ten points.

2. Diversity (10 points): Evaluates thematic differentiation (0–3 points), diversity of rules and objectives (0–4 points), and gameplay processes (0–3 points).

3. Practicality (5 points): Assesses the feasibility of the proposed game concepts in real teaching environments.

21–25 points: High fluency.

16–20 points: Fluency.

11–15 points: Moderate fluency.

6–10 points: Low fluency.

0–5 points: Minimal fluency.

Flexibility: The questions assess the students' ability to generate alternative ways to play games or to modify the existing rules for new experiences.

Test Question 3:

Describe how you would modify a classic outdoor game for an indoor setting or a classic board game for an outdoor setting, considering space and resource constraints in your school.

Test Question 4:

Generate a new feature or mechanic to enhance player experience in an existing popular game.

Scoring Criteria (25 points):

1. Environmental and Conditions Consideration (10 points): Evaluates the holistic consideration of diverse environments and conditions.

2. Adaptability to Different Scales and Settings (10 points): Assesses the skillful adjustment of games for varying student numbers and environments.

3. Practicality (5 points): Examines the feasibility of the proposed game concepts in real teaching environments.

21–25 points: High flexibility.

16–20 points: Flexibility.

11–15 points: Moderate flexibility.

6–10 points: Low flexibility.

0–10 points: Minimal flexibility.

Originality: The questions gauge the students' ability to generate unique and novel ideas or solutions related to games.

Test Question 5:

Create completely original games that have never been played before, incorporating elements from different cultures and time periods or across multiple educational domains.

Scoring Criteria (25 points):

1. Integrating Elements from Different Cultures and Time Periods, or across Multiple Educational Domains (10 points): Assesses the successful incorporation of diverse cultural or historical elements.

2. New Ideas—Quantity Generated (10 points): Each idea receives two points, with a maximum of ten points.

3. Practicality (5 points): Evaluates the feasibility of the proposed game concepts in real teaching environments.

21–25 points: High originality.

16–20 points: Originality.

11–15 points: Moderate originality.

6–10 points: Low originality.

0–5 points: Minimal originality.

Elaboration: The questions assess the students' ability to develop and expand on their ideas or solutions related to games.

Test Question 6:

Provide detailed rules, instructions, and materials for the classroom game created in Test Question 5, explaining alignment with specific learning objectives to ensure active student engagement.

Test Question 7:

Explain how the new feature/mechanic created in Test Question 4 would work and why it would be beneficial for players of the classroom game.

Scoring Criteria (25 points)

1. Clear Rules and Instructions (10 points)

Evaluates whether the student has provided clear and specific rules and instructions for the created game, ensuring comprehensive student engagement and compliance with the learning objectives.

2. Detailed Material Descriptions (10 points)

Examines whether the student has described the materials required for the game, ensuring effective implementation.

3. Additional Elements, such as Music and Sound Effects (5 points)

Assesses whether the pre-service teacher has provided the addition of extra elements beyond the standard requirements, such as incorporating music and sound effects, and how these contribute to the implementation of the game and an enhanced player experience.

21–25 points: High elaboration.

16–20 points: Elaboration.

11–15 points: Moderate elaboration.

6–10 points: Low elaboration.

Table 4 shows the criteria for the success rate of creative thinking, according to Sugiyono [29]:

Table 4. The criteria for the success rate of creative thinking.

Interval	Criteria
85–100	Very Creative (VC)
75–84	Creative (C)
65–74	Fairly creative (FC)
55–64	Less creative (LC)
30–54	Very less creative (VLC)
0–29	Completely less creative (CLC)

4.5.2. Survey Questionnaire for the Students' Perceptions of the Practical Exercise of their Creative Thinking Skills

The questionnaires enabled the students to perform self-assessments related to their creative thinking during their learning.

The questionnaires were given to the participants to gather their responses and perceptions of their creative thinking abilities. Likert-scale questions were included in the survey questionnaire.

Self-Evaluation:
Please select a number on the scale below to indicate your level of agreement
Fluency 1. I believe I can now provide **MORE** game ideas and examples after taking the course. 0 1 2 3 4 5 2. I believe I can now provide games that demonstrate a **GREATER** variety and diversity after taking the course. 0 1 2 3 4 5
Flexibility 1. I can now **MORE** effectively modify a game based on various objectives after taking the course. 0 1 2 3 4 5 2. I can now consider a **MORE** extensive range of factors when modifying game rules, including difficulty, participant experience, and rule fairness after taking the course. 0 1 2 3 4 5
Originality: 1. I can now incorporate **MORE** unique elements distinct from existing games or common concepts in my game design or modification, after taking the course. 0 1 2 3 4 5 2. I can now incorporate **MORE** diverse elements, including those from different cultures or time periods, ensuring integration across multiple educational domains, after taking the course. 0 1 2 3 4 5
Elaboration: 1.After taking the course, I can now provide **MORE** detailed and comprehensive descriptions of the rules, instructions, and materials for my classroom game, ensuring alignment with specific learning objectives for active student engagement in my game design or modification. 0 1 2 3 4 5 2. After taking the course, I can now incorporate **MORE** unexpected elements such as music and sound effects to add detail, showcasing an enhanced ability in my game design or modification. 0 1 2 3 4 5

4.6. Data Analysis

Following the data collection, the researcher conducted a thorough analysis of the data.

1. Independent Samples T-Test

An Independent Samples T-Test was used to compare the average values between the experimental and control groups. This method helps to determine whether there are statistically significant differences.

2. Descriptive Statistics

Comprehensive descriptive statistics, including the sample size, mean values, and standard deviation, offer a comprehensive comparison of creativity aspects between the two groups post-experiment. This applies to the analysis of the survey responses, quantifying the students' subjective perceptions of the course and testing the research hypotheses.

5. The Results

5.1. The PjBL-TPS Course Model

Based on five experts' analysis within the IOC (Index of Item Objective Congruence), the average scores for each assessment ranged from 0.8 to 1, exceeding the design standard midpoint of 0.5. All five experts agreed that the learning model was well-designed to conform with the aims of the research. The course was highly commended for its activities that significantly fostered the various aspects of the students' creative thinking. Overall, the experts found the learning model to be highly suitable.

To provide a concise and impactful summary, this study presents the final model through the following graphical representations (Figure 1).

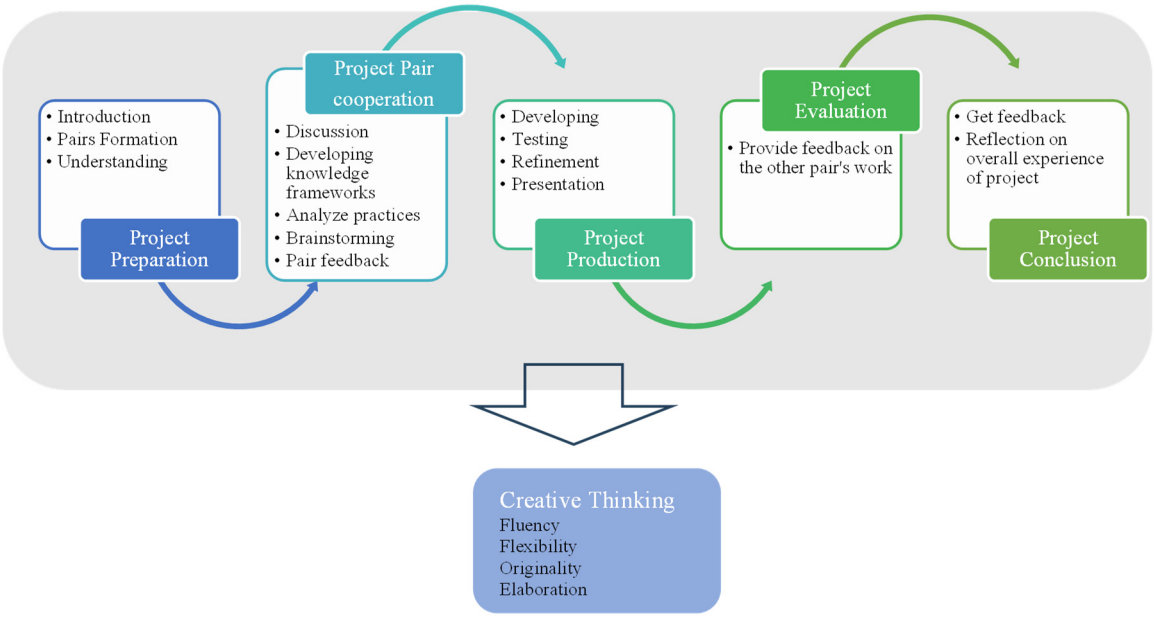

Figure 1. PjBL-TPS course model.

The PjBL-TPS course model has five stages designed to act as a reference tool across various educational domains. The five stages are as follows:

Stage 1: Project Preparation

In this initial phase, participants are introduced to the concept of creative thinking in education. The goals include providing an overview of project-based learning (PjBL) and the Think–Pair–Share (TPS) strategy, along with reviewing the essential principles relevant to the subject matter. Pairs are carefully formed to ensure a balanced mix of learning levels, laying the foundation for the subsequent steps.

Stage 2: Project Pair Cooperation

During this stage, the pairs collaboratively analyze the provided materials, brainstorm ideas, and construct knowledge frameworks. The objective is to illustrate and reinforce their understanding through class discussions, examples, and findings. The members engage in divergent thinking, adjusting their projects based on peer feedback. This stage cultivates fluency and flexibility while encouraging the exploration of diverse perspectives, facilitating the development of original and unique concepts.

Stage 3: Project Production

This phase centers on the development and playtesting of the game concept. Reflection on the process and a presentation to the class promote originality and elaboration, challenging the students to think creatively while meeting specific learning objectives. The emphasis is on fostering the creation of unique and interesting projects.

Stage 4: Project Evaluation

During this stage, the pairs critically analyze the game concepts of their peers, identifying strengths and weaknesses. This process enhances their elaboration skills and encourages originality by prompting creative thinking to make the games more unique and engaging. The goal is to boost fluency and flexibility through knowledge exchange and the exploration of multiple ideas with their peers.

Stage 5: Project Conclusion

In this final stage, the pairs reflect on their project experience, contemplate their learning, and share their insights with their peers. This encourages elaboration by considering the application of new knowledge and promotes originality by sharing unique perspectives and refining ideas.

5.2. The Impact of PjBL-TPS Course Model on Student Teachers' Creative Thinking Skills

5.2.1. Students' Creative Thinking Test Results

The pre-test and post-test data for the control and experimental classes are shown in Table 5.

Table 5. Students' creative thinking test results.

	Groups	**N**	**Mean**	**SD**	***p*-Value**
Pre-test	Control Group	50	58.00	12.91	0.71
	Experimental Group	50	57.35	13.42	
Post-test	Control Group	50	72.38	16.35	0.0001
	Experimental Group	50	85.45	16.29	
Interpretation					
	Groups		**Creative thinking**		
Pre-test	Control Group		Less creative		
	Experimental Group		Less creative		
Post-test	Control Group		Creative		
	Experimental Group		Very Creative		

It is apparent from Table 5 that:

- 50 participants were included in both the experimental class and the control class.
- The *t*-test results reveal that before the intervention there was no significant difference in the mean creative thinking scores between the two groups (t-Value = −0.44, *p*-Value = 0.71).

- Post-intervention, the mean creative thinking score of the experimental group was significantly higher than that of the control group (t-Value = 5.5, $p = 0.0001$).
- Pre-intervention, both groups of students lacked creative thinking when organizing classroom games. However, post-experiment, the creativity of the control group improved to the "Creative" level, while the creativity of the experimental group reached the "Very Creative" level.

Table 6 presents detailed results of the creative thinking levels before and after the learning process, for the control class and the experimental class.

Table 6. The post-test results of the creative thinking levels of the control and experimental classes.

Creative Thinking	Control Class			Experimental Class		
	Mean	SD	Level	Mean	SD	Level
Fluency	20.73	3.98	High Fluency	23.01	3.77	High Fluency
Flexibility	19.26	4.02	Flexibility	21.56	4.12	High Flexibility
Originality	14.38	4.23	Moderate Originality	20.07	4.22	High Originality
Elaboration	18.01	4.12	Elaboration	20.81	4.18	High Elaboration

As demonstrated by the four indicators of creative thinking shown in Table 6, the results of the control class and the experimental class on the post-test assessment are as follows.

Fluency:

The fluency test, with a maximum score of 25 points, revealed that the experimental group (mean = 23.01, SD = 3.77) outperformed the control group (mean = 20.73, SD = 3.98). This indicates that the participants in the experimental group showed a higher fluency in generating a larger number of game ideas compared to the control group.

Flexibility:

The flexibility test, with a maximum score of 25 points, revealed that the experimental group (mean = 21.56, SD = 4.12) outperformed the control group (mean = 19.26, SD = 4.02). This shows that the participants in the experimental group had a higher flexibility when generating alternative ways to play games or modifying the existing rules to create new experiences compared to the control group.

Originality:

With a maximum score of 25 points, the originality test showed that the experimental group (mean = 20.07, SD = 4.22) outperformed the control group (mean = 14.38, SD = 4.23). This shows that the participants in the experimental group had a higher originality when generating novel game ideas which showed a distinctiveness from existing games or common conventions compared to the control group.

Elaboration:

The elaboration test, with a maximum score of 25 points, revealed that the experimental group (mean = 20.81, SD = 4.18) outperformed the control group (mean = 18.01, SD = 4.12).This shows that the participants in the experimental group had a higher elaboration when providing detailed and comprehensive descriptions or explanations of their game ideas compared to the control group.

5.2.2. Students' Perceptions of the Practical Exercises for Creative Thinking Skills

The students were given questionnaires to identify their perceptions of their creative thinking abilities. Table 7 presents the results.

Table 7. Survey results showing students' perceptions of their creative thinking abilities.

Questions	M	SD	Opinion Level
Fluency 1	4.63	0.67	Strongly Agree
Fluency 2	4.41	0.74	Agree
Total	4.52	0.72	Strongly Agree
Flexibility 1	4.38	0.81	Agree
Flexibility 2	4.21	0.64	Agree
Total	4.295	0.76	Agree
Originality 1	4.03	1.29	Agree
Originality 2	4.03	1.02	Agree
Total	4.03	1.23	Agree
Elaboration 1	4.02	0.97	Agree
Elaboration 2	4.23	0.74	Agree
Total	4.13	0.84	Agree
Creative Thinking Skills	4.16	0.91	Agree

The results of the questionnaire revealed the self-perceptions of the students regarding their creative thinking abilities across the four domains.

Fluency:

Regarding fluency, the students strongly affirmed their ability to generate more game ideas and examples (M = 4.63, SD = 0.67), and to present games with increased variety and diversity (M = 4.41, SD = 0.74) after completing the course. This consensus resulted in an overall strong agreement regarding the noticeable improvement in their fluency (Total M = 4.52, SD = 0.72).

Flexibility:

In terms of flexibility, the students acknowledged their enhanced capability to modify games based on diverse objectives (M = 4.38, SD = 0.81). They also expressed agreement when considering a broader range of factors, such as difficulty, participant experience, and rule fairness, when adjusting game rules (M = 4.21, SD = 0.64). These findings led to an overall agreement on the perceptible increase in their flexibility (Total M = 4.295, SD = 0.76).

Originality:

Concerning originality, the students reported an increased ability to incorporate unique elements distinct from existing games or common concepts (M = 3.62, SD = 1.29). They also indicated an improved capability to integrate diverse elements, including those from different cultures or time periods, across multiple educational domains (M = 4.03, SD = 1.02). Overall, there was agreement on the noticeable increase in their originality (Total M = 3.83, SD = 1.23).

Elaboration:

In terms of elaboration, the students acknowledged their proficiency in providing more detailed and comprehensive descriptions of rules, instructions, and materials for their classroom games, aligning with specific learning objectives (M = 4.02, SD = 0.97). Additionally, they recognized their increased ability to incorporate unexpected elements, such as music and sound effects, to enhance the detail of their game design or modification

(M = 4.23, SD = 0.74). This resulted in an overall agreement on the perceptible increase in their elaboration skills (Total M = 4.13, SD = 0.84).

The students agreed that all aspects of their creative thinking skills had been positively impacted by the course, with a perceptible increase in their own creative thinking skills (M = 4.16, SD = 0.91).

Therefore, H1 is accepted, signifying the positive and statistically significant impact of the PjBL-TPS course model on the creative thinking abilities of student teachers.

6. Discussion

Based on the creative thinking test results, the outcomes derived from this study's data analysis and evaluation are discussed below.

1. Positive Impact of PjBL-TPS Course Model on Creative Thinking Aspects

The results of the creative thinking test indicate that the project-based learning course positively improved several aspects of creative thinking among the education students, including the fluency, flexibility, originality, and elaboration, of the students who underwent the PjBL-TPS course.

The efficacy of the PjBL-TPS course model stems from several factors. First, the PjBL strategy helps to guide students through practical projects at every stage of the course. This improves students' understanding, and also systematically fosters fluency, flexibility, originality, and elaboration. This encourages critical thinking, problem solving, and creative thinking skills, as reported by Yustina et al. [8] for pre-service biology teachers, and Chen et al.'s research [9] into engineering courses. Blended learning (BL) and project-based learning (PjBL) significantly impact creative thinking, with Yustina et al. having revealed higher scores and an increased N-gain index for the experimental class. Second, the TPS strategy adds to the effectiveness of the course model by emphasizing sharing and collaboration, and integrating diverse perspectives into projects. This fosters innovative thinking and enhances overall creativity, as noted by Utami and Rusdarti [10] and Chandra and Ety's study [11]. The Think–Pair–Share (TPS) strategy can enhance creativity and critical thinking skills, with experimental classes revealing better-than-average final test results and improved creative thinking abilities than traditional learning methods. Finally, it is important to maintain balanced learning levels through pair formation. This ensures that students benefit from diverse perspectives and skills, reinforcing the effectiveness of the PjBL-TPS course model. The careful grouping of students, as emphasized by Kagan, S. and Kagan, M. [6], enhances collaboration and facilitates comprehensive discussions, significantly improving the efficiency of the Think–Pair–Share strategy.

2. Increased "Originality" Scores

The experimental class had the most significant increase in "Originality" compared to the control class, indicating a notable role played by the PjBL-TPS course in fostering original ideas.

Several key factors may have increased the "Originality" scores. First, in the project production and evaluation process, focusing on a practical application and a reflective evaluation significantly enhances originality. Second, the collaborative nature of project development, which involves active collaboration, open peer feedback, and project adjustments based on collective input, cultivates a creative and innovative atmosphere. This collaborative dynamic not only stimulates original thinking, but also creates an environment conducive to the enhancement of originality.

3. Self-Perceived Creativity Improvements

The post-course evaluations indicated that a majority of the students perceived improvements in all facets of their creativity, reflecting a consensus on the noticeable enhancement of their creative thinking abilities. The observed advancements in creative thinking, with 'Fluency' exhibiting the highest improvement, followed by 'Flexibility', 'Elaboration',

and 'Originality', can be attributed to the specific elements of the course design, explained as follows.

Abundance of Examples:

The course exposed students to a diverse array of examples and scenarios during the "Project Preparation" and "Project Pair Cooperation" phases. This abundance helped the students build a varied mental database, contributing to their improved fluency.

Practical Application:

Emphasizing practical applications in the "Project Production" and "Project Evaluation" phases required the students to adapt to different educational requirements, fostering flexibility in game design and contributing to the observed improvement in their flexibility skills.

Idea Exchange and Sharing Insights:

Encouraging the students to exchange ideas and share insights throughout all the phases significantly enhanced their ability to provide detailed and comprehensive descriptions, leading to their heightened elaboration skills.

Collaborative Creativity:

The collaborative process during the project development, particularly in the "Project Production" and "Project Evaluation" phases, prompted the students to think creatively, consider various perspectives, and adjust their projects based on peer feedback. This collaborative creativity fostered original thinking, contributing to the enhancement of originality. However, a potential undervaluation of originality may have stemmed from a lack of confidence in recognizing unique ideas.

In summary, the course structure and activities played a pivotal role in sequentially enhancing various aspects of the students' creative thinking skills.

7. Conclusions

The PjBL-TPS course model, comprising five key elements, including Project Preparation, Pair Cooperation, Production, Evaluation, and Conclusion, provides a comprehensive framework for enhancing the creative thinking of education students.

This study, although at first found no significant differences in the mean creative thinking scores, the post-intervention revealed a notable increase in the creative thinking scores of the experimental group, particularly for the aspect of "Originality".

The post-course assessments revealed an agreement among the students regarding the improvements in their creativity. 'Fluency' showed the highest improvement, followed by 'Flexibility', 'Elaboration', and 'Originality'. These positive outcomes emphasize the effectiveness of the project-based learning course for fostering creative thinking skills.

To summarize, the PjBL-TPS model is a valuable tool for nurturing creativity in students, as demonstrated by the significant improvements in their creative thinking scores and their own perceptions of the enhancements to their creativity in multiple aspects.

8. Recommendations for Future Research

1. Examine the Impact of Individual Student Differences

Individual student differences (for example, gender, disciplinary interests, and academic backgrounds) should be a focal point to determine whether these differences affect the impact of the PjBL-TPS model on creative thinking.

2. In-Depth Analysis of the Impact at Different Course Stages

Further exploration is recommended into the impact of each stage of the PjBL-TPS course on creative thinking. For example, it could be investigated whether the different stages produce more pronounced effects on distinct creative thinking dimensions.

3. Analyze Long-Term Societal Impact

It is recommended to conduct further in-depth research on the long-term impact of students, following PjBL-TPS course completion, on their societal engagement, career trajectories, and contributions to the innovation field. This could reveal the model's role in fostering the holistic development of individuals and its broader impact on society.

4. Evaluate Parental Involvement and Support

Future study is recommended on the impact of students receiving parental involvement and support while taking the PjBL-TPS course. It would be interesting to assess whether parental encouragement and participation have an effect on the development of creative thinking skills.

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