Study on BOPPPS Application for Creativity Learning Effectiveness*

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This study aims to probe into the effect of the BOPPPS (Bridge-in, Objective, Pre-assessment, Participatory learning, Post-assessment, Summary) application on university students' creativity learning effectiveness. This study applied BOPPPS instructional strategy to creativity project making and combines creativity and creativity instruction design items as the criteria to design creativity project making and develop the "Creativity BOPPPS^2 Modle". The "Creativity BOPPPS^2 Modle" includes the following: (1) teachers' creativity instruction; (2) students' creativity learning; and (3) multiple evaluations of creativity. By case experimental instruction, and according to the statistical analysis of the student questionnaire survey and text analysis of students' creativity project making, this study found that university students' creativity learning effectiveness of BOPPPS is significant and positive. Finally, this study generalized the key points of instruction of different stages of "Creativity BOPPPS^2 Modle", and proposed the suggestions for instruction and future research, in order to enhance university students' creativity learning effectiveness and the significance of project-making courses.

Keywords: BOPPPS; creativity; project making; university students

1. Research motives and purpose

Vigorous development of the innovation industry is based on cultivating numerous innovative talents. Therefore, technological and vocational education plays an extremely important role and cultivates basic talents for national economic construction. The key is to get students to apply what they learn in the classroom. This approach combines theory and practice, developing and offering basic technical manpower for the workplace [1]. Of the technological and vocational education courses, project making is the most representative one. Project making can reinforce the students' comprehension of basic concepts and enhance creativity and knowledge [2]. Students can learn problem solving, team work, interpersonal relations and skills in the project-making courses [3].

However, due to Taiwan's long-term adherence to traditional education, universities generally use teacher-centered instructional models, in which teachers guide all instructional activities. In teaching knowledge and skills, they neglect the students' potential problem-solving capacities [4]. By promoting the cultivation of the creative thinking capacity, traditional instructional methods can be adapted. Only adapted instructional methods can develop the students' creative thinking capacities [5]. Therefore, the objectives of technological and vocational education are to enhance related skills and occupational ethics and to develop independent thinking and problem-solving capacities [6].

Hence, project-making courses should be gradually adjusted to reinforce the university students' creativity and instructional designs. BOPPPS is one of the instructional tools that helps teachers to evaluate course design effectiveness [7]. This study includes creativity instruction in a university project-making course and designs instructional content for project making with six steps of BOPPPS. In addition, it emphasizes student-centred learning and enhances problem-solving capacity through collaborative learning in order to fulfil the "learning in doing" of technological and vocational education [8]. Finally, through instructional evaluation and modification, instructional skills are strengthened to inspire students. The purposes of this study are:

1. to integrate BOPPPS and creativity instruction in project-making course design;
2. to construct a BOPPPS creativity instruction model;

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3. to probe into the effect of BOPPPS on university students' creativity learning effectiveness.

2. Literature review

The literature on project-making courses, creativity and creative teaching and BOPPPS is reviewed below.

2.1 Project-making courses

According to the research findings of Mahendran, university students' project making can enhance their comprehension of basic concepts, creativity, broad knowledge base and learning [2]. Planning for "project making" aims to combine the students' acquired theoretical base and practice to strengthen their internal motives for learning and cultivate their independent thinking and team work capacities [3, 9]. Hence, in the working process, learners can experience product design, problem solving, decision making and product development. They will independently work on the project and accomplish the result [3]. Therefore, the project-making curriculum design should be based on the students' basic professional knowledge and comprehension to develop their application, analysis and general capacities and value judgment.

Therefore, this study adopts BOPPPS to design creativity project-making instruction and to establish research topics. Thus, students confirm the research questions. Through BOPPPS's six steps of instructional strategy, this study aims to allow students to control project-making progress in order to gain experience with data collection and project making.

2.2 Creativity and creative teaching

As for creativity research from a practical one-dimensional perspective, we can use Rhodes' "4P" as an example [10]. The process perspective focuses on analyzing the process and stage to create ideas; the person perspective focuses on creators' personality traits; the product perspective focuses on analyzing creative goods; the press/place perspective aims at exploring the effect of pressure or the environment on creativity development and gauges the significance of that effect. Howe proposed six factors of creativity: personality traits, the creative process, knowledge fields, creation results, environmental variables and communication and persuasion capacities of creation [11]. Current research on creativity has suggested treating characteristics of creative goods as indicators to distinguish creativity. Creative goods can be behavior, performance, work and even thoughts [12, 13]. Based on the previous literature, this study designed a creativity learning effectiveness questionnaire and instruction

and recognizes students' creativity learning effectiveness through the students' creative work and process analysis.

Based on the definition of ERIC, "creative teaching" is "the development and use of new, original or creative instructional methods". Therefore, creativity has the acquired characteristic—the human beings' unique and continuous construction, deconstruction and reconstruction of the thinking processes [14]. According to many studies, the individuals' creative potential can be constructed and developed with practice [15]. Critical R&D capacities (e.g., system thinking capacity, communication and negotiation and team work) should be cultivated through different instructional activities [16]. Hence, multiple flexible strategies are shown to develop the students' creativity [17, 18]. Lou et al. reorganized the design items of creativity and creative teaching through several scholars' statements [19], as shown in Table 1. Teachers can use curriculum content, diverse instructional activities, evaluation and the instructional environment to stimulate students' creative behavior. Through such instruction, students' creative thinking is cultivated, and they are encouraged to present and operate freely. These changes effectively adapt the authoritative instructional role and guide students to solve problems through different channels, thus enhancing creativity learning effectiveness.

Based on the objectives listed above, this study uses Lou et al.'s proposed design items for creativity and creative teaching as a reference point for designing creativity project-making course content that reinforces students' creativity [19].

2.3 BOPPPS

BOPPPS is a tool that teachers can use to assess the effectiveness of course design [20, 21]. The basic concept of BOPPPS is to divide instructional content into units. Each course unit includes introduction, elucidation, transition and summing up. BOPPPS divides the course into six stages [7, 21, 22]. The key points of execution are in Table 1.

1. Bridge-in: The purpose is to cement students' attention and help them to focus on the content. At this stage, teachers' instructional strategies include the following: indicating the reason, importance or commonality for learning the course; describing stories related to course themes or teachers' personal experiences; proposing questions associated with instructional themes to guide students' approaches to the course; providing an attractive introduction or unusual fact; and connecting the following content with acquired or future content.

2. Objective: There are three key elements: cognitive, affective and psychomotor skills. Cognitive

Table 1. Compilation of creative instructional design objectives [19]

Creative instructional design objectives	Item
1. Create a lively and open instructional context	• Cultivate motivation for creativity • Cultivate creative personality traits • Develop capabilities in creative thinking • Cultivate a classroom atmosphere and environment that is conducive to creative behaviors
2. Administer creative and diverse instructional evaluation	• Assist students in conducting holistic evaluations of problems • Creatively use existing knowledge • Encourage the development of multiple solutions • Provide suitable problems for thought exercises
3. Skillfully utilize instructional methods in conjunction with creative thinking	• Cope with individual differences • Skillfully utilize instructional media and creative instruction design • Encourage bidirectional interaction between teachers and students • Encourage students to develop sensitivity toward the problem • Inspire the students' mental flexibility
4. Adjust the authoritative role of instructors	• Abandon instructors' authoritative roles and instead encourage students with accommodating attitudes • Respect any childish or even ridiculous questions from students • Appreciate student expression and praise student opinions • Avoid giving positive value judgments for student actions • When criticizing student opinions, explain the reasons for doing so
5. Encourage students to freely carry out presentations and operations	• Emphasize the subjectivity of learners and give them the chance to freely experiment • Give students more opportunities to engage in free experimentation and creativity • Instead of emphasizing the memorization of knowledge, focus on knowledge application • Give students chances to come into contact with nature and society • Emphasize novel, flexible, and high-efficacy learning strategies and methods • Provide learning incentives for creative activities and pursue creative learning objectives

content includes elements, theories and concepts; affective content includes attitudes, values, concepts and emotions; psychomotor skill refers to technique and performance. Teachers should clearly indicate their instructional objectives (e.g., key course knowledge, learning value and acquired capacity) to allow students to specifically control their learning direction. Objectives must be concrete descriptions, including "who", "will do what", "under what conditions" and "how well".

3. Re-assessment: Through pilot tests, teachers recognize students' interests and capacities and adjust content depth and progress. For students, they can focus on a specific learning direction in the pilot test and suggest necessary review or clarification for teachers. Tests, assignments or informal questions (e.g., open-ended questions and brainstorming) can accomplish the pilot test's purposes.

4. Participatory learning: This step includes two common types: (1) teacher–student interaction and (2) discussion among students. At this stage, teachers apply instructional strategies to increase class participation. The most common method is to divide students into groups to discuss issues in the teaching materials. Teachers can also add pauses in lectures to allow students to ponder the questions. In addition, they also encourage students to pose self-reflection questions and invite all class participants to interactive situations.

5. Post-assessment: This stage aims to recognize students' learning effectiveness and the accomplish-

ment of instructional goals. If the instruction content is different, the assessment is different. Knowledge comprehension courses are assessed with multiple-choice or short answers. Analysis courses are based on students' capacities to analyze specific situations. Skill instruction courses can be based on a checklist, and students briefly demonstrate their acquisition of the listed skills. In attitude value courses, students are invited to fill in attitude scales, write in journals or record what they have learned.

6. Summary: Teachers help students to sum up course content, integrate learning points and preview lessons for the next class. Teachers can use lecture or feedback to directly review course content. In addition, they can properly praise students' efforts and learning results, which is a common method for summing up the course.

This study treats these six BOPPPS stages as an instructional design framework for creativity project-making courses. It integrates BOPPPS into creativity project-making course design to reinforce teachers' instructional skills, the diversity of students' learning and students' creativity learning effectiveness.

3. Research design and practice

According to the research purposes and literature review, this study's research design and implementation process are shown below.

3.1 Research design

According to the design items for creativity and creative teaching that Lou et al. [19] proposed, this study designed a creativity project-making course based on BOPPPS. The course includes the following: (1) BOPPPS teachers' creativity instruction; (2) BOPPPS students' creativity learning; and (3) multiple assessments of creativity. The case instruction was based on teamwork learning and attempted to increase students' project-making creativity, as shown in Fig. 1.

3.1.1 Teachers' creativity instruction by BOPPPS

Lou et al. emphasized interesting instructional situations and instructional methods for creative thinking [19]. At this stage, teachers practiced the BOPPPS instructional strategy. In the first week of the course, they explained the bridge-in and learning objectives. They then assessed students' self-reported creativity with a pre-test and implemented a creativity course for three weeks. BOPPPS was regarded as an instructional strategy, and students would thus recognize creativity development and

learning. It was then the "project activity of a creative amphibious boat design" for four weeks. In the last week, professional teachers were invited to grade students' creative work and briefings. Students' questionnaire surveys were conducted as post-tests. Finally, teachers reorganized the course instructional objectives and students' learning result sharing.

3.1.2 Students' BOPPPS creativity learning

This approach is based on the research of Lou et al., who emphasized an authoritative instructional role and encouraged students' free presentation and operation [19]. This stage is based on teachers' BOPPPS participatory learning. At the participatory learning stage of BOPPPS creativity instruction, this study designs student-centered BOPPPS creativity learning and allows students to learn BOPPPS for project-making purposes. This approach is called the "Creativity BOPPPS[2] Model". Teachers' explanations are shown in Fig. 2 (3). As for BOPPPS, this study only elaborates the key points of students' BOPPPS practices, as shown in Fig. 2.
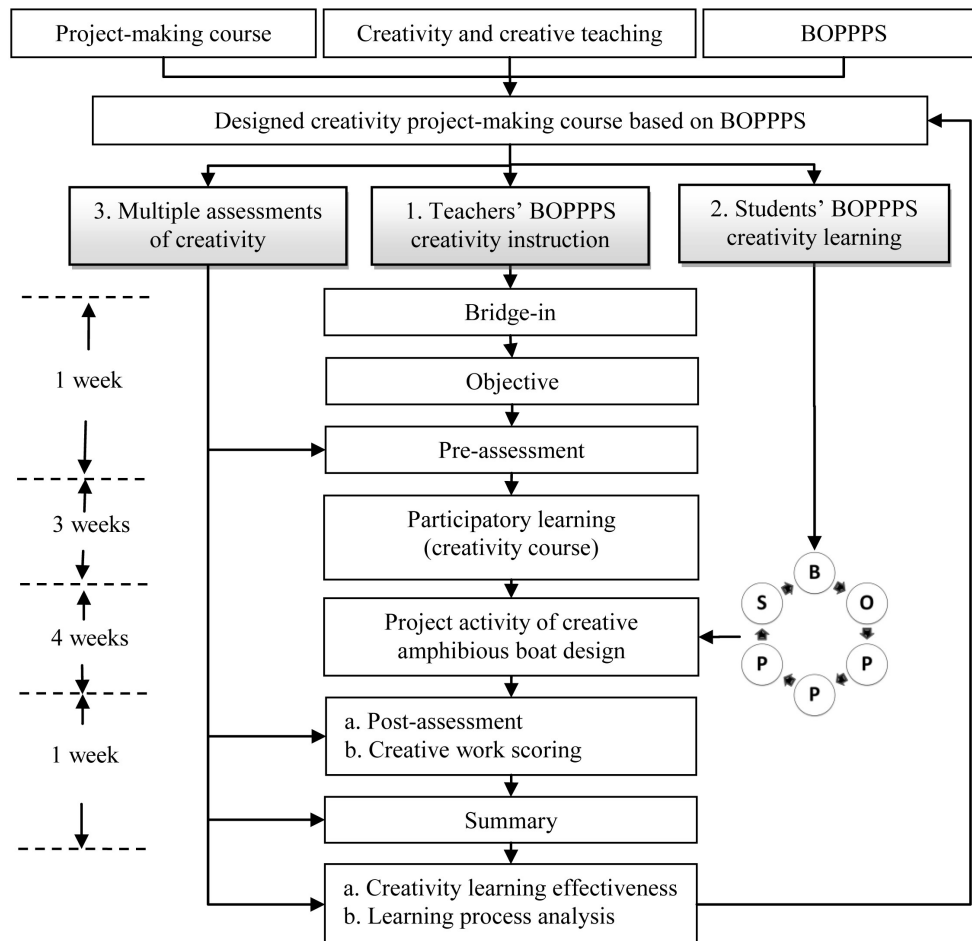

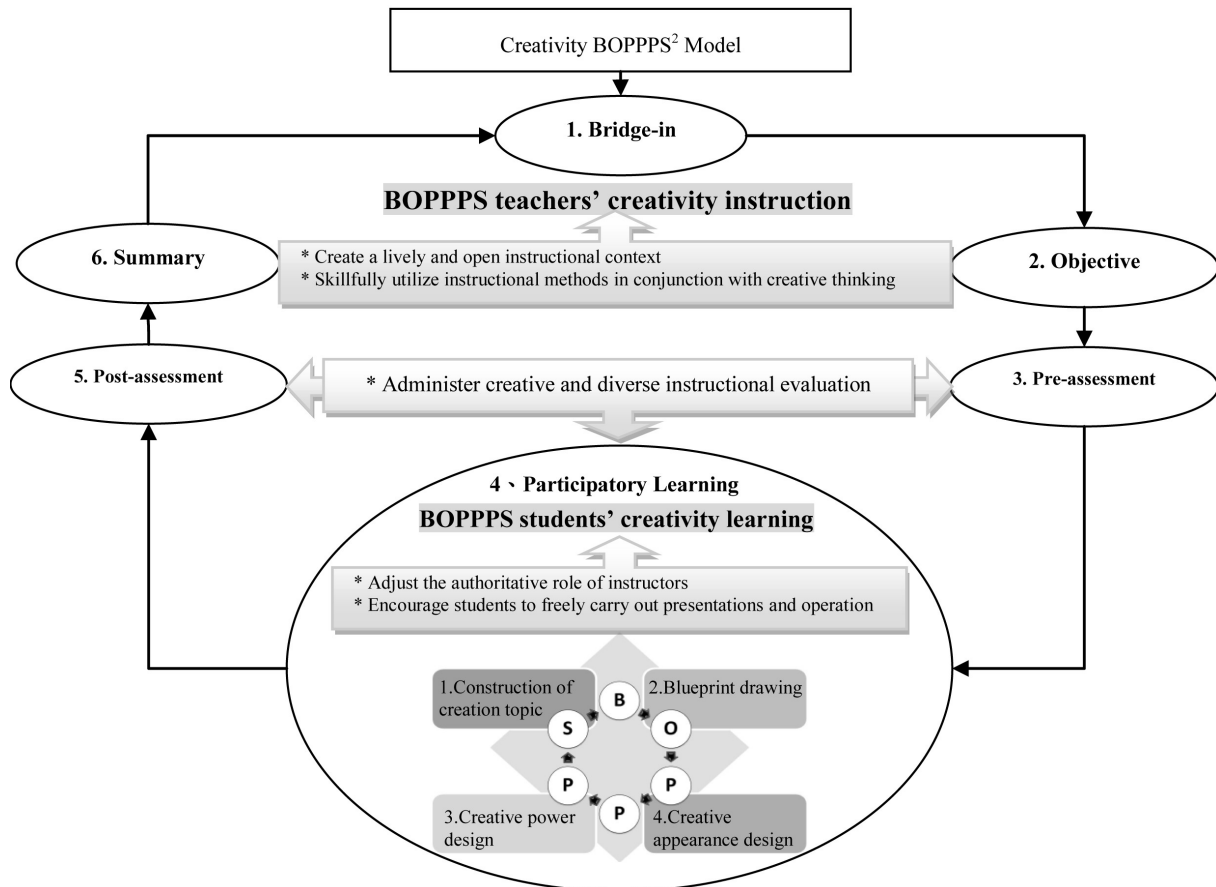**Fig. 1.** Research design and practice flow.

Fig. 2. Creativity BOPPPS[2].

First, this model explains BOPPPS to the students. The teacher's BOPPPS practices emphasize the key points of different stages so that the students will be more familiar with the process. Different student groups have "the project activity of an amphibious boat creative design". This study treats the amphibious boat as the subject of creativity, and environmental material is designated as the main design material. According to the project-making topic, this model designs four task stages: (1) construction of creation topic, (2) blueprint drawing, (3) creative power design and (4) creative appearance design. The previous tasks can be added or reduced according to the situation. In addition, leaders should be selected from each group as the bridges for student–teacher interaction. They host meetings and reorganize opinions. The selection of leaders can be based on the division of work. According to different stages' tasks, each member can be a leader. According to the BOPPPS process, they discuss and practice stages tasks with leadership and teamwork.

- Bridge-in: The leaders explain the key points of the tasks and propose creativity related issues to share and discuss with other group members.

Hence, connecting students' prior knowledge with these issues can be strengthened. It increases students' learning motives and prepares them for in-depth learning.

- Objective: The leaders explain the task's learning objectives and discuss them with group members. Thus, students recognize the tasks' content and focus on the key points of creativity learning. Subsequently, the leaders divide the work and set deadlines. Therefore, students' internal learning motives can be enhanced, and an active learning attitude will be cultivated.
- Pre-assessment: Students can focus on specific purposes through pre-tests. At this stage, the leaders must reorganize the members' opinions and conduct a vote on the future creative design. Thus, at this stage, there is no real test. A vote determines the direction of the design.
- Participatory learning: The teacher is the consultant. The leaders organize group collaboration and learning. According to the expected progress, they accomplish different stages' tasks. Students develop their communication and problem-solving capacities and enhance their teamwork. In manufacturing, the teacher guides students to address the obstacles with creative skills,

increases students' problem-solving capacities and accomplishes the instructional objectives of creativity project making. In addition, students are encouraged to pose self-report questions and discuss the advantages and disadvantages of classmates' creative work to find their own proper measures. This exercise effectively invites students into interactive situations. Through creativity learning, students can cultivate independent thinking capacities.

- Post-assessment: The purpose of post-assessment is to accomplish the learning objectives. Therefore, the leaders report the execution results of different stages'tasks, review the results with group members and indicate the advantages and disadvantages of their design. The group improves the disadvantages to complete the creative work. Students can improve the execution results to ensure that their projects' functions match the creative design requirements.

- Summary: After accomplishing the tasks, the leaders conclude the results of different stages and review the key points of creative design. The members share creative ideas and manufacturing experience. Through peer experience sharing, students' learning motives are increased. They develop independent learning attitudes and increase creativity learning effectiveness.

3.1.3 Multiple assessments of creativity

The assessments are based on the multiple creative instruction assessments proposed by Lou et al. [19]. These assessments include a creativity pre-test and post-test and creative work scoring. The pre-test and post-test are performed to recognize students' the cognition of the creativity and learning situation of creativity. In addition, this study includes the rating of creative works by groups, as well as four stages: the task learning sheet, written report, briefing and creative works. (1) Originality; (2) flexibility and (3) effectiveness are scored as the criteria to reward group creativity competition. The students' creation processes were recognized by observing their learning sheets for the four task stages. Students' briefings on their creative work also showed their creative thinking. Finally, the statistical analysis of students' pre-tests and post-tests were performed to determine their creativity learning effectiveness as a reference point for the instructional design of creativity project making.

3.2 Research subjects and method

The subjects in this case study were seniors in a creativity project-making course in the engineering department of a Taiwanese university. There were 48 subjects. Based on creativity assessment research, this study designed a questionnaire on creativity learning effectiveness, which included ten items. The measurement was based on the Likert scale, ranging from "strongly agree" to "strongly disagree". Scorer reliability is 0.977, and correlation coefficients are significant. Hence, we examined quantitative data about BOPPPS and university students' creativity project making and analyzed BOPPPS's effect on university students' creativity learning effectiveness through statistical analysis of the questionnaires. In addition, student interviews and qualitative analysis of the learning sheets for the four task stages of project-making supported the quantitative analysis findings. Coding of the interviews with students was based on students as units. For instance, S02 means that the student's ID number is 2. Coding of four stages of the learning sheet of project making is based on groups as units. For instance, G02 means the learning sheet of Group 2.

4. Results and discussion

Through research design and implementation, this study collected learning sheets to gauge students' creativity learning effectiveness, interviewed students and observed project activities for quantitative and qualitative analysis. The analytical results are presented below.

4.1 Analysis of BOPPPS application for creativity learning effectiveness

This study conducts paired-samples t-tests on pre-test and post-test questionnaires about students' creativity learning effectiveness to determine how BOPPPS affects university students' creativity learning effectiveness. The analytical results are shown in Table 2.

As to the creativity learning effectiveness, the students' mean post-test scores are higher than those of the pre-test, reaching a statistically significant difference. Hence, after BOPPPS creativity project making, most students have positive attitudes toward creativity learning effectiveness. For (1) "I think I am creative" ($t = -4.370$), (2) "I think creativity can be developed" ($t = -4.603$), (3) "I think I can have numerous ideas when I encounter problems" ($t = -4.368$), and (8) "I think I have creative thinking or can produce solutions" ($t = -4.651$), p is 0.000 (<0.001). The difference between pre-test and post-test scores is the most significant in these cases. Hence, after BOPPPS instruction in creativity project making, most students suggest that they have the capacity to develop great ideas when they encounter problems and to find solutions. Therefore, they agree that creativity can be cultivated. After BOPPPS creativity project making, they suggest that they have creative capacities [23].

Table 2. Paired-samples t-tests on the effectiveness of creativity development

Questions	Test	N	Mean	Std. Deviation	t	Sig. (2-tailed)
1. I think I am creative.	Pre-test	48	3.58	0.511	−4.370	0.000
	Post-test	48	4.29	0.439		
2. I think creativity can be developed.	Pre-test	48	3.52	0.421	−4.603	0.000
	Post-test	48	4.18	0.446		
3. I think I can have numerous ideas when I encounter problems.	Pre-test	48	3.48	0.481	−4.368	0.000
	Post-test	48	4.13	0.471		
4. I think I can generate various ideas of different types within a certain period of time.	Pre-test	48	3.70	0.468	−3.833	0.001
	Post-test	48	4.26	0.374		
5. I think I can generate some unique ideas or ideas that few have.	Pre-test	48	3.62	0.594	−3.311	0.004
	Post-test	48	4.18	0.417		
6. I think I can often question facts.	Pre-test	48	3.51	0.548	−2.845	0.012
	Post-test	48	4.09	0.557		
7. I think I can often discover problems.	Pre-test	48	3.55	0.635	−3.972	0.001
	Post-test	48	4.14	0.361		
8. I think I have creative thinking or can produce solutions.	Pre-test	48	3.40	0.476	−4.651	0.000
	Post-test	48	3.98	0.476		
9. I often make attempts to seek feasible or effective solutions.	Pre-test	48	3.55	0.427	−3.781	0.002
	Post-test	48	4.11	0.420		
10. I often take action or carry out the solution to a problem.	Pre-test	48	3.87	0.660	−2.174	0.045
	Post-test	48	4.36	0.517		

4.2 Process analysis of BOPPPS creativity project making

The process analysis of BOPPPS creativity project making includes the following: (1) teachers' BOPPPS creativity instruction and (2) students' BOPPPS creativity learning. The researcher conducts process analyses with student interview data and learning sheets from the "4 stages of project-making tasks".

4.2.1 Teachers' BOPPPS creativity instruction

According to interview with students, this section analyzes the key points for teachers when practicing BOPPPS creativity instruction. The BOPPPS process is shown below.

Bridge-in: Connecting students' prior knowledge and enhancing their learning interests

First, the teacher played the film related to creative invention, explained the importance of creativity and introduced the curriculum content on creativity in high school (e.g., life technology) to connect with their prior knowledge. Therefore, students realized that they have experienced creative thinking, and their learning interest would thus be enhanced.

- In the amphibious boat design competition, we reorganize and apply the acquired knowledge. (S01)
- In addition to school majors, we can learn knowledge that is not taught in textbooks. (S03)
- At the beginning, I refused the creativity project because I already had too many assignments.

However, after the teacher's explanation, I started being interested in the activity. (S28)

Objective: Specific description of learning objectives and encouraging active participation

The teacher explained the specific learning objectives of creativity project making, and the goal is to cultivate creativity. Hence, students controlled the specific learning direction. The project topic making was introduced: "a creative amphibious boat design". Global warming has become a serious issue, and it will result in raised sea levels. Therefore, transportation will become amphibious. Through students' creative thinking, this project aims to develop a creative amphibious boat design in preparation for the severe environmental conditions of the future. In addition, students were divided into groups. BOPPPS execution was explained to encourage students to actively participate in project activities and to cultivate students' active learning attitudes.

- As students in the Department of Engineering, we should not only focus on studying but also apply the learned mechanical knowledge to project making. (S02)
- The amphibious boat design project stimulated our creativity, and it was useful for our future. (S03)
- In manufacturing, we enjoyed the invention and design and learned to transform ideas into real objects. Finally, our group was more familiar with manufacturing. (S40)

Pre-assessment: Understanding students' current cognition and adjusting instructional content

Before the project, we conducted questionnaire surveys to measure students' cognition of creativity and gauge their understanding of creativity. In addition, students can learn creativity content through testing. Hence, these tests become a reference for teachers in adjusting instructional content.

- In the test, we recognized our shortcomings, and we encountered many difficulties in the manufacturing. However, through the teacher's instruction and classmates' cooperation, we found the solutions. (S31)
- I was not confident in the quiz, and I realized that I had not acquired sufficient knowledge. (S23)

Participatory learning: Cultivating students' independent learning and reinforcing peer cooperation

At this stage, teacher–student interaction was important. It emphasized student-centered independent learning and peer cooperative learning. Therefore, in addition to three weeks of basic instruction on creativity, this stage included the creative teaching design of student-centered BOPPPS creativity learning to guide students step-by-step in creativity learning and to accomplish learning sheets for the four stages of amphibious boat design. In addition, students were required to write reports on the discussion results and submit them regularly to allow the teacher to control their learning situation and progress and thus reinforce students' creative writing and teamwork [18]. The students' execution in detail will be shown in Section 4.2.2.

Post-assessment: Validating students' learning effectiveness and reviewing instructional strategy

The post-test includes two parts. The first part is the presentation of the students' creative design projects. They had a project report and a navigation competition. Three professional teachers were invited to grade the groups' work, as shown in Figs 6 through 8. Students learned to express their design concepts through briefings and participating in water and land competitions. They could thus demonstrate how their designs function and have precious experience in combining theory and reality. In Part 2, after students present their work, this study conducted a second investigation on creativity learning effectiveness and paired-samples t-tests to determine the students' learning effectiveness and the accomplishment of instructional objectives as the criteria for future instructional method adjustments.

- After project making, everyone's ideas were included in the topic, and we became more

familiar with it. Although we encountered many difficulties, we found solutions through life experience. (S16)
- I was lucky to participate in this project. I could experience an activity that is not taught in the textbook. I learned the capacities of invention, design and problem solving. (S36)

Summary: Review of learning points and creation process sharing

After the students presented their work, the teacher praised and encouraged them for their excellent creations and presented their projects in public as models for other students. In addition, the students' creative applications in manufacturing were connected with a creativity project-making course and shared with all students as a cross-learning exercise. This stage summed up the course and integrated learning points.

- Through the scientific method, it was fun to assemble the amphibious boat. I learned some mechanical knowledge, and everyone enjoyed learning by playing! (S11)
- When practicing for the project, we encountered many difficulties and had thought about giving up. However, after the group's discussions and experiments and the teacher's guidance, we finally progressed. (S15)
- After finishing the work, we were extremely excited. The result of our hard work was right in front of us. Fortunately, we did not give up; otherwise, we might not have been successful. (S33)
- In this activity, I experienced creation, design and teamwork. When encountering the obstacles, our cooperation became the key factor. (S35)

Based on the information above, the teacher instructs students using the steps of BOPPPS. Students can clearly recognize learning objectives and experience systematic learning. By testing before and after instruction, the teacher can understand students' learning effectiveness to adjust instructional strategies and course content.

4.2.2 Students' BOPPPS creativity learning

This study emphasized student-based creativity instruction design, and guided students to accomplish the creative design of amphibious warships in order. This section analyzes students' learning process in BOPPPS creativity according to interview with students and learning sheets at four stages of the task.

(a) Construction of the creation topic: increasing creative thinking motives

This study focuses on an amphibious boat, and

Table 3. Students' texts (1)

(a) Construction of the creation topic

(a-1) Student interview data:
- The concept and idea of our amphibious boat design can be shown in writing. (S14)
- The groups chose their own creation topics, which will strengthen their ideas and creativity. (S06)
- In the beginning, we shared and integrated our opinions. Finally, through writing, we allowed others to understand our ideas. (S45)

(a-2) Learning sheets:
- We tried to design a unique environmental amphibious boat and avoid increasing garbage on earth. Based on an environmental issue, besides imagination, we should consider the reality, such as the vehicle's weight, center, buoyancy and speed to climb on the water, and the design should be tried and improved. (G02)
- We designed a powerful multi-functional amphibious warship for the national army in 2050 to protect our country. (G08)

(b) Creative power design

(b-1) Student interview data:
- Design is the most important step, and it can help avoid manufacturing errors. (S11)
- Without design, we do things without plans. I will not know how to start, not to mention how to do it right. (S21)
- Design is the direction, and we will not be lost in the manufacturing. (S25)
We drew the blueprint with Auto CAD and realized that we used what we have learned. (S19)

(b-2) Learning sheets:
- We focused on environmental protection. Thus, we installed a clip on the vehicle to pick up the trash on the water to protect the environment. We created a space where the trash could be deposited. However, we then found that the device for loading the trash will increase the vehicle's weight. Hence, we installed one engine motor to strengthen its power. (G02)
- Because Taiwan is an island, we should have a high-speed and powerful amphibious vehicle. We planned to install many weapons to support the national army on the beach. We installed one high-speed fan to avoid being attached to the sea and to lower the number of casualties. (G08)

students establish the creation topic and explain its meaning. Through data collection and analysis, students learn to probe into things. Through group sharing and discussion, students establish interesting topics to increase their creative thinking motives, as shown in Table 3 (a-1).

According to the learning sheets, the second group's topic was an environmental amphibious boat, as shown in Table 3 (a-2). According to the BOPPPS steps, the leader explained the first stage's task. Hence, the members completed their work, and they were encouraged to share and discuss their favorite things. Finally, the groups voted to decide on a topic. After establishing the topic, they explored the environmental issue and collected related data to determine how to reduce and recycle the trash. In addition, they discussed the functions of an environmental amphibious boat. Another group's topic was a multi-functional amphibious warship. By establishing a creation topic, students can share their favorite topics through discussion with other students in order to increase learning interests. After the topic's direction is confirmed, students are guided through an in-depth study and analysis through teamwork.

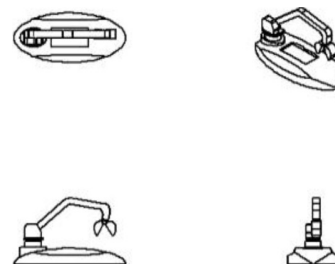*(b) Blueprint drawing: cultivating planning capacity*

At this stage, we asked the students to design the established topics and demonstrate their creative potential to draw and explain the blueprint. At this stage, the purpose is to allow students to recognize the importance of design and planning and cultivate their design capacity. With their acquired knowl-

edge and computer drawing skills, they designed the boats' functions and appearances and drew blueprints, as shown in Table 3 (b-1).

With BOPPPS guidance, group members recognized this stage's learning objective. They drew and explained the blueprint. According to the second group's learning sheet explanation and blueprint, we recognized the design concept: environmental protection, as shown in Table 3 (b-2). Therefore, a clip to collect trash is necessary, and the deck space should be sufficient to arrange the collected waste, as shown in Fig. 3. However, because the device is then larger, the vessel's weight will increase. Thus, students installed motors as power sources. In addition, Group 8 designed a high-speed fan and bomb to construct a high-speed and powerful amphibious warship, as shown in Fig. 4.

(c) Creative power design: enhancing knowledge and skills application

This stage is based on power design. In addition to basic power, this stage encouraged students to

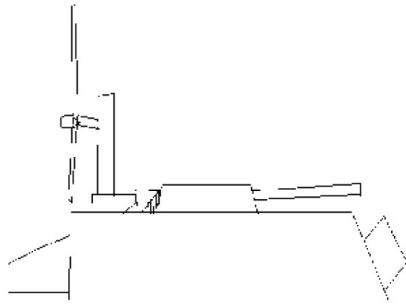**Fig. 3.** Environmental amphibious boat.

Fig. 4. Amphibious warship.

the motor's power and designed a propeller to accelerate navigation, as shown in Fig. 5. Based on the original design, Group 8 installed two powerful fans on the boat and increased the amphibious warship's speed on land and water through the wind's counterforce, as shown in Fig. 6.

Fig. 5. Two sets of propellers are installed at the back of the boat.

Fig. 6. Two sets of powerful fans are installed on the body of the boat.

demonstrate their creativity in designing unique power sources and explaining the related principles to increase the amphibious boat's power. In addition, navigation-related stability should be considered. Hence, students should apply mechanical and electric mechanical knowledge to the amphibious boat's power design and experience this applied knowledge in practice, as shown in Table 4 (c-1).

Through the circular practice of the previous two stages, students were familiar with the execution of BOPPPS. Thus, they could control the stage's learning objective: the creative design of power is shown in Table 4 (c-2). Using Group 2's environmental amphibious boat as an example, the installation of a clip to collect garbage indirectly influenced navigation stability. Therefore, it is necessary to increase the weight for the boat's stability. In addition, this weight increase directly influences the boat's speed. Therefore, the group increased

Table 4. Students' texts (2)

(c) Creative power design

(c-1) Student interview data:
- With related theories, we solved many problems in practice, such as increased speed and climbing stability. (S05)
- In the process, I enjoyed the automatic control and gradually became interested in the mechanical engineering department. (S21)
- The effects of speed, motor installation and core adjustment on navigation should be continuously tested, and the figures need to be recorded. They are then adjusted and debugged. All possible factors are controlled and solved to accomplish the original design's goals. (S35)

(c-2) Learning sheets:
- After a clip is installed on the environmental amphibious boat, the center of gravity will change. Thus, we should redistribute the weight to change the center of gravity and avoid overturning the boat upon climbing. However, after increasing the weight, the speed will be influenced. Therefore, we increase the speed with power and change the base propeller to increase the navigation speed on the water. (G02)
- According to the design, we installed two sets of powerful motors on the body to increase the vessel's power. It will accelerate the boat's speed on water and land. Generally speaking, we designed the amphibious warship with high-speed, stable climbing and a solid body. (G08)

(d) Creative appearance design

(d-1) Student interview data:
- The appearance design concept was decided by all members, who finally adopted my idea. I was really proud of myself! I had confidence in my creativity. (S21)
- We had a strong sense of achievement by transforming a plastic boat into a fully armed warship. (S13)

(d-2) Learning sheets:
- We used a magnet clip on the body and an iron plate for appearance purposes. By magnetic force, we could connect them without destroying the body. (G02)
- It was difficult to manufacture the appearance using environmental materials because it was based on DIY methods. However, we had great ideas and collected a lot of cardboard, bamboo chopsticks and a plastic box, which are all environmentally friendly, waterproof and durable. (G12)

(d) Creative appearance design: increasing the effectiveness of creative design

At this stage, according to creation topics and based on environmental material, the students designed the appearance with creativity and explained their choices. It cultivates the students' creative design capacity according to their topics. Through group cooperative learning, this stage will stimulate the students' creative potential, increase their learning and allow them to obtain a sense of achievement in the process, as shown in Table 4 (d-1).

According to the steps of BOPPPS, students can confirm the key points and learning objectives at each stage. Hence, they will focus on learning about their topics, as shown in Table 4 (d-2). This study uses basic amphibious boats to encourage the students' creative design. It is critical to combine the appearance with the body. Group 2 effectively combined appearance and body using the principle of magnetic power for metals to construct a device that can easily be assembled. In addition, appearance design is based on environmental materials, which is another key point. Group 12 designed the boat's appearance with recycled cardboard, bamboo chopsticks and plastic boxes. Colored cardboard was used for planking the boat. Bamboo chopsticks were used as supports, and the planking was fixed to the body with polysulphide. On the bow, a transparent plastic box was adopted as streamline planking. Proper lengths of bamboo chopsticks were cut to increase the intensity. After assembly, the students conducted tests for water and land navigation. The manufacturing process is shown in Figs 7, 8 and 9.

Based on the information above, this study includes BOPPPS in participatory learning and treats students as subjects. According to the BOPPPS process, this study guides students in group discussions and accomplishes the four stages of the amphibious boat task. Through BOPPPS, students confirm the key points for tasks at different stages. Their data collection, analysis, practice and problem-solving capacities are enhanced to help them acquire experiences that validate theories and practice [23].

5. Conclusions and suggestions

According to our research purposes, this study concludes the analysis and discussion and proposes the following suggestions.

5.1 Conclusions

This study applied BOPPPS instructional strategy in creativity project making and combines creativity and creative instruction design items as criteria to
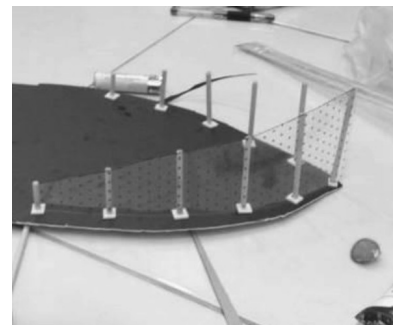

Fig. 7. Cutting and coloring cardboard.

Fig. 8. Bow assembly.

Fig. 9. Completed appearance design.

design creativity project making and develop "Creativity BOPPPS^2 Modle". In addition to the reviews on teachers' creativity instruction effectiveness, this study also focused on student-based creativity learning. After nine weeks of experimental instruction, statistical analysis of the questionnaire survey showed that most students have positive attitudes toward creativity learning effectiveness. The "Creativity BOPPPS^2 Modle" proposed by this study can enhance the students' creativity. In addition, this study collected related texts in experimental instruction for qualitative analysis. Analytical result showed that as to teachers' creativity instruction, teachers conduct creativity project-making instruction with BOPPPS. Students can learn systematically and enhance their learning efficiency. Teachers rely on multiple BOPPPS instructional assessments and students recognize the key points of learning

and their learning situation. They review their progress to increase self-cognition. Therefore, the "Creativity BOPPPS[2] Modle" reinforces the teachers' adjustment of instructional content and progress to increase students' learning interests and creativity learning effectiveness. In addition, as to the students' creativity learning, based on the guidance of BOPPPS, students recognize the learning objectives and key points at different stages' of the creativity project-making course. According to the topics, the students brainstorm and demonstrate their ideas effectively through collaborative learning. It demonstrates that the "Creativity BOPPPS[2] Modle" can fulfil students' creativity learning and practice, guide students to accomplish the task before deadlines and strengthen students' creativity learning effectiveness. Based on the above, this study integrates "creativity and design items of creative instruction" and "BOPPPS" in instructional design of "creativity project making", thus helping to review the teachers' creativity instructional effectiveness and effectively reinforce students' creativity learning results.

5.2 Suggestions

Based on previous research findings, we propose the following suggestions.

5.2.1 Instruction

Based on this study, instructional effectiveness of the BOPPPS-based creativity project making is positive and significant. Most students identify with the instructional model because they can learn systematically and efficiently with BOPPPS. In addition, the project-making course is based on both theory and practice. Therefore, we suggest that schools adopt BOPPPS in creativity project-making courses and properly arrange the positioning and application to provide students with systematic learning environments. In addition, through multiple assessments, we can review the students' learning effectiveness at different stages. Therefore, teachers should use BOPPPS, provide students with a planned learning schedule and design the learning content to match individual needs.

5.2.2 Future research

As to the "Creativity BOPPPS[2] Modle" developed by this study, the experimental instruction proved that it can increase students' creativity learning effectiveness. Future studies can conduct instructional experiment by the control group and experimental group, in order to validate the effectiveness of the "Creativity BOPPPS[2] Modle". In addition, this study analyzed students' creativity learning effectiveness by the creativity questionnaire developed. Future studies can adopt these creativity related scales to analyze creativity learning effectiveness of the pre-test and post-test of the experiment and conduct cross-comparison with the findings of this study in order to obtain a more objective evaluation result. As this study is a case study, the rating of students' creative works is the only the criterion to reward the students. Future studies can include students' creative works in the scoring to compare the difference of control group and experimental group. They can treat the text analysis of the creation process of two groups as reference to improve the "Creativity BOPPPS[2] Modle" in order to promote the "Creativity BOPPPS[2] Modle" in the course of creativity project making.

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