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Project-based Learning: Changing Students' Scientific Thinking to Be Creative from Waste Natural Materials

Marleny Leasa[1*], Pamella Mercy Papilaya[2], John Rafafy Batlolona[3], Sefnath Nuniary[4]

[1]Elementary School Education Study Program, Faculty of Teacher Training and Education, Pattimura University, Ambon, Indonesia
[2]Biology Education Study Program, Faculty of Teacher Training and Education, Pattimura University, Ambon, Indonesia
[3]Physics Education Study Program, Faculty of Teacher Training and Education, Pattimura University, Ambon, Indonesia
[4]Nonformal Education Study Program, Faculty of Teacher Training and Education, Pattimura University, Ambon, Indonesia.

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Corresponding Author:
Marleny Leasa
malenyleasa3@gmail.com

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Abstract: The main objective of this study is to analyze students' scientific creativity in each domain with an essay test referring to the Torrance Tests of Creative Thinking. This research was conducted on 50 teachers and 500 students in 10 elementary schools in Cluster 2, Nusaniwe District, Ambon City. The results of this study report descriptive demographic results of respondents and the level of creativity, namely fluency, flexibility, originality and elaboration among students is very good. The results of the study as a whole show that most of the students are at a good level after being taught with the PjBL model. Students increase their creativity with the teacher's instructions and directions. Initially in detail, many students lack the dimensions of fluency, flexibility, originality and elaboration so they cannot provide more ideas, and cannot provide answers. So that the originality becomes less and they have no ideas to elaborate further than the answers given. However, based on the findings from several student meetings, there has been a significant increase. This is because it applies a problem-oriented learning model that enhances each realm of creativity in science subjects. In addition, the researcher also recommends conducting more in-depth research on creative thinking processes among students based on the local advantages of each school based on geographical location which has its own unique value. Therefore, teachers are expected to be able to better understand cognitively, affectively and psychomotor in students' minds and possibly improve students' creative thinking skills on each dimension of creativity.

Keywords: Creativity; Project-Based Learning; Student Science

Introduction

Scientists have noted that although there are many graduates of science degrees and science teachers around the world, they do not yet have a good understanding of stimulating and training students to think creatively and even produce products that have high innovative value (Mills & Treagust, 2003). In the 21st century, creative thinking skills are fundamentally required to provide solutions to current and future multifaceted problems. The skills needed in the 21st century are 6Cs: Character, Creativity, Critical thinking, Citizenship, Communication, and Collaboration (Albar & Southcott, 2021). One of the important skills is creativity which is a key competency in 21st century education to deal with new advances brought by technology and also to prepare for future jobs (Mandumpal et al., 2022). The younger generation needs a strong basic education so they can learn and have critical and creative thinking. Therefore, the educational curriculum must be designed in such a way as to foster creativity in students (Wong & Siu, 2012; Ferrero et al., 2021).

The major responsibility carried by educational institutions today is to equip students with 21st century skills that will support life in the future (Benner & Hatch, 2010). Therefore, educational institutions contribute to developing and equipping graduates with creativity and innovation as the heart of a country's economic development. Developed countries such as France,

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Japan, Russia have excelled in terms of science and technology, even Israel has not lost, which emphasizes the cultivation of creativity and innovation among its citizens. In addition, China has proposed strategies to encourage its people to create small-scale innovations that focus on creativity and entrepreneurship (Huang et al., 2020). Recently, a number of organizations have attempted to determine what basic life skills are especially important for students in educational settings, and thus a large number of studies have been conducted (Çakır et al., 2021). Universities are often criticized for failing to produce graduates with adequate skills or expertise in creativity or innovation. To equip graduates, the skills and attitudes needed for someone to be productive. Higher education institutions must adapt curriculum developments with a focus on flexibility, adaptive skills and attitudes that support creativity and innovation (Gube & Lajoie, 2020).

Creative thinking includes many higher order thinking skills such as observation, discovery, analysis, hypothesis making, testing, problem solving, and communication (Doppelt, 2009). Creativity is currently at the forefront in playing an important role in the process of producing scientific knowledge in the face of a future of rapid social and technological change (Leggett, 2017). People who are very creative are good at solving problems (Im et al., 2015). Creativity as an individual's ability to produce something new and useful. Creative thinking is an important aspect of critical thinking and is another dimension of computational and robotic thinking (Deschryver & Yadav, 2015). Creative thinking can increase thinking to produce new solutions and facilitate the expression of knowledge and imagination (Batlolona & Jamaludin, 2022).

Creative thinking as a level of thinking for students to succeed in school and in the next life. Since the 1980s leaders in Asia such as Japan and Singapore have made it a rule to foster creativity. Over the span of three decades, Singapore has achieved a relatively high standard of living and literacy rate. A successful socio-cultural system depends on the continuous availability of creative ideas and innovative actions (Tan, 2000). Several countries report policies emphasizing the development of creative thinking (Tabach & Friedlander, 2017). It can be seen as a bitter experience that experts in Europe and the United States have failed in their careers due to a lack of creativity. Therefore, a wave of creativity began to appear in the late 1990s and developed in America and England. Most of the countries in the world are not developed and are poor because one of them is a lack of creativity (Shaheen, 2010). One of them is proven by the study of students' science learning outcomes which are still low in terms of creativity. Where it was only able to reach 20 on a scale of 100 in the sufficient category (Leasa et al., 2021), besides that another study from the GCI (Global Creativity Index) showed that Indonesia was ranked 115 out of 139 countries (Richard et al., 2015) . As one of the many factors that cannot be ignored, the family plays an important role in the development of children's creative thinking (Jankowska & Karwowski, 2019). Therefore, the process of developing children from childhood to being in the world of work will continue to be considered as an important human resource support for the country (Wang et al., 2020).

Currently, many countries include creativity as one of the goals of the school curriculum, including in the school curriculum in Indonesia. Starting in 2003, several countries in the Asian continent, namely Hong Kong, China, Singapore and Taiwan, have made policies aimed at developing students' creative potential because they view these efforts as investments for students and the nation's future (Hui & Lau, 2010). One aspect that makes students' creativity low is due to a lack of understanding of concepts, where the learning process only trains convergent thinking in general, so that when faced with a problem, students have difficulty solving problems creatively, especially in science learning (Baker, 2013).

Thinking is the most important competitive power in the development of the 21st century. The elements that are important to be described in the 21st century learning outcomes section include cognition, affective, and psychomotor which must be mastered by students in order to be successful in life and work. The ability of humans to defend themselves against changes in environmental conditions depends on the ability to think and the skills they have. Someone thinks requires a long process to be able to access a new frame of mind in order to decide something (Barahal, 2008). Based on this, it is concluded that thinking is a complex activity that involves one's cognition in the framework of adaptation to the environment. A person's thinking ability determines his adaptability to the existing environment (Hong & Milgram, 2010).

The 21st Century competency framework and educational standards in a country support each other to achieve future skills that students need to have by integrating conceptual learning and skills in the curriculum, students can gain a deeper understanding and try to solve complex problems in the real world (Nouri et al., 2020). Famous actor and writer John Clease said that the idea of thinking consists of several processes and implies that to be a creative one must be able to move between different processes (Pringle & Sowden, 2017). More formally, the theory of the creative thinking process proposes that creativity requires ideas which are then evaluated and honed for the intended purpose (Du et al., 2020). Based on the views of several experts, it can be concluded that creativity is an attribute that is inherent in a person when someone is able to produce something new. The product goes through a

process of changing attitudes because of a motivation to accept novelty with the various possibilities that exist to produce a better product. Creativity or creative thinking skills have become important skills for adapting quickly in a changing world (Gencer & Gonen, 2015).

Teachers who convey instructions creatively will provide a good environment in fostering creativity in students. Opportunities created by teachers encourage creativity explicitly in the learning process, but the actions and involvement of teachers will implicitly affect students (Leasa et al., 2021). However, the fact is that some schools do not care about students' creative thinking skills, thus hindering student creativity (Ritter et al., 2020). Many learning models do not consider creativity as a priority in the education system. Thus, the notion that schools stifle the creativity of students and teachers has received serious attention in recent years (Chen et al., 2019).

Project-based learning (PjBL) has a lot of potential to enhance 21st century skills which are basic methods that help students to deal with real world problems and meaningful problems. This model helps students develop collaboration in solving complex problems (NemerÅitski & Heinla, 2020). PjBL is the ultimate model that enhances creative abilities (Albar & Southcott, 2021). In addition, it makes it possible to find and meet students' needs through new ideas, materials or objects created by students as a result (Goyal et al., 2022). Given the importance of including creativity and PjBL in the school curriculum, Wu & Wu (2020) suggest that the curriculum should be revised to create classrooms where students are taught and initiated to have creative thinking. Such thinking can help students find, understand, analyze and apply knowledge in new situations in a given subject. Unfortunately, creativity and PjBL are not promoted in some schools (Zen & Ariani, 2022). Irembere (2019) states that the main reason why creativity is not a priority in most school curricula around the world. This is because students' creative skills are not really promoted or applied so they don't develop properly.

PjBL allows students to explore problems on their own, develop various cognitive and social skills, and produce creative learning outcomes collaboratively (You, 2020). In addition, changing the paradigm of student-centered teaching, which is expected to lead to an in-depth learning approach. In addition, it encourages teamwork, critical thinking, interpersonal communication skills and project management and improves understanding of concepts to solve real world problems (Badia, 2017). The fact is that there are still many students who have low creative thinking skills so learning innovation is needed to increase student motivation in learning and improve student abilities through direct involvement in exploring knowledge (Safaruddin et al., 2020). The reform efforts of the Ministry of Education, Culture, Research and Technology of the Republic of Indonesia and many scientists are trying to develop education that is more flexible so that it can integrate a combination of disciplines (Sacchi et al., 2021). The dimensions of student creativity can be shown in Table 1.

Table 1. Dimensions of creativity

Four Cognitive Dimensions - *Thinking Process as Creativity*			
Fluency	*Flexibility/Adaptability*	*Originality*	*Elaboration*
Generating large quantities of relevant responses. Pursuing a train of thought. Compiling collections of related ideas.	Attempting things in many ways Altering classifications as suitable. Consider the problem from alternative views.	Creating unusual, novel, unique, or brilliant ideas. Intermixing known ideas into some new construct and connecting the apparently unconnected.	Padding out thoughts and adding stimulating details. Broadening an idea.
Four Affective Dimensions - *Feeling Process as Creativity*			
Curiosity	*Complexity*	*Risk-Taking*	*Imagination & Fantasy*
Puzzling and wondering about something. Playing with ideas Following intuition to find out what will happen	Feeling challenged to do things in specified methods. Looking for diverse ways. Creating order from chaos. Noticing neglected fragments and sensing how to change between what is and what might be	Readiness to express thoughts to others. Being brave to expose self to criticism or failure. Self-reliance to keep on an instinct and invest in a humble idea.	Capability to figure rich and diverse mental images ("what if/as if"). Being thoughtful in another place, time, or person's situation. Being insightful of what might be or what something might turn into.

Table 2. The advantages of the PjBL model (Twahirwa et al., 2021)

Review the advantages of Project Based Learning
Increase creativity and critical thinking skills
Instill in students the ability to communicate effectively
Improve teamwork and promote innovation thinking
Instill specific knowledge and skills while inspiring students to actively ask questions and think critically
Promotes interactive learning
Allows students to develop a sense of responsibility and accountability
Develop students' ability to identify problems and problem-solving skills
Data collection and analysis skills and research skills
Time management, work plan and implementation, and so on

Method

Type of research

The type of research used in this research is descriptive quantitative. In the form of test questions given to students. In addition, this study collected information from teachers and students through observing the implementation and response of learning with PjBL. Questionnaires were made in two forms, namely online filling and filling on paper that had been prepared. This is done because not all elementary school students use Android phones. The questions made range from several targeted questions from individuals to obtain information related to behavior and preferences (Ponto, 2015). Before filling out the questionnaire, an approach was made and giving explanations to students so that when filling it out students did not find it difficult.

Participant

The number of samples in this study were 50 teachers (men: 10 people; women 40 people) and 500 students (men: 200 people; women 300 people) from grades 1 to 6 of 10 elementary schools in Cluster 2, Nusaniwe District, Ambon City.

Instrument

In this study the level of student creativity was measured using a test item called Torrance Tests of Creative Thinking which was adapted and adopted from studies (Hu & Adey, 2002; Orozco & Yangco, 2016) which is shown in Table 3.

Table 3. Level of Creativity

Marks	The Level of Creativity
68-100	Very Creative (High Level)
34-67	Moderate Creative (Moderate Level)
0-33	Less Creative (Low Level)

Table 3 shows the meaning of scores to determine the level of creativity among students based on (Kumari et al., 2014). Scores from 0 to 33 indicate the lowest level of creativity. Scores of 34 to 67 indicate a moderate level of creativity. While a score of 68 to 100 indicates the highest level of creativity.

Research procedure

A total of 50 teachers were given PjBL training for 3 weeks by utilizing waste as a material to produce quality products. The instructors who provided the training materials were lecturers from the Teaching and Education Faculty, Pattimura University. There are three lecturers who provide material with scientific backgrounds, namely biology education and physics education who are experts in creativity. In addition, teachers will be given the opportunity to develop learning tools from grades 1 to grade 6 that utilize waste as learning media.

Table 4. Scoring Items based on Fluency, Flexibility, Originality and Elaboration

Creative Domains	Score	Submission Against Problems
Fluency	0	Fluency 0 Student cannot give ideas/answers.
	2	Students can suggest one to two ideas/answers.
Flexibility	4	4 Students can put forward three or more ideas/answers.
	0	Students are not able to provide ideas/methods.
	2	Students can put forward one to two ideas/methods.
	4	Students can put forward three or more ideas/methods.
Originality	0	Students do not answer / general ideas / general ideas and not originality.
	2	Students come with moderate unique ideas.
	4	Students come up with very unique ideas.
Elaboration	0	There are no additional ideas from students.
	2	The addition of simple ideas from students.
	4	Amazing Ideas from Students

After the teacher has developed learning tools, presentations are made to show the results of the device development from each school and are given input by the instructor so that input and revisions are given in improving learning tools. Then the device that has been made, is tested on a number of classes that are the target

of teacher learning in class to increase student creativity with PjBL. During the learning process, the instructor made observations to find out how far the learning was implemented. Then given a test to evaluate all the learning activities carried out.

The test questions given are in the form of essays with a total of 10 items. Before these questions were given to students, 3 learning experts from Pattimura University had carried out validation of the questions, namely experts in biology education, physics education and basic education to provide input on the test questions designed. In addition, the test questions were tested by 200 students at several elementary schools in Ambon City with valid and reliable results.

Data analysis technique

After the items have been scored, the points for each are totaled and then, all filled points are totaled. The next steps were analyzed descriptively using the Microsoft Excel software program. Excel also helps determine the standard deviation, percentage and rating for each of the variables being measured.

Result and Discussion

Creative thinking looks at flexibility, fluency, novelty, and elaboration. Performance to produce creative products is evaluated by three main factors, namely novelty, resolution, and style. Therefore, to encourage someone to be creative, one way is to be given a simple project in designing and designing a material into a certain product (Huang et al., 2020).

Thinking skills can be grown and utilized properly so that experiences in the learning process are more meaningful. Thinking skills need to be instilled in students with the aim of helping students independently form cognition, produce learning effectiveness and build new knowledge in students (Ness, 2015). Therefore, thinking skills are closely related to the learning process. Students who are properly and intensively trained by teachers to think have a good impact on their educational development. Therefore it can be concluded that in order to foster thinking skills, students need to be involved in meaningful learning experiences in learning through problem solving.

Sak & Maker (2006) revealed that creative thinking is influenced by several factors, including 1) level of education, 2) knowledge gained from education at school and outside of school, and 3) age-related changes. Creative thinking skills are natural talents that are needed and nurtured so that creative individuals can help people solve different problems in everyday life (Mokaram et al., 2011). Another expression explains that creative thinking is in principle like a designer in making a valuable design, then requires ideas, solutions and produces products that did not exist before and then produces something valuable and valuable (Sarkar & Chakrabarti, 2011).

The ability to think creatively appears in students when they are involved in independent tasks, even though the answers and solutions do not appear immediately and are able to make new ways based on their own initiative. The ability to think creatively is needed in the current era of globalization so that we don't just go with the flow, but must have and make our own personal decisions. Creative is an activity that is good at producing something new and unique, which has never been thought of by others. Creative thinking in principle leads to a person's acquisition of presenting new knowledge, new information, and new concepts in understanding things (Kim, 2019).

Creative thinking skills are able to bring students to enter into very different perceptions, including different thoughts and different points of view. Creative thinking skills are included in the realm of high order competencies and are considered as a continuation of basic competencies in learning physics, so that students can use very different methods in solving a problem. Creative thinking is related to the exploration of students' perceptions. Creativity in students needs to be developed because through creativity it is a prerequisite for survival and well-being and provides its own satisfaction (Kleibeuker et al., 2013).

Table 5. Creative Thinking of Students in Science Products from Natural Materials.

Creativity category	School	Produc
Original	Elementary School of Eri	Brooch from fish scale
		

Creativity category	School	Produc
	Elementary School 41 Ambon	Papeda cracker 
	Elementary School 1 Amahusu	Wall decoration from dry bamboo fronds 
	Elementary School of Teladan	Flower pots and tissue holders from banana leaves 

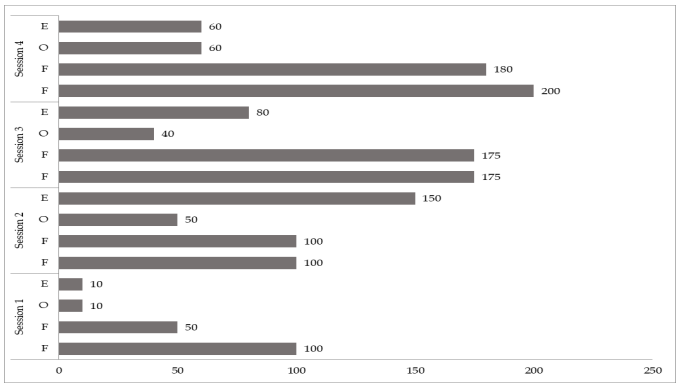

Figure 1. Thinking of students' creativity for each dimension in the four learning meetings

Table 6 shows the learning outcomes on the answered science creativity tests. A ranking system for the level of student creativity by (Abu Kasim, 2012; Kumari et al., 2014). The table aims to show the level of students' scientific creativity in the topic of waste.

Creative thinking can be realized in the learning environment. As long as the learning environment provides comfort and flexibility for students to be flexible without shame and fear, for that the teacher must always be in the midst of students, encouraging that today's learning is the most beautiful asset in the future. Creative thinking is known as a person's mental activity that aims to direct a strong desire to find

solutions or achieve original solutions that were not known before (Aleksić et al., 2016).

Table 6. Overall Student Creativity Level Research Results

The Level of Creativity (Marks Score)	Frequency (f)	Percentage (%)
Very Creative (High Level) (68 – 100)	0	0
Moderate Creative (Moderate Level) (34 – 67)	25	46.3
Less Creative (Low Level) (0 – 33)	29	53.7
Number of Students and Percentage of Students	54	100
Mean Base / Median Value	26.9	
Overall Creativity Level	Less Creative (Low Level)	

The stages in PjBL use authentic assessment according to Wiggins & McTighe (2005) known as the GRASPS method, (1) Goal, which contains an explanation of "problems that exist in the real world" to solve problems in the real world (2) Role, namely the role of students in scenario, where the role is a profession that exists in the real world, the function of choosing this role will provide opportunities for students to better understand the problem from the point of view that is played, especially in problem solving (3) Audience, namely resource persons/community/other participants who will later relate with the role of students in solving problems (4) Situations, namely challenges and details of the atmosphere or series of activities carried out.

Activities or creative processes to find good solutions take time to solve problems. Mumford et al., (2012) stated that creating a creative model is based on three critical processes. First, the problem-solving process, such as the form of problem solving is based on aspects of knowledge and information. Knowledge is important in interpreting information. Second, an individual cannot generate new ideas on the basis of acquired knowledge. Knowledge must be reorganized in order to generate new knowledge and new original ideas. Third, the ideas that are owned must be evaluated or formed in a plan that will be carried out with creative things.

Conclusion

In conclusion, this study reports descriptive demographic results of respondents and the level of creativity, namely fluency, flexibility, originality and elaboration among students, is very good. The results of the study as a whole show that most of the students are at a good level after being taught with the PjBL model. Students increase their creativity with the teacher's instructions and directions. Initially in detail, many students lack the dimensions of fluency, flexibility, originality and elaboration so they cannot provide more ideas, and cannot provide answers. So that the originality becomes less and they have no ideas to elaborate further than the answers given.

On the other hand, the majority of students only gave one and two ideas or answers. The average answer given by them is wrong because the concept of science is wrong and they also don't answer the question at all. However, based on the findings from several student meetings there has been a fairly high increase. This is due to implementing a problem-oriented learning strategy that enhances each realm of creativity in science subjects. In addition, the researcher also recommends conducting more in-depth research on creative thinking processes among students based on the local advantages of each school based on geographical location which has its own unique value. Therefore, teachers are expected to be able to better understand cognitively, affectively and psychomotor in students' minds and possibly be able to improve students' creative thinking in every dimension of creativity.

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