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Article

**The Impact of Project Based Learning towards Creative Thinking and Scientific Attitudes**Didi Nur Jamaludin<sup>1\*</sup>, Suroso Adi Yudianto<sup>2</sup>, Topik Hidayat<sup>3</sup>, Nukhbatul Bidayati Haka<sup>4</sup><sup>1</sup>Universitas Islam Negeri Sunan Kudus, Indonesia<sup>2,3</sup>Universitas Pendidikan Indonesia, Indonesia<sup>4</sup>Universitas Islam Negeri Raden Intan, Indonesia

\*Corresponding Address: didinj@uinsuku.ac.id

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**ABSTRACT**

Project-based learning (PjBL) is a learning model that develops thinking and science process skills in problem-solving. Method using a quasi-experimental research design with a matching-only pretest-posttest control group design. The study population consisted of all 10th-grade students at Bandung State Senior High School, and the study used cluster random sampling. The research instrument used a creative thinking essay test and a scientific attitude questionnaire. The research analysis used a t-test and N-Gain. The results of the study indicate that project-based learning can significantly improve creative thinking compared to conventional learning ( $0.001 < 0.05$ ). The process of determining fundamental questions and monitoring in project learning plays an important role in developing creative thinking ability. Another important thing in PjBL is providing feedback according to learning objectives when assessing results and evaluating experiences. Scientific attitudes showed a low increase, thus showed insignificantly difference analysis ( $0.069 < 0.05$ ). This is due to external factors such as personality, information, group affiliation, and the limitations of the assessment scale in the questionnaire. The further PjBL research challenges related to the use of scientific attitude instruments with a larger assessment scale, technology integration, multidisciplinary approach, developing science process skills, higher-order thinking skills (HOTS), and 21st-century competencies.

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**INTRODUCTION**

The project-based learning (PjBL) model directs students to use thinking and science process skills in problem-solving. These skills are essential in 21st-century learning and are used in developing projects and products. Ibragimov (2021) explained that PjBL helps students develop problem-solving skills and other meaningful learning outcomes by combining independent learning to build knowledge, process, and complete their work realistically and exhibit a product. Samsudin et al. (2018) emphasized that the PjBL model can improve students' problem-solving skills. Furthermore, project-based learning can foster creative thinking, training students to develop projects and products creatively.

The advantage of project-based learning is that students can apply the material they have learned to address real-world challenges, producing meaningful outcomes. This approach uses "real-world" situations to help students develop critical thinking and problem-solving skills, as well as knowledge of the subject's core principles. Project-based learning is also well-suited for distance learning, which involves the acquisition and development of knowledge and skills (Vista, 2025). Biology learning is meaningful for students when it leads to authentic experiences that foster critical thinking and develop potential skills. However, the material on plant diversity in schools is often taught through memorization, rather than fostering investigation and creativity. The PjBL model can be a learning tool that directs learning to be more contextual and meaningful, and as a means to develop students' creativity.

Project-based learning requires students to conduct experiments to solve problems and complete assigned projects. Students' creative thinking is crucial to project completion. Therefore, in this study, using a literature review, researchers sought to uncover the inherent benefits of project-based learning for improving students' creative thinking skills in science education (Sucilestari et al., 2023). Project-based protein testing using local materials can improve students' creative thinking skills (Sari et al., 2017). Based on this, project-based learning needs to be further studied for its application to science materials that foster creativity or utilize local wisdom-based learning resources.

Other research suggests that project-based learning warrants further investigation into developing thinking skills, such as creative, reflective, communication, and collaboration skills (Issa & Khataibeh, 2021). The results of this study indicate that the Project-Based Learning (PjBL) model can improve student learning outcomes in science learning and train students in problem-solving and critical thinking. It is important to connect the real world in PjBL and explain that PjBL can be used to connect classroom learning with real-world problems and situations, making learning more relevant and meaningful for students (Chistyakov et al., 2023). The PjBL model is a learning model that can facilitate students in solving problems and can improve higher-order thinking processes. However, the results of this study do not explain the project learning process given to students (Khaeruddin et al., 2023). So it is needed to develop creative thinking and scientific attitudes.

Learning activities that foster a scientific attitude include being open to ideas and thoughts, building knowledge through collaboration between teachers and students, and exchanging experiences among students during classroom activities (Anggraeni et al., 2017). Students' scientific attitudes can be developed during the learning process, such as curiosity, honesty, cooperation, openness of mind and ideas, perseverance, and caution (Mayang et al., 2020). The development of a scientific attitude needs to be cultivated in the learning process through constructive academic tasks that support thinking skills, such as creative thinking.

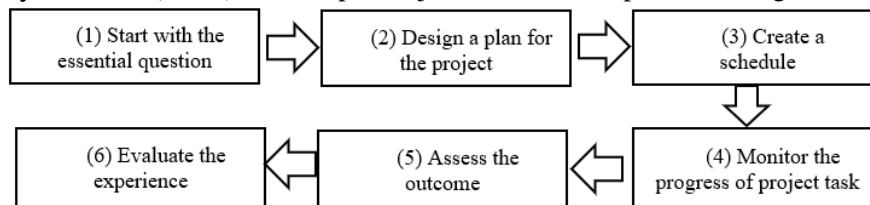
Project-based learning models require an interactive classroom environment. Students can work individually or in groups during the project-based learning process. In this learning, students engage in original, program-related, and often interdisciplinary group work to solve problems (Belayneh, 2021). The surrounding environment as a source of learning biology has not been optimal, for example, with plant material. In learning plant systematics, students have shown little interest because they perceive the material as being entirely rote. The diversity of Indonesian flora can foster higher intellectual values, so that plants are viewed not merely as a collection of concepts but as a gift with great potential for human welfare, such as food diversification, herbal medicine, crafts, and the arts. These problems and potential can be used to train students' creative thinking skills and scientific attitudes.

## **METHODS**

The research used quasi-experimental designs to determine the effects of independent variables on the dependent variable. The research sample was selected in groups. This study used a matching-only pretest-posttest control-group design (Fraenkel & Wallen, 2007). This

study had two variables, namely: 1) the independent variable in the form of project-based learning and direct instruction methods. 2) the dependent variable in the form of creative thinking skills and scientific attitudes of students. The learning material that became the object of research was seed plants.

The population of this study consisted of all 10th-grade students at one of the Senior High Schools in Bandung city, totaling 10 classes and 400 students. The sampling technique used was cluster random sampling, with two classes selected: the experimental class, using project-based learning, comprising 35 students, and the control class, using direct learning, comprising 36 students. The research analysis used the t-test, bivariate correlation, and Normalized gain (N-Gain) by Metlzer (2002). The steps of PjBL model are explained in Figure 1.



**Figure 1.** The Steps of PjBL Model

The creative thinking skills developed in this study refer to several aspects developed by Williams (Munandar, 1992), including thinking skills: 1) fluency, 2) flexibility, 3) originality, 4) elaboration, and 5) evaluation. The scientific attitude indicators developed in this study include curiosity, cooperation, conscientious, perseverance, and environmental care, measured on a Likert scale of 1-4 through self-assessments. The validity of the creative thinking and scientific attitude assessment instrument using expert judgment and its limitations has not been empirically validated.

## RESULTS AND DISCUSSION

The project-based learning model was applied to plant materials through the creation of food preparations and plant crafts, accompanied by a classification identification sheet. This aligns with the national education goals, which expect students to be creative and innovative. Learning that develops skills is expected to provide students with valuable experiences for the future. Larmer & Mergendoller (2010) explained that project-based learning assignments are more meaningful when the results are not just for teachers or tests, but also when they result in tangible products that the general public can use.

Results of the assessment of creative thinking skills and scientific attitudes in the pretest and posttest. A summary of the research results, including the average pretest and posttest scores, is shown in Table 1.

**Table 1.** Recapitulation of Research Results of the Pretest and Posttest

| No | Aspect                   | Experimental Class |          | Control Class |          |
|----|--------------------------|--------------------|----------|---------------|----------|
|    |                          | Pretest            | Posttest | Pretest       | Posttest |
| 1  | Creative Thinking Skills | 32.94              | 58.48    | 30.16         | 45.74    |
| 2  | Scientific Attitudes     | 2.96               | 3.07     | 2.91          | 2.96     |

### Test of Mean Differences in Creative Thinking Skills

The normality test was used to determine whether the data were parametric or nonparametric. The normality test results for the initial and final creative thinking skills tests are shown in Table 2.

**Table 2.** Normality Test for the Initial and Final Creative Thinking Skills Tests

| Test     | Class        | Significance Level | Significance Value Criteria | Interpretation |
|----------|--------------|--------------------|-----------------------------|----------------|
| Pretest  | Experimental | 0.655              | 0.05                        | Normal         |
|          | Control      | 0.756              | 0.05                        | Normal         |
| Posttest | Experimental | 0.482              | 0.05                        | Normal         |
|          | Control      | 0.507              | 0.05                        | Normal         |

Based on the normality analysis of Table 2, the initial test data on creative thinking ability in the experimental and control classes are normally distributed, with p-values of 0.655 and 0.756, respectively, both  $\geq 0.05$ . The final test data on creative thinking ability in the experimental and control classes are normally distributed, with significance levels of 0.482 and 0.501, respectively, both exceeding 0.05. Therefore, the initial test data and the final test of creative thinking ability are classified as parametric statistics. The pretest and posttest scores were analyzed using an independent samples t-test. The results of the test for differences in the average creative thinking skills are explained in Table 3.

**Table 3.** Test of Mean Difference of Creative Thinking Skills

| Assessment | Class                  | Significance Level | Significance Value Criteria | Interpretation              |
|------------|------------------------|--------------------|-----------------------------|-----------------------------|
| Pretest    | Experimental & Control | 0.408              | 0.05                        | Not Significantly Different |
| Posttest   | Experimental & Control | 0.001              | 0.05                        | Significantly Different     |

Based on the data in Table 3, the initial test data on creative thinking skills between the experimental and control classes show no significant difference, with a p-value of 0.408 (0.05). The final test data on creative thinking skills between the experimental and control classes show a significant difference, with a significance level of  $0.001 < 0.05$ . Based on these data, the application of the project learning model is significant in increasing creative thinking skills.

#### **Test of Mean Differences in Scientific Attitudes**

Normal data is shown in the initial and final scientific attitude assessments in the experimental and control classes in Table 4.

**Table 4.** Normality Test of Pre and Post-Scientific Attitude Assessment

| Assessment | Class        | Significance Level | Significance Value Criteria | Interpretation |
|------------|--------------|--------------------|-----------------------------|----------------|
| Pre        | Experimental | 0.404              | 0.05                        | Normal         |
|            | Control      | 0.638              | 0.05                        | Normal         |
| Post       | Experimental | 0.417              | 0.05                        | Normal         |
|            | Control      | 0.435              | 0.05                        | Normal         |

The data in Table 4 show that the initial scientific attitude data in the experimental and control classes are normally distributed, with p-values  $\geq 0.05$  for all comparisons. Therefore, the initial and final scientific attitude data are classified as parametric statistics. The test for the difference in the initial scientific attitude averages showed a significance value of 0.240 ( $\geq 0.05$ ), and the final scientific attitude assessment showed a significance value of 0.069 ( $\geq 0.05$ ). Therefore, the project-based learning model did not show a significant improvement in scientific attitudes between the experimental and control classes (Table 5).

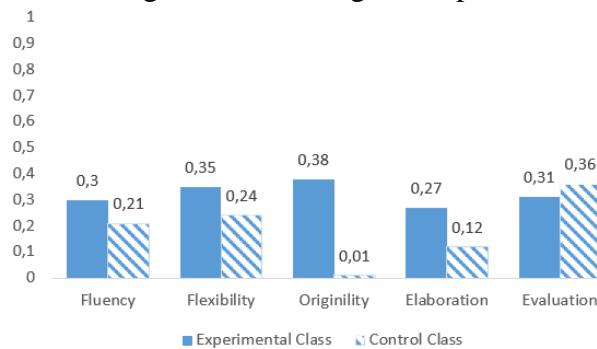
**Table 5.** Test of Mean Difference in Scientific Attitude

| Assessment | Class                  | Significance Level | Significance Value Criteria | Interpretation              |
|------------|------------------------|--------------------|-----------------------------|-----------------------------|
| Pre        | Experimental & Control | 0.240              | 0.05                        | Not Significantly Different |
| Post       | Experimental & Control | 0.069              | 0.05                        | Not Significantly Different |

#### **Creative Thinking Skills**

The difference in students' creative thinking skills was due to their being guided to investigate several questions formulated during project-based learning. The monitoring process in project-based learning provided an opportunity to reflect on their work and understanding of the material. Making processed plant products and identifying plants provided a means to develop creative thinking skills. The control class used direct instruction, with the teacher presenting material on seed plants. The teacher did not ask guiding questions or conduct investigations.

The posttest analysis showed that students' creative thinking skills in project-based learning had a higher average than those in the control class. The difference test analysis of the average posttest scores for the experimental and control classes showed a significant difference in creative thinking skills between students using project-based learning and those using conventional learning. Based on the results of the N-Gain calculation, the creative thinking skills in the experimental class were higher by 0.39 in the medium category and the control class by 0.20 in the low category, with details of the N-gain for each creative thinking indicator, with the highest increase being original thinking and the lowest being elaboration ability (Figure 2). This showed that project learning with the highest N-gain can improve the original indicator of creative thinking, and the lowest N-gain is a challenge to improve elaboration ability.



**Figure 2.** Recapitulation of N-Gain Scores on Creative Thinking Skills Indicator

Creative thinking indicators that show differences in N-gain, where the difference is higher in the original thinking indicator. Questions about the original thinking aspect regarding the use of pine strobilus (*Pinus merkusii*). Some students can answer that pine strobilus can be used for arts and crafts, but some only see that pine strobilus needs to be cleaned up from the highway, and a few students know that pine resin (turpentine) can be used as an industrial raw material. Presseisen (1988) explained that creative thinking is a process for developing new inventions, creating beauty, building ideas or products, connecting perceptions to concepts, and emphasizing intuitive aspects while thinking rationally.

Ospankulova et al. (2025) described the PjBL model as a problem-solving approach in which students identify the types of problems solved during PjBL. Examples of solving open-ended questions, solving real-world problems, real-life challenges and issues, combining theory and practice, being able to solve specific life problems, theoretical and practical problems, real and personally meaningful projects, complex questions, real-world problems and challenges, practical tasks, problems of many people, development and investigation of one particular subject, realistic and complex problems, problems in the learning process, finding answers to actual issues, projects connected to real life.

Biazus & Mahtari (2022) emphasized that the PjBL model had a significant impact on the creative thinking skills of high school students in the material on temperature and expansion. Shekh-Abed (2025) explained that self-assessment of knowledge and cognitive skills in project-based learning is very important for evaluating the effectiveness of the learning process, leading to better project outcomes and a stronger foundation for future academic and professional success. The project learning was designed and implemented for a combined hardware and software system in electronic devices. Nurhidayah et al. (2021) stated that PjBL can enhance students' problem-solving skills and improve learning outcomes. Students need effective guidance and support when implementing PjBL. This process involves making the most of the time to work on projects guided by the teacher. Furthermore, students should be taught to work collaboratively.

Sari et al. (2017) explained that creative thinking skills are one of the important cognitive aspects that must be considered in the science learning process in the classroom. Cognitive assessments that have been developed in practicums have not included creative thinking skills,

even though many stages of practicums in the laboratory require students' creative thinking skills, for example, when they have to choose practicum materials. Chistyakov et al. (2023) emphasized that the PjBL model has a positive impact on teaching, learning, motivation, and engagement based on the literature review above. Furthermore, PjBL can improve skills-based learning, creativity, and attitudes towards PjBL in science and Science, Technology, Engineering, and Mathematics (STEM) education. Mulyani & Arif (2021) explained that the PjBL model with a STEM approach can stimulate students to ask questions related to the problems they want to solve. This allows them to be more creative and critical in their approach to solving problems, significantly improving metacognitive abilities.

Creativity can play a role in building students' science experiences. Teachers need to create a framework to help students transform their creative ideas into creative products. The framework is used to listen to students' ideas, identify task constraints, and provide opportunities for reflection and experimentation. Problem-based learning, such as inquiry and engineering design, provides excellent opportunities for students to engage in creative processing and express their creativity through product creation. The type of problem should be challenging, and the use of appropriate questions has been shown to assist students in problem-solving (Shin et al., 2021). Therefore, in learning plant systematics, it is important to clarify the fundamental questions that serve as the primary objectives in developing projects such as plant identification and plant-related products.

Students gain more meaningful project learning if they conduct real inquiry, which is not only looking for information in books or internet sites, but students follow questions that have been prepared to lead to the search for sources and the discovery of answers, ultimately leading to generating new questions, testing ideas, and drawing conclusions, through inquiry can find innovation in answering guiding questions, new products, or individually solved the problem (Larmer & Mergendoller, 2010). Therefore, the problems or works produced in project-based learning need to align with the content of the learning material, so that they have a stronger meaning for students; on the other hand, works that have no relevance to the material make it less meaningful.

Teachers face challenges in project-based learning activities, including: First, students' lack of discipline in submitting project results, such as plant identification reports and processed plant products. Project-based learning is designed to encourage students' discipline in completing assignments by developing a schedule of activities that includes completion dates, submission dates, and presentation times. However, some students lack discipline and need to develop good habits, which usually takes considerable time to change. Lestari & Hadi (2022) stated that another factor influencing the level of creative thinking ability is student activity during the learning process. Activity in learning is a crucial component because when students are actively involved, they can discover their own concepts during the teaching and learning process. Therefore, students are stimulated to be active in problem-solving, thus promoting the success of the learning process.

Providing feedback in PjBL is important in accordance with learning objectives when assessing results and evaluating experiences, because students presenting project learning outcomes often receive less attention from peers, resulting in suboptimal information transfer. When this occurs, the knowledge construction process is suboptimal, resulting in some students receiving lower-than-satisfactory creative thinking scores. Therefore, student readiness for project learning is a crucial factor in supporting their understanding of seed plants. Students who are unprepared to present project learning outcomes tend to lack focus in the learning process. Larmer & Mergendoller (2010) stated that many students lack a meaningful understanding of schoolwork because they are not prepared to meet the knowledge requirements needed during the learning process.

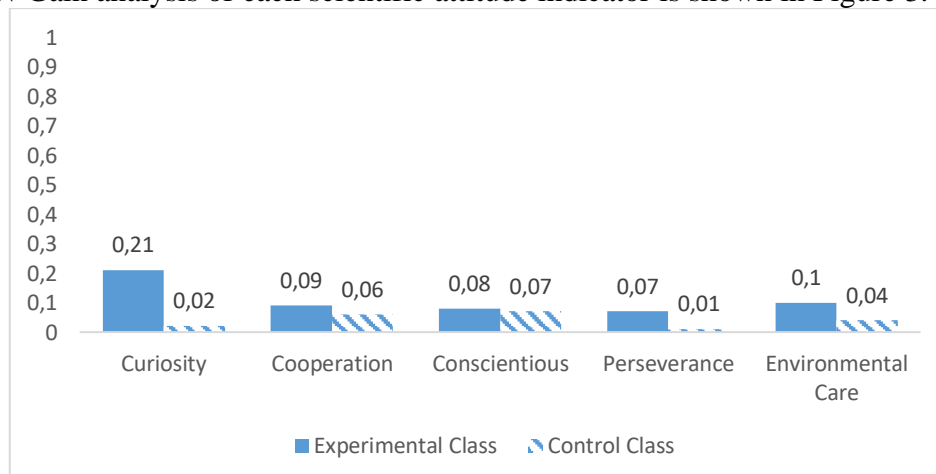
## Scientific Attitudes

Science learning should foster scientific attitudes, as these attitudes are necessary for building knowledge. Scientific attitudes in the project-based learning model showed an low increase (Table 1), so the data was not significantly different ( $0.069 < 0.05$ ) between the experimental and control classes. It was caused by external factors, such as personality, knowledge, and the limitations of the assessment scale used in the instrument. Therefore, further research is needed to strengthen the factors that influence scientific attitudes to be improved, such as personality, information, group affiliation, social influence, and the use of alternative attitude assessment instruments with alternatives from the Likert scale (1-4) to a larger scale of assessment such as the 1-5 and 1-7 scales.

Analysis of the mean difference test between pre and post-assessment for scientific attitudes in the experimental class compared to the control class showed no significant difference. The N-Gain analysis of students' scientific attitudes in the two research classes was relatively low. This could be due, first, to the relatively short time span between the initial and final scientific attitudes (approximately 3 weeks). Second, students already had a prior perspective and knowledge about perception, self-regulation, and desires. Learning that is oriented towards building positive attitudes needs to be strengthened, because other research, Taslidere & Yıldırım (2023), explained that conceptual change-oriented instruction significantly influenced students' conceptual understanding compared to traditional instruction, but had no significant effect on students' attitudes. Krech et al. (1962) explained that attitude is a tendency to act toward something influenced by factors such as desires, information, group affiliation, and personality.

Several studies have shown low scientific attitudes; for example, Izzah (2023) found that applying the Ethno-STEM approach, specifically Ethnoscience, in the batik-making process did not significantly improve attitudes towards the environment. Rahman (2016) explained that variables such as predictors of knowledge, attitude, responsibility, personality, trust, social influence, information sources, and environmental facility management contributed 44% to environmental attitudes. This shows that, to change scientific attitudes, social influence and information sources are among the factors that need to be properly improved. Duda (2010) explained that lab-based learning and its assessment on the concept of the circulatory system showed a low N-Gain in scientific attitudes and no significant difference.

The N-Gain analysis of each scientific attitude indicator is shown in Figure 3.



**Figure 3.** Recapitulation of N-Gain Scores on the Scientific Attitudes Indicator

The scientific attitudes developed in this study include curiosity, cooperation, conscientious, perseverance, and care for the environment. Overall, each scientific indicator experienced a low increase, thus hypothesis analysis shows no significant difference. Scientific attitude indicators showed varying scores, with the highest N-gain scores for curiosity and environmental care, and the lowest for conscientious, and perseverance. Further research may

show different results in scientific attitudes through improvements in the learning process and assessment instruments. Therefore, project-based learning plays an important role in stimulating students' curiosity and fostering concern for environmental conservation, including the protection and use of plants beneficial to humans, and in challenging students to develop a better sense of perseverance in working on projects.

The PjBL model needs to foster scientific attitudes such as curiosity, responsibility, and care, as these can influence students' scientific attitudes. Chheun & Kong (2023) explained that the application of scientific methods can develop scientific attitudes in the classroom, such as curiosity, honesty and objectivity, critical thinking, open-mindedness, cooperation, and responsibility. Suryanata et al. (2025) stated that the hat model provides students with the opportunity to work in groups to plan, develop, and complete projects that connect the concepts they are learning to real-world problems. The advantage of this model is that it connects learning to real-world contexts, thus improving learning outcomes.

Implementing the PjBL model can take a long time, so directed questions and assignments are also crucial to the success of student-created projects. Therefore, teachers need to manage learning effectively. Therefore, within each stage of the PjBL model, there is a monitoring stage for project progress. This activity can use learning technology devices to facilitate both synchronous and asynchronous monitoring. Vista (2025) emphasized that teachers use various technological tools to manage online PBL. Several technological tools are used to support online PBL. This can be done with WebEx, Google Meet, Zoom, and Whereby for individual and group meetings.

The application of the PjBL model, among others, indicates a weak positive correlation between students' mathematics scores and their involvement in PjBL. These results have implications for how future PjBL activities can be organized and how curricula can be developed to improve students' attitudes towards PjBL (Ospankulova et al., 2025). Cross-Disciplinary Project-Based Learning Approach (CDPBLA) can enhance the acquisition and practice of higher-order thinking skills (HOTS) among secondary school students (Chatila & Malaeb, 2025). Based on this, future challenges relate to implementing the PjBL model as part of the education curriculum policy and as a means of developing science process skills, HOTS, and 21st-century competencies such as critical thinking, creativity, cooperation, communication, character, and citizenship.

## CONCLUSION

The research findings indicate that project-based learning significantly improves creative thinking ability compared to conventional learning. Scientific attitudes showed a low increase, thus data was not significantly different. This is due to external factors such as personality, information, group affiliation, and the use of assessment instrument scales. Teachers need to monitor students during project-based learning to develop curiosity, cooperation, perseverance, environmental care, science process, and idea ability. Recommendations for further research using the PjBL Model to improve higher-order thinking skills such as critical thinking, problem solving, and creativity, involving the use of learning technology and the use of attitude instruments on a larger scale for more accurate assessment.

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