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DEVELOPMENT OF PJBL-BASED TEACHING MODULES TO IMPROVE CRITICAL AND CREATIVE THINKING SKILLS

Ina Yuliana[1]* , Toheri[2] , Bayu Sukmaangara[3]
[1,2,3] Departement of Mathematics Education, UIN Siber Syekh Nurjati Cirebon, Jl. Perjuangan By Pass Sunyaragi, Kota Cirebon, 45132, Indonesia

Email: inayull@mail.syekhnurjati.ac.id
* Corresponding Author

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ABSTRACT

This study aims to develop a Project Based Learning (PjBL)-based teaching module to enhance students' critical and creative thinking skills on the topic of the Pythagorean Theorem. The research employed a Research and Development (R&D) approach using the ADDIE model, which includes analysis, design, development, implementation, and evaluation stages. The module was validated by five experts, resulting a score of 0.71, categorized as very valid. The module was tested on 38 eighth-grade students at SMP Negeri 11 Cirebon. The effectiveness test showed a significant improvement in students' critical and creative thinking abilities, with N-Gain scores of 0.56 and 0.57 respectively, both categorized as moderately effective. The Wilcoxon test showed a significance value of 0.000 for both skills, indicating a significant difference between pretest and posttest scores. Additionally, student responses to the module were highly positive, with an average score of 85.91%. Based on these results, the developed PjBL-based teaching module is considered feasible and effective for enhancing higher-order thinking skills in mathematics learning.

Keyword: Teaching Module, Project Based Learning, Critical and Creative Thinking

How to cite

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INTRODUCTION

The 21st century education requires students to have high-level thinking skills, including critical thinking and creative thinking. This ability is needed to face the complexity of global problems and adapt to rapid social and technological changes (Nesri & Kristanto, 2020).

However, the results of the Programme for International Student Assessment (PISA) survey in 2022 show that the ability of Indonesian students, especially in the field of mathematics, has decreased significantly. Math scores decreased from 379 in 2018 to 366 in 2022 (OCDE, 2023). The results of the survey are proof that students' mathematical abilities in Indonesia are still quite low. This decline indicates the need for evaluation and innovation in learning approaches, especially in materials that require an understanding of concepts and applications such as mathematics. The causes of weak critical and creative thinking skills include conventional learning approaches, lack of student involvement in the learning process, and lack of implementation of learning models that stimulate high-level thinking activities. To improve students' ability to deal with complex challenges and problems, critical and creative thinking skills are essential in learning, especially in mathematics (Toheri et al., 2020).

According to Mahanal, the challenges faced by teachers today are that teachers need to keep updating their knowledge and skills to ensure that they can teach relevantly and effectively (Husna et al., 2023). This curriculum provides flexibility for teachers and students to develop contextual, collaborative, and character-based learning through the Pancasila Student Profile (Kemendikbudristek, 2021). In this context, the teaching module is one of the aspects that supports the optimization of the learning process. The criteria that must be possessed in the teaching module are essential, interesting, relevant and contextual, and sustainable (Mulyani & Insani, 2023).

Teaching modules are complete and structured learning tools, containing general information, learning objectives, assessments, learning activities, reflections, and attachments that support learning (Maulida, 2022). Teaching modules are an important tool to provide freedom and flexibility for teachers in designing learning that suits the needs of students. However, the teaching modules that have been available so far tend not to fully integrate contextual and innovative learning principles, so they are not optimal in developing critical and creative thinking skills.

PjBL actively engages students in problem-solving through real projects, thus practicing collaboration, deep thinking, and innovative skills. PjBL is also in line with the spirit of the independent curriculum which emphasizes meaningful and student-centered learning. Although many studies have raised the use of PjBL in learning, most of them still focus on the cognitive aspect alone and have not developed systematic and contextual teaching modules. The following are the steps to learn PjBL as developed by the George Lucas Educational Foundation (Lestari & Ilhami, 2022) among others: (1). start with the essential question, (2). design a plan for the project, (3). create a schedule, (4). monitor the students and the progress of the project, (5). assess the outcome dan (6). evaluate the experience.

Previous research, namely the research of Hakiki et al (2022), Khoiriyah (2023), and Gumanti et al (2024), showed that the integration of PjBL in teaching tools can improve students' critical and creative thinking skills. However, not many have specifically developed PjBL-based teaching modules that are fully integrated into the independent curriculum and validated through feasibility and effectiveness tests. This is where the novelty of this research lies, namely compiling a teaching module based on PjBL on the Pythagoras Theorem material which is specifically designed to improve the critical and creative thinking skills of 8th grade junior high school students.

According to Ennis in (Roviati & Widodo, 2019) critical thinking is a process whose goal is to make reasonable decisions about what to believe and what to do. Critical thinking has several indicators, according to Ennis, including: (1). Providing a simple explanation, (2). Building basic skills, (3). Summing up, (4). Making further explanations and (5). Create forecasts and integrations. In addition to critical thinking skills, creative thinking skills are also important aspects that need to be developed in accordance with the demands of the 21st century. According to the Ministry of National Education in (Sari et al., 2019) explains that creative thinking is thinking to do something by producing a way or result from something that has been owned. According to Torrance in (Riyanto et al., 2024), creative thinking has several main indicators, namely: (1). Fluency, (2). Flexibility, (3). Originality dan (4). Elaboration.

This research aims to develop a PJBL-based teaching module using the ADDIE model to improve students' critical thinking and creative thinking skills. The novelty of this study lies in the integration of the PjBL approach in the systematic design of teaching modules as well as empirical testing of its influence on the two skills of critical thinking and creative thinking simultaneously.

METHODS

This research is a Research and Development (R&D), which specifically focuses on the development of teaching modules based on PjBL. According to Sugiyono in (Widayati, 2023), Research and Development (R&D) research methods are defined where the research is used to produce a certain product, and test . The development design in this study refers to the ADDIE development model according to Aldoobie consisting of five stages, namely: 1). Analysis, 2). Design, 3). Development, 4). Implementation dan 5). Evaluation. Meanwhile, the research design used in this study is one group pretest-posttest.

Teaching modules and research instruments include expert judgement. The subjects of the field trial were students of grade VIII F SMP N 11 Cirebon. The validation results will be analyzed using the CVR and CVI formulas according to Lawshe (Lawshe, 1975):

$$CVR = \frac{2ne}{N} - 1$$

Information:

N = No. of panelists

ne = panelists who stated the essentials

The minimum CVR value in such a way that it is still declared good can be presented in the Table1 (Lawse, 1975):

Table 1. Minimum Value of CVR

No. of Panelists	Minimum Value
5	0,99
6	0,99
7	0,99
8	0,75
9	0,78

No. of Panelists	Minimum Value
10	0,62

$$CVI = \frac{\sum CVR}{k}$$

Information:

CVI = *Content Validity Index*

$\sum CVR$ = Total *Content Validity Ratio*

k = The number of grains

To determine the criteria for a good CVI index, Lawshe (1975) suggested that a score above 0.50 is a good index, while a CVI > 0.90 to 1 is a special index (Naraswari et al., 2020).

In addition, supporting data such as student response questionnaires are analyzed using the following formula:

$$P = \frac{n}{N} \times 100$$

Information:

P = Percentage of Scores

N = Total scores obtained

N = The quantity of student

The criteria that are the reference for the assessment of the results of the student response questionnaire are as follows (Andriani et al., 2021):

Table 2. Student Response Criteria

Student Response Percentage	Criterion
85% ≤ P	Very Positive
70% ≤ P < 85%	Positive
50% ≤ P < 70%	Less Positive
P < 50%	Not Positive

Meanwhile, to see the effectiveness of critical thinking and creative thinking skills, use a statistical test with the following steps:

1) Normality Test

Normality test is a method used to determine whether data comes from a normally distributed population or is contained in a normal distribution (Nasar et al., 2024). The hypothesis results are determined based on the Sig (2-tailed) value of the normality test output results with the following conditions:

If the significance value > 0.05, the data is normally distributed. If the significance value < 0.05, the data is not normally distributed.

2) Paired Sample t-test (If the data is normal)

Paired Sample t-test was used to see a significant difference between the average pretest and posttest in One Group Pretest-Posttest *Design* (Sukarelawan et al., 2024). If the data is abnormal, then the Wilcoxon test is used.

3) Wilcoxon Test

The Sign Wilcoxon test is a non-parametric test to determine whether there is a difference between two paired or related dependent samples and is used as an alternative

to the Paired Sample T-Test if the data is not normally distributed (Triwiyanti et al., 2019). The criteria for decision-making in the Wilcoxon test are as follows:

If Asymp.sig. (2 – tailed) < 0.05 then there is a difference between the score before and after the treatment. If Asymp.sig. (2 – tailed) > 0.05 then there is no difference between the before and after the treatment.

4) N-Gain Test

The N-Gain test is a commonly used method to measure the effectiveness of a learning or intervention in improving student learning outcomes (Sukarelawan et al., 2024). The N-gain test was used to look at the quality of improved critical thinking and creative thinking skills after learning. The criteria for interpreting the effectiveness of N-gain are as follows:

Table 3. Categories Interpretation of N-Gain Effectiveness

Percentage (%)	Interpretation
<40	Ineffective
40-55	Less Effective
56-76	Quite Effective
>76	Effective

RESULT AND DISCUSSION

Analysis

At the analysis stage, the researcher conducted three main forms of analysis as the basis for the preparation of PJBL-based teaching modules. First, an analysis of the curriculum used in the school is the independent curriculum. That way, the elements of the teaching module are developed based on the independent curriculum.

Second, an analysis of student characteristics was carried out, which was obtained through interviews with teachers and direct observation in the classroom. It is known that students of grade VIII F have high curiosity but still have difficulty understanding abstract material if it is not presented contextually and applicative.

Third, a needs analysis was carried out, which showed that students preferred group learning. In answering questions, they tend to focus on what the teacher exemplifies and are fixated only on easy type questions.

Design

The design stage is the process of compiling an initial design of the teaching module that will be developed based on the results of previous analysis. At this stage, the researcher determines the module structure, competency mapping, and learning strategies to be used. The learning materials are focused on the Pythagorean Theorem, which is designed to facilitate students to develop critical and creative thinking skills through project-based activities. The module is designed by paying attention to the learning principles of the Independent Curriculum, as well as integrating PjBL components such as questions that are the beginning where they can complete the project, exploration activities in the real world, where students seek answers to previous questions, and the final product of the project, namely the proof of the Pythagoras theorem that has different numbers in each group. In addition, evaluation tools were also prepared in the form of critical thinking tests, creative thinking tests, and student worksheets

(LKPD). Furthermore, the products that have been designed and research instruments that have been prepared are developed with validation to experts.

Development

The validation of the PjBL-based teaching module developed in this study was carried out by six experts as validators. The advice given by these experts is used as a basis for improving the product. The results of validation and revision will be described as follows. Overall, the results of the validation of the PjBL-based teaching modules developed are as follows:

Table 4. Validation of PjBL-Based Teaching Modules

No	Indicator	$\sum CVR$	CVI Value	Information
1	Quality of Learning Objectives	4,66	0,77	Highly Valid
2	Content Quality	9,33	0,66	Valid
3	Language Quality	1,66	0,83	Highly Valid
Total		15,66	0,71	Highly Valid

It can be seen from the results of the validation that this PjBL-based teaching module has a high validity value of CVI = 0.71. The assessment of the research instruments, namely tests and student response questionnaires, was assessed using a filling scale, namely E (Essential), TR (Irrelevant) and TE (Non-Essential). Furthermore, the assessment of test questions and the overall student response questionnaire are valid for all items.

Results of the revision of the teaching module based on PjBL

Based on comments and suggestions from validators, evaluations are carried out and followed up by revising the parts that need to be improved. The revision of the PjBL-based teaching module can be seen in the following Table 5.

Table 5. Revision of PjBL-Based Teaching Module Products

Indicator	Suggestion	Repair
Quality of learning objectives	Describe the indicators of learning objectives well learning objectives	Improve the indicators of learning objectives by describing them one by one
Content quality	Adapt teaching materials to learning objectives	Improve the material that has been prepared according to the learning objectives
	Come up with practice questions to find out the extent of students' understanding	Add some practice questions for students
	Structure project instructions clearly	Improve projects in the LKPD according to the PjBL syntax and the final goal of the project to be created

Indicator	Suggestion	Repair
	Tailor PjBL activities to clear goals	Improve learning activities in accordance with the PjBL syntax and adapt it to the LKPD
	Adjust time allocation for all learning activities	Improve by describing the time taken in core activities according to the PjBL syntax
Language quality	Clarify the instructions on the LKPD and teaching materials	Improve the instructions in the teaching materials and in the projects that will be made in the LKPD in activities 1 to 3 and clarify each activity

Implementation

The implementation stage is to implement a PjBL-based teaching module that has been revised and is suitable for use. Before the PjBL-based teaching module is implemented, students conduct an initial test first then convey an explanation of the material learned and sample questions and explain the discussion of the sample questions given, provide opportunities for students to ask questions, conduct group discussions using LKPD and complete them, then present them and finally students do the final test. Students work on projects according to the directions contained in the LKPD. Because the students are less active and easily bored, so in the final activity they make and mortify the results in the form of scientific posters and physical works that have been completed. The following are the results of the students' work on a scientific poster with a photo of the physical work of one of the groups:

Figure 1. Scientific Poster

Figure 2. Physical Work

Evaluation

The results of the evaluation were obtained from data on pretest and posttest scores, critical thinking and creative thinking skills, as well as student responses from student response questionnaires. Based on the data obtained, the researcher analyzed the improvement of critical and creative thinking skills after the implementation of the PJBL-based teaching module, and assessed the students' responses to the teaching module.

Effectiveness Results

After the PjBL-based teaching module and research instruments are validated and declared feasible to be tested, the next step is to field test in an experimental class. This field trial aims to determine the effectiveness of the PjBL based teaching module that has been developed. The field trial was carried out in an experimental class involving 38 students of SMP Negeri 11 Cirebon. The following is an explanation of the results of field trials related to the effectiveness of PjBL-based teaching modules to improve critical thinking and creative thinking skills.

Critical Thinking Ability Test Data Analysis

Normality Test

The normality test carried out in this study used the Shapiro-Wilk test assisted by the SPSS application. The criteria in decision-making are if the Sig. value > 0.05. Based on the SPSS analysis, the following results were obtained.

Table 6. Normality Test Critical Thinking Ability Test

	Shapiro-Wilk		
	Statistic	**df**	**Sig.**
Critical Thinking Pretes	.919	38	.009
Critical Thinking Postest	.904	38	.003

Based on the results contained in the Table 6, *the values of Asymp. Sig. (2-tailed)* for the above data are 0.009 and 0.003. It can be concluded that the data is unnormall distributed.

Wilcoxon Test

The Wilcoxon test was carried out with the help of SPSS. The criterion in decision-making is if the Sig. value < 0.05. Based on the SPSS analysis, the following results were obtained.

Table 7. Wilcoxon Test Critical Thinking Ability Test

	Critical Thinking Postest – Critical Thinking Pretest
Z	-5.305[b]
Asymp. Sig. (2-tailed)	.000

Based on the results contained in the Table 7, the value of Asymp. The sig. (2-tailed) for the above data is 0.000 < 0.05. It can be concluded that there is a significant difference between the critical thinking ability test and the pretest-posttest score.

N-Gain Test

Calculation of data on improvements that occurred before and after the treatment of students' critical thinking skills using N-Gain. The N-Gain test is carried out with the help of *Microsoft Excel Software.* The results obtained are as follows.

Table 8. N-Gain Critical Thinking Ability Test

No	Critical Thinking Indicators	Pre	Post	post-pre	Ideal Score	N-Gain Score	N-Gain Score Percent	category
1	Provide a simple explanation	55,26	82,24	26,97	44,74	0,60	60,29	Medium
2	Build basic skills	56,58	75,00	18,42	43,42	0,42	42,42	Medium
3	Conclude	12,17	66,45	54,28	87,83	0,62	61,80	Medium
4	Make further explanations	21,05	65,79	44,74	78,95	0,57	56,67	Medium
5	Create forecasts and integrations	11,18	63,16	51,97	88,82	0,59	58,52	Medium
	Average	**31,25**	**70,53**	**39,28**	**68,75**	**0,56**	**55,94**	**Quite Effective**

Based on the Table 8, the results of the N-Gain test for critical thinking ability tests obtained an average N-Gain Score of 0.56 in the medium category. From the Table 8 above, it can be concluded that the results of the N-Gain test of critical thinking ability are said to be quite effective because the percentage of N-Gain Score obtained is 55.94%. In the discussion of the N-Gain results on the critical thinking ability test, it can be seen that the score on the basic skill building indicator is the lowest and the score on the concluding indicator is the highest, perhaps this happens because students are more accustomed to concluding the answer directly shorter than answering long.

Creative Thinking Ability Test Data Analysis

Normality Test

The normality test carried out in this study used *the Shapiro-Wilk test* assisted by the SPSS application. The criteria in decision-making are if the Sig. value > 0.05. Based on the SPSS analysis, the following results were obtained.

Table 9. Normality Test Creative Thinking Ability Test

	Shapiro-Wilk		
	Statistic	df	Sig.
Creative Thinking Pretest	.711	38	.000
Creative Thinking Posttest	.872	38	.000

Based on the results contained in the Table 9, *the Asymp. Sig. (2-tailed)* values for the above data are 0.000 and 0.000. It can be concluded that the data is unnormally distributed.

Wilcoxon Test

The wilcoxon test was carried out with the help of SPSS. The criterion in decision-making is if the Sig. value < 0.05. Based on the SPSS analysis, the following results were obtained.

Table 10. Wilcoxon Test Creative Thinking Ability Test

	Creative Thinking Posttest - Creative Thinking Pretest
Z	-5.375[b]
Asymp. Sig. (2-tailed)	.000

Based on the results contained in the Table 10, the value of Asymp. The sig. (2-tailed) for the above data is 0.000 < 0.05. It can be concluded that there is a significant difference between the creative thinking ability test and the pretest-posttest score.

N-Gain Test

Calculation of data on improvements that occurred before and after the treatment of students' critical thinking skills using N-Gain. The N-Gain test is carried out with the help of *Microsoft Excel Software*. The results obtained are as follows.

Table 11. N-Gain Creative Thinking Ability Test

No	Indicators of Creative Thinking	Pre	Post	post-pre	Ideal Score	N-Gain Score	N-Gain Score Percent	category
1	*Fluency*	13,49	73,36	59,87	86,51	0,69	69,20	Medium
2	*Flexibility*	0	50	50	100	0,50	50	Medium
3	*Originality*	4,61	41,15	41,12	95,39	0,43	43,10	Medium
4	*Elaboration*	0	64,47	64,47	100	0,64	64,47	Medium
Average		**4,52**	**58,39**	**53,87**	**95,48**	**0,57**	**56,69**	**Quite Effective**

Based on the Table 11, the results of the N-Gain test of creative thinking ability test obtained an average N-Gain Score of 0.57 with a medium category. From the Table 11 above, it can be concluded that the results of the N-Gain critical thinking ability test are said to be quite effective because the percentage of N-Gain Score obtained is 56.69%. In the discussion of the N-Gain results on the creative thinking ability test, it can be seen that the score on the *originality* indicator is the lowest and the score on the *fluency* indicator is the highest, perhaps this happens because students are more familiar with the questions that are often exemplified than they answer *out of the box.*

Student Response Questionnaire Data

After the use of the PjBL-based teaching module in learning, the researcher provided a student response questionnaire as a form of student response to the application of PjBL-based teaching modules to improve critical thinking and creative thinking skills. Based on the analysis, the following are the results:

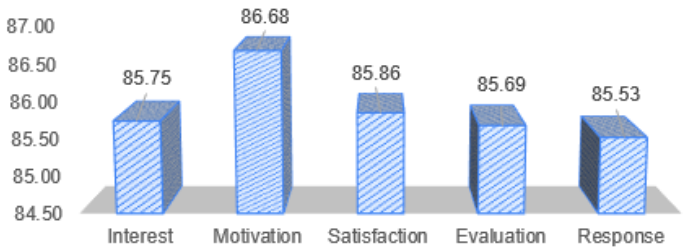

Figure 3. Student Response Questionnaire Data

Based on the results of the analysis of the Table 11 and Figure 3 above, the data that supports the development process of PjBL based teaching modules is student response data. The results of the student response questionnaire in each aspect were (1) Interest with a percentage of 85.75 categories was very positive, (2) Motivation with a presentation of 86.68 categories was very positive, (3) Satisfaction with a percentage of 85.86 categories was very positive, (4) Evaluation with a percentage of 85.59 categories was very positive and (5) Responses with a percentage of 85.53 categories were very positive. Based on the results, the average percentage obtained was 85.91 with a very positive category.

Discussion

This research develops a teaching module based on PjBL to improve critical thinking and creative thinking skills. This development process involves the stages of analysis, design, development, implementation, and evaluation. Each stage is carried out systematically by considering the needs of students, classroom conditions, and learning objectives that are in line with the Independent Curriculum. The teaching modules developed are prepared by paying attention to a systematic structure in accordance with the independent curriculum and referring to the syntax of the project-based learning model (PjBL) developed by *the George Lucas Educational Foundation*. The components contained in this teaching module include general information, core competencies and appendices. This is in line with research (Maulida, 2022) which discusses the components that must be in the independent curriculum teaching module.

The improvement of critical thinking skills can be attributed to the application of PjBL syntax that encourages students to identify problems, conduct investigations, and account for the results of their findings. In this process, students are trained to evaluate information, structure arguments, and draw logical conclusions. Meanwhile, creative thinking skills develop through exploration activities and project presentations, where students are challenged to come up with original ideas, unique solutions, and innovations from their understanding. These results are in line with the critical thinking indicator according to Ennis and the creative thinking indicator according to Torrance which is used as a reference.

The results of the study show that PjBL-based teaching modules are suitable for use in learning. Validation from experts, both lecturers and teachers, states that this module is very valid in terms of purpose, material content, and language use. Suggestions from experts are also improved through revisions made before the module is implemented in class. In addition, the effectiveness of the module is also reflected in the results of the students' pretest and posttest.

Data analysis using N-Gain and Wilcoxon test showed a significant increase in critical and creative thinking skills, with a fairly high level of effectiveness. This is in line with the findings revealed by Hakiki et al (2022) showing that the use of the PjBL model in mathematics learning can improve critical thinking skills. Meanwhile, research by Khoiriyah (2023) proves that project-based learning is effective in developing students' creative thinking skills. In addition, Nesri & Kristanto (2020) also stated that teaching modules developed with a project-based approach can support 21st century competencies which include critical, creative, collaborative, and communicative thinking. Thus, the results of this study reinforce previous findings on the effectiveness of project-based learning in encouraging higher-level thinking skills.

Another aspect that supports the effectiveness of this module is the results of the student response questionnaire which showed an average score of 85.91% in the very positive category. This indicates that students feel helped and motivated in learning. Group discussions, real-life problem-solving, and creativity-demanding project activities encourage them to be more involved and contribute to the learning process.

Overall, the development and application of PjBL-based teaching modules in mathematics learning on the Pythagorean Theorem material has proven to be effective and feasible. This module not only encourages the improvement of critical and creative thinking skills, but also forms the collaborative and communicative attitudes that are important in facing the challenges of 21st century education.

CONCLUSION

Based on the results of the study, it can be concluded that the development process used in the development of teaching modules uses Research and Development (R&D) research with the ADDIE development model. This model has five stages, including (1) the analysis stage regarding the analysis of the curriculum, characteristics and needs of students; (2) Design of the preparation of teaching module products, materials and research instruments; (3) development (Develop) regarding the validation of experts, revision and feasibility testing of instruments, (4) Implementation of field trials that adjust to PJBL steps, and (5) Evaluation in the form of suggestions during field trials are implemented. The teaching modules developed have met the eligibility criteria in terms of content and design according to the Independent Curriculum. Validation by experts showed a CVI value of 0.71, which means it is very valid. The effectiveness of the use of teaching modules can significantly improve the ability to think critically and creatively, especially in the material of the Pythagorean theorem. The N-gain test on critical thinking ability had an average of 0.56 and 0.57 on creative thinking ability with interpretation there was an increase in the medium category. The results of the statistical test on the critical thinking and creative thinking ability tests were both obtained sig values. 0.000. The students' response to the developed teaching module was very positive, with an average score of 85.91%, included in the very positive criteria. Thus, this teaching module can effectively improve critical thinking and creative thinking skills in class VIII F SMP Negeri 11 Cirebon in mathematics subjects, especially the material of the Pythagorean theorem.

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