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THE DEVELOPMENT OF ANDROID-BASED OPEN-ENDED APPROACH TEACHING MATERIALS ON SQUARES AND TRIANGLES

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ABSTRACT

In industrial revolution 4.0, education must follow and utilize information and communication technology. Android is an operating system on mobile devices, and Indonesia's most popular and widely used mobile device operating system. The Open-Ended approach is an approach in mathematics learning that provides opportunities for students to explore open problems with various strategies for solving problems. One problem that often arises in learning in schools is the study of the anchovies of each textbook varies, and the material contained in the book does not match the characteristics of the students. To realize this, the world of education needs to implement the use of e-Modules. Seeing this problem, the development of an android-based e-Module with an open-ended approach is required. Research and development with the ADDIE model is this type of research. The subjects of this study were as many as 15 middle school students in grade 8 for limited tests and 30 students for a broader test. The research aimed to produce Android-based electronic teaching materials with an open-ended approach to square and triangular materials. The resulting product is an e-Module in the form of an android package kit (APK). The result of the study concluded that the development of teaching materials with an android-based open-ended approach went well with the practicality test results obtained by 83%, which means that the teaching materials are efficient to use and got 86.6% in the effectiveness test, which means that the teaching materials developed are suitable for use.

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INTRODUCTION

In industrial revolution 4.0, education must follow and utilize information and communication technology. To realize this, the world of education needs to implement the use of e-Modules.

Seeing this problem, the development of an android-based e-Module with an open-ended approach is required.

Android is an operating system on mobile devices, commonly called smartphones, that are open and based on Linux and provide an open-source platform that makes it easier for developers to create their applications (Syafitri et al., 2020). Slightly different from Syafitri et al. (2020). Wijaya et al. (2020) explained that android is an operating system for Linux-based mobile devices that includes operating systems, middleware, and applications and provides an open platform for developers to create their applications. At the same time, Prandatama & Haryanto (2020) explained that android is the first platform or container that is open source in its development and comprehensive for mobile devices, all software that can run mobile devices without thinking about ownership constraints that hinder innovation in mobile technology.

Android is Indonesia's most popular and widely used mobile device operating system. This is in accordance with the report StatCounter (2020), where 91.5% are reported as android users in Indonesia, while iOS users are only 8.27% of users, and the rest are users of other mobile devices operating systems.

According to Rahdiyanta (2016), modules are a form of teaching materials that are packaged comprehensively and systematically to help students master specific learning goals. Directly proportional to Peniati (2012) explained that modules could help students to obtain information about learning materials and improve the acquisition of final grades or student learning outcomes. On the other hand, Laili (2019) explained that the e-Module is a module with an electronic format run with a computer or gadget such as an Android smartphone.

According to Afandi & Jalal (2019), the Open-Ended approach uses open problems in learning where the problems given to students produce solutions or answers to problems using more than one. In line with Martiani et al. (2019), who projects that an Open-Ended Approach is a problem-based approach, where the learning process begins with providing problems that are not routine and open that have more than one alternative solution to the correct solution. Meanwhile, according to Lubis et al. (2019), The Open-Ended approach is an approach in mathematics learning that provides opportunities for students to explore open problems with various strategies for solving problems.

Based on Shimada and Becker (Oktaviani et al., 2018), the open-ended approach believed in providing a lot of opportunities for students to acquire a lot of knowledge, discover experience, recognize and solve problems with different methods and have many solutions. Through an open-ended approach, students can participate actively because learning provides opportunities for students to do everything freely according to their wishes, allowing them to more freely develop their creative thinking skills (Handayani, 2018).

One problem that often arises in learning in schools is the study of the anchovies of each textbook varies, and the material contained in the book does not match the characteristics of the students. It makes students bored and lazy to learn mathematics which causes students to be unable to master some prerequisite materials while prerequisite materials are needed to understand other materials in learning mathematics. Bored and lazy to learn mathematics makes students lose interest in the material described by the teacher (Irfan et al., 2019). One of the essential mathematical materials is quadrangles and triangles.

The square and triangular matter is one of the prerequisite materials. But in fact, students still have difficulty learning the material. According to Sumiati and Agustini (2020), there are several difficulties, including students having difficulty understanding the problem, students have not been able to make a mathematical model of the existing problem, and students have

not been able to determine what the initial steps are to solve the given problem and have not been able to apply what known in the problem into formulas, and students do not understand the concept of the triangle and square material.

According to Fadhilah et al. (2020), triangular and square matter included in the geometric constructs in a two-dimensional figure is an abstract concept. Meanwhile, Kamilah and Imami (2020) explained that triangular and square matter is part of the geometry widely applied to everyday life and is needed as a prerequisite material to study other buildings such as cubes, beams, pyramids, and so on. In contrast to Fadhilah et al. (2020) and Kamilah et al. (2020), Hadiyanto (2020) explained that the material of triangles and quadrangles includes the properties of squares, the concept of area and circumference of a square, the concept of a triangle, a type of triangle both by side and angle. Seeing this problem, developing an android-based e-module with open-ended features on square and triangular materials. The purpose of this study is to find out and study (1) the development of android-based e-modules with open-ended abbreviations on square and triangular materials

METHOD

The research carried out is research and development. This study aims to produce teaching materials with an open-ended approach of android-based e-modules with an open-ended approach that valid and practical square and triangular materials. The resulting product is Teaching Materials in an Android Package Kit (APK) format. The model used in this development research is the ADDIE Model. The model has five steps: analysis, design, development, implementation, and evaluation (Jones, 2007). Visually the stages of the ADDIE Model can be seen in Figure 1.

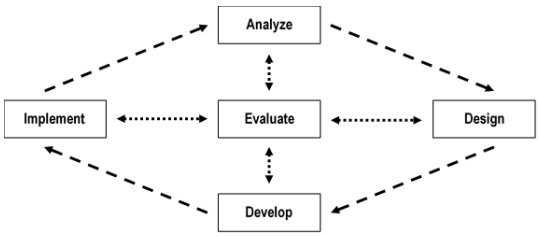

Figure 1. ADDIE Models

Based on figure 1, the Author adopts and modifies the development steps of ADDIE so that the research and development steps in this study are as follows:

1. Preliminary studies in the form of Literature reviews, material analysis, analysis of teaching material needs, analysis of student characteristics, and making drafts of Android-based e-Modules;
2. Development trials in the form of limited practices and tests on a wider scale;

The criteria for product validity according to Riduwan (2007), are presented in Table 1.

Table 1. Validation Criteria

Percentage	Criterion
0% - 20%	Invalid
21 % - 40%	Less Valid
41 % - 60%	Valid Enough
61 % - 80%	Valid
81 % - 100%	Very Valid

RESULTS AND DISCUSSION

Result

This research was carried out in two schools, to develop teaching materials with an android-based open-ended approach to quadrilateral and triangular materials. The teaching materials produced in the form of e-modules are expected to be attractive and provide convenience for students in learning. In the implementation of development, the product developed is validated by several expert validators, then by practitioners is teachers of mathematics subjects and proven the level of readability to the students concerned in the research. The following is the result of the stages of developing a teaching material that the Author did which refers to the stages of development of ADDIE.

a. Analysis

At the analysis stage, three aspects are analyzed, including material analysis, analysis of teaching material needs, and student characteristics analysis. In the process of material analysis, a study was carried out with a development team consisting of researchers, two supervisors, and a mathematics teacher at the junior high school level.

b. Design

Designing teaching materials to obtain an initial draft is the goal at the design stage. The teaching materials developed are android-based e-modules with an open-ended approach that aims to improve students' mathematical creative thinking skills in the learning process.

The use of e-modules is expected to support student learning which is carried out both offline and online. Then, students who cannot attend can still follow the learning by offering the e-module. For students to remain active during education, researchers designed an e-module with an open-ended approach. It's expected that with this approach, students have new ideas. For the initial stage design, as in the figure below.

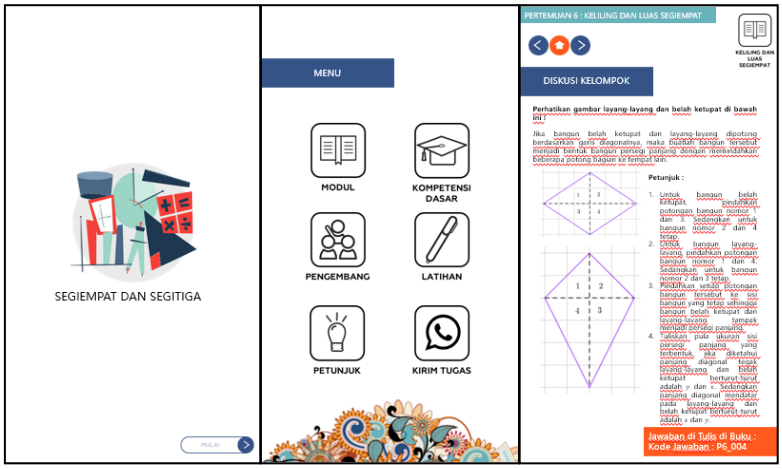

Figure 2. Initial Stage Design

Researchers develop start/opening pages, menus, and material pages in the design process. On the initial page, only the researcher does a design with simple drawings related to mathematics. On the menu page, the researcher provides several options that students can choose from, including modules, essential competencies, developers, exercises, instructions, and submitted assignments. After that, the assignment and exercise display menu has a design that contains 1) the meeting title, 2) navigation buttons, 3) open-ended stages, 4) places for material, 5) answer captions, and 6) supporting images when needed. In the design process,

researchers used Geometria typefaces with an average size of 11-20 that were consistent on each page by combining colors with the Hex code #F7C134, #FF591E, #355387, #68B2BC.

c. Development

In the development process, validation is carried out by expert validators. The validation carried out includes material expert validation, and ICT expert validation. In the validation process, several stages are carried out, including:

1) Limited Trial

The limited trial was carried out with a total of 15 respondents. This limited trial was carried out to strengthen the readability of students to the developed teaching materials. Data collection techniques in the trial process are limited through the provision of questionnaires or questionnaires on teaching materials for quadrilateral and triangular materials. The following is a table of the results of the limited trial.

Table 2. Results of the Student Readability Questionnaire on Teaching Materials

No.	Question	Response (%)			
		SA	A	D	SD
1.	e-Module uses easy-to-understand language	46,6	53,4	0	0
2.	Sentences used in e-Module are easy to understand and do not cause double meanings	26,6	73,4	0	0
3.	The writing or typeface in e-Module is easy to read	33,4	66,6	0	0
4.	The image in e-Module is clearly visible	33,4	60	6,6	0
5.	The appearance of e-Module looks beautiful	20	80	0	0
6.	The colors used in e-Module make e-Module attractive	13,4	80	6,6	0
7.	The instructions in e-Module are easy to understand	33,4	66,6	0	0
	Total	29,5	68,5	1,9	0

From the table above, it can be seen that 68.5 students agreed on the appropriateness of the use of language, sentences, and images and the appearance of the e-module. In addition to validating students, researchers validate material expert validators and ICT expert validators. Below are presented material expert validation data

Table 3. Material Expert Validation Results

No.	Assessed aspects	Item No.	Percentage
1	Conformity of Teaching Materials with an Open-Ended Approach	1,2,3 4,5,6 7,8,9	88,59
2	Eligibility of contents	1 2 3,4,5,6 7,8,9	83,33
3	Conformity of Teaching Materials with learning objectives	1 2 3	91,67
	Average Percentage		87,96
	Category		Very Feasible

Table 3 shows that the percentage of all aspects in the teaching materials has reached the category of "very feasible", but there are revision comments so that the teaching materials can be used with revisions according to the notes.

Table 4. Recapitulation of ICT Expert Assessments Based on Aspects Observed in Limited Trials

No.	Assessed aspects	Item No.	Percentage
1	Visual Appearance	1,5	75
2	Educational	2,3,4,6,7,8	87,5
	Average Percentage		81,25
	Category		Very Feasible

Based on Table 4, it is seen from the visual display aspect by 75% and the educational aspect by 87.5%. The overall average obtained was 81.25%, with a very feasible category. Thus, the teaching materials that researchers develop are feasible to use by paying attention to the revisions of the ICT validators related to "visual appearance". Then, the modification results are consulted to the Supervisory Post and re-tested at the wider-scale test stage.

2) Wider-Scale Test

The wider scale test was carried out with 30 respondents from 2 (two) different classes. This wider-scale test corroborates students' readability to the teaching materials developed after revisions from limited trials. Data collection techniques in the trial process are limited through the provision of questionnaires or questionnaires on teaching materials for quadrilateral and triangular materials. The following is a table of the results of the wider scale test.

Table 5. Results of the Student Readability Questionnaire on Teaching Materials

No.	Question	Response (%)			
		SA	A	D	SD
1.	LKS uses easy-to-understand language	73,4	26,6	0	0
2.	Sentences used in LKS are easy to understand and do not cause double meanings	66,6	33,4	0	0
3.	The writing or typeface in LKS is easy to read	76,6	23,4	0	0
4.	The image in LKS is clearly visible	86,6	13,4	0	0
5.	The appearance of LKS looks beautiful	83,4	16,6	0	0
6.	The colors used in LKS make LKS attractive	83,4	16,6	0	0
7.	The instructions in LKS are easy to understand	76,6	23,4	0	0
	Total	78,1	21,9	0	0

From the table above, it can be seen that 78.1% of students strongly agree with the appropriateness of the use of language, sentences, and images and the appearance of the e-module. In addition to looking at readability, researchers also conducted validation tests back to ICT experts based on aspects observed in wider-scale tests, as presented in Table 6 below.

Table 6. Recapitulation of ICT Expert Assessments Based on Aspects Observed in Wider Scale Test

No.	Assessed aspects	Item No.	Percentage
1	Visual Apperarance	1,5	100
2	Educational	2,3,4,6,7,8	91,7
	Average Percentage		95,8
	Category		Very Feasible

Based on Table 6 viewed from the aspect of visual appearance by 100% and the educational element by 91.7%. The overall average obtained was 95.8%, with a very feasible category.

Thus, the teaching materials that researchers develop are suitable for use in product test activities.

d. Implementation

In this case, implementation was carried with a total of 60 respondents with details of 30 students in the experimental class and 30 other students as comparisons or control classes. The purpose of this implementation stage is to implement the design of teaching materials that have been developed.

The application of the developed teaching materials was only carried out in the experimental class for ten sessions, with details of 1 session for the initial test (pre-test), after which it was given treatment using teaching materials developed during eight sessions. The last session was given a final test (post-test).

On the other hand, control classes are given different treatment as a comparison of teaching materials developed with conventional teaching materials. Similar to the experimental class, the control class also received learning for ten sessions with details of one session for the initial test (pre-test) of mathematical creative thinking ability, after which it was given treatment using conventional teaching materials, namely the 2013 curriculum mathematics student book for eight sessions. The last session was given a final test (post-test) of mathematical creative thinking ability and given a self-regulated learning attitude scale.

Table 7. Description of Mathematical Creative Thinking Ability Statistics

		Kelas Eksperimen			**Kelas Kontrol**		
		Pre-test	***Post-test***	***Gain***	***Pre-test***	***Post-test***	***Gain***
Creative Thinking	$\bar{x}$	4,53	80,86	0,79	6,03	67,60	0,65
	S	1,87	9,88	0,10	2,77	9,25	0,09
	N		30			30	
Self-Regulated Learning	$\bar{x}$		91,16			83,78	
	S		7,22			10,49	
	N		30			30	

Table 7 is a statistical description of mathematical creative thinking ability from the table obtained the average score of the initial ability of creative mathematical thinking for the experimental class of 4.35 and the control class of 6.03. In addition, the average score of the creative mathematical thinking final ability test was obtained at 80.86 for the experimental class and 67.60 for the control class. From the results of the ability of the initial test and the final test, a normalized gain was obtained for each class, with an average of 0.79 for the experimental class and 0.65 for the control class.

e. Evaluation

At this stage, an evaluation of the learning process is carried out using an attitude scale where students are respondents in the assessment of the learning process. In this stage, not all samples were made respondents, but only 30 students from the experimental class acted as respondents. The results of the evaluation process/practicality test are presented in table 8 below.

Table 8. Results of the Teaching Material Practicality Test on the Product Test

No.	**Question**	**Percentage**
1.	e-Module uses easy-to-understand language	85%
2.	Sentences used in e-Module are easy to	83%

No.	Question	Percentage
	understand and do not cause double meanings	
3.	The writing or typeface in e-Module is easy to read	83%
4.	The image in e-Module is clearly visible	82%
5.	The appearance of e-Module looks beautiful	82%
6.	The colors used in e-Module make e-Module attractive	83%
7.	The instructions in e-Module are easy to understand	83%
8.	Activities in e-Module cause discussions with friends to be established smoothly and well	83%
9.	This e-Module helps me understand the matter of quadrangles and triangles	83%
10.	The activities in e-Module help me improve my learning outcomes	84%
11.	The activities at e-Module help me improve my creative thinking skills	83%
12.	This e-Module studies the material of The Quadrangle and Triangle	81%
13.	After learning by using this e-Module, I was able to solve the problem of square and triangular materials	83%
	Average	83%

The data obtained in table 8 shows that the average student response to teaching materials and the learning process is 83%. This indicates that the percentage of the average student response to learning using teaching materials with an android-based open-ended approach has a positive response. This means that the teaching materials used at the time of product testing are efficient to use.

In addition to reviewing the practicality of teaching materials, a question was given about the ability to think creatively mathematically after being given treatment for eight sessions. The results of the effectiveness of teaching materials at the time of product testing are presented in table 9 below.

Table 9. Results of the Effectiveness of Teaching Materials in Product Tests

KKM	Number of Completed Students	Incomplete Number of Students	Percentage of Effectiveness	Interpretation
70	26	4	86,6 %	Very Effective

As can be seen from Table 9, the percentage of specificity of teaching materials can be seen from the results of the value of students' mathematical problem-solving ability to obtain a rate of 86.6%. This is included in the "Very Effective" category, which can be concluded that teaching materials with an android-based open-ended approach at the product test stage are feasible to use.

Discussion

The stages in this study used sets from the ADDIE development model. The ADDIE stage starts from the Analysis, Design, Development, Implementation, and Evaluation stages. The analysis process starts from a preliminary study of the need to develop teaching materials with an android-based open-ended approach through interviews with mathematics teachers. After the initial study, researchers designed teaching materials by considering the results of interviews and curriculum analysis as well as operating system technology widely used in smartphones in Indonesia. The results are poured into a teaching material with an open-ended android-based approach. After the draft teaching materials are completed, validation is then carried out at the development stage of the trial section limited to material experts, ICT experts, and student responses to measure the readability of the developed teaching materials and to find out what aspects.

After repairs were made following the direction, the teaching materials were tested again in the broad test section. In the wider scale test, validation was carried out back to material experts, ICT experts, and student responses to measure the readability of the teaching materials developed and to find out what aspects were lacking in the teaching materials that the researcher had redesigned. After the revision was carried out again according to the direction and consulted with the supervisor, the implementation stage was carried out, namely the test of the developed product.

The product test was carried out with a sample of 30 students as an experimental class and as many as 30 students as a control class student. The difference between the experimental and control classes is in the treatment, where the experimental class uses teaching materials with an android-based open-ended approach. On the other hand, the control class uses conventional teaching/learning materials that schools usually do.

The experimental class was given treatment using teaching materials with an android-based open-ended approach of 10 meetings. The ten sessions it was divided into 3 stages, of which one session was used to conduct an initial test (pre-test) of mathematical creative thinking ability, then as many as eight sessions as part of the treatment using teaching materials with an android-based open-ended approach, and last sessions were used to conduct a final test (post-test) of mathematical creative thinking ability.

The learning process is carried out using the open-ended stage, which includes 1) orientation; 2) material debriefing; 3) the presentation of open-ended problems; 4) individual open-ended problem work; 5) group discussions; 6) presentation; and 7) finale of learning. At this orientation stage, it is used to review previous knowledge obtained by students. At this stage, it is contained in the developed teaching materials as presented in figure 2 below.

Figure 2. Stages of Orientation to Teaching Materials

Figure 3. Students At The Orientation Stage

At this orientation stage, there are two steps: remembering and observing. In this orientation, students are faced with daily problems related to quadrilaterals, and students are expected to be able to recall previous material that has been studied related to lines and angles. Next is the debriefing stage of the material. Students are given the material on the nature of the quadrangle. The debriefing process is contained in the developed teaching materials, as shown in figure 4.

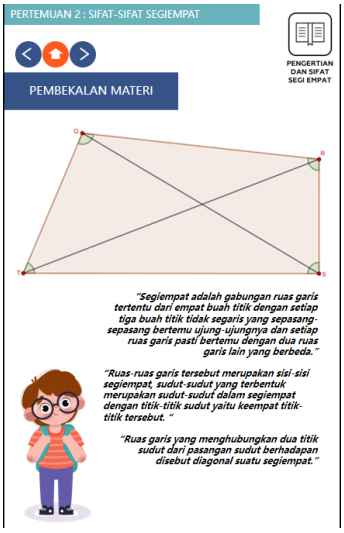

Figure 4. Material Debriefing

In the process of debriefing the material, the teacher guides students so that students get the basis of the material to be studied on that day.

Figure 5. Teachers Provide Guidance to Students at the Material Debriefing Stage

In the process of debriefing the material, students often ask about the material being studied at the meeting, and it is hoped that the teacher as a facilitator can answer questions from the student.

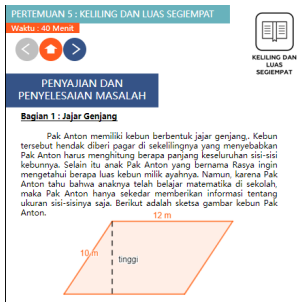

Figure 6. Open-Ended Problem Presentation Stage

The open-ended problem presented at this stage already exists in the developed teaching materials, as in figure 6. At this stage, the student is faced with the available problems so that by observing and trying, the student can resolve the problem independently. After being faced with a problem, at this stage, students are expected to be able to solve problems individually without their abilities.

Figure 7. Individual Open-Ended Problem Solving Phase

At this stage, students solve the problems in the teaching materials individually with the direction of the teacher, and it is hoped that students can find other possible alternative answers. After the previous activities have been completed, the next stage is a group

discussion. At this stage, students are expected to be able to solve problems in their own various ways by trying and observing the problems available in the teaching materials, as shown below.

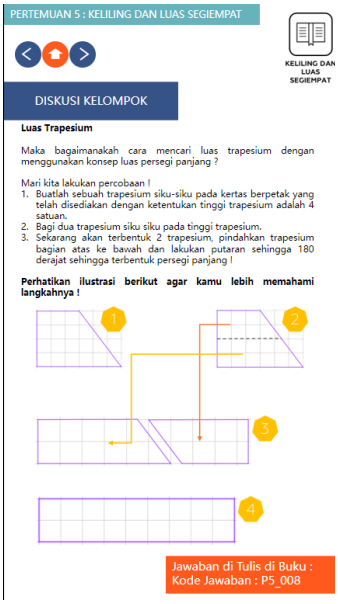

Figure 8. Group Discussion Stages

It can be seen in figure 8 that by observing and trying, students are expected to be able to find the formula of the trapezoid in their own way. With the help of a teacher, students are guided in finding formulas by paying attention to the relationship between the length of the rectangular side with the number of parallel sides in the trapezoid and paying attention to the relationship of the width of the rectangle to the height of the trapezoid so that the trapezoidal formula can be known.

The next stage is a presentation. At this stage, students make presentations about the results of discussions with their group members. Representatives of group members presented their group findings in front of the class, and some students from other groups commented on or added exposure from representatives of group members who were demonstrating.

Figure 9. Group Members Are Presenting

From the results of the discussion, it was concluded that students could already find trapezoidal formulas in their way by observing and trying. After six stages are completed, the teacher guides the students to draw conclusions regarding the material studied at the meeting independently. Thus the entire learning series is completed, and the teacher closes the learning

by providing homework and recapturing the student's self-regulated learning during the learning process.

According to Imansari and Sunaryantiningsih (2017), using e-modules in learning is a good category. This is directly proportional to this study which obtained 83% positive responses when the e-module was tested for practicality, and 86.6% was the students' response in the effectiveness test. The android-based e-module meets the criteria for good learning and is worth using in the learning process (Sidiq, 2020).

CONCLUSION

Based on the analysis of data and discussions that have been previously presented, the researcher concluded that the development of teaching materials with an android-based open-ended approach went well with the results of the practicality test obtained by 83%, which means that the teaching materials are efficient to use and got 86.6% in the effectiveness test which means that the teaching materials developed are suitable for use.

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