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Development of Ethnomathematics Learning Tools with a Scientific Approach for Problem Solving

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Abstract

This study examines the validity, practicality, and effectiveness of learning tools based on the ethnomathematics, aimed at enhancing problem-solving. Using the ADDIE model, the research involved 32 class VIII students. The results show that the developed learning tools teaching modules and textbookshave the following characteristics: (1) Learning activities integrate ethnomathematics with a scientific approach to the Pythagorean theorem for class VIII students. (2) Validity assessment: the teaching module scored 89.26%, and the textbook scored 80%. (3) Practicality assessment: teachers rated the tools at 83.33%, while students rated them at 86.27%. (4) Effectiveness: The hypothesis test showed that the tools significantly facilitated problem-solving (average score of 86.45).

Keywords: *Ethnomathematics; Scientific; Problem Solving*

Introduction

The learning process is closely related to the quality of education because it is the most important part of education. This process enables the achievement of educational functions and objectives as well as the improvement of education. Learning tools are a very important component in the educational process because they consist of various components that are systematically designed to help achieve educational objectives. A comprehensive and high-quality learning toolkit ensures that the learning process is effective and learning objectives are achieved successfully. Therefore, developing a learning toolkit presents a unique challenge for teachers. The goal is to make learning easier to implement so that learning objectives can be achieved in the most effective manner. In other words, a learning toolkit is a tool used by an educator in the learning process (Angraini et al., 2021).

Problem-solving skills are very important to teach students because they help them solve problems easily. This is also stated by Ambarani & Yunianta (2021), who say that problem-solving skills are one of the important skills for students to develop and possess. Understanding problems through reasoning is the first step in solving problems. After that, students make a plan to solve the problem, implement it, and check the process and results. Additionally, problem-solving skills can enhance students' creativity by helping them analyze and synthesize information when seeking solutions to problems. In reality, the results of the 2022 Programme for International Student Assessment (PISA) show that almost no students in Indonesia achieved the highest performance in mathematics; they reached level 5 or 6 in the PISA mathematics test (OECD average: 9%) and ranked 70th in mathematics (PISA,

2022). Additionally, Indonesia ranked 44th out of 49 countries surveyed by the Trends in International Mathematics and Science Survey (TIMSS) in 2015 (TIMSS, 2015). According to interviews with mathematics teachers at schools, students still struggle to solve mathematical problem-solving questions. Undeniably, problem solving is an action or effort undertaken by individuals to find the best solution to a problem (Sutama et al., 2021). They also have difficulty understanding and solving stories with contextual substance. In addition, they incorrectly determine the solution procedure they must follow to solve the problem. Culture-based mathematics learning is an approach that integrates local cultural elements into mathematics learning materials and processes. Suwarsono in (Disnawati & Nahak, 2019) fulfills the two main objectives of ethnomathematics studies: to help students and the community better understand the relationship between mathematics and culture through learning that is adapted to their cultural context. As a result, mathematics is no longer perceived as difficult or even intimidating for students and the broader community. Identity and life guidelines passed down from generation to generation are known as culture. Ethnomathematics demonstrates the relationship between culture and mathematics, clothing, traditions, and physical characteristics (Marsigit & Rahayu, 2018). The Souraja House, also known as Banua Oge or Banua Mbaso, was built by King Palu Jodjokodi around 1892. It is a cultural heritage of the Kaili tribe. This stilt house measures $368\ x^2$ and is made of wood. Since it was built as the center of government, the traditional meeting place of the Kaili tribe, and the residence of the king and his family, the Souraja House may not be inhabited by others.

In this case, the Souraja traditional house (Banua Oge) is a cultural treasure that has great potential as a learning resource in the ethnomathematics approach. The use of the Souraja traditional house in ethnomathematics learning also helps students to appreciate cultural diversity. The use of the Souraja traditional house in mathematics learning, especially in the Pythagorean theorem material. Research conducted by Hariastuti et al. (2019) supports this finding, with results showing that building construction uses mathematical formulas, particularly in two-dimensional geometry, the Pythagorean theorem, and similarity. The Souraja traditional house has a prism-shaped roof, and by observing the shape of the roof, students can visualize the concept of the Pythagorean theorem concretely. Culture-based learning is an important approach to incorporate into the curriculum. Integrating ethnomathematics into mathematics education in schools can help students understand abstract mathematical concepts by connecting them to more tangible and relevant aspects of their lives (Septiani & Yudhi, 2024).

Ethnomathematics-based learning, which is based on a scientific approach, offers an innovative approach that can help students improve their problem-solving skills. Research conducted by Nugroho et al. (2022) revealed that problem-solving skills can be improved through scientific ethnomathematics learning. Ethnomathematics integrates mathematical concepts with local cultures that are familiar to students, such as patterns on traditional fabrics, traditional architecture, or daily community activities. Students can understand mathematics in a more tangible and relevant way by providing a cultural context that is close to them. However, the scientific methodology encourages students to actively participate in learning through observation, questioning, testing, collaboration, and communication. The scientific approach is one method to encourage students to be more active in learning. The scientific approach focuses more on students than on the material, so to improve their mathematical understanding, students can identify concepts, discover, reason, and conclude what they have learned and gained. The scientific approach is a learning approach that allows students to observe, formulate problems, propose hypotheses, collect data in various ways, analyze data, draw conclusions, and share their results (Hosnan, 2014). According to Hosan (Hariyatmi & Septiety, 2020), the scientific approach is a specially designed step to encourage students to actively participate in the learning process through the application of constructs. Lestari (2020) states that the application of the scientific approach in school learning aims to equip students with awareness and understanding of the material. This information can come from anywhere, so do not rely solely on one-way information from the teacher. Therefore, in learning, there must be the development of teaching materials so that students do not feel bored during the learning process. Chandra & Nirwanty (2023) state that one of the objectives of developing innovative teaching materials is to improve the ability of secondary school students to solve mathematical problems so that learning becomes easier for both students and educators.

Method

Development style

This study uses a type of research called research and development (R&D). In line with what Sariani et al. (2017) stated, research and development is carried out to produce goods to be tested for effectiveness. In this study, a one-time pre-experimental trial design was used. In this design, the researcher only administered the treatment once, which was expected to have an effect, before conducting the next posttest. This study utilizes ethnomathematics-based learning tools from the Souraja traditional house and applies a scientific approach focused on problem solving.

Development Procedures

The following table shows the development procedure using the ADDIE method in development research, while the following diagram shows a schematic model of this research development:

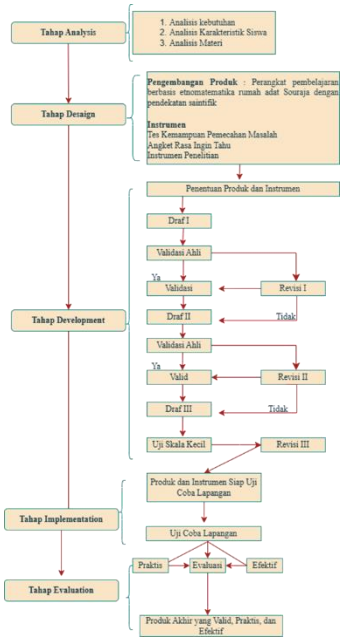


Figure 1 Development Procedure Using the ADDIE Method

Research and Development Research

The subjects in this research and development are 32 students in class VIII.A at MTS Negeri 2 Parigi.

Data Collection Techniques and Instruments

The research data was collected through tests and non-tests, namely expert validation questionnaires, teacher response questionnaires, and problem-solving test questions. The collected data can be averaged using the following formula:

$$\bar{x}_I = \frac{1}{number\ of\ respondents} \times \frac{\sum_{i=1}^{n} x_i}{n}$$

In addition, based on data obtained from validators, teachers, and eighth-grade students, these scores were converted into qualitative scores based on ideal assessment criteria. These ideal assessment criteria are described in Table 1.

Table 1 Ideal Assessment Criteria

Scoring Formula	Criteria
$X > \bar{X}_I + 1{,}8sb_i$	Very Good
$\bar{X}_I + 0{,}6sb_i < X > \bar{X}_I + 1{,}8sb_i$	Good Baik
$\bar{X}_I - 0{,}6sb_i < X > \bar{X}_I + 0{,}6sb_i$	Good Enough
$\bar{X}_I - 1{,}8sb_i < X > \bar{X}_I - 0{,}6sb_i$	Not Good
$X \leq \bar{X}_I - 1{,}8sb_i$	Very Poor

Then, for effectiveness assessment, the learning tool is considered effective if the average student score on the problem-solving test is above 74.9.

Results and Discussion

Early Product Development Results

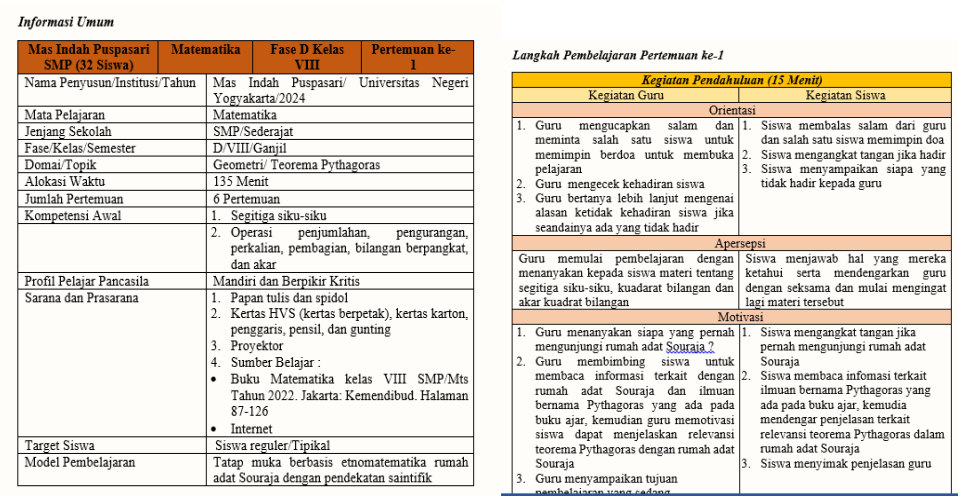
Analysis, Design, Development, Implementation, and Evaluation are the five steps in the development process that align with the ADDIE model. According to Sezer (Rayanto & Sugianti, 2020), the ADDIE model is an approach that emphasizes analyzing how each component interacts with one another in coordination with the existing phases. This is a comprehensive explanation of each step:

1. Analysis Stage

During the analysis stage, researchers conducted a needs analysis, student characteristics analysis, and material analysis. The needs analysis was used to identify student needs during learning. After analysis, the results showed that there was still a lack of learning tools that could facilitate problem-solving skills, so it is hoped that learning tools designed with a scientific and ethnomathematics-based approach will improve students' problem-solving skills. Furthermore, in the student characteristics analysis, which aims to gain a better understanding of the behavior and characteristics of the students who are the subjects of the study, the analysis results show that during learning, many students ignore the teacher's explanations and need help.

2. Design Stage

In this study, the researchers designed learning tools, namely teaching modules and textbooks. The design of the teaching module includes general information such as the Pancasila student profile, facilities and infrastructure, student targets, and the learning model. Meanwhile, the design of the textbook includes several activities tailored to the steps of the scientific approach, such as reading, observing, questioning, analyzing, and experimenting.



Informasi Umum

Mas Indah Puspasari SMP (32 Siswa)	Matematika	Fase D Kelas VIII	Pertemuan ke-1
Nama Penyusun/Institusi/Tahun	Mas Indah Puspasari/ Universitas Negeri Yogyakarta/2024		
Mata Pelajaran	Matematika		
Jenjang Sekolah	SMP/Sederajat		
Fase/Kelas/Semester	D/VIII/Ganjil		
Domai/Topik	Geometri/ Teorema Pythagoras		
Alokasi Waktu	135 Menit		
Jumlah Pertemuan	6 Pertemuan		
Kompetensi Awal	1. Segitiga siku-siku		
	2. Operasi penjumlahan, pengurangan, perkalian, pembagian, bilangan berpangkat, dan akar		
Profil Pelajar Pancasila	Mandiri dan Berpikir Kritis		
Sarana dan Prasarana	1. Papan tulis dan spidol 2. Kertas HVS (kertas berpetak), kertas karton, penggaris, pensil, dan gunting 3. Proyektor 4. Sumber Belajar : • Buku Matematika kelas VIII SMP/Mts Tahun 2022. Jakarta: Kemendibud. Halaman 87-126 • Internet		
Target Siswa	Siswa reguler/Tipikal		
Model Pembelajaran	Tatap muka berbasis etnomatematika rumah adat Souraja dengan pendekatan saintifik		

Langkah Pembelajaran Pertemuan ke-1

Kegiatan Pendahuluan (15 Menit)	
Kegiatan Guru	Kegiatan Siswa
Orientasi	
1. Guru mengucapkan salam dan meminta salah satu siswa untuk memimpin berdoa untuk membuka pelajaran 2. Guru mengecek kehadiran siswa 3. Guru bertanya lebih lanjut mengenai alasan ketidak kehadiran siswa jika seandainya ada yang tidak hadir	1. Siswa membalas salam dari guru dan salah satu siswa memimpin doa 2. Siswa mengangkat tangan jika hadir 3. Siswa menyampaikan siapa yang tidak hadir kepada guru
Apersepsi	
Guru memulai pembelajaran dengan menanyakan kepada siswa materi tentang segitiga siku-siku, kuadarat bilangan dan akar kuadrat bilangan	Siswa menjawab hal yang mereka ketahui serta mendengarkan guru dengan seksama dan mulai mengingat lagi materi tersebut
Motivasi	
1. Guru menanyakan siapa yang pernah mengunjungi rumah adat Souraja ? 2. Guru membimbing siswa untuk membaca informasi terkait dengan rumah adat Souraja dan ilmuan bernama Pythagoras yang ada pada buku ajar, kemudian guru memotivasi siswa dapat menjelaskan relevansi teorema Pythagoras dengan rumah adat Souraja 3. Guru menyampaikan tujuan	1. Siswa mengangkat tangan jika pernah mengunjungi rumah adat Souraja 2. Siswa membaca infomasi terkait ilmuan bernama Pythagoras yang ada pada buku ajar, kemudia mendengar penjelasan terkait relevansi teorema Pythagoras dalam rumah adat Souraja 3. Siswa menyimak penjelasan guru

Figure 2 Teaching Module

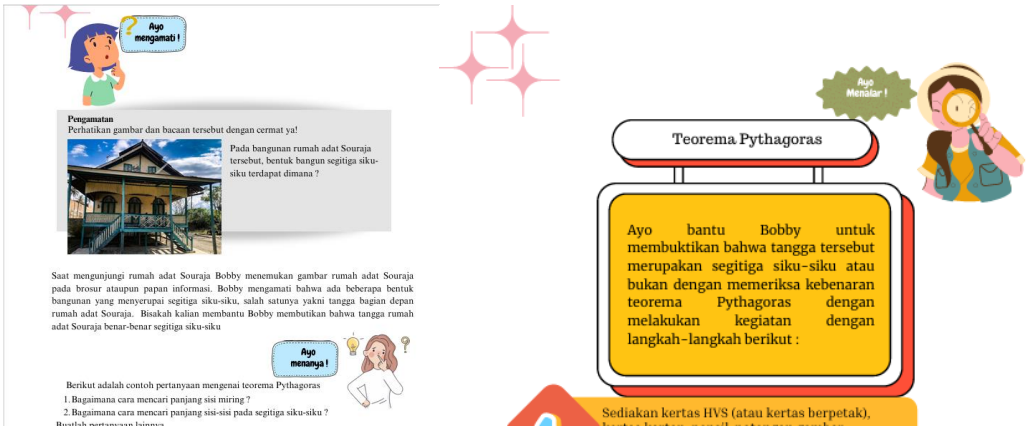


Figure 3 Book Learning

3. Development Stage

At this stage, limited trials were conducted to assess the validity and practicality of the learning tools developed. The following are the results of the analysis at the development stage:

1) Validation

The learning tools that had been designed were then validated by two validators consisting of two mathematics education lecturers. The purpose of expert validation was to determine the suitability of the material, the accuracy of the language, and the sequence of the material.

2) Product Revision

Suggestions or comments regarding ethnomathematics-based learning tools with a scientific approach were used by researchers as guidelines for revising the learning tools developed. The following are the validation results from two experts. The results of the teaching module assessment by validators are presented based on the assessment of each element separately. The following is the overall validity assessment of the teaching module:

Table 2 Validity Assessment of Each Aspect of the Teaching Module

Assessment aspects	Max Score	Score	Percentage	Validity Category
Informasi Umum	10	10	100%	Sangat Baik
Kompetensi Inti	165	128	77,57%	Baik
Lampiran	30	30	100%	Baik

The validator's assessment of the teaching module, when reviewed based on its aspects, concluded that the general information and attachments aspects were 100% valid and categorized as very good, while the core competency aspect was also valid with a percentage of 77.57% and categorized as good. The following are the validator's suggestions for the teaching module, namely regarding the steps that contain problem-solving skills.

Then, the validators examine every aspect of the textbook. The assessment results can be seen in Table 3 below:

Table 3 Assessment of the Validity of Each Aspect of the Textbook

Aspects of assessment	Max Score	Score	Percentage	Validity Category
Truth From a Scientific Perspective	45	36	80%	Good
Compliance with National Education Standards and Applicable Curriculum	5	4	80%	Good
Compliance with Scientific and Technological Developments	10	8	80%	Good
Conformity with Context and Environment	5	4	80%	Good
Unity of the Book's Contents	5	4	80%	Good
Presentation of Book Content in Accordance with Students' Psychological Development and Language Skills	15	12	80%	Good
Appropriate and Communicative Language Use in Accordance with Students' Language Proficiency Levels	5	4	80%	Good
Use of Illustrations	15	12	80%	Good
Page Design	10	8	80%	Good
Graphics	35	28	80%	Good

Overall, and for each aspect of the textbook, it can be concluded that both are valid. The results in the table above show that validator 1 assessed the textbook for each aspect with a percentage of 80% in the good category. Here are some suggestions provided by the validator regarding the textbook.

1) Revise the activities listed in the important information section; add explanations about the activities “let's observe,” “let's ask questions,” “let's read,” “let's analyze,” and “let's try.”

2) Revising the table of contents of the book

Next is the assessment of the validity of the research instrument, namely the problem-solving test. The following are the results of the problem-solving test validity assessment by the validator, presented based on the assessment of each aspect. Table 7 below shows the results of the validator's assessment of each component of the problem-solving test:

Table 4 Penilaian Kevalidan Setiap Aspek Tes Pemecahan Masalah

Assessment aspects	Max Score	Score	Percentage	Validity Category
Construction	25	20	80%	Good
Language	25	20	80%	Good

Based on Table 4, the assessment of each aspect obtained a score of 80%, which is categorized as good, so that the problem-solving test can be considered valid in terms of both the overall aspects and each aspect. The suggestions given by the validator for the problem-solving test are as follows:

1) Provide clearer and easier-to-understand instructions for answering the questions.
2) Clarify the instructions given in question 1 so that there are no conceptual or communication errors when students answer the questions.
3) Make question 2 in line with the problem-solving indicators so that it is easier to measure students' problem-solving abilities.

4. Implementation Stage

After making corrections in accordance with the validator's suggestions, the researcher then conducted product trials to measure the practicality and effectiveness of the developed product. The practicality of the developed learning tools was assessed based on the responses of teachers and students to the teaching materials.

5. Evaluate Stage

The product was evaluated based on the results of problem-solving tests and student curiosity questionnaires.

Analysis of Teacher Assessment Form Data

After the learning process was completed, a questionnaire was filled out to evaluate the ethnomathematics-based learning tools using a scientific approach. Teachers assessed the quality of the learning tools in terms of practicality, namely the teaching modules and textbooks. The practicality assessment of the learning tools is presented in Table 5 below:

Table 5 Results of the Analysis of the Practicality of Each Learning Tool by Teachers

Learning Tools	Max Score	Score	Percentage	Practicality category
Teaching Module	55	48	87,27%	Very Good
Textbook	95	77	81,05%	Good

Based on the results in the table above, teachers assessed each ethnomathematics-based learning tool developed using a scientific approach. The teaching module received a score of 87.37% in the “very good” category, and the textbook received a score of 81.05% in the “good” category. Thus, the learning tools are considered practical for each of the tools in question.

Analysis of Student Assessment Data

After the learning process was completed, the students filled out a response questionnaire. The questionnaire was completed by 32 students in class VIII.B at MTs Negeri 2 Parigi. The practicality assessment of each component of the learning tool is presented in Table 10 below:

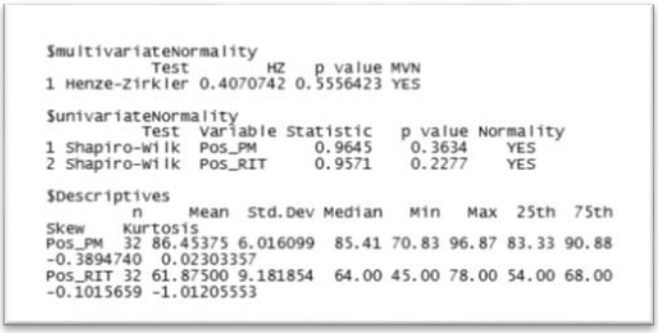
Table 5 Results of the Practicality Analysis of Each Learning Device by Teachers

Aspect	Max Score	Score	Percentage	Practicality Category
Easy-to-understand language in textbooks	256	223	87,10%	Sangat Baik
Ease of language use in textbooks	512	441	86,23%	Sangat Baik
The usefulness of textbooks in understanding the material	512	440	85,93%	Sangat Baik
The usefulness of textbooks for students	512	442	86,32%	Sangat Baik

Table 6 above shows that students responded very well to the textbook on the Pythagorean theorem, which was based on the ethnomathematics of the Souraja traditional house and used a scientific approach in every aspect. Therefore, it can be concluded that the use of well-designed textbooks can be beneficial for learning.

Learning Tools Facilitate Problem-Solving Skills

After the problem-solving test was completed, the results were used to perform normality tests. This was done using R Studio software, using the Henze-Zirkler test for multivariate normality and the Shapiro-Wilk test for univariate normality. The following figure shows the results of the normality tests.



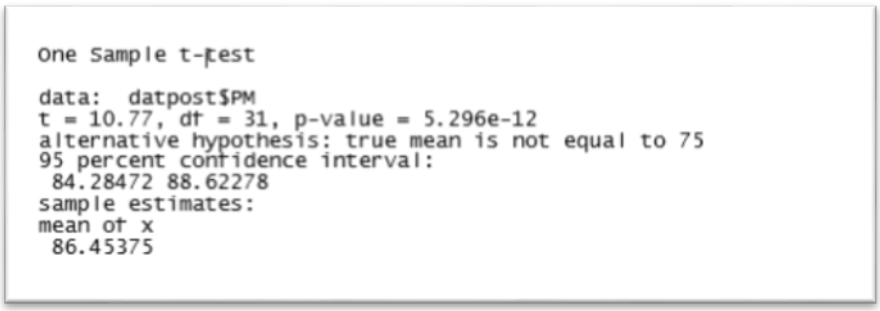
```
$multivariateNormality
           Test       HZ   p value MVN
1 Henze-Zirkler 0.4070742 0.5556423 YES

$univariateNormality
          Test  Variable Statistic   p value Normality
1 Shapiro-Wilk  Pos_PM      0.9645    0.3634    YES
2 Shapiro-Wilk  Pos_RIT     0.9571    0.2277    YES

$Descriptives
         n     Mean  Std.Dev Median   Min   Max  25th  75th
Skew    Kurtosis
Pos_PM  32 86.45375 6.016099  85.41 70.83 96.87 83.33 90.88
-0.3894740  0.02303357
Pos_RIT 32 61.87500 9.181854  64.00 45.00 78.00 54.00 68.00
-0.1015659 -1.01205553
```

Figure 4 Normality Test

Based on the normality test shown in the figure above, it can be concluded that the multivariate normality test results obtained a $p - value = 0.05556$ greater than 0.05, while the univariate normality test results obtained a $p - value = 0.3634$ greater than 0.05. This indicates that the problem-solving test data comes from a population with a normal distribution, and H_0 is accepted. A hypothesis test was then conducted using a one-sample test. At this point, the hypothesis test was conducted to determine whether the developed learning technique has the capacity to improve problem-solving skills. A one-sample t-test was also used to conduct this test with the R Studio program. The following figure shows the results of this test on the problem-solving test data.



```
One Sample t-test

data:  datpost$PM
t = 10.77, df = 31, p-value = 5.296e-12
alternative hypothesis: true mean is not equal to 75
95 percent confidence interval:
 84.28472 88.62278
sample estimates:
mean of x
 86.45375
```

Figure 5 Uji One Sample-t

According to the figure above, the value $\frac{sig(2-tailed}{2} < 0{,}05\ namely\ 0{,}0000 < 0{,}05$,, which means that H_0 is rejected. Thus, it can be concluded that students can acquire better problem-solving skills by using learning tools based on ethnomathematics with a scientific approach.

Conclusion

Meeting the criteria of validity, practicality, and effectiveness, the research findings on the development of ethnomathematics-based learning tools with a scientific approach focused on problem solving. In relation to these criteria, the explanation is as follows:

1. The validation results show that the ethnomathematics-based learning tools with a scientific approach developed in the form of teaching modules obtained an average score from the validators that falls into the "very good" category, while the textbooks developed obtained an average score from the validators that falls into the "good" category.

2. Based on the teacher's assessment of the teaching module, it received a score of 87.27% in the "very good" category and 81.06% for the textbook in the 'good' category. The students' assessment of the practicality of the textbook received a score of 86.27% in the "good" category.

3. The effectiveness of ethnomathematics-based learning tools with a scientific approach has been proven to facilitate problem-solving skills. This can be seen from the average scores obtained in the problem-solving test, which were 86,45375. Furthermore, test results show that the value of $\frac{sig.(2\ tailed)}{2} < 0{,}05$ namely $0{,}0000 < 0{,}05$ so that H_0 is rejected.

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