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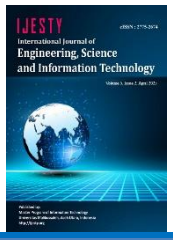

Student Learning Style Decision-Making System Using the Multi-Attribute Utility Theory Method at SMA Negeri 1 Jangka

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Abstract

Education plays a vital role in shaping individual development and national progress. One key factor influencing learning effectiveness is students' learning styles, which determine how individuals absorb, organize, and process information. Understanding these differences is crucial for designing effective teaching methods. This research develops a Decision Support System (DSS) to determine student learning styles at SMA Negeri 1 Jangka using the Multi-Attribute Utility Theory (MAUT) method. MAUT is chosen for its ability to evaluate multiple criteria, convert them into numerical values, and systematically identify the most suitable learning approach. The alternatives in this study include Project Based Learning (PBL), Problem-Based Learning (PrBL), Inquiry-Based Learning (IBL), Discovery Learning (DL), and Contextual Teaching and Learning (CTL). The MAUT analysis considers five criteria: student activeness, material understanding, collaboration, initiative and creativity, and teacher-student communication. The research stages include literature study, data collection, system and database design, MAUT implementation, and system evaluation. The results, based on MAUT calculations, show that Inquiry-Based Learning (IBL) scores the highest at 13.611, followed by Discovery Learning (DL) at 13.018, Problem-Based Learning (PrBL) at 12.975, Contextual Teaching and Learning (CTL) at 12.929, and Project Based Learning (PBL) at 12.558. This system assists educators in designing personalized learning strategies that align with students' strengths. Leveraging data-driven analysis enhances education quality, fosters a student-centred learning environment, and improves academic performance and lifelong learning habits.

Keywords: *Learning Style, Decision Support System, MAUT, Learning, Education.*

1. Introduction

Education plays an essential role in individual development and national progress. One factor influencing learning effectiveness is learning style [1], which differs in each individual. Finding the right learning style influences learning success [2], so students must learn how to achieve learning objectives optimally [3]. However, in Indonesia, challenges in the distribution and quality of education are still obstacles, including applying effective learning methods following student learning styles [4].

To overcome this problem, a decision support system (DSS) is needed to determine the most suitable learning style for students [5]. One method that can be used in SPK is Multi-Attribute Utility Theory (MAUT) [6], which allows decision-making based on the direct evaluation of various criteria [7]. This method converts important factors into numerical values from 0 to 1, which facilitates analyzing and selecting the optimal decision [8].

This research aims to develop a Student Learning Style Decision Making System using the MAUT method at SMA Negeri 1 Jangka. This system is expected to help students recognize their learning styles and support educators in developing learning strategies that are more effective and follow the characteristics of each student.

2. Literature Review

2.1. Data Mining

Information technology development has generated large databases and vast amounts of data in various areas [9]. Multiple researchers have laid forth several definitions of data mining. Some have defined data mining as discovering practical or actionable knowledge in large-scale data [10]. The amount of data in the world and our lives seems ever-increasing, and there's no end to it. We are overwhelmed with data. Today, Computers make it too easy to save things [11]. Data mining is described as sifting massive data sets kept in storage

using pattern recognition techniques such as statistical and mathematical approaches to discover new relevant correlations, patterns, and trends [12]. A recommendation system is an intelligent system that uses data mining and machine learning techniques to provide personalized recommendations based on user behaviour and preferences. The basic principles of recommendation systems include data collection, feature extraction, model training and prediction, and generating recommendation results[13].

2.2. Decision Support System

Decision-Making System (SDM) is part of a computer-based information system designed to assist decision-making [5]. SPK presents valuable information that helps decision-makers choose the best alternative based on several predetermined criteria [14]. This system helps solve complex problems by providing data-based analysis and specific models [15]. Decision-making systems consist of several main components, namely:

1. Database Management Subsystem, which functions to manage and store data used in decision-making.
2. The model Management Subsystem is used to apply mathematical models to data processing.
3. Software System/User Interface Subsystem enables interaction between the user and the system.
4. The Knowledge Component contains rule-based or experience-based knowledge that can improve the system's effectiveness.

2.3. Multi-Attribute Utility Theory

Multi-Attribute Utility Theory (MAUT) is one of the methods used in decision support systems to evaluate various alternatives based on several predetermined attributes or criteria [16]. This method converts various interests into numerical values with a scale of 0-1, where zero is the worst and one is the best [7].

The evaluation process with the MAUT method includes the following steps:

1. Create a decision framework by defining the problem.
2. Generate alternatives that may be able to solve the problem.
3. List all aspects that affect the decision.
4. Give weight to each element. The weight should reflect how important these aspects are to the problem.
5. Also, give the weight of the alternatives. For each alternative, determine how satisfactory it is against each element.
6. Process the evaluation of each alternative on the existing aspects to get a decision. For the calculation, the formula is used:

$$Vx = \sum_{i=1}^{n} W_i X_{i\ j} \quad \text{.....(1)}$$

Definition:

= Overall Assessment of the xth alternative
= Relative weight of i criterion
vi (x) = Assessment of the results of the i criterion for the x alternative
i = Index to indicate criteria n = number of criteria
n = Number of elements.

$$\sum_{i=1}^{n} W_i = 1 \quad \text{..... (2)}$$

Definition:

$wi`$ = Relative weight of I criterion
i = index to indicate criteria
n = Number of criteria

$$U(X) = \frac{x - xi -}{xi + - xi -} \quad \text{..... (3)}$$

Definition:

Calculating the normalized Utility value matrix for each alternative according to its attributes.
(x) = The utility value of each criterion of the x alternative
x = Criteria assessment of each x alternative
xi - = The lowest score of the i criterion across all alternatives
xi + = The highest score of the i criterion across all alternatives

2.4. Student Learning Style

Learning style is how individuals absorb, organize, and process the information received [17]. A person's learning style affects the effectiveness of the learning process and the achievement of learning outcomes [8]. In this study, there are five alternative learning methods analyzed, namely:

1. Project-Based Learning (PBL): A project-based learning model emphasizing in-depth topic exploration.
2. Problem-based Learning (PBL) is a method that uses real cases as learning materials to improve students' analytical skills.
3. Inquiry-based Learning (IBL) is an approach that involves students in the process of investigation and discovery.
4. Discovery Learning (DL): A method that encourages students to discover learning concepts independently.
5. Contextual Teaching and Learning (CTL): Real-life context-based learning to enhance student understanding

3. Research Method

Data collection in this study was conducted through two main sources, namely primary data and secondary data. Primary data was obtained through direct observation and interviews with teachers and students at SMA Negeri 1 Jangka to identify factors influencing learning styles, such as student activeness, material understanding, collaboration skills, creativity, and teacher communication. Meanwhile,

secondary data was obtained from relevant journals, books, and previous research as the theoretical basis for this research. Furthermore, system design uses the Unified Modeling Language (UML) to describe the system workflow systematically, and database design uses MySQL Workbench to store student information, criteria, and evaluation results. Implementing the Multi-Attribute Utility Theory (MAUT) method in this system involves several stages, from determining criteria and weights, matrix normalization, calculating utility values, and ranking alternative learning styles[18]. The results of the MAUT calculation are displayed as a report that provides recommendations for the most suitable learning style for students based on predetermined criteria[19]. Thus, this system is expected to be a tool in decision-making to determine a more effective learning method at SMA Negeri 1 Jangka.

4. Results and Discussion

This section describes the research results and provides further explanation of the study. To give a more precise understanding, the research results will be explained in more detail in the following sub-section

4.1. Multi-Attribute Utility Theory (MAUT) Method Calculation

The following is the initial data from determining the learning styles of students at SMA Negeri 1 Jangka:

1. Determine criteria and criteria weights

Table 1. Criteria and Criteria Weight of MAUT Method

No	Code	Criteria Name	Weight
1.	C1	Student Activity	0,15
2.	C2	Student Comprehension	0,35
3.	C3	Collaboration and Teamwork Skills	0,15
4.	C4	Initiative and Creativity	0,5
5.	C5	Teacher-to-Student Communication	0,15
		Total	1

To explain the calculation of the MAUT algorithm, the author uses mathematics subjects with two discussion topics, namely trigonometry and quadratic equations. The abbreviated terms in the model column in the table that will be presented next are as follows:
PBL: Problem-Based Learning
PJBL: Project Based Learning
IBL: Inquiry-Based Learning
DL: Discovery Learning
CTL: Contextual Learning

2. Alternative Data
The following is alternative data from each class that will be calculated.

Table 2. Math score on trigonometry topic for class 1A

Name	Topic	Model	C1	C2	C3	C4	C5
Amran Wali	Trigonometry	PBL	80	78	100	77	96
Arinal Khaira	Trigonometry	PBL	93	76	93	100	84
Azril Ilham	Trigonometry	PBL	81	74	77	78	84
….	….	….	….	….	….	….	….
Salman Alfarisi	Trigonometers	PBL	74	76	88	97	74

Table 3. Mathematics Score of Quadratic Equation Topic Class 1A

Name	Topic	Model	C1	C2	C3	C4	C5
Amran Wali	Quadratic Equation	IBL	70	100	98	70	78
Arinal Khaira	Quadratic Equation	IBL	70	91	91	85	84
Azril Ilham	Quadratic Equation	IBL	87	99	71	79	82
….	….	….	….	….	….	….	….
Salman Alfarisi	Quadratic Equation	IBL	74	76	88	97	74

Table 4. Grade 1B Trigonometry Topic Math Score

Name	Topic	Model	C1	C2	C3	C4	C5
Amelia Putri	Trigonometers	DL	86	87	82	77	97
Aura Humaira	Trigonometers	DL	83	97	96	70	81
Badratun Nafis	Trigonometers	DL	82	93	96	84	80
….	….	….	….	….	….	….	….
Saski	Trigonometers	DL	80	84	80	94	89

Table 5. Grade 1B Trigonometry Topic Math Score

Name	Topic	Model	C1	C2	C3	C4	C5
Amelia Putri	Quadratic Equation	PBL	98	70	78	87	80
Aura Humaira	Quadratic Equation	PBL	91	85	84	99	80
Badratun Nafis	Quadratic Equation	PBL	71	79	82	82	96
….	….	….	….	….	….	….	….
Saski	Quadratic Equation	PBL	78	87	98	88	79

Table 6. Math score of Trigonometry Topic Class 2A

Name	Topic	Model	C1	C2	C3	C4	C5
Askiya Ulhaqqi	Trigonometers	PJBL	71	80	96	100	84
Eza Saputra	Trigonometers	PJBL	96	73	92	71	91
Fadhlur Rahman	Trigonometers	PJBL	83	77	77	72	97
	….	….	….	….	….	….	….
Yusmandar	Trigonometers	PJBL	96	77	92	70	99

Table 7. Mathematics score of Quadratic Equation Topic Class 2A

Name	Topic	Model	C1	C2	C3	C4	C5
Askiya Ulhaqqi	Quadratic Equation	CTL	100	84	88	98	97
Eza Saputra	Quadratic Equation	CTL	71	91	93	72	100
Fadhlur Rahman	Quadratic Equation	CTL	72	97	82	83	82
	….	….	….	….	….	….	….
Yusmandar	Quadratic Equation	CTL	74	76	88	97	74

Table 8. Grade 2B Trigonometry Topic Math Score

Name	Topic	Model	C1	C2	C3	C4	C5
Ahmad Thairan Ababil	Trigonometry	CTL	92	74	72	71	78
Ajirna	Trigonometry	CTL	100	100	100	70	78
Akramul Ikram	Trigonometry	CTL	94	75	77	92	84
	….	….	….	….	….	….	….
Zulfakar	Trigonometers	CTL	77	85	98	79	82

Table 9. Mathematics score of Quadratic Equation Topic Class 2B

Name	Topic	Model	C1	C2	C3	C4	C5
Ahmad Thairan Ababil	Quadratic Equation	PJBL	97	89	88	79	74
Ajirna	Quadratic Equation	PJBL	92	79	82	87	97
Akramul Ikram	Quadratic Equation	PJBL	98	91	73	81	99
	….	….	….	….	….	….	….
Zulfakar	Quadratic Equation	PJBL	74	76	88	97	74

3. Convert matrix values to decimal.
   Suppose Amran Wali, a student in class 1A, has a math score on trigonometry with a student engagement score of 80. Then, multiply the score by 0.01 to convert the score to decimal form. This is applied to all grades.
4. Find the minimum and maximum values of each criterion for normalization purposes.

Table 10. Min and Max Score of Math Trigonometry Topic 1A

Description	C1	C2	C3	C4	C5
xi -	0.73	0.71	0.7	0.7	0.7
xi +	0.97	0.96	1	1	1

Table 11. Min and Max Score of Mathematics Topic Quadratic Equation 1A

Description	C1	C2	C3	C4	C5
xi -	0.7	0.73	0.7	0.7	0.74
xi +	1	1	0.98	1	1

Table 12. Min and Max Score of Math Trigonometry Topic 1B

Description	C1	C2	C3	C4	C5
xi -	0.76	0.7	0.72	0.7	0.7
xi +	0.98	1	1	0.99	1

Table 13. Min and Max Score of Mathematics Topic Quadratic Equation 1B

Description	C1	C2	C3	C4	C5
xi -	0.7	0.7	0.74	0.7	0.72
xi +	0.98	1	1	0.99	1

Table 14. Min and Max Score of Math Trigonometry Topic 2A

Description	C1	C2	C3	C4	C5
xi -	0.71	0.7	0.7	0.7	0.7
xi +	1	0.99	1	1	0.99

Table 15. Min and Max Score of Mathematics Quadratic Equation Topic **2A**

Description	C1	C2	C3	C4	C5
xi -	0.7	0.7	0.7	0.71	0.7
xi +	1	0.99	0.98	0.99	1

Table 16. Min and Max Score of Math Topic Trigonometry 2B

Description	C1	C2	C3	C4	C5
xi -	0.72	0.7	0.7	0.7	0.71
xi +	1	1	1	0.98	0.99

Table 17. Min and Max Score of Mathematics Quadratic Equation Topic 2B

Description	C1	C2	C3	C4	C5
xi -	0.7	0.71	0.7	0.7	0.71
xi +	0.98	1	1	0.97	1

5. Calculate the normalized utility of each value.
   The following is an example of utility normalization calculation using class 1A students of Mathematics subject on the topic of Trigonometry.

6. Calculating the multiplication of weight values with normalized values.
   After obtaining the normalized values of each alternative criterion, the next is to multiply the normalized value by the weight value of each criterion.

Alternative A1: Amran Wali
C1 = 0.291 0.30 = 0.437
C2 = 0.833 0.35 = 0.098
C3 = 1 0.15 = 0.15
C4 = 0.233 0.2 = 0.046
C5 = 0.866 0.15 = 0.13
Total = 0.437 + 0.098 + 0.15 + 0.046 + 0.13 = 0.468

The overall results of the MAUT algorithm calculation for math subjects can be seen in the following table:

Table 18. MAUT Algorithm Results for Quadratic Equation Topic Class 1A

Alternative	C1	C2	C3	C4	C5	Total
A1	0.04375	0.098	0.15	0.046667	0.13	0.468417
A2	0.125	0.07	0.115	0.2	0.07	0.58
A3	0.05	0.042	0.035	0.053333	0.07	0.250333
…	…	…	…	…	…	…
A27	0.00625	0.07	0.09	0.18	0.02	0.36625
Total Average:						12.96225

Table 19. MAUT Algorithm Results for Quadratic Equation Topic Class 1A

Alternative	C1	C2	C3	C4	C5	Total
A1	0	0.35	0.15	0	0.023077	0.523077
A2	0	0.233333	0.1125	0.1	0.057692	0.503526
A3	0.085	0.337037	0.005357	0.06	0.046154	0.533548
…	…	…	…	…	…	…
A27	0.02	0.038889	0.096429	0.18	0	0.335317
Total Average:						13.61094

Table 20. MAUT Algorithm Results Trigonometry Topic Class 1B

Alternative	C1	C2	C3	C4	C5	Total
A1	0.068182	0.198333	0.053571	0.048276	0.135	0.503362
A2	0.047727	0.315	0.128571	0	0.055	0.546299
A3	0.040909	0.268333	0.128571	0.096552	0.05	0.584366
…	…	…	…	…	…	…
A26	0.027273	0.163333	0.042857	0.165517	0.095	0.49398
Total Average:						13.01807

Table 21. MAUT Algorithm Results for Quadratic Equation Topic Class 1B

Alternative	C1	C2	C3	C4	C5	
A1	0.15	0	0.023077	0.117241	0.042857	0.333175
A2	0.1125	0.175	0.057692	0.2	0.042857	
A3	0.005357	0.105	0.046154	0.082759	0.128571	0.367841
…	…	…	…	…	…	…
A26	0.042857	0.198333	0.138462	0.124138	0.0375	
Total Average:						12.98732

Table 22. MAUT Algorithm Results Trigonometry Topic Class 2A

Alternative	C1	C2	C3	C4	C5	Total
A1	0.15	0.168966	0.09	0.186667	0.139655	0.735287
A2	0	0.253448	0.115	0.013333	0.155172	
A3	0.005172	0.325862	0.06	0.086667	0.062069	0.53977
…	…	…	…	…	…	…
A21	-0.00517	0.35	0.01	0.1	0.139655	
Total Average:						10.67529

Table 23. MAUT Algorithm Results for Quadratic Equation Topic Class 2A

Alternative	C1	C2	C3	C4	C5	
A1	0.15	0	0.023077	0.117241	0.042857	0.333175
A2	0.1125	0.175	0.057692	0.2	0.042857	
A3	0.005357	0.105	0.046154	0.082759	0.128571	0.367841
…	…	…	…	…	…	…
A26	0.042857	0.198333	0.138462	0.124138	0.0375	
Total Average:						11.74144

Table 24. MAUT Algorithm Results Trigonometry Topic Class 2B

Alternative	C1	C2	C3	C4	C5	Total
A1	0.107143	0.046667	0.01	0.007143	0.0375	0.208452
A2	0.15	0.35	0.15	0	0.0375	0.6875
A3	0.117857	0.058333	0.035	0.157143	0.069643	0.437976
…	…	…	…	…	…	…
A27	0.026786	0.175	0.14	0.064286	0.058929	0.465
Total Average:						14.00405

Table 25. MAUT Algorithm Results for Quadratic Equation Topic Class 2B

Alternative	C1	C2	C3	C4	C5	Total
A1	0.005357	0.132759	0.06	0.133333	0.134483	
A2	0.032143	0.253448	0.09	0.074074	0.015517	0.465182
A3	0	0.108621	0.135	0.118519	0.005172	
…	…	…	…	…	…	…
A27	0.042857	0.048276	0.05	0.037037	0.087931	
Total Average:						12.56005

After getting all the total average scores from math subjects with various topics and learning models, the following table will be produced:

Table 26. Average Total Score of Each Class with Math Subjects

Class	Subject	Topic	Metode	Average
1A	Mtk	Trigonometry		12.96225
1A	Mtk	Quadratic Equation		13.61094017
1B	Mtk	Trigonometers		13.01806986
1B	Mtk	Quadratic Equation		12.98732222
2A	Mtk	Trigonometers	PJBL	10.67528736
2A	Mtk	Quadratic Equation	CTL	11.74143678
2B	Mtk	Trigonometers		14.00404762
2B	Mtk	Quadratic Equation	PJBL	12.560052

The following are the ranking results based on the average score.

Table 27. Ranking Results of Learning Models in Mathematics Lessons

Metode	Average	Rank
PBL	12.97479	3
IBL	13.61094	1
DL	13.01807	2
PJBL	11.61767	5
CTL	12.87274	4

It can be seen that the highest average value of each learning method is the IBL (Inquiry-Based Learning) method. This learning method is the most effective method for students in mathematics lessons.

4.2. System Implementation Results

System implementation is the application or integration of a design into a system that can be operated [20]. This process involves various steps to verify that the new system can run properly and meet user needs with the right objectives.

1. Dashboard display

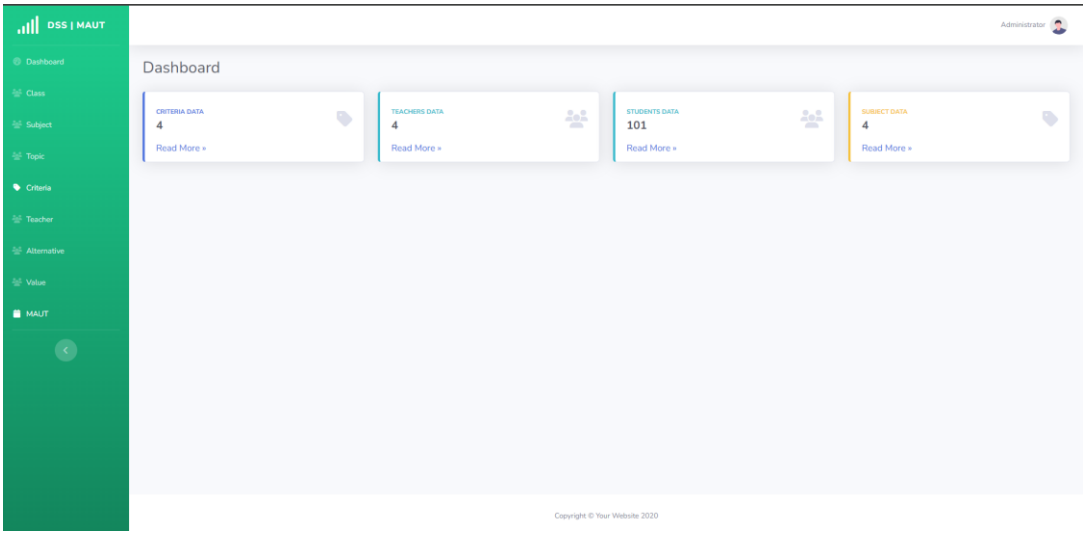

Fig 1. Dashboard page (Indonesia)

This view is the main page/dashboard that the admin can see after logging into the system.

2. MAUT Calculation result display

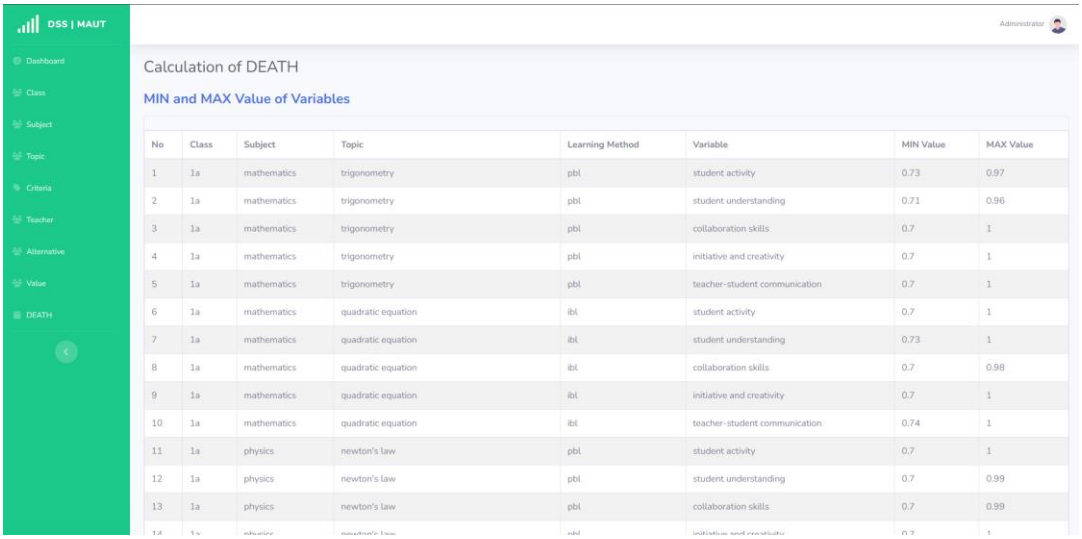

Fig 2. MAUT calculation page (Indonesia)

When the admin opens this page, MAUT will be calculated immediately. This page contains MIN and MAX calculation data for each criterion, normalized values, utility values and utility multiplication with criterion weights.

5. Conclusion

Based on the results of the research that has been conducted, this study produces a web-based decision support system designed to assist in determining the learning styles of students at SMA Negeri 1 Jangka. This system uses the Multi-Attribute Utility Theory (MAUT) method, which can evaluate and rank based on the highest utility value of various alternative learning styles available. The system functions by processing student data through several predetermined criteria, such as students' level of understanding, learning preferences, and the effectiveness of previously applied methods. After processing the data, the system will provide learning style recommendations through rankings based on the highest utility value. Thus, teachers can have a more objective reference in determining each student's most suitable learning approach. Based on this system's calculations, the Inquiry-Based Learning method obtained the highest utility value of 13,611, making it the most appropriate learning method for math subjects. Inquiry-based learning is an approach that emphasizes exploration, questioning, and active investigation by students to understand the concepts being taught, making it suitable for improving conceptual and applied mathematics understanding

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