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Decision Support System for Determining Effective Learning Strategies for Students Using the SMART Method

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ABSTRACT

Effective learning strategies are essential factors in improving students' academic achievement. However, at SMP Negeri 2 Binjai, several challenges remain, including the low effectiveness of applied learning methods, the lack of adaptation to individual learning styles, and the limited use of academic data in supporting learning decisions. These issues were further exacerbated by the post-pandemic shift toward hybrid learning models, which has not been fully optimized. To address this problem, this study designed a Decision Support System (DSS) using the SMART (Simple Multi-Attribute Rating Technique) method to recommend suitable learning strategies for students. The system was developed through stages of requirement analysis, logical design of the SMART calculation, and the implementation of integrated multi-criteria processing. The results show that the system can provide objective and accurate learning strategy recommendations. From 32 students analyzed, 11 students (34.37%) were recommended to adopt E-learning, 7 students (21.87%) to use Blended Learning, and 14 students (43.75%) to apply Traditional Learning. The highest score of 1.00 was achieved by two students in the E-learning category, while the lowest score of 0.125 was recorded in the Traditional category. These findings confirm that the application of the SMART method in DSS is effective in helping teachers and students determine more adaptive and personalized learning strategies, thereby supporting the improvement of learning quality in schools.

INTRODUCTION

Effective learning strategies are one of the determining factors in achieving students' academic achievements. However, in practice, many students have difficulty in choosing a learning strategy that suits their individual characteristics and needs. This also happened at SMP Negeri 2 Binjai, where a number of problems were found related to the low effectiveness of the learning methods applied, both by teachers and students.

Some indicators that reflect this condition include low academic achievement in several subjects, as well as learning methods that are monotonous and have not been adjusted to students' learning styles such as visual, auditory, and kinesthetic. In addition, students' learning motivation shows fluctuations, especially after the pandemic which led to a shift in learning methods towards a hybrid model. Adaptation to this new learning system has not been fully optimal, so many students have difficulty adjusting.

This problem is exacerbated by the lack of tools or systems that can help teachers and students identify the most appropriate learning strategies. Although data on students' learning styles, academic grades, and learning habits are available, the use of these data to support learning decision-making is still very minimal. Educational technology in the school environment is generally only used for e-learning purposes and has not touched the implementation of a more personalized and adaptive decision support system (SPK).

According to (Gunawan et.al., (2019)), Decision Support Systems have been proven to be effective in supporting decision-making in the field of education, including in the selection of appropriate learning methods. This systematic support makes it easy to analyze various alternative options based on relevant criteria. Furthermore, (Suryana et al., (2021)) stated that the SMART (Simple Multi-Attribute Rating Technique) method has proven to be effective in evaluating learning criteria and providing more measurable recommendations. This approach is able to rank learning strategies objectively based on a number of attributes such as learning style, motivation, and environmental conditions.

In addition, Prasetyo & Wijaya (2020) stated that a learning recommendation system based on Multi-

Criteria Decision Analysis (MCDA), such as the SMART method, is able to increase student learning effectiveness by adjusting the learning approach to the individual characteristics of each student. This is in line with the trend of personalized learning which is the main focus in modern education.

METHOD

To complete a research, of course, a set of stages is needed to obtain the desired research results. Good research results certainly have a good process of stages. The process of stages in the research to build a decision system support system in determining effective learning strategies for students uses the *Simple Multi Attribute Rating Technique* (SMART) method.

The expected result of the research to be carried out is the construction of a system that can make a decision in determining an effective learning strategy for students at SMP Negeri 2 Binjai.

1. Problem Formulation
   Determining the problems faced when conducting research at SMP Negeri 2 Binjai, namely analyzing what problems are happening and what are needed by SMP Negeri 2 Binjai.
2. Goal Setting
   Determine the goals to be carried out, namely building a system that can be used to determine effective learning strategies for students.
3. Study Literature
   Conduct a search for resources related to information technology. Resources can be obtained from books, *e-books*, articles, journals or the internet that can help in finding materials related to those methods and research.
4. Data Collection
   Data collection is carried out by conducting observations or direct interviews to SMP Negeri 2 Binjai to teachers to obtain the needed data. The data obtained are data in accordance with predetermined criteria such as learning style, learning motivation, learning environment and academic ability.
5. Interface design
   It is carried out to determine the flow of the system to be built and facilitate communication between users and the system when used.
6. System implementation
   It is the implementation stage of all the stages that have been carried out, namely building a decision support system in determining effective learning strategies for students at SMP Negeri 2 Binjai.
7. System testing
   Testing is carried out to ensure that the system that has been designed is completely in accordance with the results of the analysis of the application of the SMART method that was previously done manually. This stage aims to assess whether the developed system is functioning as it should. If the system is suitable, it can be operated immediately. However, if there are still discrepancies or deficiencies, it is necessary to check and repair them until the system produces outputs that are in accordance with expectations.

The data collection process in this study was carried out through two main sources. First, data is obtained from various references on the internet that provide information related to information technology. Second, data was collected through direct observation at SMP Negeri 2 Binjai by conducting interviews with grade VIII teachers.

The process design in this study serves to understand the flow of application creation and the stages in building the system. System design itself can be interpreted as the activity of drawing, planning, and sketching the system to be developed. As a tool, the Unified Modeling Language (UML) is used to visualize the design in a structured manner. In this study, there are three types of diagrams used, namely use case diagrams, activity diagrams, and class diagrams, each of which provides an overview of the design of the system to be built.

RESULTS AND DISCUSSION

The data obtained in the research at SMP Negeri 2 Binjai are as shown in the table below.

Table 1. Student Assessment Data

No	Student Name	Learning Style	Learning Motivation	Learning Environment	Academic Ability
1	Adriel Daffinta Tarigan	Visual	Moderate	Conducive	Good
2	Agatha Zefanya Br Simbolon	Auditory	High	Conducive	Very Good
3	Alethea Kinata L Br Kaban	Kinesthetic	High	Conducive	Good
4	Andini Putri	Auditory	Moderate	Conducive	Good
5	Adrianto Fransiskus Sbln	Visual	Low	Not Conducive	Good
6	Anugrah Rizqi Mizwar	Auditory	Low	Conducive	Good
7	Baginda Emir Elfawwaz Srg	Visual	Moderate	Conducive	Good
8	Celino Bryan Okta Sianturi	Kinesthetic	Moderate	Conducive	Good
9	Dzaky Almer Jamil	Visual	Moderate	Not Conducive	Poor
10	Fadilah Ramadhani	Auditory	Moderate	Conducive	Good
11	Fadilla Ayu	Kinesthetic	High	Conducive	Very Good
12	Fathan Tanjaya	Auditory	High	Conducive	Very Good
13	Jean Zevanya Aquila Br Gntg	Visual	Moderate	Conducive	Good
14	Jiovani Andin Permata	Auditory	Moderate	Not Conducive	Poor
15	Kenzie Zhafif Arrasyid LB	Visual	Moderate	Conducive	Good
16	Loren Piero Sigiro	Auditory	High	Not Conducive	Good
17	M Rafi Fahrezi	Auditory	Moderate	Conducive	Good
18	Marko Joel Kristian Surbakti	Kinesthetic	Low	Conducive	Good
19	Muhammad Fadhilah Nst	Visual	Moderate	Conducive	Good
20	Muhammad Farhan Batubara	Auditory	High	Conducive	Very Good

To select the best learning strategy, several decision-making criteria are required.

Table 2. Criteria Data

Code	Criteria
C01	Learning Style
C02	Learning Motivation
C03	Learning Environment
C04	Academic Ability

Table 3. Subcriteria Values for Learning Style Criterion

No	Subcriteria Name	Description	Value
1	Visual	Through visual means such as images, graphics, and written texts	1
2	Auditory	Through hearing, such as lectures, discussions, and music	2
3	Kinesthetic	Through movement and direct experience, such as practice, experiments, and simulations	3

Table 4. Subcriteria Values for Learning Motivation Criterion

No	Subcriteria Name	Value
1	Low	1
2	Moderate	2
3	High	3

Table 5. Subcriteria Values for Learning Environment Criterion

No	Subcriteria Name	Value
1	Not Conducive	1
2	Conducive	2

Table 6. Subcriteria Values for Academic Ability Criterion

No	Description	Value
1	Poor	1
2	Good	2
3	Very Good	3

The above values were obtained from teacher evaluations of students at SMP Negeri 2 Binjai.

Table 7. Alternative Score Data

No	Alternative	C01	C02	C03	C04
1	SW-01	1	2	2	2
2	SW-02	2	3	2	1
3	SW-03	3	3	2	2
4	SW-04	2	2	2	2
5	SW-05	1	1	1	2
6	SW-06	2	1	2	2
7	SW-07	1	2	2	2
8	SW-08	3	2	2	2
9	SW-09	1	2	1	3
10	SW-10	2	2	2	2
11	SW-11	3	3	2	1
12	SW-12	2	3	2	1
13	SW-13	1	2	2	2
14	SW-14	2	2	1	3
15	SW-15	1	2	2	2
16	SW-16	2	3	1	2
17	SW-17	2	2	2	2
18	SW-18	3	1	2	2
19	SW-19	1	2	2	2
20	SW-20	2	3	2	1

Assigning weights to the criteria is done using values ranging from 1 to 100, based on the level of importance of each criterion.

Table 8. Criteria Weight Values

Code	Criteria	Criteria Weight (w_i')
C01	Learning Style	30%
C02	Learning Motivation	25%
C03	Learning Environment	20%
C04	Academic Ability	25%

The normalization of criteria weights is calculated by dividing each weight value by the total sum of all weights. The normalized criteria weights are as follows:

Table 9. Normalized Criteria Weights

Code	Criteria	Criteria Weight (w_i')	Normalized Criteria Weight (w_i)
C01	Learning Style	30%	0,30
C02	Learning Motivation	25%	0,25
C03	Learning Environment	20%	0,20
C04	Academic Ability	25%	0,25
Total		**100%**	**1.00**

Determining the utility value depends on the nature of each criterion. The type of each criterion in this case study is shown below:

Table 10. Utility Values

Code	Criteria	Criterion Type
C01	Learning Style	Benefit
C02	Learning Motivation	Benefit
C03	Learning Environment	Benefit
C04	Academic Ability	Benefit

To calculate the utility values of the criteria, the maximum (Cmax) and minimum (Cmin) values for each criterion must first be identified. The Cmax and Cmin values for each criterion are shown in the following table:

Table 11. Cmax and Cmin Values for Each Criterion

No	Alternative	C01	C02	C03	C04
1	SW-01	1	2	2	2
2	SW-02	2	3	2	1
3	SW-03	3	3	2	2
4	SW-04	2	2	2	2
5	SW-05	1	1	1	2
6	SW-06	2	1	2	2
7	SW-07	1	2	2	2
8	SW-08	3	2	2	2
9	SW-09	1	2	1	3
10	SW-10	2	2	2	2
11	SW-11	3	3	2	1
12	SW-12	2	3	2	1
13	SW-13	1	2	2	2
14	SW-14	2	2	1	3
15	SW-15	1	2	2	2
16	SW-16	2	3	1	2
17	SW-17	2	2	2	2
18	SW-18	3	1	2	2
19	SW-19	1	2	2	2
20	SW-20	2	3	2	1
	Cmax	**3**	**3**	**2**	**3**
	Cmin	**1**	**1**	**1**	**1**

After determining the Cmax and Cmin values, the next step is to calculate the utility value for each criterion.

Table 12. Results of Utility Value Calculation

No	Alternative	C01	C02	C03	C04
1	SW-01	0	0,5	1	0,5
2	SW-02	0,5	1	1	1
3	SW-03	1	1,0	1	0,5
4	SW-04	0,5	0,5	1	0,5
5	SW-05	0	0,0	0	0,5
6	SW-06	0,5	0,0	1	0,5
7	SW-07	0	0,5	1	0,5

No	Alternative	C01	C02	C03	C04
8	SW-08	1	0,5	1	0,5
9	SW-09	0	0,5	0	0
10	SW-10	0,5	0,5	1	0,5
11	SW-11	1	1	1	1
12	SW-12	0,5	1	1	1
13	SW-13	0	0,5	1	0,5
14	SW-14	0,5	0,5	0	0
15	SW-15	0	0,5	1	0,5
16	SW-16	0,5	1	0	0,5
17	SW-17	0,5	0,5	1	0,5
18	SW-18	1	0	1	0,5
19	SW-19	0	0,5	1	0,5
20	SW-20	0,5	1	1	1

After calculating the utility values for each criterion and alternative, the next step is to compute the final score in order to determine the most effective learning strategy for students at SMP Negeri 2 Binjai based on the data that has been provided.

SW-01 = ((0 *0,30) + (0,5 *0,25) + (1 *0,20) + (0,5 *0,25)) = 0,45
SW-02 = ((0,5 *0,30) + (1 *0,25) + (1 *0,20) + (1 *0,25)) = 0,85
SW-03 = ((1 *0,30) + (1 *0,25) + (1 *0,20) + (0,5 *0,25)) = 0,875
SW-04 = ((0,5 *0,30) + (0,5 *0,25) + (1 *0,20) + (0,5 *0,25)) = 0,60
SW-05 = ((0 *0,30) + (0 *0,25) + (0 *0,20) + (0,5 *0,25)) = 0,125
SW-06 = ((0,5 *0,30) + (0 *0,25) + (1 *0,20) + (0,5 *0,25)) = 0,475
SW-07 = ((0 *0,30) + (0,5 *0,25) + (1 *0,20) + (0,5 *0,25)) = 0,45
SW-08 = ((1 *0,30) + (0,5 *0,25) + (1 *0,20) + (0,5 *0,25)) = 0,75
SW-09 = ((0 *0,30) + (0,5 *0,25) + (0 *0,20) + (0 *0,25)) = 0,125
SW-10 = ((0,5 *0,30) + (0,5 *0,25) + (1 *0,20) + (0,5 *0,25)) = 0,60
SW-11 = ((1 *0,30) + (1 *0,25) + (1 *0,20) + (1 *0,25)) = 1
SW-12 = ((0,5 *0,30) + (1 *0,25) + (1 *0,20) + (1 *0,25)) = 0,85
SW-13 = ((0 *0,30) + (0,5 *0,25) + (1 *0,20) + (0,5 *0,25)) = 0,45
SW-14 = ((0,5 *0,30) + (0,5 *0,25) + (0 *0,20) + (0 *0,25)) = 0,275
SW-15 = ((0 *0,30) + (0,5 *0,25) + (1 *0,20) + (0,5 *0,25)) = 0,45
SW-16 = ((0,5 *0,30) + (1 *0,25) + (0 *0,20) + (0,5 *0,25)) = 0,525
SW-17 = ((0,5 *0,30) + (0,5 *0,25) + (1 *0,20) + (0,5 *0,25)) = 0,60
SW-18 = ((1 *0,30) + (0 *0,25) + (1 *0,20) + (0,5 *0,25)) = 0,625
SW-19 = ((0 *0,30) + (0,5 *0,25) + (1 *0,20) + (0,5 *0,25)) = 0,45
SW-20 = ((0,5 *0,30) + (1 *0,25) + (1 *0,20) + (1 *0,25)) = 0,85

Based on the final score calculation above, a decision can be made in determining the most effective learning strategy for students at SMP Negeri 2 Binjai by referring to the criteria outlined in the table below.

Table 13. Learning Strategy Decision Value

No	Analysis Score Range	Learning Strategy	Description
1	≥ 0.75 – 1.00	E-learning	A highly efficient learning strategy with a very high level of relevance. Students can learn without being limited by time and location.
2	0.50 – 0.74	Blended Learning	This learning strategy is a combination of e-learning and traditional approaches. It utilizes available electronic facilities without disregarding the added

			value of face-to-face interactions.
3	< 0.50	Traditional Learning	A conventional, classroom-based learning strategy led by a teacher. Learning takes place at the same time and in the same place.

Based on the table above, the decision results and ranking analysis using the SMART method are shown in the table below.

Table 14. Ranking Results

No	Alternative	Final Score	Ranking	Learning Strategy
1	SW-11	1,0000	1	E-learning
2	SW-03	0,8750	2	E-learning
3	SW-02	0,8500	3	E-learning
4	SW-12	0,8500	4	E-learning
5	SW-20	0,8500	5	E-learning
6	SW-08	0,7500	6	E-learning
7	SW-18	0,6250	7	Blended learning
8	SW-04	0,6	8	Blended learning
9	SW-10	0,6000	9	Blended learning
10	SW-17	0,6	10	Blended learning
11	SW-16	0,525	11	Blended learning
12	SW-06	0,4750	12	Traditional Learning
13	SW-01	0,4500	13	Traditional Learning
14	SW-07	0,45	14	Traditional Learning
15	SW-13	0,4500	15	Traditional Learning
16	SW-15	0,45	16	Traditional Learning
17	SW-19	0,4500	17	Traditional Learning
18	SW-14	0,275	18	Traditional Learning
19	SW-05	0,125	19	Traditional Learning
20	SW-09	0,1250	20	Traditional Learning

From the 20 student data shown above, the analysis results indicate that there are 6 students recommended for the E-learning strategy, 5 students for the Blended Learning strategy, and 9 students for the Traditional Learning strategy. Therefore, the recommended overall learning strategy for this class is the Traditional Learning approach.

Discussion

The decision support system designed in this study functions as an assistive tool for educators, school counselors, and even the students themselves in selecting the most optimal learning strategy. Through the SMART method, each learning strategy alternative is evaluated quantitatively based on the values obtained for each criterion. The results of these calculations are then qualitatively analyzed to identify the relationship patterns between student characteristics and the effectiveness of the recommended learning strategies.

This approach does not only provide general recommendations but also aligns the learning strategy with the unique profile of each student. This is important because the success of the learning process is closely related to the compatibility between the applied learning method and internal factors (such as learning style and motivation) as well as external factors (such as learning environment conditions). Therefore, the following discussion elaborates in detail on the influence of each criterion and its relationship with the final system results.

Based on the implementation and testing of the decision support system in determining effective learning strategies for students using the SMART method, a clear picture is obtained regarding the influence of each criterion on the generated strategy recommendations. This analysis is conducted to assess the extent

to which the system can accommodate individual student needs based on parameters such as learning style, learning motivation, learning environment, and academic ability.

The implementation of the system in this study aims to demonstrate that the Decision Support System (DSS) based on PHP–MySQL adopting the SMART method is capable of reproducing previously performed manual calculations. The implementation is primarily focused on the SMART Analysis menu, as this menu processes the entire calculation logic (normalization/utility, weighting, weighted summation, and ranking) and displays the final output in the form of Total Score, Rank, and Decision (learning strategy).

Based on calculations using the SMART method for 32 students in Grade VIII-1 at SMP Negeri 2 Binjai with the criteria of Learning Style, Learning Motivation, Learning Environment, and Academic Ability, three categories of learning strategies were obtained: E-learning, Blended Learning, and Traditional Learning.

CONCLUSION

Based on the results of the research and system implementation, it can be concluded that the Decision Support System (DSS) utilizing the Simple Multi-Attribute Rating Technique (SMART) method has been successfully developed to recommend effective learning strategies for students at SMP Negeri 2 Binjai. The system is capable of objectively and efficiently identifying appropriate learning strategies according to the individual characteristics of each student. From the analysis of 32 students, the results show that 11 students (34.37%) were recommended to use E-learning, 7 students (21.87%) were recommended Blended Learning, and 14 students (43.75%) were recommended Traditional Learning, with the highest score of 1.00 in the E-learning category and the lowest score of 0.125 in the Traditional Learning category. These findings demonstrate that the SMART method is effective in assisting teachers in determining appropriate and adaptive learning strategies. In the future, this system can be further enhanced by adding features such as automatic report export (PDF or Excel), integration with online learning platforms to enable real-time data updates, and testing with a larger number of respondents to improve recommendation accuracy. Furthermore, the incorporation of machine learning techniques may also be considered to generate more dynamic recommendations that adapt to the evolving abilities and learning motivation of students.

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