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Application C4.5 Algorithm Predicting Students' Learning Styles Based on Somatic, Auditory, Visual, and Intellectual

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Abstract: Education in Indonesia has seen significant development over the past few decades, with government efforts to improve access and quality of education throughout the country. Programs such as the 12-Year Compulsory Education and curriculum revitalization have driven an increase in school participation rates. However, challenges such as the quality gap between urban and rural areas and the low competence of teachers remain key issues in achieving more equitable and high-quality education for all segments of society. This study aims to apply the C4.5 algorithm to predict students' learning styles based on the Somatic, Auditory, Visual, and Intellectual (SAVI) model. Learning styles are an important aspect of education that affects the effectiveness of learning. By understanding individual learning styles, educators can optimize teaching methods according to students' needs. In this study, student learning style data was collected and analyzed using the C4.5 algorithm, an effective decision tree method for data classification. The results of this algorithm are decision trees that categorize students into one of four learning styles based on specific features. This study shows that the C4.5 algorithm has good accuracy in predicting learning styles, with an entropy value of 1.55 and a gain of 0.156. The implementation of the results of this study is expected to help teachers develop more optimal teaching strategies in preparing learning materials according to students' learning styles.

Keywords: Data Mining, C4.5 Algorithm, Learning Styles, Decision Tree, Prediction, Student.

INTRODUCTION

The government program requiring at least 12 years of education is a tangible manifestation that every community should have access to quality education. The growth of education in Indonesia is beginning to develop, demonstrating that society is becoming aware of the importance of education (Rahmayumita & Hidayati, 2023). 21st-century learning brings significant changes, including competencies that students need to develop, such as critical thinking. Consequently, the learning process must gradually transform from teacher-centered learning to student-centered learning (Rizki et al., 2023). The curriculum changes through the implementation of the Merdeka Curriculum policy have brought changes to educational units in carrying out the learning process, underscoring that the learning process should be student-centered (Masri et al., 2023).

Challenges faced by teachers in the learning process form a major foundation that needs to be addressed to achieve optimal learning outcomes. Innovation by teachers in preparing teaching materials is crucial (Yadi et al., 2022). This remains an issue for some teachers in designing student-centered materials, which impacts students' interest in the learning process. Low competence in knowledge and achievement of learning processes in the classroom is a serious issue that needs urgent attention, as evidenced by students' lack of interest and the monotonous and less interactive learning environment. Innovation and collaboration in learning are essential to creating an enjoyable learning atmosphere for

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both students and teachers. This can be achieved through mapping students' learning styles, which will support the learning process and facilitate students' understanding. By using a learning style approach, teachers can better prepare teaching materials (Pratiwi & Puspasari, 2021).

The SAVI learning model approach is one solution for mapping students' learning styles, and it has been shown to positively influence student learning outcomes (Selly Ardila, Nurjannah, 2022). There is a significant positive effect of the somatic, auditory, visual, and intellectual learning models on student learning outcomes (Kiki et al., 2023). In line with research by Wakhidah & Arif (2022), the SAVI model approach is very effective in the learning process because it allows all students to understand the learning process well.

Mapping learning styles is necessary so that the teaching materials designed by teachers align with students' characteristics, ensuring that tasks are appropriately assigned (Sudriyanto et al., 2022). However, mapping students' learning styles has not yet received special attention from teachers in classroom space allocation (Yulia et al., 2022). The C4.5 algorithm is one solution for mapping students' learning styles according to specified attributes. The implementation of the C4.5 algorithm for prediction has proven effective, as decision trees can be used in decision-making processes (Esthiningtyas & Prasetyaningrum, 2020) (Ginting et al., 2020)

Predicting students' learning styles using the C4.5 algorithm aims to facilitate both students and teachers in carrying out the learning process in the classroom. By mapping learning styles, students can be grouped so that teachers can prepare teaching materials according to students' learning styles, which will impact the achievement of learning objectives in each subject within the educational.

LITERATURE REVIEW

Data Mining

Data mining is a process of analyzing data to discover meaningful relationships, patterns, and trends by filtering large datasets using various statistical techniques (Anwar & Sutomo, 2023). Predictive and descriptive techniques are used for analyzing large datasets; predictive techniques are employed to forecast values of specific attributes, while descriptive techniques are used to create patterns that link key data points (Yulia et al., 2022).

Data mining is utilized for large-scale data extraction, significantly aiding the data analysis process and improving decision-making accuracy. Given the need for extensive data, data mining can also be used for data prediction to estimate future values (Purba & Yadi, 2023) (Kumar & Sharma, 2019).

Algorithm C4.5

The C4.5 algorithm is a supervised learning technique that uses attributes as a structure to determine decision trees (Anwar & Sutomo, 2023). The design of decision trees in the C4.5 algorithm involves calculating the entropy and gain values from the attribute determination process. Decision trees are an indicator for making predictions in decision-making (Yadi, 2022) (Yadi, 2024). The application of the C4.5 algorithm for decision-making utilizes several key indicators affecting dataset attributes (Meila Azzahra Sofyan et al., 2023). The results of decision trees can provide recommendations in the decision-making process (Bachtiar & Mahradianur, 2023).

SAVI Learning

The application of somatic, auditory, visual, and intellectual learning models enhances the learning process in the classroom (Ali & Syam, 2023). Additionally, the SAVI learning approach improves student engagement in learning (Wakhidah & Arif, 2022). The implementation of the SAVI learning model provides teachers with the opportunity to innovate teaching materials according to students' learning styles, supporting the learning process (Widiantari et al., 2022). The SAVI learning model shows a significant positive effect on students' learning outcomes, as it involves all learning styles and creates a new environment for students to complete tasks and study materials within the educational unit (Panjaitan et al., 2024).

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METHOD

Research on predicting students' learning styles using the C4.5 algorithm involves constructing decision trees based on entropy and gain values by determining attributes in the decision-making process (Yudiana et al., 2023). The stages in the algorithm are illustrated in Figure 1.

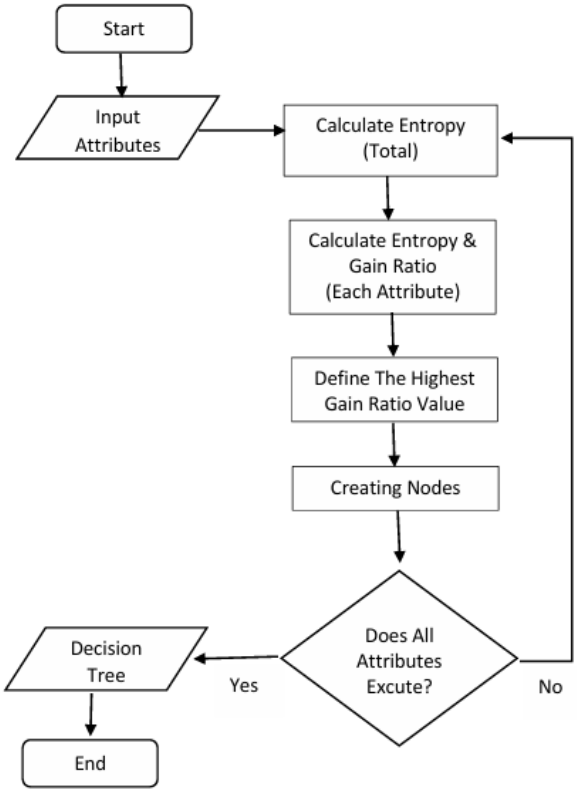

Fig 1. Flowchart Research Algorithm

In the C4.5 algorithm stages, it is clear that attributes must be determined before calculating entropy and gain values for decision tree construction (Abdillah et al., 2020). The attributes are determined based on the analysis of students' learning styles using the SAVI learning model, which includes somatic, auditory, visual, and intellectual styles. The prediction of students' learning styles is based on these attributes, as shown in Table 1.

Table 1. *Attribute*

No	***Attribute***
1	*Somatic*
2	*Auditory*
3	*Visualization*
4	*Intellectual*

The process of determining a decision tree using the C4.5 algorithm involves several stages, such as calculating the entropy and gain values for each attribute and case. The calculation of entropy is performed using the following formula:

$$Entropy(S) = \sum_{i=1}^{n} -pi * Log\ 2\ pi$$

Information :

S = Case Set; n = Number of Case Partitions; pi = Proportion of Si to S

After calculating the entropy values, the gain values are computed by calculating the entropy values to obtain the highest gain ratio. The formula for calculating gain is as follows:

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$$Gain(S,A) = entropy(S) - \sum_{i=1}^{n} \frac{|Si|}{|S|} * Entropy\ (Si)$$

Information :
S = Case Set. A = Attributes .n = Number of Partitions Attribute A
|Si| = Number of Partition Cases –I; |S| = Number of Cases in S

The entropy and gain values obtained then serve as criteria for determining nodes in the decision tree, based on the highest entropy and gain values. Thus, the decision tree in the C4.5 algorithm is constructed accordingly (Kurniawan et al., 2020).

RESULT

In The results of this study show the importance of choosing an algorithm in predicting students' learning styles in educational units. The C4.5 algorithm is used to build a decision tree in predicting students' learning styles consisting of somatic, auditory, visual and intellectual. because this algorithm can be used in classifying based on heterogeneous data and is able to work on limited data distribution. In this study, the C4.5 algorithm was applied to identify the dominant learning style of a sample of 30 students with a distribution of somatic, auditory, visual and intellectual learning styles. the main steps include calculating the entropy and gain values to find the best attributes in dividing the dataset. the research on predicting students' learning styles using the C4.5 algorithm, several attributes are involved, as shown in Table 2. The C4.5 algorithm is used to identify the dominant learning styles of students at SMK Muhammadiyah Pagar Alam.

Table 2 Dataset

Responden	Somatic	Auditory	Visual	Intellectual	Learning Style
S1	4	4	3.4	3	Somatic
S2	3.6	3.8	3.4	3.2	Auditory
S3	4.6	4.6	3.2	2.6	Somatic
S4	3.6	3.8	2.8	3	Auditory
S5	3.6	3.8	2.8	2.8	Auditory
S6	3.6	3.4	3	3.6	Somatic
S7	3.6	3.6	3.2	3	Somatic
S8	3.8	3.2	3.2	3.4	Somatic
S9	4	3	3.2	3.4	Somatic
S10	4.4	4.4	2.8	2.2	Somatic
S11	3.6	3.8	4.2	3.4	Visual
S12	3.8	4	3	2.8	Somatic
S13	3	3.2	3.6	3	Visual
S14	4	4.6	4	3.8	Auditory
S15	3.8	4.2	4	3.8	Auditory
S16	3.8	3	3	3	Somatic
S17	3.8	4.4	3.4	3.8	Auditory
S18	3.6	3.6	4	3.4	Visual
S19	3.8	3.4	3.4	3.6	Somatic
S20	3	3.4	3.4	3	Auditory
S21	4	2.6	3.8	2.8	Somatic
S22	3.6	3.2	3.4	3	Somatic
S23	4.2	3.6	2.4	3.4	Somatic

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S24	3.2	3.6	3	2.8	Auditory
S25	3.4	2.8	2.8	2.8	Somatic
S26	4.6	3.2	2.6	2.6	Somatic
S27	4.8	3.6	3.4	4.2	Somatic
S28	2.8	2.8	2.8	3	Intellectual
S29	2.4	3	3	2.8	Auditory
S30	2.2	2.6	3	3	Visual

Based on the dataset processed with 30 students as samples, there are several differences in learning styles, including somatic learning style with 16 students, auditory with 9 students, visual with 4 students, and intellectual with 1 student. Calculation of entropy values

$$Entropy(S, Somtic) = \sum_{30=1}^{16} -0.5333 * Log\ 2(0.5333)$$
$$= 0.4822$$
$$Entropy(S, Auditory) = \sum_{30=1}^{9} -0.3000 * Log\ 2(0.3000)$$
$$= 0.5211$$
$$Entropy(S, Visual) = \sum_{30=1}^{4} -0.1333 * Log\ 2(0.1333)$$
$$= 0.3878$$
$$Entropy(S, Intellektual) = \sum_{30=1}^{1} -0.0333 * Log\ 2(0.0333)$$
$$= 0.1668$$

The entropy value for the dataset is calculated as follows: Entropy (s) = 0.4822 + 0.5211 + 0.3878 + 0.1668 = 1.5579, based on the distribution of dominant learning styles among 30 respondents at SMK Muhammadiyah Pagar Alam. Meanwhile, the gain value is calculated using the following formula:

$$Gain(S, A) = entropy(S) - \sum_{i=1}^{n} \frac{|Si|}{|S|} * Entropy\ (Si)$$

$$Gain(S, A) = entropy(S) - \sum_{i=1}^{30} \frac{10}{30} * Entropy\ (S1) + \frac{10}{30} * Entropy\ (S2) + \frac{10}{30} * Entropy\ (S3)$$

$$Gain(S, A) = 1.5579 - (\frac{1}{30} * 1.4855\ (S1) + \frac{1}{30} * 1.3568\ (S2) + \frac{1}{30} * 1.3610\ (S3)$$

Gain (S,A) = 1.5579 – 1.4012 = 0.1567

The decision tree is shown in Figure 2. The dominant learning style of students at SMK Muhammadiyah Pagar Alam is somatic. This is because students prefer learning processes that involve hands-on activities, such as large projects, experiments, and simulations to understand the material.

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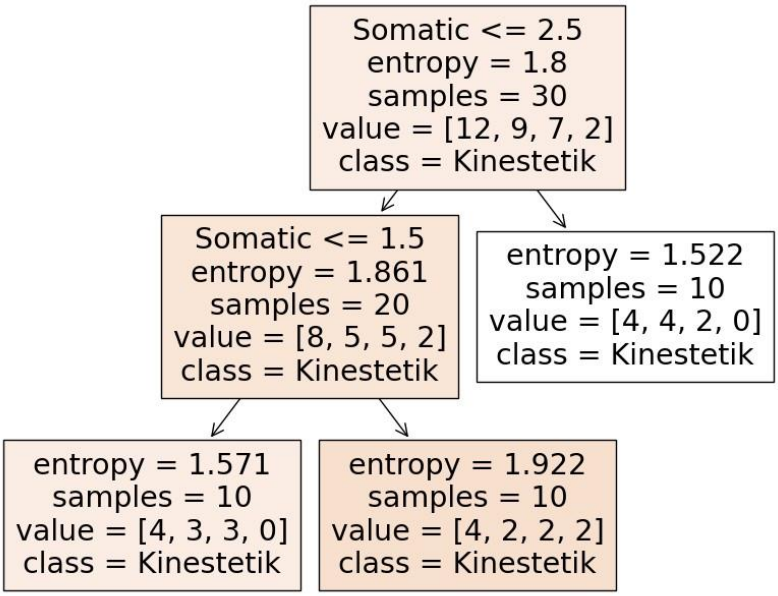

Figure 2 Decision Tree of Learning Styles

Based on the decision tree, the results indicate that the somatic attribute has a significant influence in grouping students' learning styles according to the data analysis. Thus, the C4.5 algorithm performs very well in predicting students' learning styles.

DISCUSSIONS

The C4.5 algorithm has a good capacity to handle small datasets with several attributes, as produced by this study, the findings show that the C4.5 algorithm can help in classifying student learning styles with somatic as the dominant attribute possessed by students in the learning process. as the dominant attribute in this study answers several questions that one dominant attribute is not enough to predict a large number of students' learning styles optimally. The C4.5 algorithm works well in providing initial classification so that the analysis carried out becomes more accurate, but it needs to be developed using a more holistic approach.

The results of this study show that the C4.5 algorithm, with its decision tree design, can be effectively used to classify students' learning styles based on predefined attributes. According to the sample, the somatic learning style is more dominant, with students preferring hands-on learning through experiments, simulations, and practical activities, which helps build their knowledge and critical thinking skills for problem-solving in the subject matter. Therefore, the C4.5 algorithm is highly effective in prediction calculations, aligning with research by (Sudriyanto et al. 2022; Putri et al. 2020), which indicates that the use of the C4.5 algorithm is very good for prediction in decision tree design. Additionally, research by (Rahmawati et al. 2022) supports that the C4.5 algorithm's accuracy can be utilized in decision-making. This indicates that teachers should understand students' learning styles to ensure that materials and assignments are easily comprehended, which will positively impact achieving learning objectives in educational settings. This understanding can help teachers design more engaging learning approaches tailored to students' needs and learning preferences.

CONCLUSION

Predicting students' learning styles using the C4.5 algorithm is highly effective, as indicated by the analysis showing that the dominant learning style among students is somatic, which aligns with kinesthetic learning processes. With a gain value of 0.156, the decision tree provides a clear representation for teachers to understand the mapping of students' learning styles in the classroom. This can be used as a foundational strategy for designing learning activities that better meet students' needs, thereby achieving educational objectives. However, this research could be further developed by applying other algorithms that may offer more varied results in predicting students' learning styles.

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Additionally, a better understanding of learning styles can help teachers develop more comprehensive learning tools to support the learning process.

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