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Integrated Decision Support System for Student Academic Activities Using a Combination of AHP and SMART Methods

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ABSTRACT

Digital transformation in the world of education requires educational institutions to have an objective and integrated decision-making system. However, the results of observations at SMKN 13 Medan showed that there are still problems in the form of data fragmentation between departments which causes the process of determining outstanding students and selecting new students' majors to be inefficient and prone to subjectivity. This study aims to develop an integrated web-based Decision Support System (DSS) using a combination of the Analytic Hierarchy Process (AHP) and Simple Multi-Attribute Rating Technique (SMART) methods to improve accuracy and fairness in the academic decision-making process. The system development method used is Waterfall, with stages of analysis, design, implementation, testing, application, and maintenance. The results of quantitative calculations show that in determining outstanding students, student Amira obtained the highest score of 95.79, while in selecting majors, student Aulia Fatimah Al Zahra obtained the highest score of 86.11 and was recommended to the Computer and Network Engineering (TKJ) department. The system testing results show that the AHP-SMART combination successfully provides accurate and consistent results with a weighting consistency level of CR = 0.08 for achievement and CR = 0.06 for majors. It can be concluded that the developed system is able to integrate data across majors, improve assessment efficiency, and support transparent, objective, and data-based decision-making in the vocational school environment.

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1. Introduction

The development of information technology over the past decade has had a significant impact on various areas of life, including the education sector[1][2][3]. Digital transformation encourages educational institutions to adapt to integrated data-based systems in order to improve efficiency, accuracy, and objectivity in academic decision-making. Administrative and academic processes that were previously carried out manually have now shifted to digital systems that are capable of presenting information quickly and accurately[4][5]. This shift is not only limited to the learning process, but also includes student data management, academic performance evaluation, and data-based school policy making[6][7].

However, digitalization has not completely solved the fundamental problems faced by educational institutions[8][9][10]. Based on interviews and observations at SMKN 13 Medan on May 15 2025, it was discovered that the main obstacle lies not in the absence of a system, but rather in the separation of academic data management between departments. Each department, such as Computer and Network Engineering and Accounting, has a different data management system, making it difficult for the school to conduct a comprehensive analysis. As a result, the process of determining outstanding students, selecting new students' majors, and placing them in industrial internships is inefficient, prone to subjectivity, and takes a long time.

This condition is reinforced by the findings of Chaudhary et al. (2025) who stated that data fragmentation between departments is a major obstacle to the effectiveness of vocational education management[11][12][13]. Scattered data prevents decision-making from holistically reflecting student performance. Therefore, an academic data integration system is needed that can bring together all information on student grades, attitudes, skills, and interests in a single, centralized platform to enable comprehensive and objective decision-making. Rafida et al. (2023) emphasized that the use of a cloud-based system can be an effective solution to address this issue, as it can consolidate data from various sources in real time[14][15][16].

One appropriate approach to solving these complex problems is through a Decision Support System (DSS). DSS helps decision-makers address multi-criteria problems that require objective consideration[17][18][19]. In the educational context, the implementation of SPK can support the evaluation, selection, and policy processes directly related to students. The two main cases focused on in this research are the selection of high-achieving students and the selection of majors for new students, both of which require systems capable of processing various assessment criteria efficiently and consistently.

To address these needs, this study combines two Multi-Criteria Decision-Making (MCDM) methods: the Analytic Hierarchy Process (AHP) and the Simple Multi-Attribute Rating Technique (SMART). AHP is used to systematically determine criteria weights through pairwise comparisons, while SMART provides utility values and ranks alternatives based on predetermined weights[20][21][22].
The combination of the two results in more objective and transparent decisions because AHP minimizes bias in weighting, while SMART simplifies the calculation of final scores. Although several previous studies, such as Ratsanjani et al. (2024) and Tambunan (2024) have applied similar methods, this study offers a new innovation in the form of integrating two decision-making contexts into a single web-based system that can process data in real time and across departments[23][24][25]. Thus, the system developed is expected to be able to increase efficiency, fairness, and accuracy in the academic decision-making process, as well as support the application of the principle of objectivity in education in accordance with Islamic values.

2. Research Method

Quantitative research methods are a systematic and objective scientific approach, which is used to investigate phenomena by collecting and analyzing numerical data [26][27]. This research focuses on measuring quantifiable variables, using structured instruments such as interviews, surveys, or experiments, to test predetermined hypotheses. The collected data are then statistically processed to identify patterns, relationships, or causal effects between variables, resulting in findings that can be generalized to a broader population. Quantitative approaches emphasize objectivity, bias reduction, and replicability, and are therefore often used to answer research questions that compare, predict, or empirically confirm theories[28] [29].

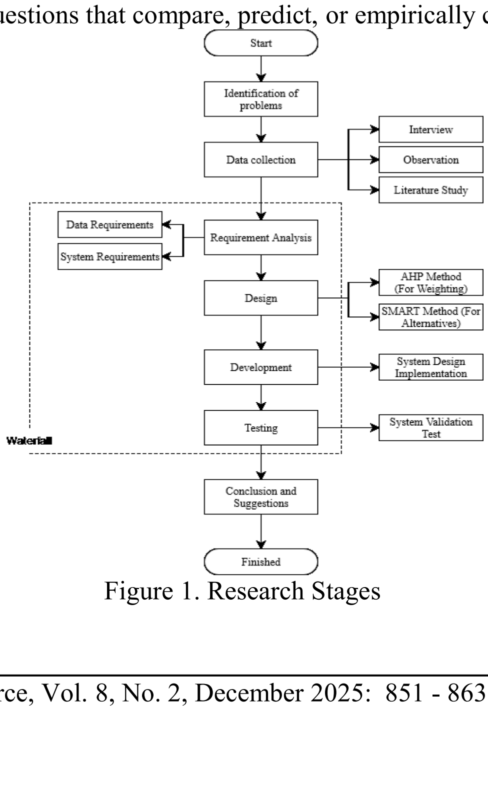

Figure 1. Research Stages

The following is an explanation of the stages in the research method[30]:

a. Problem Identification
This stage is the initial step in research aimed at understanding the main problems within SMKN 13 Medan. Researchers identified the obstacles faced by the school, particularly those related to the process of determining high-achieving students and assigning new students majors, which is still done manually, lacks integration across majors, and is prone to subjectivity.

b. Data Collection
This stage is carried out to obtain the data and information needed for system design. Data collection is carried out using three methods:
1) Interviews with the Vice Principal for Curriculum and teachers to understand the system requirements and current assessment procedures.
2) Observation, by directly observing the academic administration process, determining high-achieving students, and selecting majors at school.
3) Literature Study, by reviewing supporting theories, journals, and previous research on Decision Support Systems, the AHP method, and the SMART method.

c. Analysis
This initial stage aimed to identify needs and problems at SMKN 13 Medan through interviews and observations. The analysis revealed data fragmentation between departments, which hampered the process of identifying high-achieving students and accepting new students. This stage identified functional and non-functional requirements, as well as the criteria to be used in the AHP and SMART methods.

d. Design
In this stage, system requirements were transformed into a technical design, consisting of a system architecture, a centralized database design, and a user interface design. The design also illustrated data integration between departments and the flow of applying the AHP method for weighting and SMART for ranking.

e. Implementation
The implementation stage realized the design into a PHP and MySQL-based system. At this stage, AHP logic was applied for criteria weighting and SMART for normalization and student ranking. All modules were integrated into a single platform that centrally processed cross-departmental data.

f. Testing
Testing was conducted in stages through unit testing, integration testing, and user acceptance testing. This stage ensures that each module runs smoothly and that the system's recommendations align with the school's needs and manual decisions.

g. Conclusions and Recommendations
The final stage of this research yields conclusions regarding the effectiveness of the developed system and recommendations for further development. Based on the trial results, the system has proven effective in assisting schools in objective and efficient decision-making. Recommendations include the development of a machine learning-based predictive analysis feature to expand the system's capabilities in continuously monitoring student achievement..

2.1 AHP

The Analytical Hierarchy Process (AHP) is a multi-criteria decision-making method developed by Thomas L. Saaty, which allows pairwise comparisons between elements to determine priority weights. AHP structures problems into a hierarchy, starting from objectives, criteria, sub-criteria, and then decision alternatives. AHP's distinctive feature lies in its ability to measure the consistency of assessments through a consistency ratio (CR) and a clear hierarchical structure[31]. AHP is particularly useful in complex decision-making, such as selecting a student's major, because it can combine various relevant criteria in a structured manner.

The application of the AHP method to decision-making involves several stages [32]:

1. Determine the purpose of the decision
The first step is to clearly formulate the problem to be solved or the decision to be taken.
2. Develop a hierarchical decision structure
Problems are broken down into several levels starting from objectives, criteria, to decision alternatives.
3. Pairwise comparison
Each element at one level is compared in pairs based on its impact on the element at the upper level, on a preference scale of 1–9.

4. Compile a comparison matrix and calculate priority weights
   The comparison values are used to form a matrix and the eigenvectors are calculated to obtain the relative weight of each criterion.
5. Consistency Ratio/CR
   This ratio is used to assess whether pairwise assessments are consistent. CR ≤ 0.1 is considered consistent.
6. Accumulate weights and determine the best alternative
   The final value is calculated by adding up the results of multiplying the criteria weights by the scores of each alternative

2.2 SMART

Simple Multi-Attribute Rating Technique (SMART) is a multi-criteria decision-making method that utilizes a scoring and weighting approach for each alternative based on predetermined attributes. SMART emphasizes simplicity of calculation, namely by multiplying the score of each alternative by the weight of each criterion, then adding these together to obtain the total utility value[33]. This method is suitable for application in an educational context because it provides results that are fast, transparent, and easy to understand for decision makers and students.
The steps in the SMART method begin with:

1. Using the following formula, determine the normalization of the criteria by comparing the individual criteria weight values with the overall criteria weight.

   related:

$$W_j = \frac{Wj}{\sum_{j=1}^{m} wj} \quad (1)$$

   where:
   W_j = Normalization of criterion weights to j
   W_j = weight value of criterion j
   j = Weight of criteria

2. Determine the utility value for each criterion, which depends on the characteristics of the criterion, namely: Criteria that are Cost-based or "prefer smaller values," with the equation:

$$u_i(a_i) = 100 * \left(\frac{C_{max} - C_{out}}{C_{max} - C_{min}}\right) \quad (2)$$

   Criteria that are Benefit-oriented "the greater the value, the more desirable", with the equation:

$$u_i(a_i) = 100 * \left(\frac{C_{out} - C_{min}}{C_{max} - C_{min}}\right) \quad (3)$$

   Where:
   $u_i(a_i)$ = utility value of the first criterion for the first criterion
   C_{max} = maximum criteria value
   C_{min} = minimum criteria value
   $C_{out\ i}$ = first criteria value (i)

3. Calculate the final value and perform the ranking. To calculate the final value for each attribute, use the following equation.

$$u(a_i) = \sum_{j=1}^{m} w_j u_i(a_i) \quad (4)$$

Where:
$u(a_i)$ = total alternative value
w_j = normalization results of criteria weights
$u_i(a_i)$ = results of determining utility values
$_i$= 1,2,…m

2.3 AHP And SMART Method Algorithms

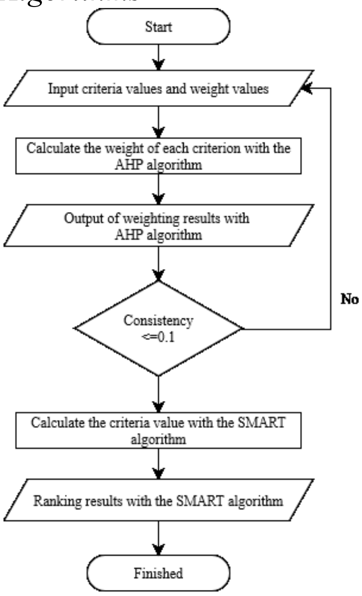

Figure 2. AHP and SMART Algorithms

This diagram explains the decision-making process based on the AHP (Analytic Hierarchy Process) and SMART (Simple Multi Attribute Rating Technique) methods in determining alternative academic activities for students in a systematic and objective manner

3. Result and Discussion

This research produced a web-based decision support system that integrates two main processes, namely determining high-achieving students and recommending majors. The assessment process is carried out using a combination of the AHP (Analytic Hierarchy Process) method for weighting criteria and the SMART (Simple Multi Attribute Rating Technique) method for ranking alternatives. The main objective of this system is to assist schools in identifying high-achieving students while providing major recommendations that are objectively suited to the academic abilities of students.

3.1. Calculation Results for Outstanding Students

In the initial stage, the criteria used to assess student achievement consisted of four aspects, namely:

Table 1. Outstanding Student Criteria Data

Code	Criteria
C1	School Exam Scores
C2	Competition Achievement Scores
C3	Organizational Activity Scores
C4	Report Card Average

The first stage involves weighting the criteria using pairwise comparisons. Each criterion is compared based on its level of importance to the goal, which is to determine high-achieving students. The calculation results yield the following comparison matrix and final weights:

Table 2. Comparison Matrix Results of Outstanding Students

Criteria	AHP Weight	Description
C1 (school exams)	0,442	Most influential
C2 (competition achievements)	0,168	Quite important
C3 (Organization)	0,234	Moderate
C4 (Average Report Card)	0,155	Relatively low

The Consistency Ratio (CR) value obtained was 0.08, which indicates consistency (<0.1). This means that the comparison between the criteria is acceptable and the resulting weights are mathematically valid

After the weights are obtained, the normalization stage and calculation of student preference values are carried out based on the predetermined criteria. The student's initial values (Xij) are converted into utility values (Ui) based on the formula:

$$U_{ij} = \frac{X_{ij}}{X_{max}} x100 \tag{5}$$

Then the total preference value (Vi) is calculated by adding up the results of multiplying the weight of each criterion by its utility value.:

$$V_i = \sum (W_j x U_{ij}) \tag{6}$$

Based on the processed data, the final results are shown in the following table:

Table 3. Final Results of Outstanding Students

Rank	Name	Final score	Determination of Achievement
1	AMIRA	95,79	Achieved
2	AULIA FATIMAH	79,86	Achieved
3	AZIZAH	78,90	Achieved
4	ARISAH BALQISH	65,47	Not Achieved
5	Alisa Rahayu	63,38	Not Achieved
6	Anggun Syahputri	58,23	Not Achieved
7	ALUL AL FAHRI	52,91	Not Achieved
8	AULIA NUR HAFIZA	27,18	Not Achieved
9	ARDIAN DARA	13,88	Not Achieved
10	Allysha Putri	4,58	Not Achieved

From the calculation results above, it was found that Amira had the highest preference score, namely 95.79, indicating that she has the most outstanding academic and non-academic performance among other alternatives. Meanwhile, Allysha Putri had the lowest score because her organizational activity score and competitive achievements were relatively small. These results indicate that the AHP-SMART method is able to combine qualitative and quantitative assessments in a balanced manner, resulting in an accurate, transparent, and accountable ranking of high-achieving students.

3.2. Major Selection Calculation Results

In the major selection process, the system considers six criteria that influence a student's suitability for a particular major, namely:

Table 4. Major Selection Criteria Data

Code	Criteria
C1	Nearest Residence
C2	Age
C3	School Exam Scores
C4	Math Scores
C5	Science Scores
C6	English Scores

From the results of pairwise comparisons between criteria, the following weights were obtained:

Table 5. Results of the Comparison Matrix for Major Selection

Criteria	AHP Weight	Description
C1 (Domicile)	0,0984	Least influential
C2 (Age)	0,0401	Lowest
C3 (School Exam)	0,3518	Most dominant
C4 (Mathematics)	0,2352	Important
C5 (Science)	0,1669	Moderate
C6 (English)	0,1076	Supporters

The consistency value (CR) is 0.06, indicating that the weighting results are valid and can be used in further calculations.

Each student's utility value for each criterion is calculated using the SMART normalization formula. The result is then multiplied by the weight of each criterion to obtain the total preference value (Vi). The calculation results are as follows:

Table 6. Final score results for major selection

Ranking	Student Name	Final Score	Major Recommendations
1	Aulia Fatimah Al Zahra	86.1114	Computer and Network Engineering
2	Arisah Balqish Asnan	78.2996	No Recommendations Yet
3	Alisa Rahayu	71.5124	No Recommendations Yet
4	Amira	63.2944	No Recommendations Yet
5	Alil Al Fahri	58.7657	No Recommendations Yet
6	Aulia Nur Hafiza	54.6001	No Recommendations Yet
7	Azizah	49.5813	No Recommendations Yet
8	Anggun Syahputri	42.4226	No Recommendations Yet
9	Allysha Putri	38.3836	No Recommendations Yet
10	Ardian Dara	12.6613	No Recommendations Yet

Based on these results, Aulia Fatimah Al Zahra achieved the highest score of 86.11, thus being recommended for admission to the Computer and Network Engineering (TKJ) department. This score reflects the match between academic ability (high test and math scores) and location and interest factors. Meanwhile, Arisah Balqish Asnan and Ardian Dara received lower scores due to less favorable academic and distance factors, resulting in no major recommendations.

3.3. System Implementation

The developed web-based system uses the PHP programming language and MySQL as its database. The entire AHP and SMART calculation process is automated through an interactive interface that is easy to use for both school administrators and users. The system is integrated into a single platform with the ability to accommodate data from various departments, simplifying the analysis and reporting process. The following is a visualization of the system along with an explanation:

a. Initial Display

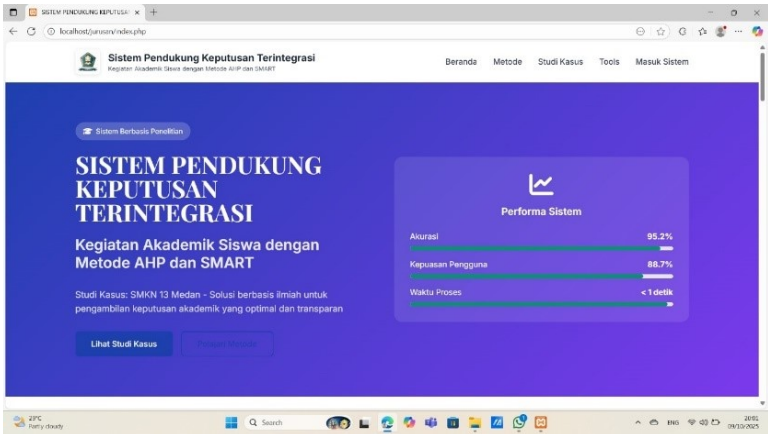

Figure 3. Initial Display

This display is the first page accessed by the user, containing an introduction to the system, graphs about system performance and access to enter the system.

b. Dashboard Display

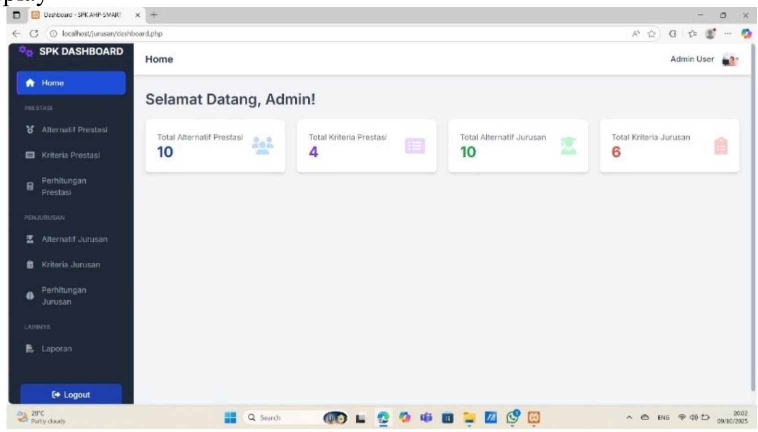

Figure 4.Dashboard Display

After successfully logging in, users are directed to a dashboard page that displays a summary of information such as the number of alternative achievements, achievement criteria, alternative majors, and major criteria. The dashboard also features a navigation menu that leads to features for achievement assessment, majors, and results reports.

c. Alternative Display of Achievements

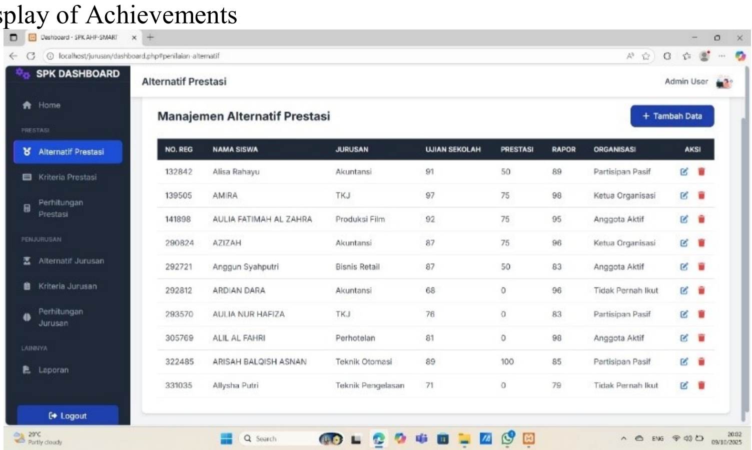

Figure 5.Alternative Display of Achievements

This page displays a list of student names used as alternatives in the achievement assessment process. Admins can add, edit, or delete student data, as well as view baseline scores for each criterion that will be processed using the AHP-SMART method.

d. Display of Performance Criteria

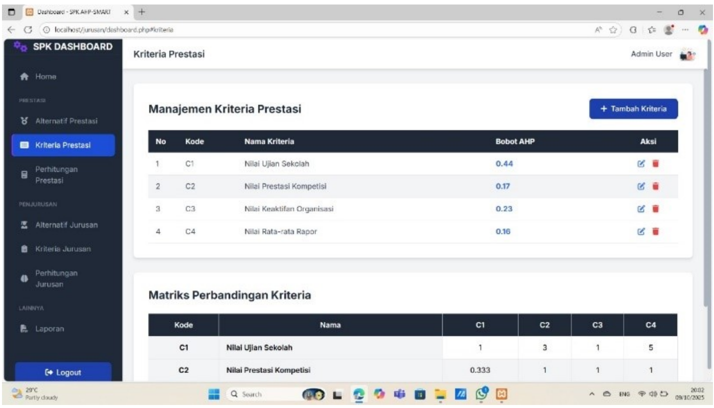

Figure 6. Display of Performance Criteria

Displays a list of criteria for assessing high-achieving students (C1–C4) along with the weights for the AHP calculations. This page allows administrators to update the criteria weights if there are changes to the school's assessment policy.

e. Performance Calculation Display

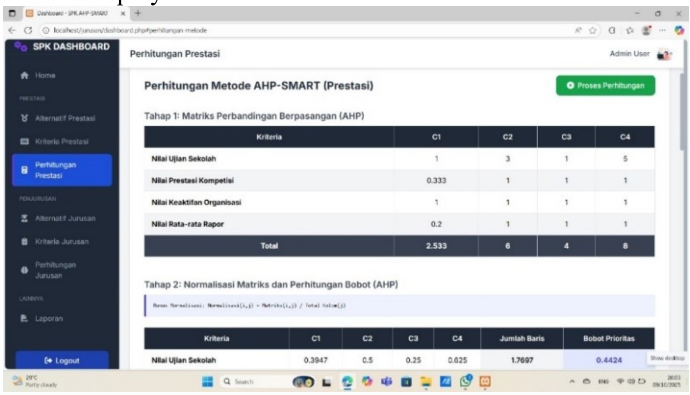

Figure 7.Performance Calculation Display

This page contains the automated process for calculating normalization, utility values, and preference scores for each student. The results are displayed in a table so users can transparently monitor the assessment process.

f. Final Achievement Results Display

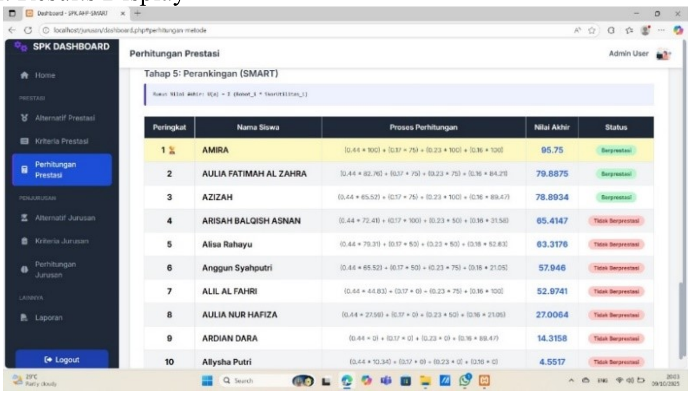

Figure 8.Final Achievement Results Display

Displays the student ranking based on their final grade (V). Students with the highest scores are categorized as "Outstanding," and the results can be exported as a printed report. This display provides accurate and objective results based on predetermined criteria weighting.

g. Alternative View of Majors

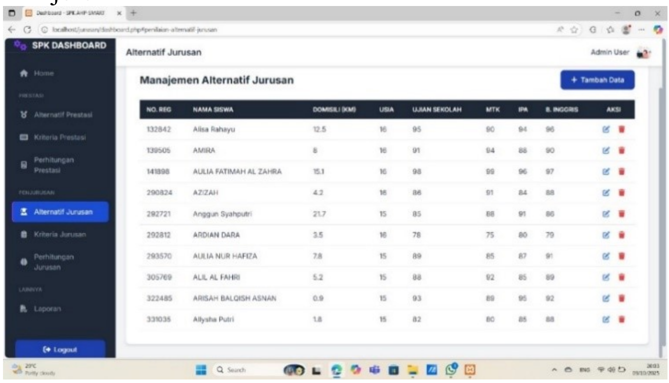

Figure 9. Alternative View of Majors

Displays a list of students who will be recommended for a specific major. Each student is an alternative and will be analyzed based on six main major criteria. Admins can add new data based on the student admissions selection results.

h. Major Criteria Display

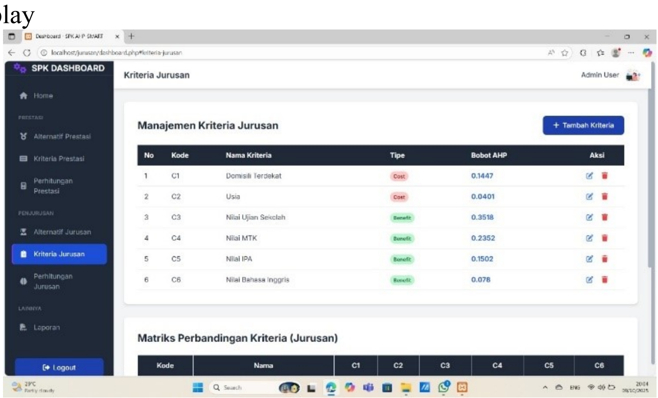

Figure 10. Major Criteria Display

Displays a list of majoring criteria (C1–C6) and the weights of the AHP results. This page also features a weight setting menu so the system remains flexible to changes in importance between criteria.

i. Major Calculation Display

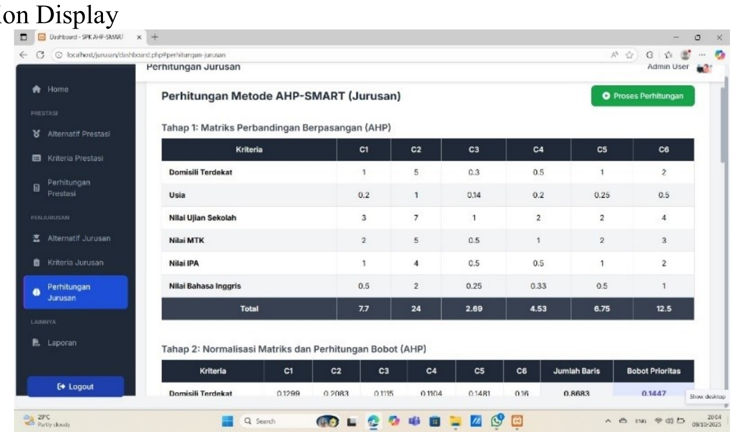

Figure 11. Major Calculation Display

This page displays the results of the SMART method calculations, adjusted to AHP weights. The system automatically calculates utility values, preferences, and major rankings for each student. This process produces optimal final major recommendations.

j. Final Results Display for the Department

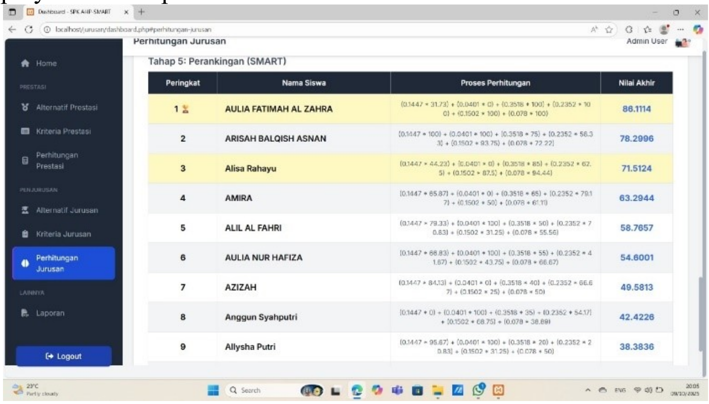

Figure 12. Final Results Display for the Department

Contains a list of recommended majors for each student based on their highest score. For example, Aulia Fatimah was recommended to major in Computer and Network Engineering (TKJ) with a score of 86.11. These results can be downloaded in report format for school documentation purposes.

k. Report View

Figure 13.Report View

The report page provides a summary of analysis results for both student achievement and major recommendations. The report is presented in tabular format to facilitate school management analysis. A print report feature is also available for administrative purposes

3.3. *System Implementation*

The results of this study indicate that the combination of the AHP and SMART methods can produce objective and consistent decisions in two different contexts: selecting outstanding students and determining majors for new students. This finding aligns with Fadhullah's (2024) research in "Decision Support System for Selecting the Best Teachers Using a Combination of AHP and SMART," where the use of both methods was shown to improve the accuracy of assessment results because AHP provides more rational criteria weighting, while SMART simplifies the ranking process. However, this study's advantage over Fadhullah's research lies in the integration of the two decision-making processes into a single, centralized system, and its web-based implementation that allows for real-time data processing across majors.

Furthermore, this study expands the application of the AHP-SMART method, as demonstrated by Ratsanjani et al. (2024) in "Optimizing the Selection of Exemplary Students: A Combination of AHP and TOPSIS." That research focused on a single decision context with a limited scope, whereas the system developed in this study simultaneously combines achievement analysis and major recommendations. This comparison shows that the AHP–SMART combination is more efficient for integrated education systems, as it is able to handle multi-criteria calculations with a high level of complexity without reducing the transparency of the results. Thus, this study provides practical and theoretical contributions to the development of a more adaptive and data-oriented Decision Support System (DSS) in vocational education environments.

4. Conclusion

Based on the results of the research and system implementation, it can be concluded that the Integrated Decision Support System for Student Academic Activities Using a Combination of AHP and SMART Methods is able to increase objectivity, efficiency, and accuracy in the process of determining outstanding students and recommending majors for new students at SMKN 13 Medan. The combination of AHP and SMART methods has proven effective because AHP provides rational and consistent criteria weighting, while SMART simplifies the ranking process to produce transparent and easy-to-understand decisions. The developed web-based system also successfully integrates cross-department data in real-time, thereby minimizing subjectivity and accelerating the academic evaluation process. Suggestions for further development are that this system can be developed by adding a machine learning-based predictive analysis feature to continuously monitor the development of student achievement, as well as expanding its implementation to other levels of education so that its benefits are broader and more sustainable in supporting data-based decision-making in the world of education).

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