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Implementation of A Decision Support System for Major Selection using AHP and TOPSIS Method

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Abstract−With the rapid development of science and technology, new technology is starting to be used in various fields including education. Education has a very important progress in a nation, because it can optimize individual potential. The educational process in higher education has a big influence on a student's future. However, there are many students who experience difficulties in choosing a college major after graduating from vocational high school (SMK) or senior high school (SMA), because of the complexity in identifying the suitability between interests and study programs. Decision making is a problem that everyone faces, especially in choosing an appropriate college major. There are many factors to consider, and with many options available, the decision-making process can be difficult. To overcome this problem, this research aims to create a decision support system (DSS) using the AHP (Analytical Hierarchy Process) and TOPSIS (Technique For Order By Similarity To Ideal Solution) methods. The AHP method is used to solve complex problems by structuring a hierarchy of criteria and developing weights or priorities. However, when the AHP method is used with many criteria and alternatives, other methods are needed for more effective results. Therefore, a combined method of AHP and TOPSIS was chosen, where AHP focuses on pairwise comparison matrices and consistency analysis, while TOPSIS can measure relative performance and alternative decision making simply and efficiently. The results of research on decision support systems for selecting majors using the AHP and TOPSIS methods show that the application of the combined AHP-TOPSIS method can be used to determine the best alternative in selecting majors by comparing alternatives based on predetermined criteria. In addition, system testing results show that the system functions as expected and meets user needs. With a decision support system for selecting college majors implemented on the website, it can simplify the decision-making process for students and BK teachers in choosing college majors. The results of the calculation of the percentage of system feasibility in blackbox testing show a value of 95.71%, which indicates that this major selection decision support system website can be used.

Keywords: DSS; AHP; TOPSIS; SMK; Majors

1. INTRODUCTION

The development of digital science technology supports the birth of new technologies, every field has started to utilize technology to make work easier, including in the field of education[1]. Education is one of the important factors in determining the progress of a nation, because with education, the potential contained in individuals can be developed optimally[2]. Many students choose a major based solely on their desire to study without considering the consequences that may arise during the study period or after graduation[3]. As a result, this can lead to low academic achievement, which in turn can hinder the student's graduation.

A decision support system (DSS) is a platform designed to assist institutions or companies in carrying out the decision-making process. This platform serves to handle a wide variety of problems, both semi-structured and fully structured[4].

Telkom Schools SMK Telkom Purwokerto is vocational school established on January 30, 1993. The school always keeps up with the latest technology and curriculum. It provides state-of-the-art facilities and infrastructure to support and improve the achievement of its students. It also encourages its students in developing their interests and talents for further education.

And based on the results of the author's interview with Guidance Counseling at the school for class XII, currently there is no special approach or method used to help students choose an appropriate college major. And no research or evaluation has been carried out in determining majors for Telkom Purwokerto Vocational School students. Decision making is one of the problems faced every day[5]. There are many factors that need to be considered to reach the best decision and sometimes the many choices available can make us face difficulties in the decision making process[6].

In connection with the above, a decision-making system was created to solve complex problems in the process of selecting an appropriate college major in order to determine accurately according to the expected criteria[7]. The system created uses the AHP (Analytical Hierarchy Process) and TOPSIS (Technique For Order By Similarity To Ideal Solution) methods[8]. The AHP method itself is used to effectively addres intricate challenges, a well-organized framework should be established that encompasses key factors, those involved, and desired outcomes. By carefully considering various aspects, relative importance can be assigned to effectivelly navogate these complexities[9]. When the AHP method is used with a number od criteria and alternatives, the method is not effective. Therefore, it is necessary to combine other methods with AHP for more effective results[6].

Decision support systems have many problem solving methods[10]. Where methods such as Fuzzy, MOORA, MOSRA, SAW, WASPAS, ELECTRE, and PROMETHEE have been proven to help the problem-solving process in the decision-making process[11][12].

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Some previous research conducted in 2020 Istiqoomatun Nisaa and Arief Wibowo found that the decision support system for determining the best lecturers with the AHP and TOPSIS methods is able to handle data processing and can help calculations according to needs[13]. other research conducted in 2021 by Silvi Dwi Megafani, Joseph Dedy Irawan and Hani Zulfia Zahro found that the system built can help recruitment properly using the AHP and TOPSIS methods with an accuracy rate of 96%[6]. Another study conducted in 2022 by Muh. Nifky Jufani, Hani Zulfia Zahro and Sentot Achmadi found that it can make it easier for schools to calculate majors with AHP and TOPSIS methods[14].

Other research conducted in 2021 by IM Khusna and N Mariana found that the system created can help and facilitate farmer group officers in determining quality rice seeds using the AHP and TOPSIS methods[15]. And other research in 2021 by M. Rasyid Ridho, Hairani Hairani, Kurniadin Abd Latif and Rifqi Hammad with the results obtained in research using a combination of AHP-TOPSIS methods can be implemented to get the best alternatives as scholarship recipients[16].

Gap analysis or research contribution in this research compared to previous research is in the decision support system of this research using AHP and topsis methods for choosing majors in college, while others determine the best lecturers, recruitment of new members, student majors in schools, selection of rice seeds and employee recruitment. Then in this research raises a ranking table, while the previous research does not exist.

The combination of the AHP and TOPSIS method was chosen because AHP focuses on superior pairwise comparison matrices and consistency analysis, due to it's straightforward concepts, TOPSIS offers a computationally effecient approach to decision-making. It excels at evaluating the relative performance of various options, making it a valuable tool for complex choices[17].

The AHP and TOPSIS methods will be applied to a website-based system which will be implemented using programming languages such as Typescript and Javascript, as well as the Visual Studio Code development tool. In creating this website, it provides an output for decision making in choosing a college major for Telkom Purwokerto Vocational School students.

The aim of developing this system is to make decisions about choosing a college major easier for students and also to implement the AHP and TOPSIS methods on website in making decisions about choosing a college major for vocational students. This research has the potential to help teachers and students at Telkom Purwokerto Vocational School to be able to direct their students according to their interests and talents by using a decision support system for selecting majors using the AHP and TOPSIS methods.

2. RESEARCH METHODOLOGY

2.1 Stages of Research

In this research, there are several stages in conducting research, the following stages are in the following diagram.

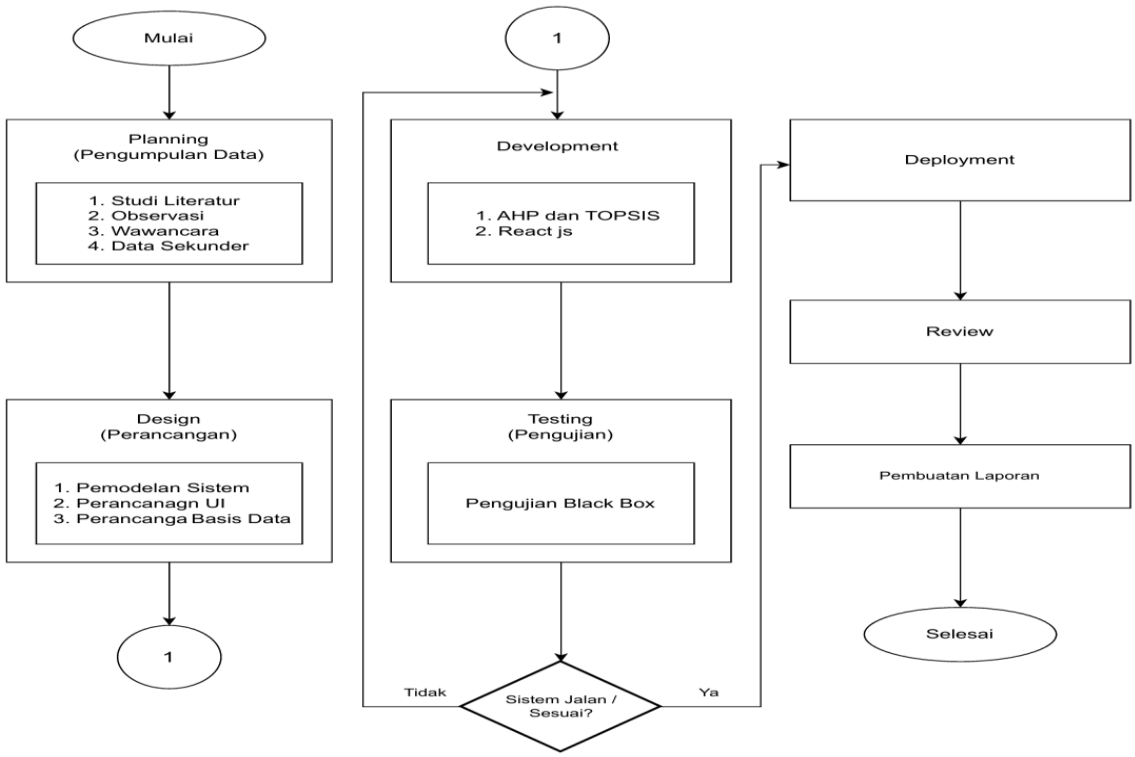

Figure 1. The research stages

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Figure 1 is a research flow chart consisting of 6 stages that will be carried out in this study, the stages will be explained more clearly in the system development methods.

2.2 System Development Methods

Software development in this research was carried out using the agile method which prioritizes collaboration and an iterative process. The application of the agile method was chosen because in this research feedback from users is needed in the system development process.
The stages in software development using the agile method are:

a. Planning

At the planning stage, researchers carry out initial planning, namely data collection. In the process of carrying out this research, complete data and information are needed as supporting documents. The data collection stage was carried out in 4 ways, namely by conducting literature studies, observation, interviews and secondary data collection.

b. Design

Designing a system that aims to complete a decision support system in selecting majors using the website-based AHP and TOPSIS methods.

c. Development

1. Implementation of the AHP and TOPSIS Methods
   The following is a flowchart for the combination of the AHP and TOPSIS methods.

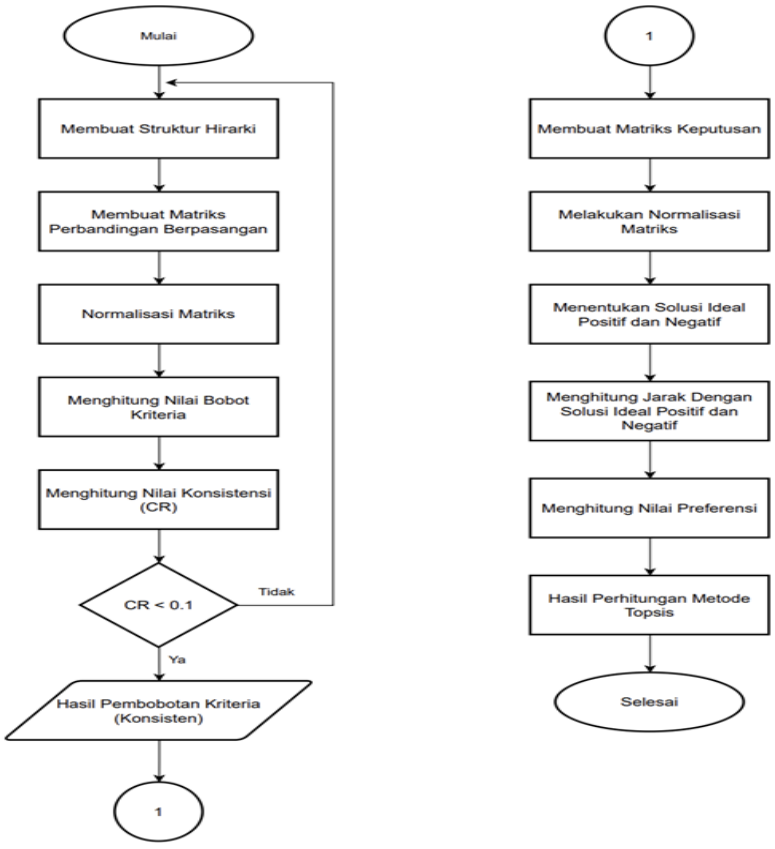

Figure 2. Flowchart Combination of AHP and TOPSIS Methods

Figure 2 depicts the calculation sequence when combining the AHP and TOPSIS methods. First, a hierarchical structure is established, followed by the creation and normalization of a pairwise comparison matrix. This step calculates the weight for each criterion and assesses its consistency using the Consistency Ratio (CR). If CR is less than 0.1, the criteria weights are deemed consistent. Otherwise, the initial steps need to be repeated. Once consistent weights are obtained through AHP, the decision matrix is normalized based on student data. Subsequently, both positive and negative ideal solutions are calculated, along with the distance of each alternative from these ideals. Finally, a preference value is derived to determine the ranking of each alternative based on the calculated distances.

2. React JS implementation
   At this stage, use Visual Study Code as a tool and use the React JS framework. At this stage, starting from the frontend and then the backend.

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d. Testing

At this stage, program testing is carried out which aims to see that the system that has been created can run well as desired or if there are errors so that they can be corrected. The program testing process uses black box testing by testing for incompatibilities in the system with the aim of finding out whether the system created can work and function properly.

e. Deployment

Deployment is the stage of uploading a website to a web hosting, which is the step where the website is placed on a web server so that it can be accessed by users via the internet. The deploy process is the stage where the software is handed over to the user to be used in accordance with the analysis and system design that has been developed.

f. Review

At this review stage, the System Usability Scale (SUS) is used to determine the level of user satisfaction in using the system that has been created.

2.3 Data, Instruments, and Data Collection Techniques

The type of data used is secondary data where data is obtained from the Telkom Purwokerto Vocational School in the form of student subjects and student data. And to obtain this data, observations and interviews were carried out with Guidance Counseling teachers at Telkom Vocational School, Purwokerto. The instrument used to support data collection techniques is a smartphone to take pictures of the data shown by the Guidance Counseling teacher. Apart from observation, interviews and secondary data collection, data collection was also carried out by studying literature from various scientific journals to ensure the accuracy of the information.

2.4 Data Analysis Techniques

This research employs a combined approach using the Analytical Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) for data analysis. AHP tackles complex, unstructured problems by breaking them down into hierarchical components. It facilitates subjective assessment of each variable's relative importance, pinpointing those with the most significant influence on the outcome. Notably, AHP extends its utility to multi-objective and multi-criteria scenarios by enabling comparisons of preferences across hierarchical elements[7]. Complex or unstructured problems can be tackled by establishing a hierarchy. This involves dividing the problem into smaller, more manageable components and then arranging them in a structured hierarchy for effective analysis[18]. The following figure 12 shows the structure of the Analytical Hierarchy Process:

According to Kadarsyah and Ali, the AHP method follows these key steps:

a. Problem definition and solution identification: Clearly define the problem and identify potential solutions.
b. Hierarchical structure development: Establish a hierarchical structure with the main goal at the top.
c. Pairwise comparison matrix construction: Create a matrix that compares the relative importance or influence of each element within a level to the goals or criteria above it.
d. Define pairwise comparisons so that the total number of raters is n x [(n-1)/2], where n is the number of elements being compared.
e. Consistency Check: Calculate eigenvalues and assess their consistency. If the data isn't consistent (indicated by a high Consistency Ratio), repeat steps 3, 4, and 5 (pairwise comparisons, consistency calculation) to refine the judgments and ensure reliable weights.
f. Iterative Weighting: Repeat steps 3 (pairwise comparisons) and 4 (eigenvalue/consistency check) for each level in the hierarchy. This ensures consistent weights are assigned across all elements within the decision-making process.
g. Deriving Final Weights: Calculate eigenvectors from each pairwise comparison matrix. These eigenvectors represent the weights of each element, ultimately determining the priority of elements at the lowest hierarchical level (the alternatives). This allows you to identify the option that best achieves the overall goal[19].

TOPSIS, or Technique For Order Preference By Similarity To Ideal Solution, excels at ranking potential solutions. It identifies the optimal choice by considering two key factors: proximity to an ideal scenario (positive ideal solution) and distance from an undesirable outcome (negative ideal solution) (Mubarok et al., 2019). TOPSIS identifies two hypothetical solutions: the ideal scenario and the worst-case scenario. The ideal scenario represents the best possible outcome on each attribute (think of it as achieving all A's on your report card). Conversely, the worst-case scenario reflects the least desirable outcome for each attribute (think of all failing grades). The Technique for of Preference by Similarity to Ideal Solution Order (TOPSIS) is one of the multicriteria multicriteria decision-making method that first introduced by Yoon and Hwan. TOPSIS uses the principle that the selected alternative must have the closest distance from the ideal solution ideal solution and the longest (farthest) distance from the negative ideal solution from a geometric point of view by using the Euclidean distance (distance between two points) to determine the relative closeness of an alternative to the optimal solution[20].

2.5 Type of Research

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This research uses a quantitative approach where the data is obtained from an interview process with Guidance and Counseling teachers at Telkom Purwokerto Vocational School. The interview data is used to determine assessment criteria and needs in creating a departmental decision support system.

2.6 Time and Place of Research

The research, approved by the school for a smooth execution, spanned from December 4th, 2024 to May 21st, 2024. Conducted at Telkom Purwokerto Vocational School (Jl. DI Panjaitan No. 128, Karangreja, Purwokerto Kulon, Purwokerto Sel, Banyumas Regency, Central Java), it centered on students' academic activities, particularly their decision-making process when choosing a major.

2.7 Research Target/Subject

The aim of this research is to make decisions about choosing a college major easier for students. In this research, the author chose students as research subjects. This is because they themselves understand the interests and talents they have. And the object of this research is the Decision Support System website.

3. RESULT AND DISCUSSION

This section delves into the implementation and results of the previously designed major selection decision support system. It details the integration of the Analytic Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods within the website's decision-making framework. Additionally, it presents the findings from researcher-conducted tests and showcases the developed user interface.

3.1 Implementation of AHP and Topsis Methods

This section outlines the steps involved in using the Analytical Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to determine suitable majors. AHP plays a crucial role by assigning objective weights to different criteria, minimizing the influence of personal biases. TOPSIS then takes center stage, ranking potential majors by considering both "ideal" and "worst-case" scenarios. This combined approach helps students make informed decisions about their academic pursuits.

a. Create a Hierarchical Structure that starts with the main goal.
Here is the hierarchical structure that has been created

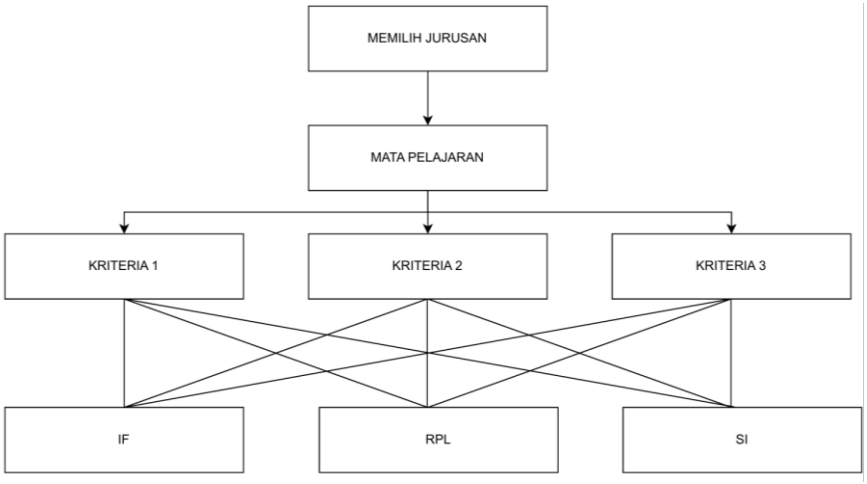

Figure 3. AHP Hierarchical Structure of Major Selection

Figure 3 shows the structure of the Analytic Hierarchy Process, creating a hierarchical structure is the first step taken before creating a pairwise comparison matrix.

b. Creating a pairwise comparison matrix of criteria

Table 1. Pairwise Comparison between Criteria

Pairwise	K1	K2	K3
K1	1,00	3,00	4,00
K2	0,33	1	2,00
K3	0,25	0,50	1
Total	1,58	4,500	7

Making a pairwise comparison matrix between criteria is based on a predetermined importance value. This criterion comparison decision matrix is shown in Table 1.

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c. Determination of index rasio

As in table 2, the determination of the index ratio can be done by looking at the number of criteria used, as follows:

Table 2. Random Consistency Index

Number of Criteria	Random Consistency Indeks(RI)
1	0,00
2	0,00
3	0,58
4	0,9
5	1,12
6	1,24
7	1,32
8	1,41
9	1,46
10	1,49

Table 2 shows the random consistency index table used as a reference in determining RI

d. Normalization of criteria comparison matrix

Table 3. Normalization of Pairwise Comparison between Criteria

	K1	K2	K3
K1	0,6313	0,6667	0,6667
K2	0,2105	0,2222	0,1667
K3	0,1579	0,1111	1,1667
Total	0,1579	1,0000	1,0000

Normalization of each value in the pairwise matrix is done by dividing each value in the column by the total number of columns.

e. Determine the eigenvectors and vectors of the criterion matrix

Determine the eigen vactor or average value of the criteria matrix by dividing the sum of all row values by the number of criteria.

Table 4. Weight Results of Each Criterion

	K1	K2	K3	Eigen Vector
K1	0,6313	0,6667	0,6667	0,6232
K2	0,2105	0,2222	0,1667	0,2395
K3	0,1579	0,1111	1,1667	0,1373
Total	1,0000	1,0000	1,0000	1,00

The values shown in table 4 will be used as weights to continue calculations on the Topsis method in making weighted normalization.

f. Finding the maximum lamda value ((λmax)

The maximum Lamda value will be used to measure consistency, to get the λmax value, it can be calculated by the concept of matrix multiplication between the pairwise comparison matrix in table 3 and the weight value in table 4.

Table 5. Maximum Lamda Value Results

Criteria	K1	K2	K3	Total
Lamda Max	0,987	1,078	0,961	3,025

Table 5 shows the maximum lamda results that have been calculated by multiplying the value of the pairwise comparison matrix by the weight value.

g. Calculating Consistency Index (CI)

To calculate the Consistency Index CI using the formula

$$CI = \frac{\lambda\, maks - n}{n-1} \quad (1)$$

CI = 0,0127

Description: CI = Consistency Indeks, Lamda max ($\lambda\, maks$) = maximum eigenvector, N = number of elements

h. Calculating Consistency Ratio (CR)

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To calculate the consistency ratio value by means of the CI value divided by the Random Index (RI) value obtained from table 2 In this study, the criteria used by researchers are 3 with a value of RI = 0.58. The CR calculation process uses the formula

$$CR = \frac{CI}{RI} \quad (2)$$

CR = 0,0220

Description: CR = Consistency Indeks, CI = Consistency Rasio, RI = Random Consistency Indeks

Table 6. Criteria Weighting Results

Criteria		
Criteria	Weight	Cost/Benefit
K1	0,623224728	Benefit
K2	0,239487608	Benefit
K3	0,137287664	Benefit

Table 6 shows the results of the weight value of each criterion to be used in continuing the calculation in the TOPSIS method.

Next Ranking Stages using the Topsis method

a. Determining alternatives and criteria in the form of a decision matrix.

The stage in this Topsis method is to create a decision matrix based on alternative data and criteria for selection.

Table 7. Alternative Decision Matrix

Alternative	Criteria		
	K1	K2	K3
A1	1	4	5
A2	5	4	1
A3	5	1	4

Table 7 shows the results of the decision matrix based on alternative data and criteria.

b. Determining the normalized decision matrix

The normalization of the decision matrix is done using the formula

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (3)$$

Description: r_{ij} = elements of the normalized decision matrix, x_{ij} = performance rating of the i-th alternative against the j-th attribute

Table 8. Normalized Matrix

Dividers	7,141428429	5,744562647	6,480740698
Alternative/Criteria	K1	K2	K3
A1	0,140028008	0,696310624	0,77151675
A2	0,700140042	0,696310624	0,15430335
A3	0,700140042	0,174077656	0,6172134

Table 8 shows the results of normalizing the decision matrix which aims to compare criteria and alternatives.

c. Determining a weighted decision matrix using the priority weights obtained from the AHP method.

The calculation of the weighted normalized matrix is done by multiplying the value of each alternative in the normalized decision matrix by the weight value generated from the AHP method with the formula

$$y = \begin{bmatrix} y_{11} & y_{12} & y_{ij} \\ y_{21} & y_{22} & y_{2j} \\ y_{i1} & y_{i2} & y_{ij} \end{bmatrix} \quad \text{for} \quad y_{ij} = w_j r_{ij} \quad (4)$$

Description: w_j = weight of the jth criterion, y_{ij} = elements of the weighted normalized decision matrix

Table 9. Weighted Normalized Matrix

Alternative/Criteria	K1	K2	K3
A1	0,0873	0,1668	0,1059
A2	0,4363	0,1668	0,0212
A3	0,4363	0,0417	0,0847

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Table 9 shows the results of the weighted normalized matrix

d. Determine the matrix of positive ideal solutions (A+) and negative ideal solutions (A-).

$$A^+ = (y_1^+, y_2^+, \ldots y_j^+) \quad (5)$$

$$A^- = (y_1^-, y_2^-, \ldots y_j^-) \quad (6)$$

Description: A^+= positive ideal solution, A^-= negative ideal solution, y = alternative

Table 10. Positive and Negative Ideal Solution Matrix

	Max	Min
K1	0,436344588	0,087268918
K2	0,166757766	0,041689441
K3	0,105919732	0,021183946

Table 10 shows the values of the positive ideal solution and negative ideal solution for each criterion shown.

e. Determining the distance of positive ideal solutions and negative ideal solutions.

To determine the distance of positive ideal solutions (di+) and negative ideal solutions (di-) using the formula

$$d_i^+ = \sqrt{\sum_{j=1}^{m}(y_i - y_{ij}^+)^2} \quad (7)$$

$$d_i^- = \sqrt{\sum_{j=1}^{m}(y_{ij} - y_i^-)^2} \quad (8)$$

Description: y_i^+= positive ideal solution matrix element, y_i^- = negative ideal solution matrix element

Table 11. Distance Value Results of Positive and Negative Ideal Solutions

Distance	Positive	Negative
A1	0,34907567	0,151070312
A2	0,084735786	0,370804408
A3	0,126849696	0,354813556

Table 11 shows the results of the ideal solution distance value

f. Determine the preference value for each alternative.

Obtained by using the calculation formula

$$c_i \frac{d_i^-}{d_i^- + d_i^+} \quad (9)$$

Description: Ci = preference value, the alternative with the highest preference value indicates that it is the preferred alternative.

Table 12. Preference Value

Alternative	Preference (Vx)
A1	0,302052435
A2	0,813988344
A3	0,736642363

Table 12 shows the preference value resulting from the closeness of an alternative to the ideal solution.

g. Ranking

The final results obtained using the Topsis method are sorted based on the highest value of each alternative. The order of the results is shown in table 13.

Table 13. Ranking Results

Alternative	Preference (Vx)	Ranking
A1	0,302052435	3
A2	0,813988344	1
A3	0,736642363	2

Table 13 shows the results of the ranking where alternative one gets rank 3 then alternative two gets rank 1 and alternative three gets rank 2.

3.2 System Implementation

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The user interface implementation stage is carried out based on the design that has been made. The results of the system implementation are as follows:

Figure 4. Home Page

Figure 4 shows the results of the design that has been done in the previous chapter, this main page will appear for the first time when accessing the website.

a. The following image is the Registration page

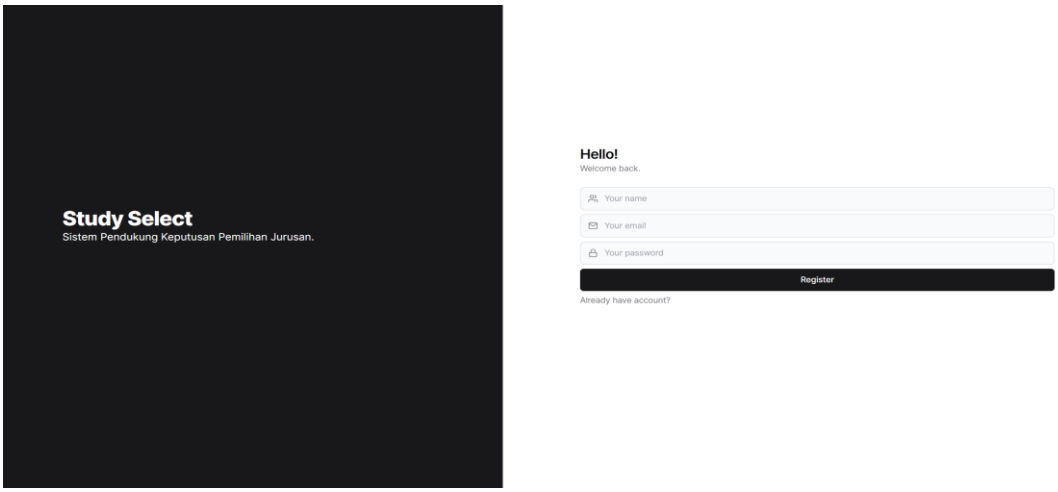

Figure 5. Registration Page

Figure 5 This page is a registration page that can be used by users who do not have an account to register an account first to be able to enter the website.

b. The following image is the Login page

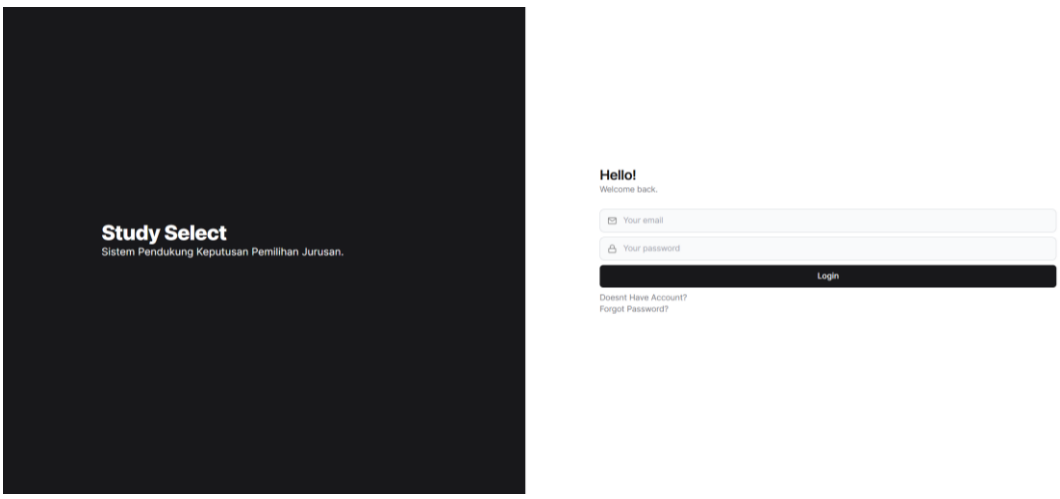

Figure 6. Login Page

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Figure 6 This page is the login page for admin and users, where you must enter your email and password.

c. The following image is the Dashboard page

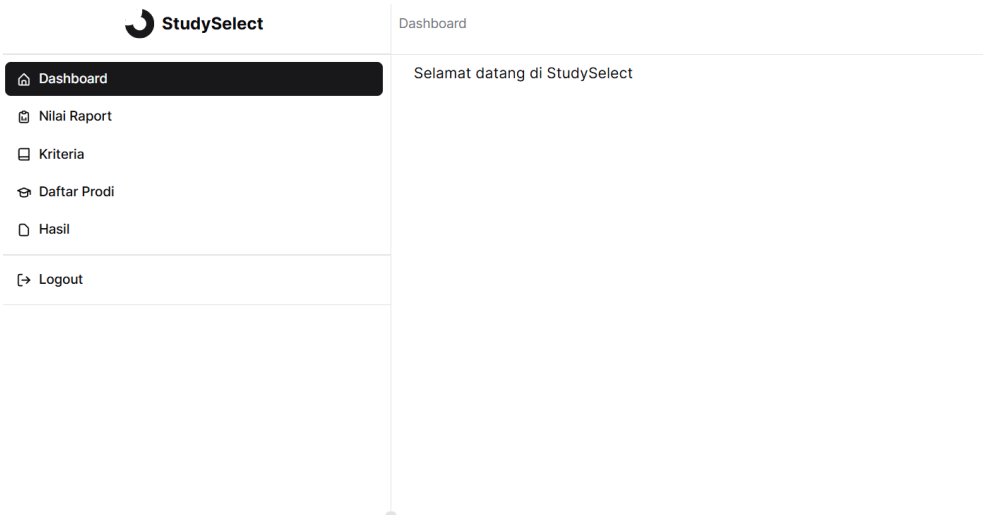

Figure 7. Dashboard Page

Figure 7 is a dashboard page that contains information that the user has successfully logged in.

d. The following image is the report card score page

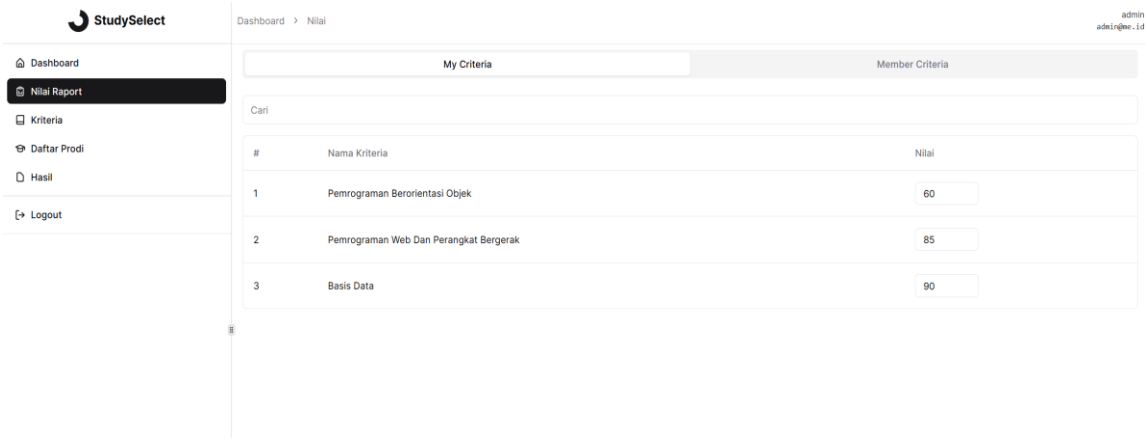

Figure 8. Report Card Value Page

Figure 8 is a report card value page that displays information on the report card value used which can be changed and deleted.

e. The following image is the Criteria page

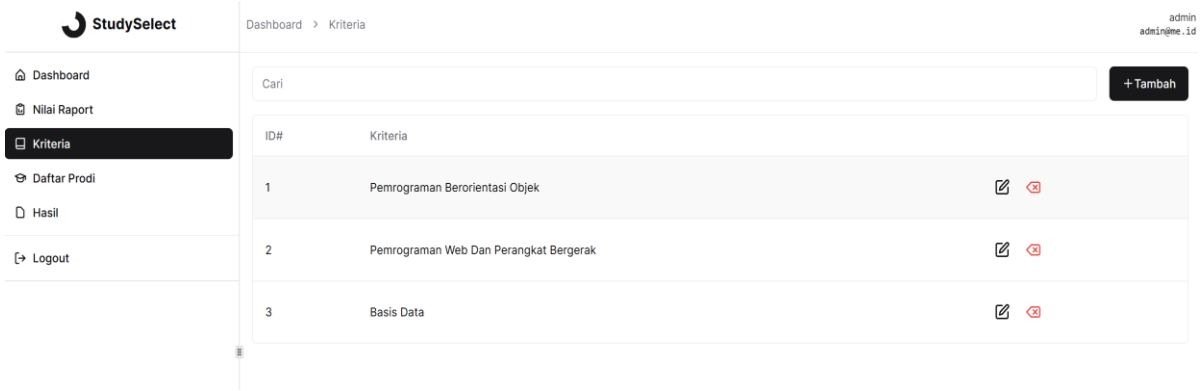

Figure 9. Criteria Page

Figure 9 criteria page shows information about the criteria used, namely subjects. The criteria can be changed, updated, and deleted.

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f. The following image is the Study Program page

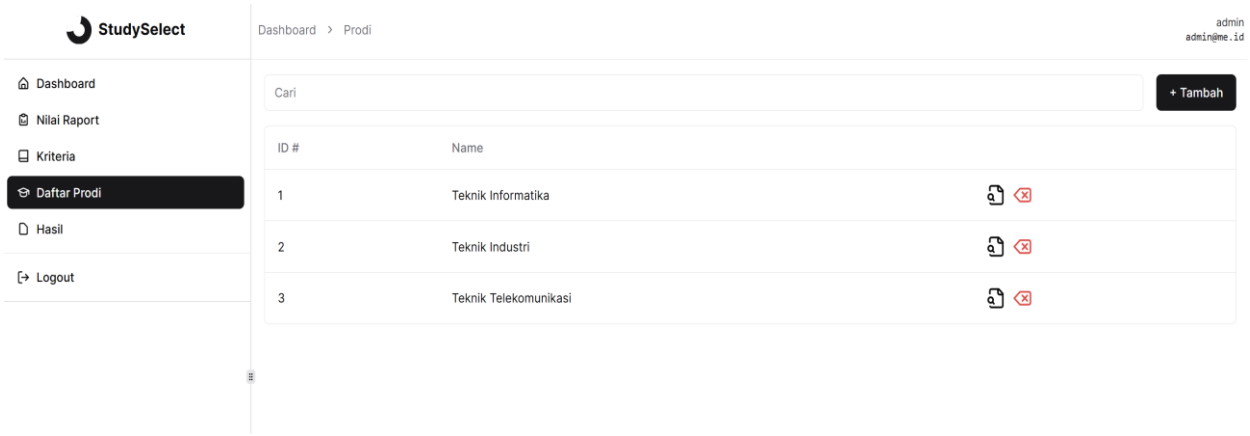

Figure 10. Study Program List Page

Figure 10 of the study program list page shows information about the alternatives used, namely study programs. On this page can add alternatives, deleted and can fill in the criteria value for each alternative.

g. The following image is the Results page

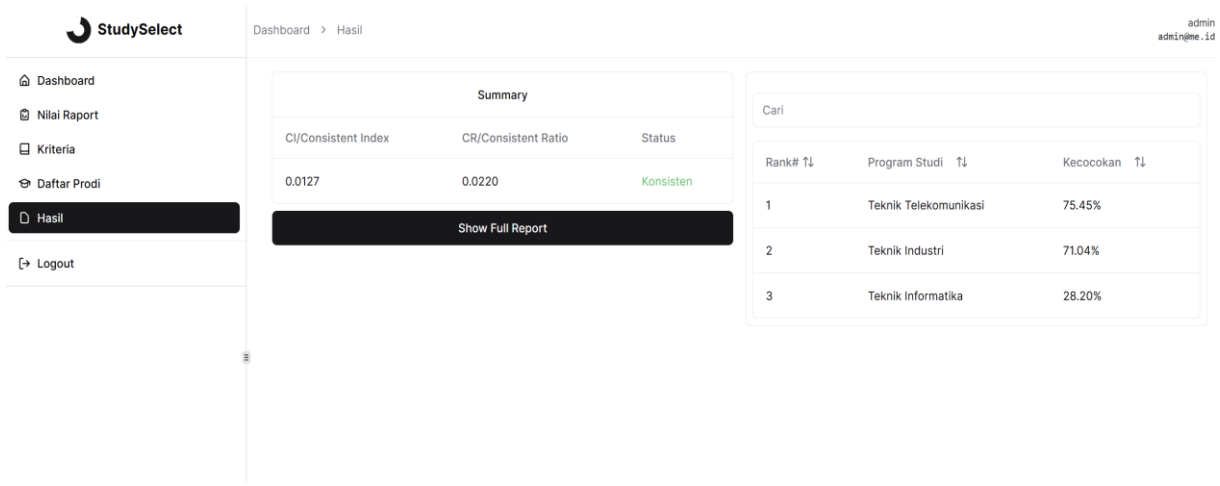

Figure 11. Results Page

In Figure 11 the results page displays a brief result of consistent calculations with the AHP method as well as alternative ranking results.

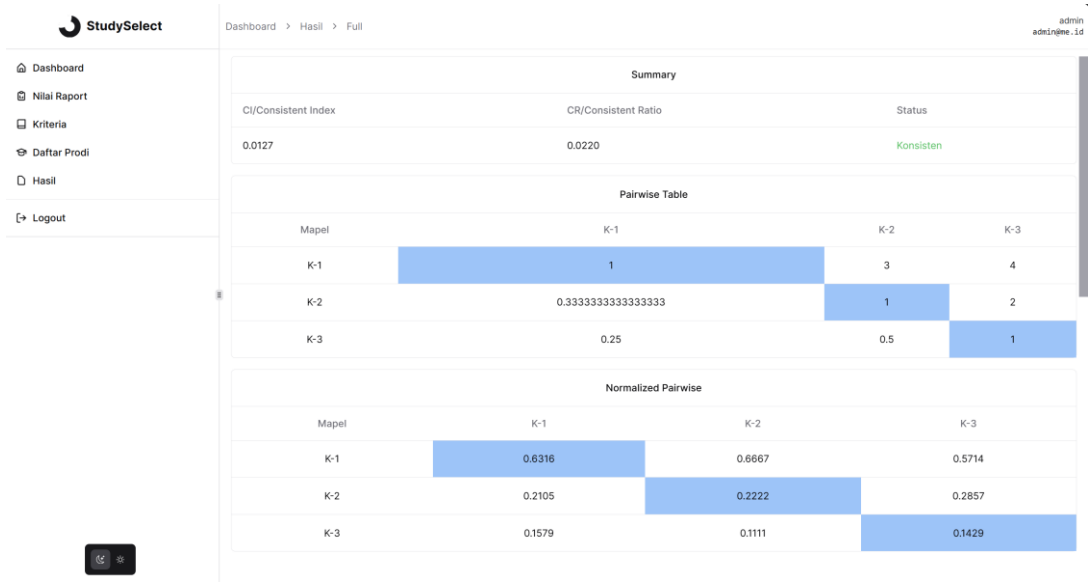

Figure 11.1 Results Page

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Figure 11.1 displays the results of more complete calculations, there are results of comparisons between criteria and normalization of criteria comparisons using the AHP method.

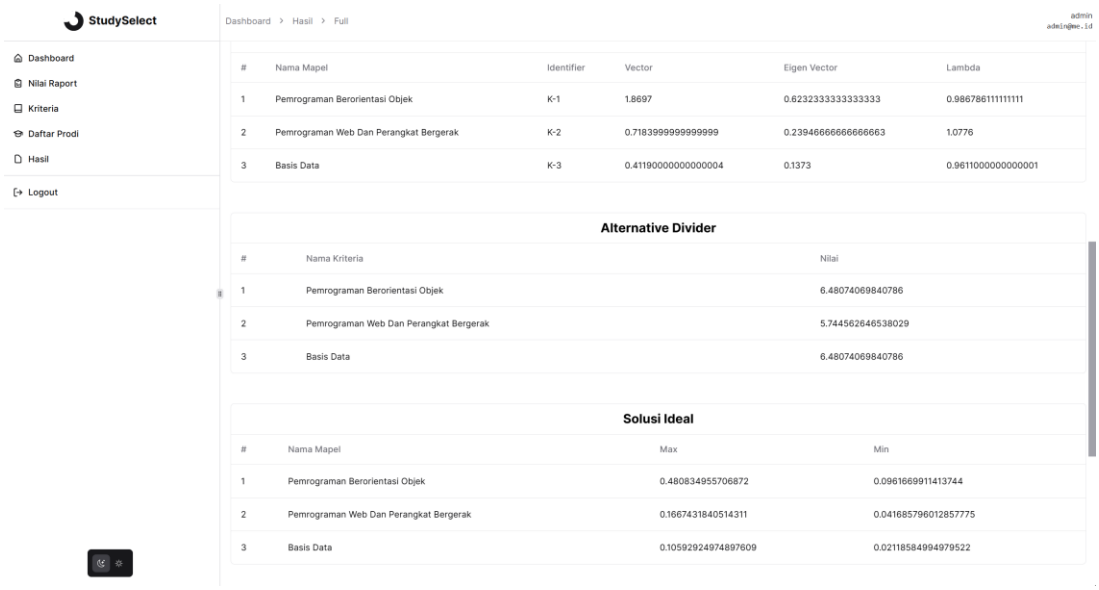

Figure 11.2 Results Page

Figure 11.2 displays the advanced calculation results, namely in the vectorization table there are results of the average value of each criterion, eigen vector results and maximum lamda results. Then the alternative divider table displays the divider results for each alternative. The next table displays the results of the calculation of positive and negative ideal solutions using the Topsis method.

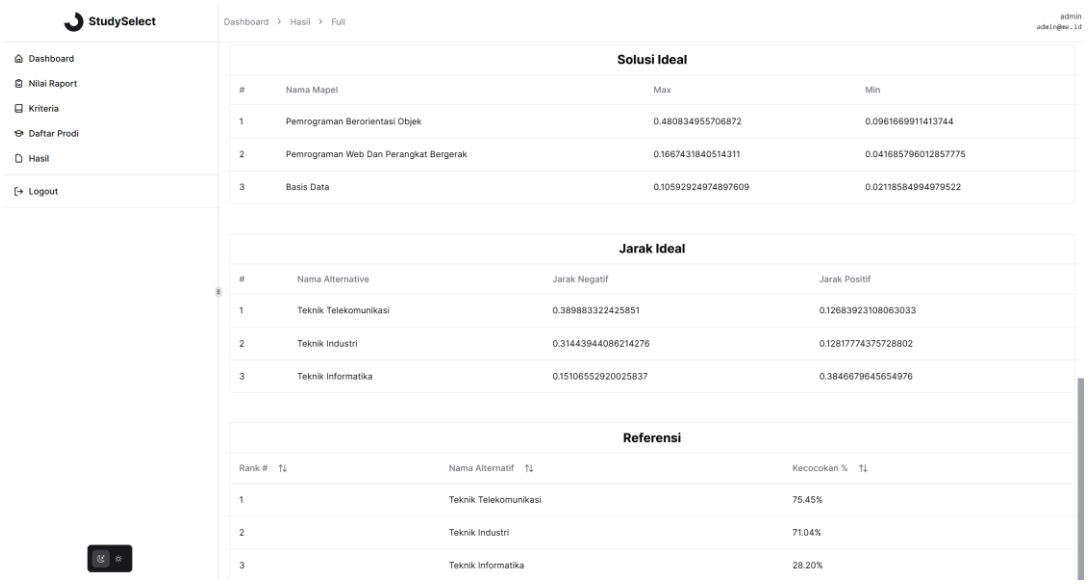

Figure 11.3 Results Page

In Figure 11.3 displays the advanced calculation results, in the Ideal distance table displays the results of positive and negative ideal solution distances. Then the reference table displays the results of alternative rankings along with the percentage of suitability.

4. CONCLUSION

Based on the research conducted on the decision support system for selecting college majors using the Analytical Hierarchy Process method and Technique for Order Preference By Similarity To Ideal Solutions, the results can be concluded. The Analytical Hierarchy Process and Technique for Order Preference By Similarity To Ideal Solutions methods can be implemented on a college major selection website for students who will continue their education to college. By using three samples of criteria and three alternative samples for manual calculations calculated using AHP and Topsis method calculations and having the results of ranking majors in accordance with the calculations between

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criteria and alternatives, AHP and Topsis methods can be implemented. The developed website offers valuable assistance to students and prospective students in navigating the college major selection process. Hasil perhitungan persentase kelayakan sistem dalam pengujian blackbox menunjukkan nilai 95,71%, yang menunjukkan bahwa situs web sistem pendukung keputusan pemilihan jurusan ini dapat digunakan.

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