Decision Support System for Indonesia Smart Card (KIP) Scholarship Selection Using The AHP And VIKOR Method Integrated with EKTP

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Abstract. The Indonesia Smart Card (KIP) for college is a government-sponsored educational assistance program that builds upon the foundation of the Bidikmisi scholarship, providing continued support for eligible students. In the 2018/2019 academic year, Sebelas Maret University Surakarta (UNS) received approximately 2,000 applicants, while the recipient quota was limited to less than 1,000. In the current selection process for KIP UNS scholarships, the criteria weighting method is utilized. However, there is a notable absence of consistency checking during this crucial process. Additionally, incorporating consistency checks is imperative to attain an optimal solution and mitigate the risks associated with subjective decision-making. Relying solely on Microsoft Excel software can also restrict data accessibility and availability. Therefore, this study aims to address the issue of inconsistency in KIP scholarship process by proposing Decision Support System that incorporates consistency checking and improves decision outcomes. The AHP and VIKOR method were used in providing recommendations for KIP scholarship recipients. By employing the AHP method, the calculated weighting criteria exhibited consistency, as indicated by a ratio value of 0.0746. The result showed that VIKOR produced a ranking of KIP scholarship candidates, validated by the confusion matrix method, indicating an accuracy and error rate value of 87% and 13% respectively. These findings confirmed that the AHP and VIKOR method serve as an effective decision-support solution for selecting KIP scholarship recipient.

1 Introduction

The Indonesia Smart Card (KIP) for college is a program initiated by the government under the Minister of Education and Culture Regulation Number 10 of 2020. It serves as a continuation of the Bidikmisi scholarship and provides ongoing support to eligible students. Sebelas Maret University Surakarta (UNS) received around 2,000 applicants in the 2018/2019 academic year, while the admission quota was limited to less than 1,000 students [1]. The Bureau of Student Affairs and Alumni of UNS conducted selection process using the Criteria Weighting Method and Microsoft Excel software which lacks reliability. The

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absence of consistency in the process undermines the ability to ensure a solution and introduces subjectivity. Furthermore, relying solely on Microsoft Excel software limits data accessibility and availability.

This study aims to solve the inconsistency in KIP scholarship process by proposing Decision Support System which checks consistency and provides improved decision-making. This system assists decision-makers by providing organizational data support and modeling outcome [2]. The study proposes the use of the AHP and VIKOR method to support selection process for KIP scholarship recipients. The AHP approach was selected for its ability to address multi-criteria problems and establish a functional hierarchy decision support model, while VIKOR process was selected to overcome the limitations of the AHP and rank the closest alternative as the ideal solution [3]. These two methods were selected because each offers specific advantages that contribute to finding the best recommendations for deciding on KIP scholarship recipients at UNS.

An E-KTP (Electronic ID Card) system was implemented to enhance this study which incorporates advanced biometric security and serve as a computerized identification method. This system enables the documentation of population data and prevents individuals from having multiple identities or duplications. The E-KTP reader is used to regularly verify data and ensure the authenticity of personal details. This additional feature facilitates quick and easy reading of information during registration processes for users/students.

2 Theory Basis

2.1. KIP Scholarship

KIP is a government initiative aimed at addressing the issue of education dropouts due to financial constraints. This program consists of two components, namely KIP Students and College. KIP College is a follow-up program to the government’s Bidikmisi scholarship, specifically designed for academically promising high school graduates or equivalent students from underprivileged backgrounds. Through this program, the government provides educational assistance, enabling these students to pursue higher education [4].

2.2. Decision Support System

Decision Support System is an interactive, computer-based information system designed to tackle structured or semi-structured problems by utilizing data and models. It intends to support decision-making processes that require judgment or cannot be solely guided by algorithms [5].

2.3. Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) is system engineering method that effectively combines qualitative and quantitative analyses. By considering this method, it effectively overcomes challenges and facilitates the determination of the accurate weight of each factor [6].

The AHP method involves several steps or procedures, as outlined below [8]:
1. Identify the problem and define the solution.
2. Determine the priority of elements by conducting pairwise comparisons between criteria. This involves comparing elements in pairs based on the given criteria.
3. Synthesize the comparisons to obtain the overall priority.
4. Measure the Consistency of the comparisons.
5. Calculate the Consistency Index (CI) using Equation (1).

\[
CI = \frac{\lambda_{max} - n}{n-1}
\]  

6. Calculate the Consistency Ratio (CR) using Equation (2).

\[
CR = \frac{CI}{IR}
\]
7. Checking the consistency of the hierarchy.
   If the consistency value is less than or equal to 0.1, the pairwise comparisons between criteria are considered correct (consistent).

2.4. VIKOR

VIšekriterijumsko Kompromisno Rangiranje (VIKOR) is a Multi-Criteria Decision Making (MCDM) method that enables the selection of alternatives based on multiple criteria. The main focus is on the selection and ranking of alternatives, ultimately leading to determining a compromise solution in conflicting criteria. This method was specifically developed to optimize solutions in complex systems that involve multiple responses [9]. VIKOR offers a ranking that identifies the closest solution, even in the presence of conflicting criteria. This empowers decision-makers, such as the student affairs department, to make informed choices from the available alternatives, aligning with specific needs and preferences.

VIKOR method involves a series of steps or procedures, outlined below [10]:
1. Organize the criteria and alternatives in matrix form.
2. Determine the ideal solution for each criterion by assigning positive or negative values.
3. Calculate the utility measures, Si and Ri, using Equations (3) and (4).
   
   \[ S_i = \sum_{j=1}^{n} w_j \left( \frac{f_j^* - f_{ij}}{(f_j^* - f_j^-)} \right) \]  
   \[ R_i = \max \left( \frac{w_j (f_j^* - f_{ij})}{(f_j^* - f_j^-)} \right) \]  

4. Calculate VIKOR index (Q) using Equation (5).
   
   \[ Q_i = \nu \frac{S_i - S^-}{S^+ - S^-} + (1 - \nu) \frac{R_i - R^-}{R^+ - R^-} \]  

5. Rank the alternatives based on VIKOR Value.

Once the Qi value is calculated, a compromise solution is determined by selecting the alternatives with the best ranking. This decision is made based on two conditions, namely, Acceptable Advantage and Stability in Decision Making. If both conditions are satisfied, the alternative with the minimum VIKOR index is considered as the compromise solution.

2.5. E-KTP Reader

E-KTP, also known as KTP-el, is a comprehensive document that securely stores population data and employs advanced information technology control and security system. It utilizes a Radio Frequency Identification (RFID) chip for efficient data storage and retrieval, and on the administrative side, the data is centralized in a national population database, ensuring efficient management of citizen records. To read E-KTP, an E-KTP Reader equipped with an RFID reader is utilized. The transceiver module within the reader captures the signal from each tag, which is then transmitted and processed by the controller circuit [11]. The E-KTP Reader also includes essential components such as card and fingerprint reader for identity verification purposes. EKTP reader as shown in Fig 1.
3 Methodology

3.1. Dataset Collection

The dataset used in this study comprised information regarding KIP UNS scholarship applicants in 2020. A formal request letter was submitted to the Bureau of Student Affairs and Alumni UNS to obtain this data. The dataset provided include comprehensive details regarding KIP UNS scholarship applicants in the year 2020, the criteria data and, their corresponding standards. The received applicant data specifically pertains to the information submitted by prospective students at UNS who applied. From the dataset that has been collected, several important steps will be processed. The flow of this paper's research methodology can be seen as Fig. 2.

![Fig 2. Methodology Stages](image)

3.2. Dataset Preprocessing

After the dataset has been obtained, the data manipulation/preprocessing which involved transformation was performed. The process involves several steps, such as ensuring consistent file and field names that align with the existing data and determining standard content, such as job_father, job_mother, income_father, income_mother, and house_ownership.

The process in this study aimed to change all attributes into numeric ones. This conversion takes place during data entry into system and preparing it in a suitable format for mining purposes. The scoring values used by the Bureau of Student Affairs and Alumni UNS in selection of Bidikmisi/KIP scholarship in 2019 serve as the basis for determining the score values in the transformed data.

3.3. System Implementation

The implementation stage involved the design and development of system by incorporating the AHP and VIKOR method into a web-based program using the PHP programming language. During this stage, debugging was performed to identify and correct any errors that arise, and an E-KTP Reader was integrated into system to view the ranking outcomes obtained. Its implementation requires establishing a connection between the device and the UNS network through an RJ45 LAN cable connection. The E-KTP Reader serves as a tool to read the data and verify it by inputting the NIK which helps prevent the occurrence of multiple identities or duplication within system.

3.4. Dataset Processing

The dataset processing stage was carried out by applying the AHP and VIKOR method to produce recommendations for ranking prospective KIP scholarship recipients. This stage included several steps, such as determining the criteria and processing them using the AHP method to obtain the appropriate standards. The values of KIP scholarship candidates were then processed using VIKOR method to produce rankings.

3.5. Evaluation

The final stage was system evaluation, which was performed to assess whether KIP scholarship decision support system ran accurately as expected. The evaluation involved the validation of the confusion matrix method which was used to calculate the performance or correctness of the classification process [12]. Evaluation with the confusion matrix produced
inaccuracy, error rate, recall, precision, and false positive rate. The first step to calculate accuracy is to use sensitivity and specificity.

\[
\text{precision} = \frac{TP}{(TP + FP)} \quad (5)
\]

\[
\text{recall} = \frac{TP}{(TP + FN)} \quad (6)
\]

Next, the accuracy is calculated using Equation (7). Furthermore, the error rate can be measured by applying Equation (8) to the calculation.

\[
\text{accuracy} = \frac{(TP + TN)}{(TP + FP + FN + TN)} \quad (7)
\]

\[
\text{error rate} = 1 - \text{accuracy} \quad (8)
\]

4 Result

4.1. Needs Analysis

KIP selection decision support system utilized various aspects of student data during its implementation, such as information on parents' income, their occupations, and home ownership. The criteria data used for selection process were obtained from the Bureau of Student Affairs and Alumni at UNS. The requirements employed in scholarship decision support system were based on selection utilized for the Bidikmisi/KIP scholarship in 2019.

<table>
<thead>
<tr>
<th>No.</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1</td>
<td>Per capita (SJ)</td>
</tr>
<tr>
<td>K2</td>
<td>Father's Status (STA)</td>
</tr>
<tr>
<td>K3</td>
<td>Mother's Status (STI)</td>
</tr>
<tr>
<td>K4</td>
<td>House Status (SR)</td>
</tr>
<tr>
<td>K5</td>
<td>Father's Occupation (SKA)</td>
</tr>
<tr>
<td>K6</td>
<td>Mother's Occupation (SKI)</td>
</tr>
</tbody>
</table>

Table 1. Criteria Data

Once the necessary information was obtained, an adjustment process was conducted by preprocessing the dataset through transformation techniques applied to the student information which was referred to as alternative data. It then underwent processing utilizing the AHP and VIKOR method to generate rankings for KIP scholarship recipients.

4.2. System Implementation

The implementation stage involved developing system using the PHP programming language, incorporating the AHP and VIKOR method. System was configured in a client-server architecture, with JavaScript serving as the communication tool for the E-KTP Reader, which was connected to a computer device.

4.3. AHP Method Calculation Analysis

The AHP method was initiated by creating a hierarchical structure, representing KIP selection process. The steps for weighting criteria in the AHP method are as follows:

1. Determine the Pairwise Comparison Value of the Criteria

At this stage, each criterion is compared with others using the Saaty comparison scale, which provides a numerical representation of their relative importance. The pairwise comparisons between criteria are then modeled in the form of matrix. Matrix captures the comparison values between each pair of criteria.
Next, the fractional form in matrix was converted into the decimal form using Equation (9). The pairwise comparison matrix between criteria is presented in the following table format:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>K1</th>
<th>K2</th>
<th>K3</th>
<th>K4</th>
<th>K5</th>
<th>K6</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1</td>
<td>1.0000</td>
<td>5.0000</td>
<td>5.0000</td>
<td>7.0000</td>
<td>7.0000</td>
<td>7.0000</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K5</td>
<td>0.1429</td>
<td>0.5000</td>
<td>0.5000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>2.0000</td>
</tr>
<tr>
<td>K6</td>
<td>0.1429</td>
<td>0.3333</td>
<td>0.3333</td>
<td>0.5000</td>
<td>0.5000</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Subsequently, the values of each column in the weighting matrix are summed to calculate the normalization value. The summation outcomes are as follows: K1 = 1.8286, K2 = 8.3333, K3 = 8.3333, K4 = 12.5000, K5 = 13.5000, and K6 = 18.0000

2. Calculating Criteria Weight

Normalization was performed at this stage to determine the eigenvector value or local priority. The first step involved normalizing each column value of the pairwise comparison matrix between criteria, and resulted in the following: K1 = 3.1803, K2 = 0.8174, K3 = 0.7374, K4 = 0.5165, K5 = 0.4599 and K6 = 0.2885.

The eigenvector is known as K1 = 3.1803 / 6 = 0.5303, K2 = 0.8174 / 6 = 0.1362, K3 = 0.7374 / 6 = 0.1229, K4 = 0.5165 / 6 = 0.0861, K5 = 0.4599 / 6 = 0.0767 and K6 = 0.2885 / 6 = 0.0481.

3. Conduct Criteria Weight Consistency Test

The consistency test was conducted to assess the consistency of the weighting process. If the resulting CR value was less than 0.1, it indicated that the weighting was consistent. At this stage, the calculation of the CR value involved determining λ max (maximum eigen) and CI value based on Equation 9.

\[ Ax = \lambda_{max} x \]  

To obtain λ max, the step involved summing up all the multiplication outcomes between the priority vectors and the corresponding values in the comparison matrix, so \( \lambda K1 = 6.2285, \lambda K2 = 6.1281, \lambda K3 = 6.0925, \lambda K4 = 6.1058, \lambda K5 = 6.0556 \) and \( \lambda K6 = 6.0643 \). Then follows:

Summing \( \Sigma \lambda = 6.2285 + 6.1281 + 6.0925 + 6.1058 + 6.0556 + 6.0643 = 36.6747 \) and \( \lambda_{max} = 36.6747 / 6 = 6.1125 \)

After λ max was determined, the next step was to check the CI value using the following values:

\[ CI = \frac{6.1125 - 6}{6 - 1} = 0.0225 \]

Subsequently, the CR value was checked using the following values:

\[ CR = \frac{0.0225}{1.24} = 0.0746 \]

The calculation demonstrated that the weighting between the entered criteria was consistent, as the resulting CR value was smaller than 0.1. Once the weights for each criterion were determined, the next step involved ranking the available alternatives using VIKOR method.
4.4. VIKOR Method Calculation Analysis

The following stages were undertaken to determine the optimal decision using VIKOR method:

1. Create Decision Matrix
   The initial step involved organizing the alternatives and criteria into decision matrix. Positive and negative values were determined in the following manner:
   
   $$ f_i^+ = \max (5.0000, 5.0000, 5.0000, ..., 8.0000) = 10.000 $$
   
   $$ f_i^- = \min (5.0000, 5.0000, 5.0000, ..., 8.0000) = 0 $$
   
   The calculation continued for each criterion until the final one. Each criterion was assigned positive and negative values. The computed values for the ideal solution were as follows as Table 3

<table>
<thead>
<tr>
<th>K1</th>
<th>K2</th>
<th>K3</th>
<th>K4</th>
<th>K5</th>
<th>K6</th>
</tr>
</thead>
<tbody>
<tr>
<td>F Min</td>
<td>0.0000</td>
<td>3.0000</td>
<td>3.0000</td>
<td>2.0000</td>
<td>1.6600</td>
</tr>
<tr>
<td>F Max</td>
<td>10.0000</td>
<td>10.0000</td>
<td>10.0000</td>
<td>10.0000</td>
<td>10.0000</td>
</tr>
</tbody>
</table>

2. Normalization of Decision Matrix
   Normalization of decision matrix between criteria involved utilizing the previously calculated positive and negative values for each criterion. This process resulted in obtaining a normalization matrix $N$. The normalized decision matrix was subsequently multiplied by the weights of the criteria. This multiplication resulted in obtaining the normalization matrix $N$.

3. Calculating utility measures $S_i$ and $R_i$
   Following the normalization, the utility measure value of each alternative was calculated. The $S_i$ and the $R_i$ value were calculated using the formula in Equation (3) and (4) simultaneously. Consequently, the values of $S_i$ and $R_i$ were determined as Table 4.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>$S_i$</th>
<th>$R_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0.6390</td>
<td>0.2650</td>
</tr>
<tr>
<td>A2</td>
<td>0.5006</td>
<td>0.2650</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1215</td>
<td>0.4974</td>
<td>0.1362</td>
</tr>
</tbody>
</table>

4. Calculating VIKOR Index
   The calculation of the $Q_i$ ranking involved determining VIKOR index value ($Q$), which represents a compromise ranking. Before calculating the $Q$ value for each alternative, the values of $S^+$, $S^-$, $R^+$, and $R^-$ were determined as follows $S^+ = 0.8030$, $S^- = 0.1621$, $R^+ = 0.2350$, and $R^- = 0.0841$

   VIKOR index value for each alternative was calculated using the formula in Equation (5). VIKOR index values were determined as Table 5:

<table>
<thead>
<tr>
<th>Alternative</th>
<th>$Q_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0.5307</td>
</tr>
<tr>
<td>A2</td>
<td>0.4547</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
<tr>
<td>A1215</td>
<td>0.3146</td>
</tr>
</tbody>
</table>
3. Conducting Rankings

The ranking was performed by sorting VIKOR (Q) index values in ascending order. The findings of the ranking are presented in Table 6 as follows:

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Weight</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>A63</td>
<td>0.0000</td>
<td>1</td>
</tr>
<tr>
<td>A762</td>
<td>0.0000</td>
<td>2</td>
</tr>
<tr>
<td>A1190</td>
<td>0.0000</td>
<td>3</td>
</tr>
<tr>
<td>A955</td>
<td>0.0349</td>
<td>4</td>
</tr>
<tr>
<td>A54</td>
<td>0.0570</td>
<td>5</td>
</tr>
</tbody>
</table>

Finally, a compromise solution was made by proving both conditions, as follows:

**Condition I**: Proof of Acceptable advantage conditions

This proof was carried out using Equations 3.13 and 3.14, as follows:

\[ DQ = \frac{1}{1215 - 1} = 0.0008 \] and \[ Q_{A4} - Q_{A3} = 0.0349 \]

As Q A1 to Q A3 have identical values, the values used for comparison are Q A3 and Q A4. It was evident that the resulting difference value surpassed the DQ value, indicating the fulfillment of the Acceptable Advantage condition.

**Condition II**: Proof of condition Acceptable stability in decision making.

This proof was calculated by ranking using the value of v (the weight value strategy of the maximum group utility) as v = 0.44 (with veto), v = 0.5 (by consensus), and v = 0.56 (voting by majority rule), respectively. Then this proof is presented in Table 11.

The best ranking result, with a value of 0.56, was obtained for alternative A63, which coincided with the highest ranking based on the Q values. Moreover, both the rankings with values of 0.44 and 0.5 also corresponded to alternative A63, which aligned with the top Q ranking. These results provide evidence that the condition of Acceptable Stability in decision-making was fulfilled.

Based on the findings confirming the fulfillment of both conditions, it is evident that both criteria have been met. The value of A63, along with other alternatives, was proposed as a suitable compromise solution for KIP scholarship recipient quota.

4.5. Decision Support System Evaluation

Once the rankings were obtained through method process, accuracy testing was conducted. The testing involved the utilization of the confusion matrix method. The performance of decision support system was then represented in the form of a confusion matrix, which is presented in Table 7 as follows:

<table>
<thead>
<tr>
<th></th>
<th>predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>yes</td>
</tr>
<tr>
<td><strong>actual</strong></td>
<td></td>
</tr>
<tr>
<td>yes</td>
<td>1013</td>
</tr>
<tr>
<td>no</td>
<td>82</td>
</tr>
</tbody>
</table>
Based on the information provided in Table 4.16, there were 1013 True Positive and 38 False Negative data. There were 82 data for both False Positive and True Negative. To calculate the accuracy of decision support system, the first step involved determining the sensitivity and specificity using Equation (5) and (6) respectively

\[
\text{precision} = \frac{1013}{1095} = 0.9251 = 93\%
\]

\[
\text{recall} = \frac{38}{120} = 0.3167 = 31.67\%
\]

From the above equation, the accuracy was then calculated using the formula in Equation (7).

\[
\text{accuracy} = 87\%
\]

To calculate the error rate, it can be performed using the formula in Equation (8) return 13%. Based on the aforementioned calculations, the accuracy value of decision support system is determined to be 87%, while the error rate value is 13%.

4.6. System Deployment

The architecture of deployment is showed Fig 3.

![Deployment Architecture](image)

**Fig 3. Deployment Architecture**

The result of application is showed Fig 4. This decision support system can show data sent by EKTP Reader. The EKTP Reader reads from the EKTP card via RFID and is matched to the owner's fingerprint. Data from the EKTP Reader is sent via RJ45 and is then processed by the application and the results of the previous process are searched.

![Application Result](image)

**Fig 4. Implementation of E-KTP and SPK KIP**
The subsequent step involved developing an integrated implementation with the E-KTP equipment. A reader capable of validating an E-KTP card along with the owner's fingerprint was utilized. This implementation was employed for new students who brought their data to the campus to validate whether they were included in the list of students receiving KIP recommendations.

5 Conclusion

Based on the process of developing decision support system for selecting KIP scholarship recipients, it was found that the AHP method consistently generates structured standards compared to VIKOR model, with a ratio value of 0.0746. VIKOR method produced rankings for prospective applicants, and the findings showed the fulfillment of both conditions, thereby providing a compromise solution. The confusion matrix testing showed an accuracy of 87% and an error rate of 13%. The implementation of a decision support system successfully facilitated the development of an effective ranking for KIP scholarship recipient at UNS.

References