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Scholarship Recipients Recommendation System Using AHP and Moora Methods

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Abstract: Providing scholarships to students is an important action in helping students succeed in their studies. The scholarship recipients are students who meet the specified criteria. However, it is not easy to decide which scholarship recipients are genuinely eligible to receive scholarships, especially if the selection process for prospective scholarship recipients is done manually. Many prospective scholarship recipients must be selected, and more than one criterion is required. That is why it is not surprising that awarding scholarships to selected candidates takes a long time and the accuracy of the results is dubious. It means there needs to be a system that can assist in choosing prospective students who meet the criteria for the best requirements as scholarship recipients. Therefore, the purpose of this research is to build an application system that can provide recommendations for eligible candidates for scholarship recipients based on consideration of the criteria possessed by prospective scholarship recipients. This research method is an experimental study using a combination of the Analytical Hierarchy Process (AHP) and the Multi-Objective Optimization Method by Ratio Analysis (Moora) method to rank scholarship recipients. The study results indicate that using an application system integrated into the database in recommending prospective scholarship recipients according to the desired conditions is more accurate using a combination of AHP and Moora methods (up to 94.07%) than using only one Moora method (which is only 89.62%). This means that the selection of scholarship recipients according to the desired qualifications using the AHP method for weighting and the Moora method for ranking is a combination of methods that have relatively more reliable accuracy.

Keywords: Scholarship, Recommendation, AHP, Moora, Decision making.

1. Introduction

As has been emphasized by previous research, in higher education, not only pay attention to the approach or method of education but also other factors that determine the success of schooling [1]; it turns out that one of the other factors is the cost of education. Recently, education payments have continued to increase significantly every year [2]. It becomes a stumbling block for low-income families to finance their children's studies due to their inability to pay the tuition fees. Therefore, higher education fees for the poor have been a significant issue in some countries [3]. It means financial support in education through scholarships to students in tertiary institutions is vital in helping students learn during the study period [4] [5]. Scholarships are financing that does not come from own funds or parents but are provided by the government, private companies, universities, and educational institutions to help to increase the capacity of human resources through education. Scholarships are awarded to students based on classification, quality, and competence. Thus, scholarships facilitate education just for eligible students [5]. It means, providing scholarships for students is a solution that can help finance low-income families [5]. What's more, the scholarship proves to help students study success [6]. Scholarships for students are generally in the form of tuition fees due to students' poor economic

background and because of the outstanding academic achievements of students [6] [5].

Decision-making is not an easy task because the decisions impact the results obtained [7]. Difficulties in making decisions are frequent because decision-makers must consider criteria (Dos Santos, Neves, Sant'Anna, Oliveira, & Carvalho, 2019). Likewise, selecting scholarship recipients is not easy because of many scholarship recipients [9]. Especially if the selection process for prospective scholarship recipients is still manual and the criteria for receiving scholarships are more than one criterion. Processing of scholarship recipients takes a long time, and errors often occur due to inaccuracy [5]. It means there needs to be a system that can assist in selecting prospective students who meet the criteria for the best requirements as scholarship recipients. Therefore, the purpose of this study is to build a system that can provide recommendations for eligible candidates for scholarship recipients based on consideration of the criteria possessed by prospective scholarship recipients. This study uses a combination of Moora and AHP methods to select student scholarship recipients.

AHP is very popular for its use by scientific researchers and decision-makers [10]; because AHP is a valuable method in solving problems effectively and efficiently [11]. AHP is a method that can assist in making decisions on a problem even though it has multiple criteria [12] [13]. Furthermore, AHP is effective in helping solve complex and unstructured problems [12]. In other words, the AHP method can optimize decision-making very effectively when faced with complex issues involving qualitative and quantitative data, with several criteria being considered in decision-making [14]. Therefore, AHP is very dominantly used to calculate the weight of criteria and alternatives [15] [10].

Although several decision-making methods exist, Moora is a computationally easy method to make the most appropriate decision [16] and more straightforward to calculate than other decision-making methods [17]. Moora is a multi-objective (multi-attribute or multi-criteria) optimization method [18]. Optimization with the Moora method considers both favorable and unfavorable criteria in ranking the available alternative choices [15]. While referring to the opinion of Mandal and Sarkar (2012), the method Moora is the best method compared to other methods [19]. Moora is a method that can perform a more precise ranking without being influenced by the weight of the problem criteria and the normalization procedure achieved [15].

In this study, the AHP method is utilized to normalize the weights or find the weight values for each criterion. In addition to finding the weights, the AHP method will also test the consistent level of the weights; if the weights are consistent, then the weight values can be said to be correct. In contrast, the Moora method is utilized for the ranking process, where this method will use the weights obtained from the AHP method. There are six conditions or criteria used as the basis by the system to determine the most appropriate candidate to receive the scholarship in this study.

Some of the latest related works conducted by previous studies are as follows:

- Russo & Camanho (2015) conducted a systematic literature review of applying the AHP method to determine the decisions made from the prerequisite criteria of several selected problems. The difference between the previous research and the research in this article is that the previous research focused on using the AHP method to make decisions on various issues unrelated to student scholarships. In contrast, the research in this article focused on using the AHP method and the Moora method in making decisions for prospective scholarship recipients. College student.
- Jibrin et al. (2016) built an application program that allows prospective students to apply as scholarship recipients using the Hypertext pre-processor (PHP) programming language and MySQL database. The similarity of this previous research with the research in this article is that they both build application programs with programming languages and use MySQL databases. The difference is in the previous study using the PHP programming language, while in this article, the study uses the VB.Net programming language. Another difference is that the previous research only built an application program to register prospective scholarship recipients and did not rank scholarship candidates with AHP or Moora. In contrast, this article research makes an application program that is useful for assessing all prospective student scholarship recipients and then ranking the scholarship recipient candidates according to the criteria possessed by each candidate. scholarship grantee.
- Anthony Anggrawan, Khasnur Hidjah, and Jihadil Qudsi S. (2017) implemented an application system to detect kidney failure [20]. The previous research and this article have similarities in realizing a computer application system using the PHP programming language and MySQL database. The difference is in the research methods and topics. Whereas in previous studies, it was related to the diagnosis of kidney disease using the CBR

(Case-Based Reasoning) method, while in this study, it was related to scholarship recommendations using the Moora and AHP methods.

- Andani et al. (2019) build a recommendation system for recipients of foundation scholarships using the Moora method. This previous research and the research in this article both developed a recommendation system for prospective scholarship recipients [17]. However, the previous study used the Moora method only, while the research in this article uses the Moora and AHP methods. The difference is also in the number of criteria that become a reference in providing recommendations for prospective scholarship recipients. The number of criteria in the previous study was only three: student academic index, parental income, and the number of dependents of students' parents. In comparison, the number of criteria in the research in this article there are six criteria, namely the student average academic index for the last two semesters, total achievement points inside and outside campus, a recommendation from the head of the study program, organizational activity, semester level, and other completeness of required documents.
- Zaitun et al. (2019) implemented the Moora method for decision-making on recipients of financial assistance for Indonesian Smart Card participants [21]. This previous study determined the ranking of student candidates who received financial aid with eight prerequisite criteria: Smart Cards Recipient Status, Social Protection Card Recipient Status, Student Living Type, transportation used, Father's Occupation, and Mother's Occupation, Father's Income, and Mother's Income. In contrast to the research in this article, using the AHP and Moora methods in determining scholarship recipient candidates with six criteria as a ranking prerequisite. In addition, this article examines the accuracy of the method used in determining the ranking, which was not carried out in the previous research.
- Chosy Yuda Sakti et al. (2019) ranked hospitals in serving public health with criteria for payment, prone road module, hospital registration, pharmacy model, inpatient, and emergency module [22]. This previous study used the average value of AHP and Moora's ranking (meaning that the two methods each stand alone in calculating the ranking, then each result is found for the average value). In contrast to the research in this article, ranking is carried out to determine scholarship recipients by combining the AHP and Moora methods with weighting using the AHP method and ranking using the Moora method. Besides that, the previous research did not test the ranking accuracy of the method used; meanwhile, the article in this study tested the ranking accuracy of the Moora method and a combination of the AHP and Moora methods.
- Tasrif et al. (2021) developed an application to manage scholarships using the AHP method. In this previous study, five criteria requirements became a reference in determining the decision of scholarship recipients, namely academic index, achievement in the academic field, achievement in the non-academic field, the income of parents, and the number of dependents of parents. The similarity between the previous research and the research in this article is that both of them make computer applications to build a system for managing scholarship recipients. The difference is that the previous method used only one method, namely the AHP method, while in this study, two methods were used, namely the AHP method and the Moora method. Besides that, the difference between the previous research and this article research also lies in the criteria that become the requirements for scholarship recipients are not the same. In the research in this article, there are six criteria, namely the average achievement index value for the last two semesters, total achievement points inside and outside campus, a recommendation from the head of the study program, organizational activity, semester level, and other completeness of required documents.
- Siregar, Tampubolon, Parapat, Malau, & Hutagalung (2021) researched to select the most worthy students as scholarship recipients. This previous research used the Moora method and only used one criterion: the academic index value of students in recommending scholarship recipients [23]. In contrast to this article, the AHP method is used in addition to the Moora method. Besides, the study in this article uses not only one criterion but five other criteria besides the student's academic value criteria that are as a reference in recommending prospective scholarship recipients.
- Eri Satria et al. (2021) researched the manual ranking of candidates for financial assistance via Indonesian Smart Cards using the AHP method [24]. However, unlike the research in this article, the results of the ranking of scholarship recipients by building a web-based computer application are not only the AHP method but a combination of the AHP and Moora methods. In addition, the criteria for determining candidates for receiving financial assistance differ between the previous research and this article.

Table 1. Comparison of this article's work with some previous related works

Research by	Research methods		Criteria		Build apps	Accuracy Test	Aid fund	Weighting and Ranking
	AHP	Moora	Number	Criteria name				
Russo & Camanho	Yes	No	-	No mention	No	No	No	-
Jibrin et al.	No	No	-	No mention	Yes	No	Yes	-
Anthony Anggrawan et al.	No	No	21	Symptom of Kidney Failure	Yes	Yes	No	-
Andani et al. (2019)	No	Yes	3	Academic index, parental income, and family dependents	No	No	Yes	-
Zaitun et al. (2019)	No	Yes	8	Smart Cards Recipient Status, Social Protection Card Recipient Status, Student Living Type, Transportation used, Father's Occupation, Mother's Occupation, Father's Income, and Mother's Income	No	No	Yes	-
Chosy Yuda Sakti et al.	Yes	Yes	6	Payment, Road Prone Modules, Hospital Registration, Pharmacy Model, Inpatient, and Emergency Module	No	No	No	Use the average value of AHP and Moora rankings
Tasrif et al. (2021)	Yes	No	5	academic index, achievement in the academic field, achievement in the non-academic field, the income of parents, and the number of dependents of parents	Yes	No	Yes	-
Siregar et al.	No	Yes	1	academic index			Yes	-
Eri Satria et al.	Yes	No	5	average achievement index for 3 courses, Indonesian Smart Card participant, Parents' job, Parents' Income, married or not married	Yes	No	Yes	-
This (our) research	Yes	Yes	6	achievement index for the last two semesters, achievement points inside and outside campus, recommendation from the head of the study program, organizational activity, semester level, and completeness of documents	No	Yes	Yes	Weighting using AHP while ranking using Moora

In essence, this research has novelties that have not been studied by previous researchers in using the AHP method for weighting and the Moora method for ranking and the criteria used in determining the ranking. In addition, testing the method's accuracy in ranking scholarship recipients in this article is also a novelty that other researchers have not done before (see table 1). Table 1 shows a comparison of the differences between the work of this article and several previous related works.

The structure of the subsequent writing of this manuscript is as follows: the second part describes the Research Methodology, which includes explaining the programming language used in building the application system and the method used in recommending scholarship recipients. The third part discusses the research results and then ends by recapitulating the conclusions obtained from the research results, the novelty of the research, and suggestions for further study.

2. Proposed method

This research is a case study conducted at the STAHN (*Sekolah Tinggi Agama Hindu Negeri*) state tertiary education in Mataram, Indonesia. The number of prospective student scholarship recipients who became case studies in the ranking of scholarship recipients was 161 students. The programming language used is Visual Basic.Net or VB.Net, and the database used is MySQL

MySQL is an open-source database system with the most users and is server-based [25]. VB.Net is a popular and superior visual programming language [26]. VB.Net is an event-based and object-oriented programming language [27] [28]. VB.NET is suitable for interface embodiment and database building [28] [26]. Meanwhile, the development of an application system to provide recommendations for prospective scholarship recipients in this study uses the Waterfall model. The waterfall is a software development management model [29]. The sequence of phases in the Waterfall model is sequential from one stage to the following [30]. The development of a recommendation system for prospective scholarship recipients in this study is as shown in Figure 1.

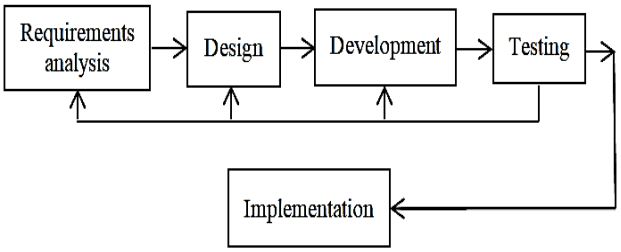

Figure. 1 Waterfall model of system development in this research

The requirements analysis stage is digging up the information needed (data retrieval) to develop the application system built. The design stage is an advanced stage of the Requirements Analysis stage. At this stage, the design of the application system development program in the form of a data flow diagram (DFD) and flowchart is realized. DFD is a diagram that describes the actors who enter data into the system and the system's primary users [31]. DFD also represents the flow of data from the built system, which is mainly used at the design stage [32]. In addition, DFD also presents the sequence of processes involved so that DFD is essential to achieve a structured system analysis [32]. The flowchart is an important part used at the development stage of any application system. Besides that, the flowchart describes the sequence of the application program process [33]. The development stage is the stage of realizing the developed application system. After the final stage of development, the application system testing stage is carried out whether it is following the desired needs. If something is not expected at this testing stage, improvements are made from the previous stage. The last stage is the implementation stage. At this stage, the system unit is integrated, and an application system implementation experiment is carried out to determine the reliability of the application system built. At the last stage, the accuracy of the application system was also tested.

3. Result and Discussion

3.1. Requirement Analysis

Based on the interviews conducted, it was revealed that six criteria became the requirements for considering prospective scholarship recipients. Table 2 shows the interview results from each interview question that has been carried out in collecting requirements analysis data.

Table 2. Interview result

Interview Questions	Interview Answers
How does the scholarship manager recommend/predict students who are eligible for scholarships?	Management is still done manually.
What are the criteria or requirements that prospective scholarship recipients must submit?	Achievement index for the last two semesters, a recommendation from the head of the study program, year of college/semester, certificate of achievement ever obtained, active organizational activities, and supporting required documents (registration form, identity card, family card, proof of paid tuition fees, student identity card).
Which of these criteria has the greatest weight?	Achievement index for the last two semesters, total activity points (calculated based on the number of certificates of achievement obtained), a recommendation from the head of the study program, activeness of organizational activities, year of college/semester entry, and supporting requirements documents.
Does the campus scholarship management department have difficulty in recommending or predicting students who will receive scholarships?	Yes, it isn't easy because of the many student applicants, and the criteria are quite a lot.
Does the scholarship management department need a computer application system that helps in recommending students who will receive scholarships?	Yes, so that the calculation and ranking process can be faster and more accurate.

The weight of the assessment of the six criteria is successive as follows: achievement index of the last two semesters of students, total activity points (calculated based on the number of certificates of achievement obtained) students, letters of recommendation from the head of the study program, activeness of organizational activities from students, year of entry college/semester level of students, and other supporting requirements documents.

Table 3. Criteria and the weight of each criterion

Code	Criteria	Information
C1	The average cumulative achievement of academic index score for the last two semesters	The range of these criteria includes: Achievement index less than 2.50; The achievement index is less than 3.00 and greater than or equal to 2.50; The achievement index is less than 3.50 and greater than or equal to 3.00; and Achievement index greater than or equal to 3.50
C2	Total activity point	The assessed activity's total points are based on how many achievements students have achieved, both internally and externally. The range of the criteria used are: < 50; 50 – 99; 100 – 149; 150 – 199; 200 – 249; 250 – 299; and > 300
C3	Letter of recommendation	This criterion is based on a letter of recommendation from the head of the study program to students who are eligible for scholarships. Here is the range of these criteria: (1) Have not a recommendation; (2) Have a recommendation
C4	Organizational activity	This criterion is assessed based on the student's organizational activity. Here is the range of these criteria: Inactive and Active
C5	Semester	On the criteria for the semester level of students being assessed, the assessment ranges are as follows: (1) Semester 7 or 8; (2) Semester 5 or 6; (3) Semester 3 or 4; and (4) Semester 1 or 2
C6	Other completeness of required documents	This criterion is in the form of other documents required for each prospective scholarship recipient, including the scholarship application letter, statement letter, registration form, student identity card, institutional fee payment, identity card and family card. The following is the assessment range of these criteria: Incomplete; Complete enough; and Complete

The interviews were obtained that manual scholarship management is complicated in determining prospective scholarship recipients because many applicants get student scholarships. Therefore, several criteria must be a reference in deciding student scholarship recipients accurately and quickly. Table 3 shows the criteria and weights of each criterion used in this study.

3.2. Design

The embodiment of the DFD of the application system to recommend prospective scholarship recipients is as shown in Figure 2 and Figure 3. The DFD level 0 (or context diagram) in Figure 2 illustrates the relationship between external entities involved in the application system. Meanwhile, the DFD level 1 in Figure 3 contains the core processes that exist in the system.

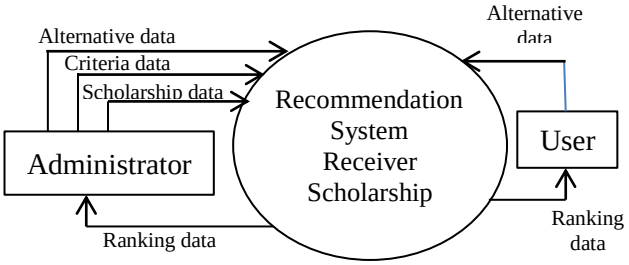

Figure 2. DFD Level 0 of the Scholarship Recipients Recommendation System

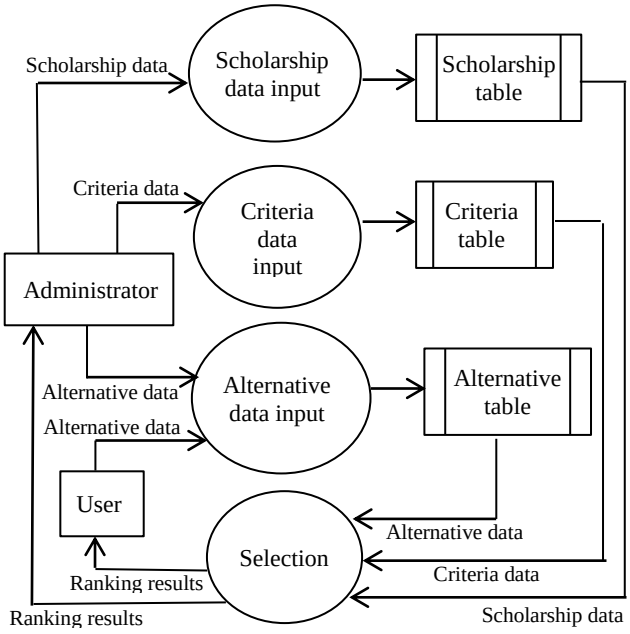

Figure 3. DFD level 1 of the Scholarship Recipients Recommendation System

DFD Level 2 (figure 4) describes the weighting process of AHP to see the consistency of the criteria data. Normalization of the comparison matrix with the initial value obtained from the criteria table where the

realization of the results of normalization of the comparison matrix is by a weighting calculation process; The weighting results are checked for consistency in order to produce accurate values and can be continued to the Moora calculation stage.

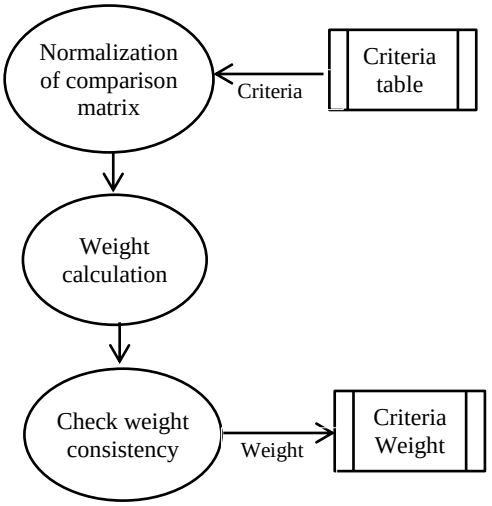

Figure 4. DFD Level 2 AHP Weighting Process

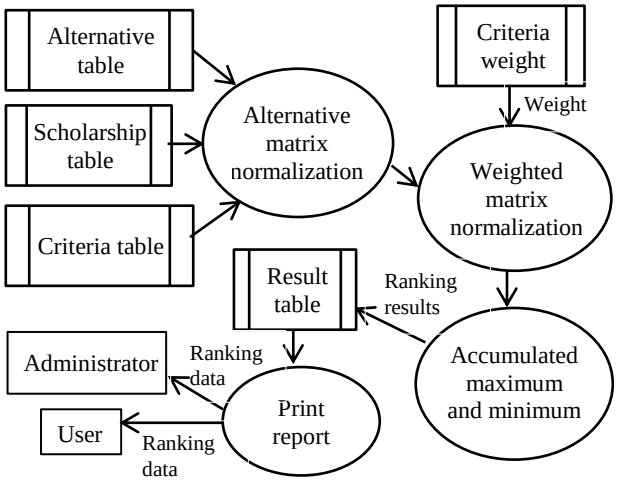

Figure 5. DFD Level 3 Moora Ranking

Figure 5 illustrates the flow or work steps of the Moora method in ranking, where the results of this ranking will be used as a report on the results of determining scholarship recipients. In this process, there are four processes that Normalizing Alternative Matrix carries out, Normalizing Weighted Matrix, Accumulating Max and Min Values, and Printing the results.

Alternative Matrix Normalization describes the process of normalizing the data, namely normalizing the uniformity of the values of each criterion into a dimension that has an interval (0.1). The alternative matrix normalization process comprises three tables: the alternative table, the scholarship table, and the criteria table. The alternative matrix normalization calculation results are obtained from the process of squaring of each scholarship criteria. Meanwhile, Weighted Matrix Normalization describes the weighting process from the Alternative Matrix Normalization process results, which is multiplied by the weight value for each criterion taken from the criteria weight table.

The accumulated maximum and minimum scores describe the calculation process to get the ranking results from scholarship recipients. However, the maximum value is obtained from the sum of the criteria values that benefit, while the minimum value is obtained from the sum of the cost values. After obtaining the maximum value and minimum value, the maximum value will be deducted from the minimum value. The result will be the basis for sorting or ranking; the highest value will be the first rank, and so on. The results of the accumulated maximum and minimum values are stored in the results table in the database file.

The print report process is the process of printing reports whose data is taken from the results table. The printing of this report displays the ranking results of prospective scholarship recipients, which are presented sequentially starting from the highest rank to the lowest rank.

The flowchart in Figure 6 shows the ranking process, which starts with data collection. After the ranking process, the data preprocessing process is carried out at this stage, the data is processed, and invalid values will be deleted or changed so that the data becomes valid data for use in the following process. After preprocessing the data, the next stage is the weighting stage using the AHP method, and the results of this AHP method are in the form of the weights of each criterion. Finally, the weight of each of these criteria is used in the Moora method of ranking. The results of the Moora are in the form of ranking results from all criteria and alternatives.

3.3. Development

At the stage of the system development process, achievement scholarship registrant data, comparison scale and scholarship criteria data are processed to eliminate empty or null values so that the data can be processed. In carrying out the AHP and Moora process, it is necessary to determine the criteria from the basic requirements. The criteria used here are six criteria (C6). The assessment criteria used are as follows: C1 = average GPA in the last 2 semesters; C2 = Total activity points; C3 = Letter of recommendation; C4 = Organizational activity; C5 = Semester; C6 = Completeness of required documents.

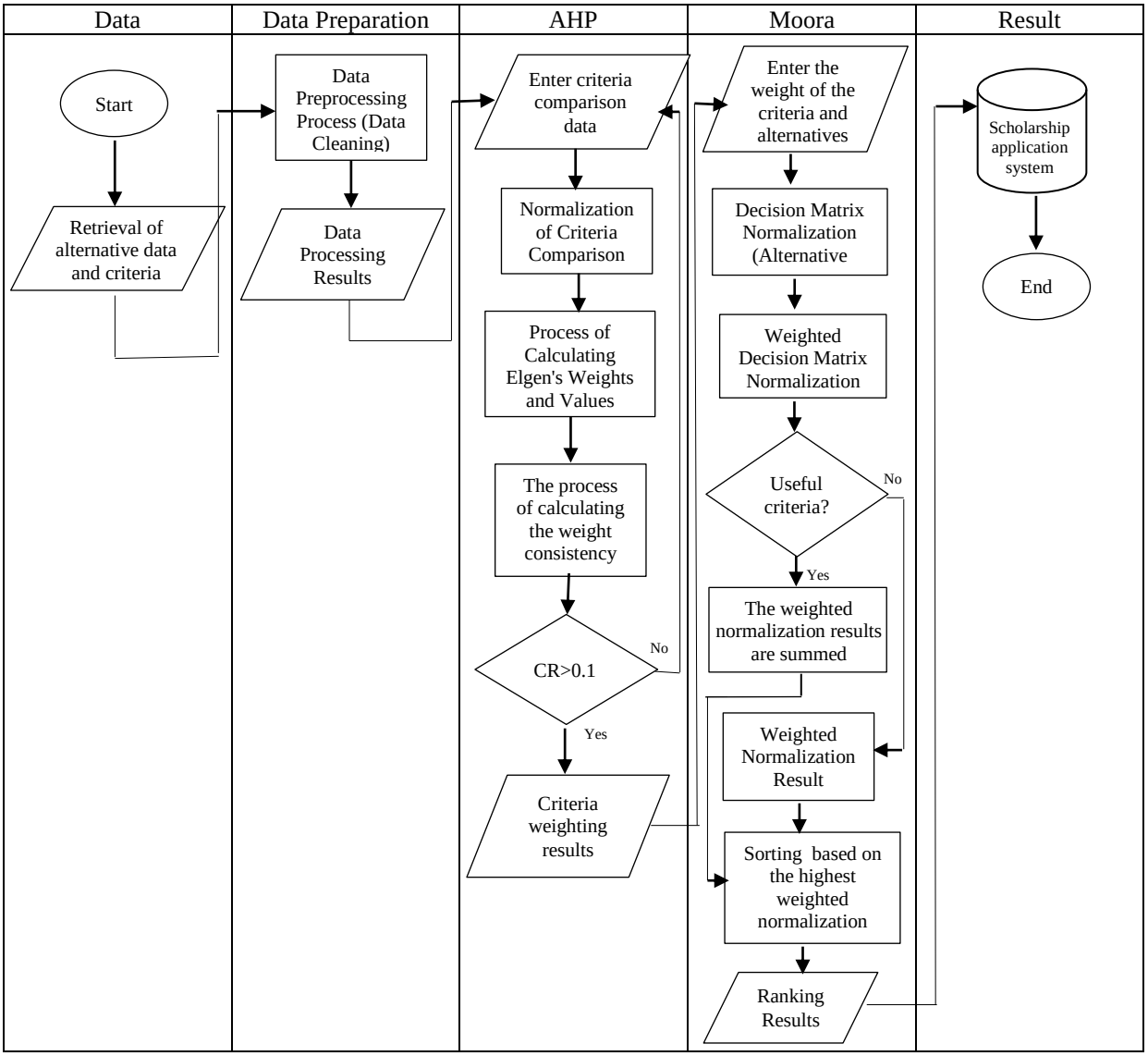

Figure 6. Flowchart of the Application System Built

3.3.1 Calculation with AHP

3.3.1.1 Comparison Scale

Table 4 shows a comparison scale as a determinant of the level of confidence in the prerequisites in applying for scholarships; the higher the level of importance, the greater the weight given, and when the requirements for submitting the level of importance are low, the value given is small.

Table 4. Comparison Scale

Interest level	Definition	Information
1	Equally important	Both elements have the same effect.
3	A little more important	Rating is slightly more in favor of one element than its partner
5	More important	The assessment is strongly in favor of one element compared to its partner.
7	Very important	One element is very influential and its dominance is evident.
9	Absolute more important	It is evident that one element is more important than its partner at a high level of confidence.
2,4,6,8	The middle value of the judgment above	This value is given if there is doubt between two adjacent ratings
Opposite	Aij = 1/ Aij (if for activity i gets one point when compared to activity j then j has the opposite value compared to i).	

3.3.1.2 Create a pairwise comparison matrix for the criteria.

The scholarship requirement value is based on the criteria given as a prerequisite for applying for a scholarship. The value is obtained from the value of the comparison scale. The value given is based on the level of importance for the scholarship requirements, such as C1 requirements. Is it more important with C2 conditions? Apparently, C2 is three times more important than C1; then, the value is given three, as the results are presented in Table 5.

Table 5. Pairwise Comparison Matrix

	C1	C2	C3	C4	C5	C6
C1	1	3	3	5	5	7
C2	1/3	1	1	3	3	5
C3	1/3	1	1	3	3	5
C4	1/5	1/3	1/3	1	1	3
C5	1/5	1/3	1/3	1	1	3
C6	1/7	1/5	1/5	1/3	1/3	1

The results of the comparison matrix process are converted into fractional numbers to make it easier to calculate the next process, as presented in table 6.

Table 6. Fractional Numbers of Pairwise Comparison Matrix

	C1	C2	C3	C4	C5	C6
C1	1.000	3.000	3.000	5.000	5.000	7.000
C2	0.333	1.000	1.000	3.000	3.000	5.000
C3	0.333	1.000	1.000	3.000	3.000	5.000
C4	0.200	0.333	0.333	1.000	1.000	3.000
C5	0.200	0.333	0.333	1.000	1.000	3.000
C6	0.142	0.200	0.200	0.333	0.333	1.000

3.3.1.3 Normalizing each paired matrix value

The next stage in the AHP calculation is to normalize by dividing each value in the column by the total value of each column. Table 7 shows the column sum results for each paired matrix value.

Table 7. Total value in Pairwise comparison Matrix

	C1	C2	C3	C4	C5	C6
C1	1.000	3.000	3.000	5.000	5.000	7.000
C2	0.333	1.000	1.000	3.000	3.000	5.000
C3	0.333	1.000	1.000	3.000	3.000	5.000
C4	0.200	0.333	0.333	1.000	1.000	3.000
C5	0.200	0.333	0.333	1.000	1.000	3.000
C6	0.142	0.200	0.200	0.333	0.333	1.000
Total	2.208	5.866	5.866	13.333	13.333	24.000

The next step is to find the results of matrix normalization with each column value in the pairwise comparison matrix divided by the total number of column values in the pairwise comparison matrix.

Table 8. Normalized Result Matrix

	C1	C2	C3	C4	C5	C6
C1	0.453	0.511	0.511	0.375	0.375	0.292
C2	0.151	0.170	0.170	0.225	0.225	0.208
C3	0.151	0.170	0.170	0.225	0.225	0.208
C4	0.091	0.057	0.057	0.075	0.075	0.125
C5	0.091	0.057	0.057	0.075	0.075	0.125
C6	0.064	0.034	0.034	0.025	0.025	0.042

Table 8 is the result of normalization for each criterion based on the importance of the scholarship requirements.

3.3.1.4 Determining the average value of the criteria matrix

To get the average value of the criteria matrix, it is by adding up the values of each row and dividing by the number of elements to get the priority value. Table 9 shows the results of the calculation of the average value of the criteria matrix that will be used to measure the consistency of the priority values (criteria weight).

Table 9. Priority Value (Criteria Weight)

	C1	C2	C3	C4	C5	C6	Average
C1	0.453	0.511	0.511	0.375	0.375	0.292	0.420
C2	0.151	0.170	0.170	0.225	0.225	0.208	0.192
C3	0.151	0.170	0.170	0.225	0.225	0.208	0.192
C4	0.091	0.057	0.057	0.075	0.075	0.125	0.080
C5	0.091	0.057	0.057	0.075	0.075	0.125	0.080
C6	0.064	0.034	0.034	0.025	0.025	0.042	0.037

3.3.1.5 Finding the Lambda (λ) maximum (max) value that will be used to measure consistency

The way to get the lambda (λ) maximum (max) value is the column in the normalized matrix table multiplied by the average column in the priority value table.

Table 10 shows the result of measuring the consistency of the data used for the criteria for scholarship requirements by using the max. The max results will be used as a reference for the consistency of the criteria of the scholarship requirements.

Table 10. Lambda Max value

	C1	C2	C3	C4	C5	C6	Average	λ Max
C1	0.453	0.511	0.511	0.375	0.375	0.292	0.420	2.63
C2	0.151	0.170	0.170	0.225	0.225	0.208	0.192	1.19
C3	0.151	0.170	0.170	0.225	0.225	0.208	0.192	1.19
C4	0.091	0.057	0.057	0.075	0.075	0.125	0.080	0.48
C5	0.091	0.057	0.057	0.075	0.075	0.125	0.080	0.48
C6	0.064	0.034	0.034	0.025	0.025	0.042	0.037	0.23

3.3.1.5 Measuring consistency

To measure the consistency of the criterion value of the scholarship requirements using the formula: $CR = CI / IR$. CR = Consistency Ratio; CI = Consistency Index; and IR = Random Index.

1. Calculate the value of t. The t-value is obtained by dividing the max value by each cell of the average value and adding then dividing by the number of criteria data.
   t = (2.63/0.420) + (1.19/0.192) + (1.19/0.192) + (0.48/0.080) + (0.48/0.080) + (0.23/0.037)
   t = 6.1417

2. Calculate the CI value. The CI value is obtained by using the formula: $CI = (t-n) / (n-1)$
   CI = (6.1417-6)/(6-1)
   CI = 0.022834
3. Determine the IR value from the IR table based on many criteria data.
   IR = 1.24
   CR = 0.022834 / 1.24 = 0.022856
   Status: Consistent

3.3.2 Calculations with Moora

Based on the calculation of max, the resulting CR value is less than 0.1, the weight of each criterion can be said to be consistent so that it can be continued for the Moora process.

Table 11. Scholarship Recipients Assessment Matrix

Code	Student Name	C1	C2	C3	C4	C5	C6
A1		4	2	2	2	3	2
A2	Ida Ayu Putu	4	2	2	2	1	3
A3	Gta Pt. Lely	4	1	2	2	4	2
A4	Asmarani Pamela	4	1	2	2	3	2
A5	Ni Made Sri Dwi	4	1	2	2	3	2
A6	Ariani	4	1	2	2	3	2
A7	Ni Luh Ayu	4	2	2	2	4	2
A8	Ni Nyoman Ayu	4	2	2	2	1	2
A9	I Made Agus	4	2	2	2	1	2
A10	Ni Wayan Ayuni	4	1	2	2	1	2
…..	…..	…	…	…	…	…	…
…..	…..	…	…	…	…	…	…
A159	Nengah Putra	3	1	2	2	1	2
A160	Dewa Komang	3	1	2	2	1	2
A161	Ni Wayan Sinta	3	1	2	2	4	2

Table 11 shows data on prospective scholarship recipients. The total data used in the manual calculation trial is 10 data on prospective scholarship recipients.

The calculation process with Moora is as follows:

- Create a normalized decision matrix using the Moora method. The formula used to create a normalized matrix is:

$$Xij = \frac{Xij}{\sqrt{\sum_{j=1}^{m} x_{ij}^2}} \quad (1)$$

  Xij is a dimension value with an interval of [0,1] representing the alternative normalization result i on the jth attribute. Table 12 is the result of the normalization of scholarship applicant data.
- Create a weighted normalized matrix:
  This stage is the weighted normalization stage using the priority weights that have been obtained Using the AHP method in Table 9. The way to create a weighted normalized matrix is that the results in the Moora normalization table are multiplied by the priority weight value to produce a weighted normalized matrix value, as shown in Table 13.

Table 12. Normalized Matrix Results

Code	Student Name	C1	C2	C3	C4	C5	C6
A1	I Wayan Suwira	0.316	0.4	0.316	0.316	0.354	0.298
A2	Ida Ayu Putu	0.316	0.4	0.316	0.316	0.118	0.447
A3	Gta Pt. Lely	0.316	0.2	0.316	0.316	0.471	0.298
A4	Asmarani Pamela	0.316	0.2	0.316	0.316	0.354	0.298
A5	Ni Made Sri Dwi	0.316	0.2	0.316	0.316	0.354	0.298
A6	Ariani	0.316	0.2	0.316	0.316	0.354	0.298
A7	Ni Luh Ayu	0.316	0.4	0.316	0.316	0.471	0.298
A8	Ni Nyoman Ayu	0.316	0.4	0.316	0.316	0.118	0.298
A9	I Made Agus	0.316	0.4	0.316	0.316	0.118	0.298
A10	Ni Wayan Ayuni	0.316	0.2	0.316	0.316	0.118	0.298
…..	…..	…..	…..	…..	…..	…..	…..
…..	…..	…..	…..	…..	…..	…..	…..
A159	Nengah Putra	0.611	0.056	0.079	0.079	0.030	0.069
A160	Dewa Komang	0.611	0.056	0.079	0.079	0.029	0.069
A161	Ni Wayan Sinta	0.611	0.056	0.079	0.079	0.119	0.069

Table 13. Weighted Normalized Matrix

	Student Name	C1	C2	C3	C4	C5	C6
A1	I Wayan Suwira	0.133	0.077	0.061	0.025	0.028	0.011
A2	Ida Ayu Putu	0.133	0.077	0.061	0.025	0.009	0.017
A3	Gta Pt. Lely	0.133	0.038	0.061	0.025	0.038	0.011
A4	Asmarani Pamela	0.133	0.038	0.061	0.025	0.028	0.011
A5	Ni Made Sri Dwi	0.133	0.038	0.061	0.025	0.028	0.011
A6	Ariani	0.133	0.038	0.061	0.025	0.028	0.011
A7	Ni Luh Ayu	0.133	0.077	0.061	0.025	0.038	0.011
A8	Ni Nyoman Ayu	0.133	0.077	0.061	0.025	0.009	0.011
A9	I Made Agus	0.133	0.077	0.061	0.025	0.009	0.011
A10	Ni Wayan Ayuni	0.133	0.038	0.061	0.025	0.009	0.011
…..	…..	…..	…..	…..	…..	…..	…..
…..	…..	…..	…..	…..	…..	…..	…..
A159	Nengah Putra	0.032	0.15	0.140	0.006	0.010	0.002
A160	Dewa Komang	0.032	0.15	0.140	0.006	0.002	0.002
A161	Ni Wayan Sinta	0.032	0.15	0.140	0.006	0.010	0.002

Table 13 is the result of the weighted normalized matrix process. The results of the weighted normalization process are used to find the maximum and minimum values.

• Finding the maximum and minimum values for each

alternative.

The maximum value is obtained from the sum of the criteria that are beneficial in the weighted normalized matrix, while the minimum value is obtained from the sum of the criteria that are costly in the weighted normalized matrix. Table 14 results from the search calculation of the minimum-maximum value where the minimum value is 0 because each criterion is a benefit.

Table 14. Maximum and Minimum Value

Code	Student Name	Maximum Value	Minimum value	Yi
A1	I Wayan Suwira	0.335	0	0.335
A2	Ida Ayu Putu	0.321	0	0.321
A3	Gta Pt. Lely	0.306	0	0.306
A4	Asmarani Pamela	0.296	0	0.296
A5	Ni Made Sri Dwi	0.296	0	0.296
A6	Ariani	0.296	0	0.296
A7	Ni Luh Ayu	0.344	0	0.344
A8	Ni Nyoman Ayu	0.316	0	0.316
A9	I Made Agus	0.316	0	0.16
A10	Ni Wayan Ayuni	0.277	0	0.277
…..	…..	…..	…..	…..
…..	…..	…..	…..	…..
A159	Nengah Putra	0.072	0	0.072
A160	Dewa Komang	0.072	0	0.072
A161	Ni Wayan Sinta	0.079	0	0.079

- Determine the final value
  To get the final value of the Moora process (as shown in Table 15) is to reduce the maximum value with the minimum value.

Table 15. Final Value Matrix

Code	Student Name	Maximum Value	Minimum value	Yi
A1	I Wayan Suwira	0.335	0	0.335
A2	Ida Ayu Putu	0.321	0	0.321
A3	Gta Pt. Lely	0.306	0	0.306
A4	Asmarani Pamela	0.296	0	0.296
A5	Ni Made Sri Dwi	0.296	0	0.296
A6	Ariani	0.296	0	0.296
A7	Ni Luh Ayu	0.344	0	0.344
A8	Ni Nyoman Ayu	0.316	0	0.316
A9	I Made Agus	0.316	0	0.16
A10	Ni Wayan Ayuni	0.277	0	0.277
…..	…..	…..	…..	…..
…..	…..	…..	…..	…..
A159	Nengah Putra	0.072	0	0.072
A160	Dewa Komang	0.072	0	0.072
A161	Ni Wayan Sinta	0.079	0	0.079

In the next stage, the process of finding the final value is sorting the data based on the Yi value in table 15 to get the final result or ranking results.

Table 16 is the result of the ranking process of the Moora results sorted from the largest to the smallest value. The order of ranking scholarship recipients from the top to the lower ranking is I Wayan Suwira. Ida Ayu Putu, Gta Pt. Lely, Asmarani Pamela, Ni Made Sri Dwi, Ariani, Ni Luh Ayu, Ni Nyoman Ayu, and so on.

Table 16. Ranking Matrix

Code	Student Name	Value
A1	I Wayan Suwira	0.102
A2	Ida Ayu Putu	0.099
A3	Gta Pt. Lely	0.089
A4	Asmarani Pamela	0.087
A5	Ni Made Sri Dwi	0.087
A6	Ariani	0.105
A7	Ni Luh Ayu	0.098
A8	Ni Nyoman Ayu	0.098
A9	I Made Agus	0.082
A10	Ni Wayan Ayuni	0.105
……	……	……
……	……	……
A159	Nengah Putra	0.072
A160	Dewa Komang	0.072
A161	Ni Wayan Sinta	0.079

3.3.3 System Calculation Results

The ranking results using the combined AHP and Moora methods are shown in table 17.

Table 17. System Ranking Results Moora and AHP

No.	Ranking	Student Name	Value
1	1	I Made Kavin Pradipa	0,1065496
2	2	Ni Putu Virgi Eka Ayu Rasta	0,1052412
3	2	Dewa Nyoman Mayuradana	0,1052412
4	2	Ni Luh Ayu	0,1052412
5	2	I Gede Putra	0,1052412
6	2	Dewayu Paramita Ari Utami	0,1052412
7	2	Ni Luh Ayu Puniawati	0,1052412
8	2	Ni Nengah Mega Juniarsini	0,1052412
9	2	Ni Wayan Noviyanti	0,1052412
10	3	Komang Dewi Patmini	0,1041529
…..	…..	…..	…..
…..	…..	…..	…..
A159	27	Nengah Putra	0,0722262
A160	27	Dewa Komang	0,0722262
A161	27	Ida Ayu Tamara Nandini	0,0722262

The number of available scholarship quotas is 135 scholarships, which is smaller than the number of prospective scholarship participants, which amounted to 161 candidates. So it is necessary to screen prospective scholarship participants so that only 135 students get scholarships. This study tested the accuracy of the Moora method and a combination of

the AHP and Moora methods to find out which method is more effective or more accurate in ranking candidate participants. As a note, the accuracy test of AHP and Moora methods has never been done by previous related works (see Table 1). The method that has better accuracy will be applied in the development of the application program that is built. The test is carried out based on actual data of scholarship recipients obtained from case study data with the existing criteria and weight values. The formula used to calculate accuracy is the confusion matrix test with the formula:

$$Accuracy = \frac{(TP+TN)}{(TP+FP+FN+TN)} \quad (2)$$

Notes:
TP = True Positive; *TN* = True Negative; *FP* = False Positive; and *FN* = False Negative.

Table 18. The predicted value of the actual data and the ranking results in using the Moora and AHP methods

Predicted Value	**Actual Data**	
	Positive	**Negative**
Data True	TP= 127	FP= 8
Data False	FN= 0	TN = 0

Recommendation Accuracy with Moora and AHP = (TP + TN) / (TP + FP + FN + TN) = (127 + 0)/(127 + 0 + 8 + 0) = 127/135 = 0,9407 (See Table 18). Or if expressed in percent, the accuracy of the recommendation with Moora and AHP is 94.7%.

Table 19. The predicted value of the actual data and the ranking results in using the Moora method

Predicted Value	**Data actual**	
	Positive	**Negative**
Data True	TP= 121	FN= 14
Data False	FP= 0	TN = 0

Recommendation Accuracy with Moora = (TP + TN) / (TP + FP + FN + TN) = (121 + 0)/ (121 + 0 + 14 + 0) = 121/135 = 0,896 (See Table 19). Or if expressed in percent, the accuracy of the recommendation with Moora is 89.6%.

Based on the calculation results, it is found that the accuracy generated in providing recommendations for scholarship recipients using the Moora and AHP methods is 94.07%.

Table 20 shows a comparison of the accuracy between the Moora method and the combination of the Moora and AHP methods in providing recommendations for scholarship recipients.

Table 20. Scholarship Recipients Recommendation Accuracy

Method	**Amount of data**	**Result Accuracy**
Analytical Hierarchy Process (AHP) and Multi-Objective Optimization based on Ratio Analysis (Moora)	135	94.07%
Multi-Objective Optimization on the basis of Ratio Analysis (Moora)	135	89,62%

Referring to the trial use of the application program built in this study, it shows that: determination of scholarship recipients using an application program created by applying a combination of the Moora and AHP methods takes work time only on entering data into a computer (2 working days). Meanwhile, determining the ranking of scholarship recipient candidates using the built application program requires less than one minute processing time. In contrast, manual or semi-manual work for scholarship recipients who have a better ranking of requirements takes time to complete not only in data typing but sorting out and choosing a better ranking takes more than two weeks of working time. It means that selecting candidates who receive scholarships according to better eligibility as much as the available quota takes a shorter time than manual or semi-manual processing with the help of a spreadsheet application program. In addition, the accuracy of the ranking results for scholarship recipients does not raise any doubt for the officeholders, considering that the computer work process has very high accuracy.

4. Conclusion

Developing an application system integrated with the database to provide recommendations for prospective scholarship recipients makes the ranking process faster and more accurate. The combination of the AHP and Moora methods in recommending eligible scholarship recipients based on the criteria for prospective scholarship recipients is more accurate (up to 94,07%) when compared to using only one Moora method (whose accuracy is only 89.62%). In addition, the selection of prospective scholarship recipients following better eligibility as much as the available quota by using the built application program helps speed up the completion of the determination of the ranking of prospective scholarship recipients compared to the manual process. In addition, the accuracy of the results related to the ranking of scholarship recipients does not doubt its accuracy for

officeholders.

The novelty of the results of this study is to use a combination of two methods (AHP and Moora) and criteria items in the ranking process that has never been done by other studies before. In addition, this study examines the accuracy of the methods used in ranking scholarship recipients, which is another novelty of this research that previous researchers have never done.

This research was conducted using a combination of AHP and Moora methods in recommending prospective student scholarship recipients; therefore, it is necessary to carry out further research for other cases and various methods.

Conflicts of Interest

The authors declare no conflict of interest.

Author contributions

The first author carried out research background, research analysis and comparison of results with previous works, and conclusions including supporting references. The second author has carried out data collection and completed the necessary calculations, including calculating the accuracy of the results of the research method. The third author has worked on editing and visualization, including creating and testing application programs. Finally, the fourth author re-checked the manuscript's contents, including the writing.

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