The Implementation of Analytical Hierarchy Process Method for Outstanding Achievement Scholarship Reception Selection at Universal University of Batam

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Abstract: Universal University of Batam offers outstanding achievement scholarship to the current students to be each year of new academic year, seeing the large number of new Students who are interested to get it then the selection team should be able to filter and choose the eligible ones. The selection process starting with evaluation and judgement made by the experts. There were five criteria as the basic of selection and each had three alternatives that must be considered. Based on the policy of University the maximum number of recipients are five for each of six study programs. Those programs are art of music, dance, industrial engineering, environmental engineering, telecommunication engineering, and software engineering. The expert choice was subjective that AHP method was used to help in making decision consistently by doing pairwise comparison matrix process between criteria based on selected alternatives, by determining the priority order of criteria and alternatives used. The results of these calculations were used as supporting decision-making to determine the eligible students receiving scholarships based on alternatives of selected criteria determined by the final results of AHP method calculation with the priority criterion A (0.37%), C (0.23%), E (0.21%) , D (0.14%) and B (0.06%), value of consistency ratio 0.05. Then the alternative priorities 1 (0.63), 2 (0.26) and 3 (0.11) the consistency ratio values 0.03, where each CR ≤ 0.1 or consistent weighting preference.

Keywords: Analytical Hierarchy Process (AHP); Criteria; Alternative; Outstanding Scholarship.

1. Introduction
Universal University is one of the universities located in Batam City, Riau Islands Province, newly developed and able to open eleven undergraduate study programs, namely Dance Art, Music Art, Accounting, Management, Information Systems, Informatics Engineering, Software Engineering, Engineering Industry, Environmental Engineering, Telecommunication Engineering and Mandarin Language Education. To support the lecture process, Universal University provides scholarship for outstanding students. It is applied to six study programs of Music Art, Dance Art, Industrial Engineering, Environmental Engineering, Telecommunication Engineering, and Software Engineering. It aims to motivate students, alleviate the cost of lectures as well as improve students learning performance in achieving the vision of the studies taken by them.

The scholarship recipients are those who eligible. It involves the analysis of multi-criteria decision-making by prioritizing which criterion was the most important for students in the selection process [1]. The scholarship distribution process for the students was conducted by the selection team as the expert and with the scholarship budget which has been determined by Universal University. In the selection process, some criteria of assessments are need to be considered in order to know the students who deserve scholarship, with many enthusiastic scholarship enthusiasts it takes time and excessive expert. Thus one of the solutions offered is to find the best alternative based on the criteria that have been determined using Analytical Hierarchy Process (AHP) method by finding the weight value for each attribute and sorting the candidates that will determine the optimal alternative is that the eligible recipients. Because the expert choice is subjective so AHP method assists in making decisions consistently by performing pairwise matrix comparison process between criteria based on
selected alternatives, by determining the priority order of the criteria and the alternatives used. By that alternative, the system gives information needed to know which students deserve the scholarship.

2. Literature Review and Method

2.1 Literature Review

AHP method is one of analysis technique in decision making involving multi criteria and alternative criterion, build hierarchy with different level of importance so as to produce weighting with acceptable level of consistency.

The previous study used AHP method as a simple methodology for selecting suppliers in the automotive industry in Pakistan, identifying criteria in terms of price, quality, delivery and service determined by expert opinion. The use of AHP helps in prioritizing criteria and gives the impression of consistency throughout the decision making process, thus providing insight into the various factors that managers need to consider when making decisions [2].

The model of decision making in construction management is multi criteria, one of the optimization methods used is AHP in the selection of contractor for swimming pool construction. The multi-criteria aspect is important when making construction management decisions based on 9 criteria according to experts namely technical experience, resource performance, financial stability, performance management and employee qualifications, capacity, safety, operation and equipment. The results of this study were found to be the best contrast factor with a total score of 0.551 as the preferred constructor [3].

The AHP method was also used in housing renovation priorities combined with geographic information systems. This study took into account one of the basic human needs, society and civilization to ensure the quality of living standards. The city planning and management institutions were doing housing renovations because of the high occupancy rate, so the low economic people find it too expensive. Priority and preparation of the renovation plan required consideration relative to existing resources. This study considered all units with field study and census data collection techniques. The first priority result was 17.86%, the second priority was 77.24% and the remainder included priority 3, 4 and 5 [4].

2.2 Analytical Hierarchy Process Method

AHP is one of the proven techniques in solving a multi-criteria problem or sub criteria in which each criterion has a different level of importance in decision-making [1].

To get a decision using AHP method, there are 3 basic stages as shown in the following figure 1.

Figure 1. Basic AHP Analysis [1]

Figure 1 explains that the main basic stage in performing analysis of decision making involving multiple criteria or sub criteria is to build and develop a hierarchical criterion model which is relatively more important than the awardees of outstanding scholarship. Pairwise comparison performs a comparative assessment or defining and implementing data collection to obtain pairwise comparison data on hierarchical structure elements. Priority synthesis builds priority ranking overall.

The Criteria and Alternative Process are done by having pairwise comparison. According to Saaty for various issues, the scale 1 to 9 is the best scale for expressing opinions. In determining the priority of criterion, AHP performs the element priority analysis by applying pairwise comparison method between the two elements so that all elements are met. Priorities are determined on the basis of an expert's view of interest in decision-making, as shown in the following table 1.
Table 1. AHP Importance Scale [5]

| Score | Relative Importance                      |
|-------|------------------------------------------|
| 1     | Objectives A and B are of equal importance |
| 3     | Objective A is weakly more important than B |
| 5     | Objective A is strongly more important than B |
| 7     | Objective A is very strongly more important than B |
| 9     | Objective A is absolutely more important than B |

2, 4, 6, 8 are intermediate values

The application of AHP method for the selection process of outstanding scholarship was done through a procedure, as shown in the following figure 2.

Figure 2. AHP procedure [2]

Figure 2 illustrates that the hierarchical criteria structure was the scholarship recipients that had been set by the university, the next step was to collect data by expert in pairwise matrix matrices, then calculated the criteria and alternative priority weighting. The next step was to evaluate whether the result of the calculation is acceptable or not measured by the consistency ratio where CR <0.1 if not then do the improvement [6].

3. Analysis
3.1 Needs Analysis
Analysis of needs related to input data that will be processed into output on the selection process of outstanding achievement scholarship obtained from the administration of the University and the selection team as the experts, the needs analysis obtained as follows:

a. Needs input. The required input data is student data consisting of student's number, name, study program, class information, history of achievement, average score of semester 1 to 5, recommendation of principal, score of achievement scholarship test and interview result. The data is the consideration of an expert that is formed in a hierarchy of criteria and alternative criteria.

b. Process Requirement. Criteria and alternative criteria data are processed by an expert using a pairwise matrix scale and AHP Random Index Consistency list.

c. Output Needs. The resulting output is a priority weighting sequence of criteria and alternative criteria that assist in consistent decision making.

3.2 Data Collecting Technique
Data collecting techniques used to help obtaining the appropriate data are:

a. Interview. Collecting data through face-to-face interview directly to the interviewee, namely the administration department along with the scholarship selection team as the experts, related to data, process and criteria comparison scale and alternative criteria.

b. Library. Collecting data through journal literature, books and documents related to scholarship data.
3.3 Analysis of AHP
The next stage of analysis was to model business processes to map out the process flow on which development was based, as shown in the following figure 3.

![Figure 3. General framework of the AHP model [5]](image)

Based on Figure 3 there were 5 criteria used in the selection process of outstanding scholarship, the existing criteria as shown in the following table 2.

Table 2. Criteria scale and its definition

| No | Definition                                                                 | Criteria |
|----|--------------------------------------------------------------------------|----------|
| 1  | Interested in the study programs of Art Music Art, Dance Art, Industrial Engineering, Environmental Engineering, Telecommunication Engineering and Software Engineering | A        |
| 2  | Principal recommendation                                                 | B        |
| 3  | Average grades in semester 1 - 5 min 8 (Scale 10)                        | C        |
| 4  | Pass the scholarship program selection of Universal University min 7 (scale 10) | D        |
| 5  | Have a good discipline and great desire for college and achievement      | E        |

From some criteria there was a need to be tested whether the consistency ratio was acceptable or not. In particular, a matrix (i, j) is said to be consistent if all elements follow some rule rules. As shown in equations (1) and (2) [6]:

\[
a_{ij} = a_{ik} \cdot a_{kj} \\
a_{ij} = \frac{1}{c_{ij}}
\]

(1)

(2)

Where i, j and k represent any alternative of the matrix. If "A" is 9 times more important than "B", then "B" should be 1/9 times more important than "A". The relational scale used in the rankings as shown in the following table 3.

Table 3. Criteria Comparison Matrix

| Criteria | A   | B   | C   | D   | E   |
|----------|-----|-----|-----|-----|-----|
| A        | 1   | 9   | 2   | 3   | 1   |
| B        | 0.11| 1   | 0.33| 0.33| 0.33|
| C        | 0.5 | 3   | 1   | 3   | 1   |
| D        | 0.33| 3   | 0.33| 1   | 1   |
| E        | 1   | 3   | 1   | 1   | 1   |
| Total    | 2.94| 19  | 4.67| 8.33| 4.33|
Based on Table 5 the matrix element \( a[i, i] = 1 \) where \( i = 1, 2, \ldots, n \), where each element of the upper triangular matrix was the input and the lower triangle with the formula for \( i j \).

The pairwise comparison matrix can also be shown in equation (3) [8].

\[
A = \begin{bmatrix}
\frac{a_{11}}{a_{11}} & \frac{a_{12}}{a_{11}} & \cdots & \frac{a_{1n}}{a_{11}} \\
\frac{a_{21}}{a_{22}} & \frac{a_{22}}{a_{22}} & \cdots & \frac{a_{2n}}{a_{22}} \\
\vdots & \vdots & \ddots & \vdots \\
\frac{a_{n1}}{a_{nn}} & \frac{a_{n2}}{a_{nn}} & \cdots & \frac{a_{nn}}{a_{nn}}
\end{bmatrix} = \begin{bmatrix}
\frac{w_i}{w_1} & \frac{w_i}{w_2} & \cdots & \frac{w_i}{w_n} \\
\frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\
\vdots & \vdots & \ddots & \vdots \\
\frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n}
\end{bmatrix} \tag{3}
\]

Then the next step summed each column to determine the value of the element in each criteria column by dividing the value of each cell with each number of columns as shown in the following table 4.

**Table 4. Normalized Relative Weights of Criteria Comparison Matrix**

| Criteria | A  | B  | C  | D  | E  | Total |
|----------|----|----|----|----|----|-------|
| A        | 0.34 | 0.47 | 0.43 | 0.36 | 0.23 | 1.83  |
| B        | 0.04 | 0.05 | 0.07 | 0.04 | 0.08 | 0.28  |
| C        | 0.17 | 0.16 | 0.21 | 0.36 | 0.23 | 1.13  |
| D        | 0.11 | 0.16 | 0.07 | 0.12 | 0.23 | 0.69  |
| E        | 0.34 | 0.16 | 0.21 | 0.12 | 0.23 | 1.06  |
| Total    | 1   | 1   | 1   | 1   | 1   | 5     |

After obtaining the element value in each column, the next step was determining the average value of the row of criteria for each row in Table 4 where the number of rows was divided by the number of criteria as shown in the following table 5.

**Table 5. Value of Eigen Vector**

| Criteria | A  | B  | C  | D  | E  |
|----------|----|----|----|----|----|
| A        | 0.37 | 0.06 | 0.23 | 0.14 | 0.21 |
| B        | 0.04 | 0.06 | 0.08 | 0.05 | 0.07 |
| C        | 0.18 | 0.17 | 0.23 | 0.42 | 0.21 |
| D        | 0.12 | 0.17 | 0.08 | 0.14 | 0.21 |
| E        | 0.37 | 0.17 | 0.23 | 0.14 | 0.21 |

Based on the result of the priority criteria calculation, it was found the priority results with the following criteria as A, C, E, D and B.

Create a matrix of sums for each row, for a consistent matrix, as shown in equations (4), (5) and table 6 [8].

\[
A \cdot W = \lambda W
\]

where :

- \( A = \) Comparison Matrix
- \( W = \) Vector eigen
- \( N = \) Dimensions of the matrix

**Table 6. Matrix of the Sum of each row**

| Criteria | A  | B  | C  | D  | E  | Total |
|----------|----|----|----|----|----|-------|
| A        | 0.37 | 0.50 | 0.45 | 0.42 | 0.21 | 1.95  |
| B        | 0.04 | 0.06 | 0.08 | 0.05 | 0.07 | 0.29  |
| C        | 0.18 | 0.17 | 0.23 | 0.42 | 0.21 | 1.21  |
| D        | 0.12 | 0.17 | 0.08 | 0.14 | 0.21 | 0.72  |
| E        | 0.37 | 0.17 | 0.23 | 0.14 | 0.21 | 1.11  |

The next step was to obtain the lambda (\( \lambda \)) value used to determine the Maximum Eigen value (\( \lambda_{\text{max}} \)) obtained from the sum of the total matrix of the sum of each row divided by the Eigen vector as shown in the following table 7.
Table 7. Calculation of Consistency Ratio

| Criteria | Number of rows | Eigen Vector | Results |
|----------|----------------|--------------|---------|
| A        | 1.95           | 0.37         | 5.32    |
| B        | 0.29           | 0.06         | 5.19    |
| C        | 1.21           | 0.23         | 5.32    |
| D        | 0.72           | 0.14         | 5.16    |
| E        | 1.11           | 0.21         | 5.23    |
| **Total** |                | **26.22**    |         |

Then calculate the consistency value as a deviation or degree of consistency as shown in equations (6) [9]:

\[
C_R = \frac{C_I}{R_I}
\]  

(6)

The index was used by comparing it with a random consistency index as shown in the following table 8.

Table 8. List of Random Index Consistency (RI) [4]

| n  | RI  | n  | RI  |
|----|-----|----|-----|
| 2  | 0.0 | 9  | 1.45|
| 3  | 0.58| 10 | 1.49|
| 4  | 0.9 | 11 | 1.51|
| 5  | 1.12| 12 | 1.48|
| 6  | 1.24| 13 | 1.56|
| 7  | 1.32| 14 | 1.57|
| 8  | 1.41| 15 | 1.59|

After finding the CI value, the next step was calculating the value of CR as shown in equations (7) [9]:

\[
C_R = \frac{C_I}{R_I}
\]  

(7)

The calculation of consistency ratio was to know whether the criterion comparative assessment is consistent or not. Where \((CR) <= 0.1\). If the CR value was greater than 0.1, then the pairwise comparison matrix must be corrected.

Amount (sum of result values): 26.22

N (number of criteria): 5

\(\lambda_{max} \) (number / n): 5.24

Consistency Index (CI) = CI \((\lambda_{max} - n) / (n-1)\): 0.06

Consistency Ratio = CI / RI, the RI value for n = 5 is 1.12 \(C_R / RI\): 0.05

CR <0.1, then the consistency ratio of the calculation was acceptable (consistent weighting preference).

Alternative criteria as a material comparison of existing criteria as shown in the following table 9.

Table 9. Alternative Criteria

| No | Criteria | Alternative                  |
|----|----------|------------------------------|
| 1  | A        | A1. Very interested          |
|    |          | A2. Interested               |
|    |          | A3. Quite Interested         |
|    |          | B1. Very worthy              |
| 2  | B        | B2. Worthy                   |
|    |          | B3. Quite worthy             |
Based on Table 9 the criterion alternative was calculated in the same way as the criteria process modeling, as shown in the following table 10.

**Table 10. Pairwise Comparison Matrix of Alternative Criteria and Consistent Results**

| Alternative | 1 | 2 | 3 | Priority |
|-------------|---|---|---|----------|
| A           | 1 | 3 | 5 | 0.63     |
| B           | 0.33 | 1 | 3 | 0.26     |
| C           | 0.2 | 0.33 | 1 | 0.11     |
| Total       | 1.53 | 4.33 | 9 | 1        |

- **Sub-Criteria Priority**
  - **A**: 9.12
  - **λ_max**: 3.04
  - **CI**: 0.02
  - **CR**: 0.03

CR <0.1, so the consistency ratio of the calculation is acceptable. The results of the scholarship selection process, as shown in the following table 11.

**Table 11. AHP Implementation**

| Code | A       | B     | C       | D       | E       | Priority |
|------|---------|-------|---------|---------|---------|----------|
| 1    | Interested 0.10 | Worthy 0.01 | Excellent >=9 0.14 | Average =7<8 0.06 | (0.32) |
| 2    | Very Interested 0.23 | Worthy 0.01 | Very Good Average =8.5<9 0.06 | Very good =7<8 0.13 | (0.45) |
| 3    | Interested 0.10 | Very Worthy 0.04 | Very Good Average =8.5<9 0.06 | Very good =7<8 0.13 | (0.34) |

And so on…

Based on the implementation of the student data in table 11, the priority was obtained from the results of criteria and alternative calculations used with the results of student 2 more eligible to receive the scholarship compared to students 1 and 2, while student 3 was more eligible for the scholarships compared to student 1.

4. Results and Discussion

AHP plays an important role to help solving problems in choosing the best alternative to prioritize based on multi-criteria data of awardees of outstanding scholarship at university. The results obtained by the AHP method in the selection process of outstanding scholarship at Universal University with the priority criteria A, C, E, D and B, the consistency ratio value 0.05, based on the order of priority the main factor in the selection of awardees of scholarship was interest in 6 study programs related to the priority value 0.37%, followed by the average value of report cards 0.23%, having good discipline and great desire to lecture and achievement 0.21%, pass the
selection of universal university education scholarship program 0.14% and the recommendation of the principal 0.14%. The recommendation of the principal had a relatively low importance although it strengthened achieving conformity between the criteria fulfilled with the responsible party in previous education so that this criterion should not be ignored. Alternative priorities 1 (0.63), 2 (0.26) and 3 (0.11) had a consistency ratio of 0.03 in which each CR < 0.1.

The AHP method could be used to avoid contradictions, because AHP could only be used for consistent decisions. For decisions in the selection of awardees were made by experts who evaluated and assessed them carefully. Expert choices were subjective but the AHP structure assisted in consistent decision making [10].

In the previous study the AHP method had been used for decision making in selection of logistics service providers for a company in Istanbul, Turkey. The most important factor in the selection of logistic service provider companies was compatibility 47.15% and factors with relatively low importance, long term relationship 10.82% [9]. AHP was also applied in construction management decisions to select the best swimming pool contractors based on the six criteria used [3].

5. Conclusions
The AHP method provides the ease of decision making for the selection process of scholarship awardees in Universal University, through the multi criteria and alternatives used this method is able to prioritize each criteria and alternatives based on the level of expert interest so as to generate weight value that determines the outcomes of students who deserve to receive outstanding scholarship.

6. Suggestions
Suggestions for the development of next research are as follows:
1. This research can be developed into a new one on the selection of dedicated scholarship at Universal University of Batam.
2. The research data can be processed by using different methods such as Topsis or combination of AHP - Topsis and Fuzzy Logic methods, to produce the development method with the comparison of methods applied.
3. This research can be developed by building applications that can assist stakeholders in work, research and development.
4. Melakukan integrasi sistem dengan aplikasi penyeleksian penerimaan calon mahasiswa baru secara online, sehingga proses bisnis untuk seleksi penerima beasiswa berprestasi berjalan beriringan dengan seleksi penerimaan calon mahasiswa baru sehingga lebih optimal.
5. Having integrated online the system with the application of new student candidates selection, so that the business process for selection of scholarship achievers goes hand in hand with the selection of new students that will be more optimal.

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