Fuzzy Multi Attribute Decision Making (FMADM)
Implementation for Classifying Student’s Single Tuition Fee (UKT) Based on Android Applications

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Abstract. Universitas Negeri Yogyakarta is one of the state universities in Indonesia that assigned Student’s Single Tuition Fee (UKT) policy. UKT is an Indonesian government policy of tuition fees charged to every student with nominal based on the student’s financial capabilities. Although the implementation of UKT nominal has been arranged in such ways, there are problems occurred, such as inconsistency and inaccuracy of UKT nominal classification. This causes so many dissatisfactions between students to the UKT nominal that did not meet the expectations and raises questions about the transparency of the determination of student’s UKT nominal. Therefore, the application of Fuzzy Multi Attribute Decision Making (FMADM) can improve the accuracy and the effectivity of the determination of student’s UKT nominal also answering the student’s questions and giving clarifications about student’s UKT nominal. The result of this research was an Android-based application that can be used for determining student’s UKT nominal and determining what group that nominal belongs to with ease for under 5 minutes fast. With this android application, determining and calculating student’s UKT nominal will be much faster and more accurate when grouping the UKT nominal than the conventional method used before.

1. Introduction
Universitas Negeri Yogyakarta is one of the state universities in Indonesia that assigned Student’s Single Tuition Fee (UKT) policy. UKT policy was set based on circular letter from Dirjen Dikti Number 97/E/KU/2013 about UKT that instructs all state universities in Indonesia to write off base fees while setting and implementing UKT policy for the new undergraduate and diploma regular students starting from academic year of 2013/2014 [1][2].

UKT is an Indonesian government policy of tuition fees charged to every student with nominal based on the student’s financial capabilities [3][4]. UKT included in the Overall Tuition Fee (BKT). BKT is the total of academic operational costs per student per semester [5]. The application of UKT nominal was set corresponding to the university operational costs by the constitution of UU Number 12 Year 2012 about higher education on State University Operational Subsidies, BKT, and UKT [4] and Regulation of Ministry of Education and Culture of Republic Indonesia Number 55 Year 2013 about BKT and UKT on State University under Ministry of Education and Culture [6].

UKT nominal affected by some criteria that affecting student’s financial capabilities [3], such as parent’s income, building and land area, and number of family dependents [7]. UKT nominal in the
Universitas Negeri Yogyakarta on 2018 was divided from group I to group VII and has been set by the Decision of Ministry of Research, Technology, and Higher Education Number 91/M/KPT/2018 [8].

According to Karim et al. (2011) [6] although the implementation of UKT nominal has been arranged in such ways, there are problems occurred, such as inconsistency and inaccuracy of UKT nominal classification, for example there are students with lower financial capabilities got higher UKT nominal than the students with higher financial capabilities. This causes so many dissatisfactions between students to the UKT nominal that did not meet the expectations and raises questions about the transparency of the determination of student’s UKT nominal. Therefore, the application of Fuzzy Multi Attribute Decision Making (FMADM) can improve the accuracy and the effectivity of the determination of student’s UKT nominal also answering the student’s questions and giving clarifications about student’s UKT nominal.

In fuzzy systems there are many algorithms that can be used for classification such as fuzzy inference system (FIS), fuzzy C-means (FCM), and FMADM [9]. FMADM is a method to find the alternative from the alternatives by some specific criteria [10]. FMADM involving two main processes, the rating and ranking of the alternatives [11]. The researchers chose to use this method because it can determine the best alternative from the alternatives using some specific criteria [12]. FMADM method is used for determining the UKT classification combined with Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method for ranking the alternatives [13]. The solution of the Multi Attribute Decision Making (MADM) case can be done by considering problem representation, evaluation of fuzzy sets, optimal alternative selection, also data sources and types [14].

The objective of this research was to create an Android-based application that can be used for determining student’s UKT nominal and determining what group that nominal belongs to. With this android application, determining and calculating student’s UKT nominal will be much faster and more accurate when groupping the UKT nominal than the conventional method used before.

2. Method of Research

2.1. Data Processing Method

In general, data processing method starts as the data become problems representation, then Fuzzi Sets began the evaluation producing optimal alternatives selection from the data as the result. The method for data processing as shown at figure 1.

![Diagram of Data Processing Method](image)

In this research, FMADM and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) were used for determining student’s UKT nominal group. According to [14] steps for solving this MADM case are problem representation, fuzzy sets evaluation, and optimal alternatives selection.

In the problem representation there are 3 things to do: research objectives identification and groups of alternatives decision, criteria identification, and building structural hierarchy of the problems based on specific considerations. After performing a problem representation process, a fuzzy set evaluation process is carried out. TOPSIS method was used by the researchers on this step for evaluating the fuzzy sets on this MADM case. TOPSIS is one of the multicriteria decision making method based on the concept that the best-chosen alternative did not only have the shortest length from the ideal positive solution, but also have the longest length from the ideal negative solution. On the TOPSIS method, there are some steps as follows: Determining fuzzy sets from each criteria, calculating normalized decision matrix, building weighted normalized decision matrix, determining positive ideal solution matrix and negative ideal solution matrix, determining range between each alternative value with the positive ideal solution matrix and negative ideal solution matrix, determining preference score for each alternatives [13]. This research did not stop at the end of the last TOPSIS process, but it continues to rank the
preference score from each alternative from the biggest to the smallest. In the last step to process the data, we must select the best solution from some of the optimal solution variable. On this step, the results from the fuzzy sets evaluation step will be ranked based on the alternatives preferences and will be grouped based on the percentage of the data for determining every UKT groups. On this research, there are 7 UKT groups, the group I for the lowest group, group II, III, IV, V VI, and group VII as highest group.

2.2. Data Sources and Types
Data source for this research comes from the 50 students input. Students will fill out the online form including 26 questions. From the 26 questions, 13 points will be taken as main criteria to describe financial capabilities of the new student of Universitas Negeri Yogyakarta, these 13 points are:

- a. Number of Family Dependents (person) (C1)
- b. Number of Family Dependents on Education (person) (C2)
- c. Latest Electric Bill (Rp.) (C3)
- d. Latest Land and Building Tax (Rp.) (C4)
- e. Building Ownership Status (C5)
- f. Land Ownership Status (C6)
- g. Overall Area of Building (m²) (C7)
- h. Motorcycle Price (Rp.) (C8)
- i. Car Price (Rp.) (C9)
- j. Overall Gold Value (Rp.) (C10)
- k. Monthly Father’s Gross Income (Rp.) (C11)
- l. Monthly Mother’s Gross Income (Rp.) (C12)
- m. Overall Monthly Family Income (Rp.) (C13)

3. Result and Discussion
On this research, economic data from the new student of Universitas Negeri Yogyakarta will be ranked. There are 13 criteria used for determining student’s UKT nominal on this research: C1 = Number of Family Dependents, C2 = Number of Family Dependents on Education, C3 = Latest Electric Bill, C4 = Latest Land and Building Tax, C5 = Building Ownership Status, C6 = Land Ownership Status, C7 = Overall Area of Building, C8 = Motorcycle Price, C9 = Car Price, C10 = Overall Gold Value, C11 = Monthly Father’s Gross Income, C12 = Monthly Mother’s Gross Income, dan C13 = Overall Monthly Family Income.

The researchers using TOPSIS method for solving this MADM case. These are steps:

**Step 1: Problems Representation**
- a. The objective of this decision was to achieve the determination for grouping student’s UKT nominal starting from group I to group VII based on the data obtained from the new students of Universitas Negeri Yogyakarta.
- b. There are 13 decision criteria: C = \{C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C12,C13\}.
- c. Structural hierarchy of the problems as shown in figure 2.
Figure 2. Structural Hierarchy of the Problems

Step 2: Fuzzy Sets Evaluation
On this step, researchers used TOPSIS method explained as follows:

a. Determining Fuzzy Sets from Each Criteria

The first thing to do is to form fuzzy sets for each criteria, in this research using discrete data so that fuzzy sets from each criteria on this research as shown in figure 3 for criteria C1, figure 4 for criteria C2, figure 5 for criteria C3, figure 6 for criteria C4, figure 7 for criteria C5, figure 8 for criteria C6, figure 9 for criteria C7, figure 10 for criteria C8, figure 11 for criteria C9, figure 12 for criteria C10, figure 13 for criteria C11, figure 14 for criteria C12, dan figure 15 for criteria C13.
b. Calculating Normalized Decision Matrix

Normalized decision matrix calculation can be done using equation 1.

\[
r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^{n} x_{kj}^2}}; \text{where } i = 1, 2, ..., m; \text{ and } j = 1, 2, ..., n
\]  

(1)

Where, \( x_{ij} \) is the i-th alternative performance rating of the j-th criteria.

c. Building Weighted Normalized Decision Matrix

A’ positive ideal solution and A’ negative ideal solution can be determined by normalized score rating \((Y_{ij})\) as shown on the equation 2.

\[
y_{ij} = w_{i} r_{ij}; \text{where } i = 1, 2, ..., m; \text{ and } j = 1, 2, ..., n
\]  

(2)

Where, \( w_{i} \) is the weight value of the i-th criteria chosen in accordance with the policies in force at each university.

d. Determining Positive Ideal Solution Matrix and Negative Ideal Solution Matrix

Positive ideal solution \((A^+)\) calculated using equation 3.

\[
A^+ = (y_{1}^+, y_{2}^+, y_{3}^+, ..., y_{n}^+)
\]  

by,

\[
y_{j}^+ = \begin{cases} 
\max y_{ij}; & \text{if } j \text{ is a profit attribute} \\
\min y_{ij}; & \text{if } j \text{ is a cost attribute}
\end{cases}
\]

(3)

On this research, the researchers using criteria C1, C2, C5, and C6 as profit attributes while using criteria C3, C4, C7, C8, C9, C10, C11, C12, and C13 as cost attributes in the \(y_{j}^+\) calculation.

Negative ideal solution \((A^-)\) calculated using equation 4.

\[
A^- = (y_{1}^-, y_{2}^-, y_{3}^-, ..., y_{n}^-)
\]  

by,

\[
y_{j}^- = \begin{cases} 
\min y_{ij}; & \text{if } j \text{ is a profit attribute} \\
\max y_{ij}; & \text{if } j \text{ is a cost attribute}
\end{cases}
\]

(4)
On this research, the researchers using criteria C3, C4, C7, C8, C9, C10, C11, C12, and C13 as margin attributes while using criteria C1, C2, C5, and C6 as cost attributes in the $y_j$ calculation.

e. Determining Range Between Each Alternative Value with the Positive Ideal Solution Matrix and Negative Ideal Solution Matrix

Range between alternative $A_i$ with positive ideal solution formulated on the equation 5.

$$D_i^+ = \sqrt{\sum_{j=1}^{n}(y_i^+ - y_{ij})^2}; i = 1, 2, \ldots, m$$  

Range between alternative $A_i$ with negative ideal solution formulated on the equation 6.

$$D_i^- = \sqrt{\sum_{j=1}^{n}(y_{ij} - y_i^- )^2}; i = 1, 2, \ldots, m$$

**Step 3: Optimal Alternative Selection**

There are processes on this step as follows:

a. Determining Preference Score for Each Alternatives

Proximity of each alternatives to the ideal solution calculated using equation 7.

$$V_i = \frac{D_i^+}{D_i^- + D_i^+}; i = 1, 2, \ldots, m$$

b. Data Ranking based on Preference Score

After each new students’ family economic preference score obtained, process carried out by ranking the data from the biggest to the smallest. From the sequence taken 5% data from the first sequence as UKT group, next 5% as UKT group II, next 10% as UKT group III, next 15% as UKT group IV, next 20% as UKT group V, next 20% as UKT group VI, and the rest as UKT group VII.

On this research, the result from the TOPSIS method in this MADM case compiled in an android application so it can be used directly. Figure 15 shows the input page of student’s economic data. Meanwhile, figure 16 shows the configuration page where settings related to the score of each variable are located.
After the student input their family economic data and the admin input score configuration of each criteria, the system will perform calculations using TOPSIS method that has been applied in the system. The implementation process is finding the model first after that the coding process is carried out to form an android application based on the model. In designing this application, the database system used is the Firebase online database so the calculation process is based online. Figure 17 shows UKT nominal calculation page based on the economic data input and TOPSIS method.

![Figure 17. UKT Nominal Calculation Page](image)

On the nominal calculation page of the UKT that has been shown in figure 17 it is shown that after the data is entered into the application system, the UKT group is generated from each data. The classification of UKT from each data is based on the order of the economic level taking into account the proportion of each class of UKT that has been previously determined. The results was 7 category or group, group I UKT is the lowest group, with UKT nominal as Rp500,000,00 then group II as Rp1,000,000,00 group III as Rp2,400,000,00 group IV as Rp3,630,000,00 group V as Rp4,235,000,00 group VI as Rp4,840,000,00 and group VII as the highest UKT group with UKT nominal as much as Rp5,645,000,00.

4. Conclusion and Recommendation

From this research result, we can conclude that by using Fuzzy Multi Attribute Decision Making, we can classify UKT groups for the new students of Universitas Negeri Yogyakarta starting from group I UKT to group VII UKT faster and easier. By using the TOPSIS method, we can improve the decision-making process for MADM case for better results. Process needed for determining new student’s UKT group will be more effective and accurate by using the android application compared to conventional method used before because it can prevent human error when grouping the UKT nominal and can determine what group that nominal belongs to with ease for under 5 minutes fast. The process become more effective because the system was created as an application based on android. Users only needed to input the data then the application will process it, so users did not need to manually process the data. This application will do the calculation with better accuration because in the calculating process was more clearly and objective than manual calculation. In this study only limited to implementing calculations from the TOPSIS technique on FMADM problems so that even though the data has the
same type it can always classified into 7 UKT groups. The recommendation for further research is to consider the condition if the data has the same type must produce a UKT group or not depend entirely on the proportion distribution for each UKT group.

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