

Application of the Electre Method for Predicting Student Graduation

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Abstract – The use of student data cannot be utilized optimally and efficiently, the university still has difficulty in analyzing data and evaluating student graduation rates. This is because there is no integration in a good database. The University needs to evaluate the graduation rate to improve and maintain and even improve the quality of graduates and accreditation of the University or Study program, so that it is necessary to maximize student graduation data and information as a basis for data sources to become a strategic information system for the University or Study Program. The ELECTRE method is one of the effective methods for MADM with qualitative and quantitative features. So the development of this method is to improve the ability to make such decisions. The basic concept of the ELECTRE method is to deal with outranking relationships by using paired comparisons between alternatives under each criterion separately. The application of the ELECTRE method in determining the prediction of the study period and the graduation predicate of students is able to produce predictive information on student graduation and is able to overcome existing problems, the prediction results of student graduation are very effective in helping universities predict student graduation data. The results of student graduation prediction testing using function testing of the system using blackbox testing get a value of 100% in accordance with the prediction application function that has been made.

Keywords: Application, Decision, ELECTRE, Graduation, Prediction

1. INTRODUCTION

The application of information technology in the world of education today can produce abundant data about students and the resulting learning process[1]–[3]. With the advancement of information technology, it has grown rapidly in all areas of life. A lot of data is produced by sophisticated information technology, ranging from the fields of industry, economics, science and technology and various other fields of life[4], [5]. Universities are required to provide quality education for students so as to produce human resources who are knowledgeable, capable, creative, and competitive[6], [7]. In the student education system is an important asset for an educational institution and for that it is necessary to pay attention to the student's graduation rate in a timely manner[8]. The ups and downs of students' ability to complete studies on time are one of the elements of university accreditation assessment[9].

The presence of technology has a very strong influence on the world of education[10]. Education is an effort to attract potential from humans as an effort to provide an organized learning experience through formal, non-formal, and informal education both at school and outside of school, lasting a lifetime and aiming to optimize individual potential in order to play a role in life appropriately and wisely[11]. Technology gives color in every joint of life, gives a way out of the problems of life, provides an alternative in the ease of human activity[12]. Technology will always evolve, and will always be a life partner. The world of education is also inseparable from technological developments[13], [14]. In fact, technology has changed the face of education to be more sophisticated, easier to follow, more varied, and present learning models that can increase the capacity and quality of learners[15], [16].

The use of student data cannot be utilized optimally and efficiently, the university still has difficulty in analyzing data and evaluating student graduation rates[17], [18]. This is because there is no integration in a good database. The University needs to evaluate the graduation rate to improve and maintain and even improve the quality of graduates and accreditation of the University or Study program, so that it is necessary to maximize student graduation data and information as a basis for data sources to become a strategic information system for the University or Study Program[19], [20].

Decision Making is a thought process in the selection of several alternatives or possibilities that best suit the individual's value or goal to obtain results or solutions regarding future predictions. Decision making is a dynamic process that is influenced by many forces including the organizational environment and knowledge, skills and motivation[21]. Decision making is the science and art of selecting alternative solutions or alternative actions from a number of alternative solutions and actions available to solve problems.



A decision support system is basically a form of selecting various possible decision alternatives where the process goes through a certain mechanism in the hope that it will produce a decision that is considered the best of several existing alternatives with predetermined criteria[22]. Fuzzy Multi Attribute Decision Making (FMADM) is a method of decision making on a limited number of alternatives[23]. FMADM is to determine the weight value for each attribute, then continue with the ranking process that will select the alternatives that have been given[22]. Three approaches to the search for attribute weight values, namely the subjective approach, the objective approach and the integration approach between subjective and objective[24], [25]. Each of the approaches has its advantages and disadvantages. In the subjective approach, the weight value is determined based on the subjectivity of the decision makers, so that some factors in the process of alternative rankings can be determined freely[26], [27].

In a study related to data, a method or technique is needed that can help in the process of its implementation. Data mining is a process of finding relationships and patterns to draw a conclusion from an existing data warehouse to be analyzed and explored so that it is useful in decision making. Elimination and Choice Expressing Reality (ELECTRE) method is one of the methods used to rank and determine the best alternative[28]. The ELECTRE method is one of the effective methods for MADM with qualitative and quantitative features. So the development of this method is to improve the ability to make such decisions. The basic concept of the ELECTRE method is to deal with outranking relationships by using paired comparisons between alternatives under each criterion separately[29].

The ELECTRE method was developed by means of the concept of ranking, namely by using paired comparisons between alternatives on the appropriate criteria. An alternative is said to dominate the other alternative if one or more of its criteria exceed compared to the other criteria and are the same as the other remaining criteria. The Electre method is one of the multicriteria decision-making methods based on the concept of outranking by using paired comparisons of alternatives based on each appropriate criterion[30]. The ELECTRE method is used under conditions where appropriate alternatives can be produced. So, ELECTRE is used for cases with many alternatives but few criteria involved.

2. RESEARCH METHODS

2.1 Stages of Research

Research framework design and application model electre in predicting study period and graduation predicate can be seen in figure 1.

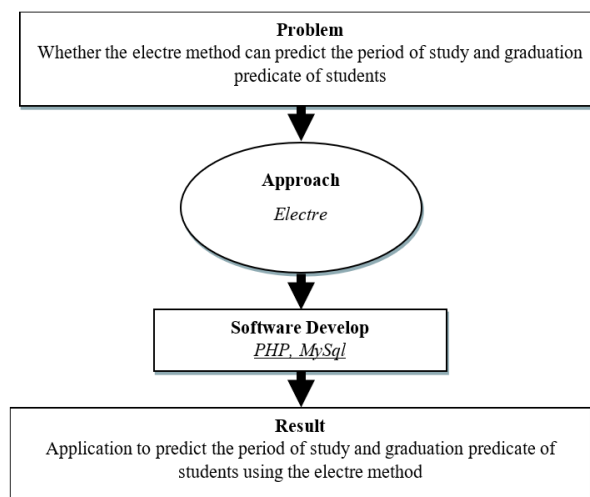


Figure 1. Stages of Research

ELECTRE in predicting the study period and student graduation predicate, in this study it will be a problem, whether the electre method can predict the study period and graduation predicate of students, for the application development approach using the prototype method and the electre method as an approach to predict the study period and graduation predicate students, while to develop applications using php and mysql databases, This application can be used to find out whether the electre method can be used to predict the student's study period and graduation predicate.

2.2 Elimination and Choice Expressing Reality (ELECTRE)

The Electre method is one of the multicriteria decision-making methods with the concept of outranking using paired comparisons of alternatives based on each appropriate criterion. The calculation process begins with the

input of student data from the user which will then be calculated using the ELECTRE method to produce a relevant group that meets the criteria, namely the group of students received. As for the stages of application of the Electre method, namely.

a. Normalization of the Decision Matrix

Each attribute is converted into a comparable value. Any normalization of the X_{ij} value can be done by formula.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \quad \text{for } i = 1,2,3,\dots,m \text{ and } j = 1,2,3,\dots,n \quad (1)$$

So that the R matrix of normalization results is obtained

$$\begin{matrix} r_{11} & r_{12} & r_{1n} \\ r_{21} & r_{22} & r_{2n} \\ r_{m1} & r_{m2} & r_{mn} \end{matrix} \quad (2)$$

R is a matrix that has been normalized, where m states the alternative, n states the criterion and r_{ij} is the normalization of the measurement of the choice of the i-th alternative in relation to the j-th criterion.

b. Weighting on the normalized matrix

Once normalized, each column of the matrix R is multiplied by the weights (w_j) determined by the decision maker, so that the resulting weight normalized matrix is

$$V = R * W \quad (3)$$

$$\begin{matrix} v_{11} & v_{12} & v_{1n} & r_{11} & r_{12} & r_{1n} & w_{11} & w_{12} & w_{1n} \\ v_{21} & v_{22} & v_{2n} & r_{21} & r_{22} & r_{2n} & w_{21} & w_{22} & w_{2n} \\ v_{m1} & v_{m2} & v_{mn} & r_{m1} & r_{m2} & r_{mn} & w_{m1} & w_{m2} & w_{mn} \end{matrix}$$

c. Define the concordance set and discordance index

For each pair of alternative k and l ($k,l=1,2,3,\dots,m$ and $k \neq l$) the j set of criteria is divided into two partitions namely concordance and discordance. A criterion in an alternative includes concordance if: $C_{kl} = \{j, v_{kj} \geq v_{lj}\}$, for $j = 1,2,3,\dots,n$.

In contrast, the complementary part of the concordance subset section is the discordance set, i.e. if: $D_{kl} = \{j, v_{kj} < v_{lj}\}$, for $j = 1,2,3,\dots,n$.

d. Calculating the concordance and discordance matrix

1. Calculating the concordance matrix

To determine the value of the elements on the concordance matrix is to sum the weights included in the concordance set, mathematically it is as follows

$$c_{kl} = \sum_{j \in C_{kl}} w_j \quad (4)$$

2. Calculating the discordance matrix

To determine the value of the elements in the discordance matrix is to divide the maximum difference of criteria included in the discordance subset by the maximum difference in the value of all existing criteria, in the mathematical is as follows:

$$d_{kl} = \frac{\max\{|v_{kj} - v_{lj}|\}_{j \in D_{kl}}}{\max\{|v_{kj} - v_{lj}|\}_{\forall j}} \quad (5)$$

e. Determining the dominant matrix of concordance and discordance

1. Calculating the concordance dominant matrix

The matrix F as the dominant matrix of concordance can be constructed with the help of threshold values, that is, by comparing each value of the concordance matrix element with the threshold value.

$$C_{kl} \geq \underline{c} \quad (6)$$

where the threshold value \underline{c} is:

$$\underline{c} = \frac{\sum_{k=1}^m \sum_{l=1}^m c_{kl}}{m(m-1)} \quad (7)$$

2. Calculating the discordance dominant matrix

The matrix G as the discordance dominant matrix can be constructed with the help of the threshold value \underline{d} :

$$\underline{d} = \frac{\sum_{k=1}^m \sum_{l=1}^m d_{kl}}{m(m-1)} \quad (8)$$

f. Determining the aggregate dominance matrix

Matrix E as an aggregate dominance matrix is a matrix whose each element is a multiplication between the elements of the matrix F and the corresponding elements of the matrix G, mathematically it can be expressed as

$$e_{kl} = f_{kl} g_{kl} \quad (9)$$

g. Elimination of less favourable alternatives

atriks E gives the order of choice of each alternative, if $e_{ki}=1$ then alternative A_k is a better alternative than A_i . That is, rows in the matrix E that have the least number $e_{ki}=1$ can be eliminated. Thus, the best alternatives are those that dominate the other alternatives.

3. RESULTS AND DISCUSSIONS

The current process, the University is still getting suboptimal results in making decisions. From the existing decision-making problems, the problems have been analyzed to create a new system that is more effectively expected to be able to overcome problems in decision making for student graduation predictions.

3.1 Implementation of ELECTRE

In this study the criteria variables used in table 1 dan table 2.

Table 1. Criteria Variable

Input Criteria	Input Variables
IP 1	X1
IP 2	X2
IP 3	X3
IP 4	X4
UN value	X5
Parents' Income	X6

Table 2. Criteria Studi

Study Period
Remain
Late

Next, conduct training data from student data in table 3.

Table 3. Data Training

IP 1	IP 2	IP 3	IPS4	IP 5	IP 6	Parent Assimilation	Graduation
2.76	2.8	3.2	3.17	3.3	3.2	1	LATE
3	3.3	3.14	3.14	3.3	3.14	2	LATE
3.5	3.3	3.7	3.29	3.41	3.7	3	LATE
3.17	3.41	3.61	3.36	2.89	3.61	1	TRUE
2.9	2.89	3.3	2.85	2.82	3.3	2	TRUE
2.95	2.82	3.09	3.1	3.14	3.09	3	LATE
2.76	3.14	2.6	2.95	2.89	2.6	2	LATE
2.62	2.89	2.32	2.5	3.54	2.32	2	LATE
3.6	3.54	3.52	3.39	2.86	3.52	3	LATE
2.86	2.86	2.45	1.86	3.27	2.45	3	LATE
2.71	3.27	2.54	3.36	3.32	2.54	2	TRUE
2.9	3.32	2.83	2.91	2.8	2.83	3	LATE
2.7	2.8	2.9	2.91	2.8	2.9	2	?

Table description:

IP : Achievement Index

Parental Income Weight

1 = Capable

2 = Capable Enough

3 = Incapable

From table 3. 5 will be predicted whether the graduation status with grades, parent income 2, ip1: 2.7, ip2: 2.8, ip3: 2.9 and ip4: 2.91 ,ip5: 2.9, ip6: ? .

Conduct experiments from training data on student data for which predictions will be made.

Table 4. Data Criteria Student

Alternative	Criterion						
	IP 1	IP 2	IP 3	IP 4	IP 5	IP 6	Parents
Student	2.7	2.8	2.9	2.91	2.8	2.9	2
Student	2.9	3.32	2.83	2.91	2.8	2.83	3
Student	2.62	2.89	2.32	2.5	3.54	2.32	2
Student	3.6	3.54	3.52	3.39	2.86	3.52	3

Calculate the weight of the student data in the table 5.

Table 5. Weighth

Weight	
4	0.333333333
3	0.25
3	0.25
2	0.166666667
12	

The weight value has been determined by the University as stated in the University student guidebook.

Table 6. X Value Table

X value data			
3	1	2	2
4	2	4	2
1	2	3	2
3	1	3	1
5.916079783	3.16227766	6.164414	3.605551275

The next step is to perform normalization calculations based on the data in table 4 and table 5. The results of normalization of calculation data are as in table 7 below

Table 7. Normalization Table

R (Normalization)			
0.507092553	0.316227766	0.32444284	0.554700196
0.676123404	0.632455532	0.64888568	0.554700196
0.169030851	0.632455532	0.48666426	0.554700196
0.507092553	0.316227766	0.48666426	0.277350098

After the normalization results are obtained, the next step is to calculate the weighting on the normalized matrix based on the data in table 4 and table 6. The results of the weighting on the normalized matrix are shown in table 8.

Table 8. Table V Normalization

V (normalization * weight) (R*W)			
0.169030851	0.079056942	0.081110711	0.092450033
0.225374468	0.158113883	0.162221421	0.092450033
0.056343617	0.158113883	0.121666066	0.092450033
0.169030851	0.079056942	0.121666066	0.046225016

The next step is to Determine the set of concordance and index of nonconformity as shown in table 9.

Table 9. Determine the set of concordance and index of nonconformity

Concordance		Discordance	
C12	4	D12	1,2,3
C13	1,4	D13	2,3
C14	1,2	D14	3
C21	1,2,3,4	D21	
C23	1,2,3,4	D23	
C24	1,2,4	D24	
C31	2,3,4	D31	1
C32	2,4	D32	1,3
C34	2,3,4	D34	1
C41	1,2,3	D41	4
C42		D42	1,2,3,4
C43	1,3	D43	2,4

The last step is to determine determining the dominant matrix of concordance and discordance

Table 10. Matrix Concordance & Discordance

Produce Matriks Concordance			
-	0.166666667	0.5	0.583333333
1	-	1	0.75
0.666666667	0.416666667	-	0.666666667
0.833333333	0	0.583333333	-
Generating Matriks Discordance			
-	1	0.70156076	0.877346478
0	-	0	0
1	1	-	1
1	1	0.70156076	-
Concordance Dominant Matrix Threshold Value			
c	0.597222222		
Discordance Dominant Matrix Threshold Value			
d	0.690039		

Produce Matriks concordance			
-	0	1	0
1	-	0	0
1	1	-	1
1	1	1	-
Produce Matriks Discordance			
-	1	1	1
0	-	0	0
1	1	-	1
1	1	1	-
Matrix Dominant Aggregate E			
-	0	1	0
0	-	0	0
1	1	-	1
1	1	1	-

The last step is to determine determining the dominant matrix of concordance and discordance.

Table 11. Calculating Matrix Concordance & Discordance

Produce Matriks Concordance			
-	0.166666667	0.5	0.583333333
1	-	1	0.75
0.666666667	0.416666667	-	0.666666667
0.833333333	0	0.583333333	-
Generating Matriks Discordance			
-	1	0.70156076	0.877346478
0	-	0	0
1	1	-	1
1	1	0.70156076	-
Concordance Dominant Matrix Threshold Value			
c	0.597222222		

Discordance Dominant Matrix Threshold Value			
d	0.690039		
Produce Matriks concordance			
-	0	1	0
1	-	0	0
1	1	-	1
1	1	1	-
Produce Matriks Discordance			
-	1	1	1

0	-	0	0
1	1	-	1
1	1	1	-
Matrix Dominant Aggregate E			
-	0	1	0
0	-	0	0
1	1	-	1
1	1	1	-

3.2 ELECTRE Implementation Application

The Application of Electre Application Model in Predicting Study Period and Student Graduation Predicate is made using PHP and MySQL with a bootstrap approach. The prediction results of student data are the implementation of the ELECTRE method, looking at the predictions of student testing data that have been entered, the results of predicting student data are as shown in Figure 1.

Laporan Data Mahasiswa Hasil Prediksi Electre
Laporan 10 Terbaik Data Mahasiswa Hasil Prediksi Electre

No	Nama Mahasiswa	IPS 1	IPS 2	IPS 3	IPS 4	IPS 5	IPS 6	IPK	Pendapatan Ortu	Kelulusan	Predikat
1	Kartika Dwi Putri	3.4	3	3.67	3.67	3.67	3.8	3.535	Mampu	TEPAT	Dengan Pujian
2	Sintia Meida	3.5	3	3.67	3.67	3.67	3.6	3.51833	Mampu	TEPAT	Dengan Pujian
3	Yohanes Bayu	3.3	3	3.67	3.67	3.45	3.8	3.48167	Mampu	TEPAT	Sangat Memuaskan
4	M. Ali Maksum	3.1	3	3.67	3.67	3.45	3.9	3.465	Mampu	TEPAT	Sangat Memuaskan
5	M. Hillman	3.2	3	3.67	3.67	3.45	3.7	3.44833	Mampu	TEPAT	Sangat Memuaskan
6	M. Abdul Aziz	3	3	3.67	3.67	3.45	3.8	3.43167	Mampu	TEPAT	Sangat Memuaskan
7	Teo Dwi Stiawan	2.9	3	3.67	3.67	3.45	3.8	3.415	Mampu	TEPAT	Sangat Memuaskan
8	Rio Rinaldi	2.8	3	3.67	3.67	3.45	3.67	3.37667	Mampu	TEPAT	Sangat Memuaskan
9	Ricky Novriansyah	2.7	3	3.67	3.67	3.47	3.67	3.36333	Mampu	TEPAT	Sangat Memuaskan
10	Dini Alfionita	2.5	3	3.67	3.67	3.67	3.5	3.335	Mampu	TEPAT	Sangat Memuaskan
11	Abiyasa	2.5	3	3.67	3.67	3.67	3.5	3.335	Mampu	TEPAT	Sangat Memuaskan

Figure 1. Student Data Prediction Results

3.3 Blackbox Testing

The next stage after the implementation of the system is to test the system. The first system test uses a blackbox testing model. The results of the blackbox testing that have been tested on 4 system testers are made in Table 12.

Table 12. Blackbox Testing

Testing Criteria	Jawaban	
	Yes	No
Login Menu Form	3	0
Master Form	3	0
Student Data Upload Form	3	0
Electre Menu Form	3	0
Prediction Reset Form	3	0
Prediction Result Form	3	0
Print Menu Form Prediction Results	2	0
User Menu Form	2	-

Total Answers	22	0
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Based on the results of the calculation of the assessment of 8 criteria that have been tested, the results of the answers from respondents get 100% results, meaning that all system functions run according to and are the same as expected.

4. CONCLUSION

The application of the ELECTRE method in determining the prediction of the study period and the graduation predicate of students is able to produce predictive information on student graduation and is able to overcome existing problems, the prediction results of student graduation are very effective in helping universities predict student graduation data. The results of student graduation prediction testing using function testing of the system using blackbox testing get a value of 100% in accordance with the prediction application function that has been made.

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