



vol. 16 / 2023



## **The 7th International Conference on Science Technology**

organized by  
Faculty of Social Science and  
Law Universitas Negeri Manado and  
Consortium of International Conference  
on Science and Technology

# **The Innovation Breakthrough in Digital and Disruptive Era**

## Determining Student Achievements using Multicriteria Approach with Electre Method

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**Abstract.** In the field of education, assessing student achievement is critical for determining students' levels of success and academic progress. However, the high cost of desire is frequently complicated since it incorporates a variety of student characteristics and aspects that must be taken into account. In this study, a multi-criteria approach using the ELECTRE method was suggested to measure student achievement holistically. The ELECTRE technique is a multi-criteria analysis method that employs a comparison matrix to evaluate alternatives based on a variety of criteria. This way to evaluate student progress allows for more accurate and objective decision-making than a single strategy that focuses on a single factor. An application was created to make its use easier. Applications that can be utilized to assist determine excellent students via black box testing are stated to be successful because 33 features provided in the application work as intended. This study is expected to help improve student accomplishment assessment policies and methods at various levels of education. **Keyword:** Student achievements, ELECTRE, Application, Decision.

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## 1 Introduction

Academic websites are now a crucial part of supporting learning activities and academic growth in the current. The demand for information has become a basic requirement for information seekers in the 4.0 revolution age for numerous needs such as detecting a scenario in an organization, solving difficulties, and much more. If the information presented is of high quality, information users will find it easier to make decisions and solve problems swiftly. The current advancement of information technology has had an impact on the education industry. In general, information systems will have a significant impact on educational institutions in terms of improving educational quality, and they can also help policymakers make decisions on how to govern the education system [1].

The existence of the Dapodik application (<https://dapo.kemdikbud.go.id/>) developed by the Ministry of Education and Culture for the development of education in Indonesia is real evidence that the development of information technology also plays an important role in the world of education. Reliant on the field's reality, the assessment of excellent students is still reliant on the student's academic results, thus the decisions made are subjective [2], [3]. Subjective judgements are often unjust to students, and the decisions made are generally unfavourable. Therefore, there must be care in determining excellent kids so that the quality and quality of education in schools can subsequently be increased. Excellent students must be determined based on factors other than academics, such as involvement in competitions, extracurricular activities, and student attitudes/behavior at school [4]. As a result, a mechanism is required to support and help teachers in identifying excellent kids. Therefore, the researcher wants to use one of the MCDM (Multi Criteria Decision Making) methods, notably ELECTRE, as a decision-support system in identifying excellent students. ELECTRE (Elimination Et Choix Traduisant La RealitE) is a method for finding a ranking (priority) based on the outranking idea by doing pairwise comparisons between existent alternatives according to each specific criterion. The purpose of ELECTRE is that the data entered will be integrated into one with the weights of the assessment on each preset criterion [5], [6], so that the best selection from multiple alternatives can be produced afterwards.

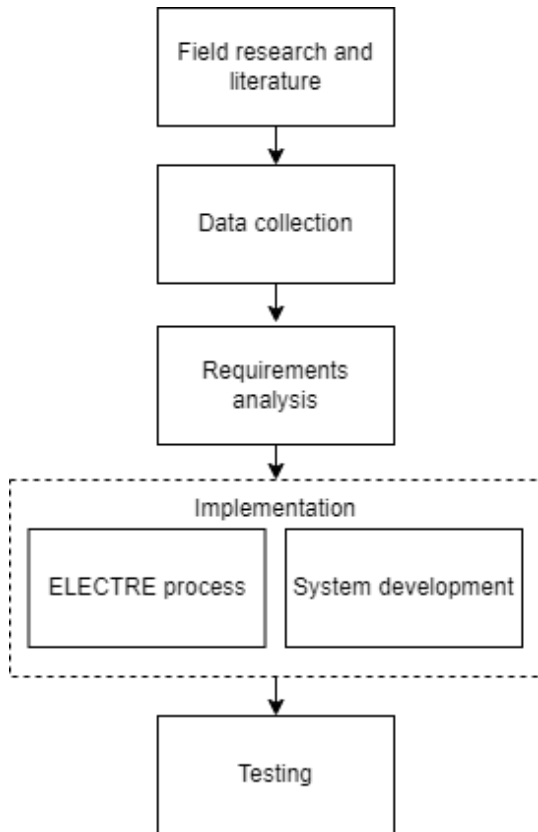
## 2 Methodology

This methodology gives a broader overview of student success, assures fairness in tests, and helps schools improve the effectiveness of their assessment systems. Figure 1 depicts the system architecture to assist in determining students who succeed at various stages of the research cycle.

This research methodology was designed to develop a student achievement determination system using a multi-criteria approach with the ELECTRE

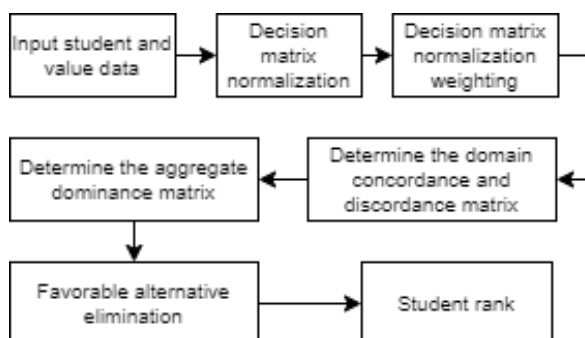
method. This study will follow several stages of research as shown in Figure 1. A literature study will be conducted to gather up-to-date information on relevant theories, student achievement assessment approaches, as well as previous research that has used the ELECTRE method or similar multi-criteria approaches. In addition, field research will be conducted through surveys and interviews with teachers, school staff and education experts.

The goal of the field research is to comprehend the continuous practice of student success assessment, identify important criteria, and understand the system's demands from the perspective of educational practitioners. Student achievement data, such as grade records, performance evaluations, and data on involvement in extracurricular activities, will be acquired as a result of the two studies. Furthermore, data on the assessment criteria and relative weights will be derived from the findings of literature studies and field research. Conduct a system requirements analysis based on the obtained data to identify the functional and non-functional requirements of the student accomplishment determination system. This will aid in the design of the features and functionalities required for system implementation. Following the completion of the system requirements analysis, the ELECTRE method is used to determine the relative weight of each assessment criterion. The ELECTRE algorithm is used to create a pairwise comparison matrix and calculate the criteria weight values. The right programming language and technology will be used for system development. The system will be programmed to accept student accomplishment data and criterion weights and then calculate student achievement scores using the ELECTRE method. The final stage is to test the entire system to assure system performance and accuracy. To evaluate the system in various settings and scenarios, simulated data and real data from students will be used.



**Fig. 1.** Overview design system

The ELECTRE method is a decision analytic method that allows for the identification of a set of solutions to a given problem, as well as the comparison or classification of those options from best to worst [7][8]–[10]. The approach demands that at least the list of activities, the list of criteria, the evaluation of each action by criteria, and the weight of each criterion be evaluated. In multi-attribute decision-making situations, the ELECTRE method is used to rank and determine the optimal choice [11], [12]. The approach is effective in providing quantitative and qualitative elements to decision-making operations. Electre method stages:



**Fig. 2.** ELECTRE method flow

Normalization of the decision matrix is carried out by converting each value on the criteria to a comparable value. To determine the normalization value ( $r_{ij}$ ) you can use the following formula:

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

$r_{ij}$  is the normalization of the choice measurement of  $i$  alternative in relation to the  $j$  criterion,  $x_{ij}^2$  is the rating value of each respondent's answer in the row and column,  $m$  is the number of alternatives, and  $n$  is the number of criteria. So that the normalized  $r$  matrix is obtained as follows:

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

Normalized matrix weighting. The calculation can be written in the formula below:

$$v = r \times w \quad (3)$$

Thus, a weighted normalization matrix ( $v$ ) can be formed which is written in the formula:

$$v = \begin{bmatrix} v_{11} & v_{12} & v_{1n} \\ v_{21} & v_{22} & v_{2n} \\ v_{m1} & v_{m2} & v_{mn} \end{bmatrix} r w = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & w_n r_{1n} \\ w_1 r_{21} & w_2 r_{22} & w_n r_{2n} \\ w_1 r_{m1} & w_2 r_{m2} & w_n r_{mn} \end{bmatrix} \quad (4)$$

Determine the set of concordance and discordance on index. A criteria in one alternative includes the concordance set if:

$$c_{kl} = \{j | v_{kj} \geq v_{lj}\}, \text{ for } j = 1, 2, 3, \dots, n \quad (5)$$

Conversely, the complement of this subset is discordance, if:

$$d_{kl} = \{j | v_{kj} < v_{lj}\}, \text{ for } j = 1, 2, 3, \dots, n \quad (6)$$

Where  $c_{kl}$  is the concordance set,  $d_{kl}$  is the discordance set,  $v_{kj}$  and  $v_{lj}$  are the elements of the matrix  $v$ .

Calculating the concordance and discordance matrices. The concordance matrix is to add up the weights included in the concordance subset, or it can be written in the formula below:

$$c_{kl} = \sum_{j \in c_{kl}} w_j \quad (7)$$

So the concordance matrix can be written as follows:

$$c = \begin{bmatrix} c_{11} & c_{12} & \dots & c_{1n} \\ c_{21} & c_{22} & \dots & c_{2n} \\ c_{31} & c_{32} & \dots & c_{3n} \\ \dots & \dots & \dots & \dots \\ c_{m1} & c_m & \dots & c_{mn} \end{bmatrix} \quad (8)$$

The discordance matrix is to divide the maximum difference in the values of the criteria included in the discordance subset by the maximum difference in the values of all existing criteria, mathematically this is:

$$d_{kl} = \frac{\max\{v_{kj} - v_{lj}\}_{j \in d_{kl}}}{\max\{v_{kj} - v_{lj}\}_{set \text{ all } j}} \quad (9)$$

so that the discordance matrix is obtained

$$d = \begin{bmatrix} d_{11} & d_{12} & d_{13} & \dots & d_{1n} \\ d_{21} & d_{22} & d_{23} & \dots & d_{2n} \\ d_{31} & d_{32} & d_{33} & \dots & d_{3n} \\ \dots & \dots & \dots & \dots & \dots \\ d_{m1} & d_{m2} & d_{m3} & \dots & d_{mn} \end{bmatrix} \quad (10)$$

Determine the dominant matrix of concordance and discordance. Construct the dominant concordance matrix with equations:

$$c_{kl} \geq \underline{c} \quad (11)$$

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

$$f_{kl} = 1, \text{ if } c_{kl} \geq \underline{c} \text{ and } f_{kl} = 0, \text{ if } c_{kl} < \underline{c}$$

Build the dominant discordance matrix as well, with the same formula, ie:

$$d_{kl} \geq \underline{d} \quad (12)$$

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

$$g_{kl} = 1, \text{ if } d_{kl} \geq \underline{d} \text{ and } g_{kl} = 0, \text{ if } d_{kl} < \underline{d}$$

Determine the aggregate dominant matrix.

$$e_{kl} = f_{kl} \times g_{kl} \quad (13)$$

Eliminate less favourable alternatives. The  $e$  matrix provides a rating of each alternative, that is, if the value of  $e_{kl} = 1$  then alternative  $k$  is a better choice than alternative  $l$ . So that the row in matrix  $e$  which has the least number of values  $e_{kl} = 1$  can be set aside. Thus, the alternative with the highest number of  $e_{kl} = 1$  is the best alternative compared to the other alternatives. If no alternative has been selected from the search results for matrix  $e$ , where the results of the matrix were worth 0 and none were worth 1, then ranking is carried out using the values  $c_{kl}$  and  $d_{kl}$ .

### 3 Result

#### 3.1 Field research and literature

A literature review is utilized to comprehend the concept of a decision-making system as well as the theory of a commonly used method, specifically the ELECTRE method. The next element of the field study involved conducting interviews at SMKN X. The interview was performed by asking questions of the school's Deputy Head of Curriculum, who is in charge of identifying excellent students.

#### 3.2 Data collection

The data was collected at the SMKN X school on Jalan Raya Labang in Bangkalan, East Java, Indonesia. The information is in the form of student scores on academic grades, attendance, attitudes, extracurricular activities, English, and achievement. Table 1 is an example of a sample of three student data from SMKN X.

Table 1. Student data

Name	Academic grade	Attitude	Absence	Extracurricular	English	Performance
Abdul Hijjah Akbarul	90,2	80	100	80	0	0
Arisky Habibil Mustofa	87,2	80	99,33	80	0	0
Basmal Hadi Wijaya H	89,5	80	100	80	0	0

#### 3.3 Requirement analysis

This student data application necessitates a well-designed user interface. Researchers designed an interface for the implementation of ELECTRE on the Selection of excellent students with a user-friendly design so that users (users) can use it as easy as feasible. Table 2 summarizes the system requirements in terms of actors or users.

Table 2. System requirement

User	Features
Admin	Login, Dashboard, User Data Menu, Class Data Menu, Extracurricular Menu, Student List Menu, Check Grades, Attendance Menu, Student Achievement List Menu, Level Ranking Results Menu, Class Ranking Results Menu, Print Ranking Results.
Homeroom teacher	Login, Dashboard, Student List Menu, Grade Check, Attendance Menu, Student Achievement List Menu, Principal Interface.
Headmaster	Login, Dashboard, Level Ranking Results Menu, Class Ranking Results Menu, Print Ranking Results

#### 3.4 Implementation

##### 3.4.1 ELECTRE process

The system calculation results are intended to determine the calculation results obtained by the system utilizing the ELECTRE method. In this calculation, a sample of three students' data will be chosen to identify which students excel. The student data that will be calculated to determine excellent students using the ELECTRE method is described below. Sample data has been shown in Table 1. In determining the criteria, each criterion is assigned a code with a weighting defined by the institution (Table 3).

Table 3. Criteria weight

Criteria	Description	Weight
K1	Academic grade	5
K2	Attitude	2
K3	Absence	1
K4	Extracurriculaire	1
K5	English	3
K6	Performance	4

Based on the weight values, normalization calculations can be performed. The normalization process is carried out to change the values in the comparison matrix into a consistent size, so that all criteria have an equal effect on the ranking process. The  $r$  matrix is the normalized matrix and the  $v$  matrix is the decision matrix normalized weighting. The 5th criterion and 6th criterion cannot be counted because the 4th criterion has no value.

$$r = \begin{bmatrix} 0,58529 & 0,57735 & 0,57864 & 0,57864 \\ 0,56583 & 0,57735 & 0,57476 & 0,57735 \\ 0,58075 & 0,57735 & 0,57864 & 0,57735 \\ 2,92647 & 1,15470 & 0,57864 & 0,57735 \end{bmatrix}$$

$$v = \begin{bmatrix} 2,82913 & 1,15470 & 0,57476 & 0,57735 \\ 2,90376 & 1,15470 & 0,57864 & 0,57735 \end{bmatrix}$$

The next calculation is to determine the  $c$  matrix (Concordance) and  $d$  matrix (Discondance). When the two matrices have been determined, the next process can calculate the dominant matrix  $f$  for concordance,  $g_{kl}$  for discordance, and matrix  $e$ .

$$c = \begin{bmatrix} - & 9 & 9 \\ 3 & - & 3 \\ 4 & 9 & - \end{bmatrix} \quad d = \begin{bmatrix} 1 & - & 1 \\ 1 & - & - \end{bmatrix} \quad f = \begin{bmatrix} - & 1 & 1 \\ 0 & - & 0 \\ 0 & 1 & - \end{bmatrix}$$

$$g = \begin{bmatrix} - & 0 & 0 \\ 1 & - & 1 \\ 1 & 0 & - \end{bmatrix} \quad e = \begin{bmatrix} - & 0 & 0 \\ 0 & - & 0 \\ 0 & 0 & - \end{bmatrix}$$

Because there is no alternative that has been selected from the search results for matrix  $e$ , where the results of the matrix earlier have a value of 0 and no one has a value of 1, then ranking is carried out using the values of  $c$  and  $d$ .

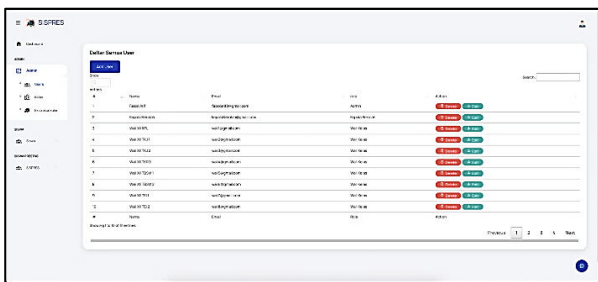
**Table 4.** Calculation results for selection of exelent students

Name	$c$	$d$	$c - d$	$e$	Rank
Abdul Hijjah Akbarul	9	0	9	18	1
	9	0	9		
Arisky Habibil Mustofa	3	1	2	4	3
	3	1	2		
Basmal Hadi Wijaya H	4	1	3	12	2
	9	0	9		

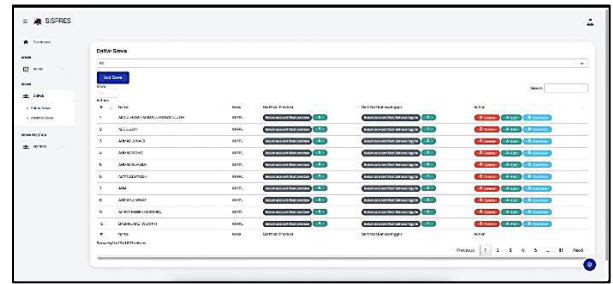
As a result, the alternative with the greatest  $e$  value is proclaimed the most exceptional student, namely Abdul Hijjah Akbarul.

### 3.4.2 System development

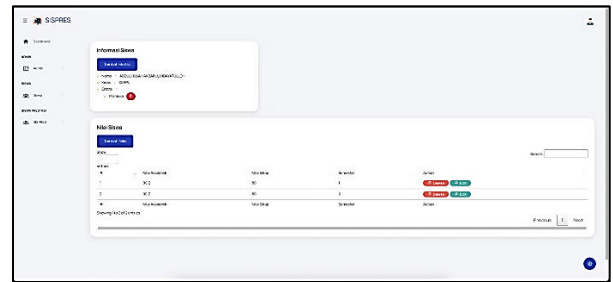
The application is developed using the previously formulated data and stages. A web-based program that is accessed through a browser. The goal of application development is to make it easier for users to carry out their work in determining excellent students by incorporating the ELECTRE method into their calculations. There are several features in the application including:



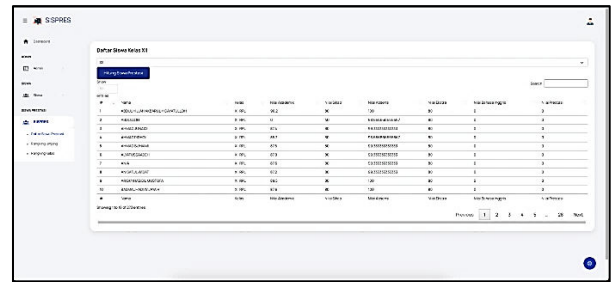
**Fig. 3.** Users page



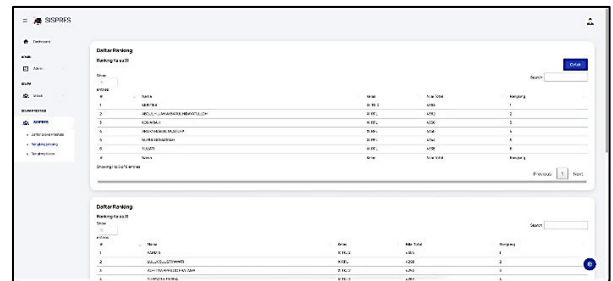
**Fig. 4.** Student list page



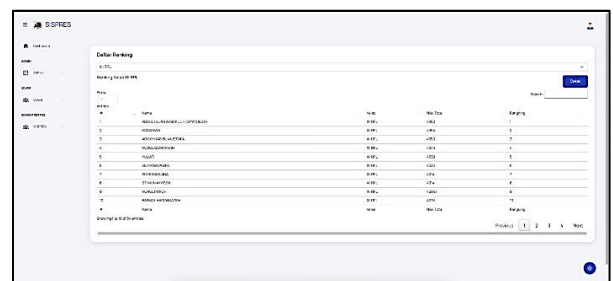
**Fig. 5.** Mark page



**Fig. 6.** Achievement list page



**Fig. 7.** Rank level page



**Fig. 8.** Class rank page

### 3.5 Testing

Applications that have been designed and built need system testing to meet the expected results. To test this decision support system using the Black Box Testing method. Black box testing is a software testing method

that focuses on functionality [13]–[15]. Table 5 is a black box testing table for functionality testing. Black Box testing is carried out by the tester by running the scenario described.

**Table 5.** Blackbox testing

Feature	Scenario	Result application	State
Login	User enters email and password	Displays dashboard	√
Users	admin presses the users menu then it is directed to the page of all users	Displays all user pages	√
Add User	Admin added a new user	Successfully added a new user	√
Edit User	Admin edit user data	Successfully updated user data	√
Delete User	Admin delete user data	Managed to delete user data	√
Class	admin pressing the class menu then directed to the page listing all classes	Displays the entire list of classes	√
Add Class	Admin added a new class	Successfully added a new class	√
Edit Class	Admin edit class data	Successfully updated class data	√
Delete Class	Admin delete class data	Successfully deleted class data	√
Extracurricular	admin pressing the extracurricular menu then directed to the page listing all extracurriculars	Displays all extracurricular data	√
Add Extracurricular	Admin adds extracurricular list	Successfully add extracurriculars	√
Edit Extracurricular	Admin edit extracurricular data	Successfully updates extracurricular data	√
Delete Extracurricular	Admin delete extracurricular data	Successfully deletes extracurricular data	√
Share Extracurricular	Admin adds extracurriculars to all students	Successfully added extracurriculars to all students	√
Add Student	Admin and homeroom teacher add new student data	Successfully added new student data	√
Edit Student	Admin and homeroom teacher edit student data	Successfully updated student data	√
Delete Student	Admin and homeroom teacher delete student data	Successfully deleted student data	√
upload Student's certificate	Admin and homeroom teacher upload certificates	successfully uploaded a certificate of achievement	√
Mark check	Admin and homeroom teacher press the mark check button, they will be directed to the student grade information page	Displays student grade information	√
Add Mark	Admin and homeroom teacher add academic mark and attitude	Managed to add mark	√
Edit Mark	Admin and homeroom teacher edit student grade data	Successfully updated student grades	√
Delete Mark	Admin and homeroom teacher delete student grades	Managed to delete student grades	√
List Student	Homeroom teacher pressing the student list menu will be directed to the list page of all students	Displays a list of all students	√
Homeroom teacher added extracurricular followed	The homeroom teacher adds extracurriculars that students take part in	succeeded in adding extracurriculars that students followed	√
Homeroom delete extracurricular followed	The homeroom teacher deletes the extracurriculars the student is participating in	succeeded in removing the extracurriculars that the students participated in	√
Homeroom teacher added mark	Homeroom teacher adds academic and attitude mark	Managed to add mark	√
Cek attendance	Admin and homeroom teacher press the check attendance button, a popup with attendance recap will appear	Popup modal attendance recap	√
list of high achieving students	Admin and homeroom teacher pressing the list of achievement students menu will be directed to the information page of the list of achievement students per level	Displays information on the list of achievement students per level	√
Count students achievers	Admin pressing the calculate button will calculate student achievement using the Electre method according to the level chosen	Calculating student achievement using the ELECTRE method according to the level chosen	√
level ranking	Admin and headmaster press the ladder ranking menu, they will be directed to the per-level ranking page	Displays ranking per level	√
print ranking	Admin and headmaster pressing the print button will download the ranking per level and per class in PDF format.	Returns ranking per level in PDF format.	√
level ranking by Headmaster	Headmaster presses the level ranking menu, then he will be directed	Displays ranking per level	√

r	to the ranking page per level		
Logout	The user presses the logout menu, it will be removed from the application	Log out user and return to login page	√

## 4 Conclusion

The outcomes of the Achievement Student Application installation utilizing the Electre technique, including academic scores, attitude scores, attendance scores, extracurricular scores, achievement certificate scores, and English language certificate scores. In terms of obtaining a ranking based on the initial rank Electre technique for each class level. The Achievement Student application g program black box testing was deemed successful since it is clear that all 33 features contained in the Achievement Student Decision Support System Application program functioned as planned. Some ideas for future study include developing features if students are already in the database when they attend to class or graduate. Furthermore, the attendance process is developed every day during the teaching and learning process, so there is no need to recap at the conclusion of the semester.

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