Utilization of the SAW Algorithm in Decision Support Systems for Determining Learning Strategies for Adaptive Learning

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Abstract

During the Covid-19 pandemic, where the teaching process is carried out online, adaptive learning can be an alternative choice in distance learning due to different conditions of each student with various learning instruments. Despite the many advantages of implementing adaptive learning in online learning and using digital materials, many teachers and students are not prepared for this sudden change. Not all teachers feel ready to make adjustments in carrying out distance learning and helping students optimally as when teaching directly in class. As a result, many students may find online learning materials too simple, or even very complicated. This of course results in treatment that is not in accordance with their needs so that learning outcomes are less than optimal. One solution to this problem is the use of IT-based learning technology which refers to the adaptive learning method. A decision support system (DSS) is built by applying the Simple Additive Weight (SAW) algorithm. From this, the teacher can obtain an overview related to the condition of the students as well as recommendations for treatment according to their condition. The system was tested in the distance learning process in the Informatics Education study program at Universitas Sebelas Maret.

Keywords
Adaptive Learning, Decision Support System, Optimization, Simple Additive Weight

1. Introduction

On January 9, 2020, WHO announced that a mysterious disease caused by a virus had emerged in Wuhan, China (ECDC's, 2020) This disease is transmitted from one individual to another through touch, droplets or the air. The disease, known to the public as Covid-19, is also slowly starting to attack Indonesia. As a result, starting in March 2020, face-to-face teaching and learning activities immediately experienced paralysis (Waruwu, 2020).

Various ways are done so that the teaching and learning process can still be implemented. There are schools located in the green zone that continue to carry out direct learning activities, some do full distance learning, some use a combination of both (Malyana, 2020).

One of the methods that is currently used by teachers in conducting distance learning activities is adaptive learning. This learning method observes the needs of students according to the conditions experienced (Sutardi, 2016). This is different from learning that applies uniformity of treatment to all students in a class. The teacher pays attention to the learning conditions of students and combines with the learning outcomes obtained (Sukajaya, 2017). From these parameters it can be seen what treatment is appropriate if given to students, so that each individual will get personalization in the teaching and learning process.

Even though the adaptive learning teaching method is very appropriate and in accordance with current conditions, there are still many teachers who feel confused about what steps should be taken in providing appropriate treatment according to the needs of each student. This is due to a very sudden change in the situation, from offline to online, so that teachers are less prepared with the implementation of adaptive learning (Yulia Indahri, 2020).

Based on the problems that arise in the world of education in the Covid-19 era, especially in the implementation of adaptive learning combined with distance learning that is not yet optimal, the solution offered is the use of a decision support system that is specifically designed to help teachers take the right steps. related to appropriate teaching approaches and strategies to students.

1.1 Objectives

The algorithm used to set recommendations in this decision support system is Simple Additive Weight (SAW). The SAW algorithm is proven to be reliable in setting the right recommendations in every problem that requires consideration in decision making (Faqih, 2014). Some examples are the selection of raw materials in making bread (Suwarti, 2018) or the selection of recipients of village assistance from the government (Sukerti, 2014).

Web-based decision support system is expected to be implemented in real terms in the world of education, especially universities. The location of the application test in this research is the Informatics and Computer Engineering Education Study Program, Faculty of Teacher Training and Education, Sebelas Maret University. The main target of system users is used by lecturers, but the data is obtained directly through a questionnaire that is generated automatically by the application. will be evaluated and developed gradually so that in the future it can be widely used.

Based on the research reference, the State of The Art adopted from this research is the development and implementation of a web-based decision support system with the SAW algorithm that can be accessed anytime and anywhere and is specially formulated to help teaching staff in the environment. universities in determining the appropriate learning strategies personally.

The accuracy of the recommended results is adjusted to the determining factors in the selection of teaching strategies. This application can be used as a decision support media from the teaching staff in determining a learning strategy that suits the conditions of the students. Thus, the teacher will be able to focus more on the substance of the material provided and the development of student learning outcomes without the need to mess around with who should be given a special approach and what treatment is right for these students.

2. Literature Review

Literature study was conducted to understand the theory related to the concept of making a decision support system with Simple Additive Weight. Researchers also conducted a literature study related to the parameters needed in the weighting process with the SAW algorithm. The parameters in question are criteria that play a role in determining appropriate treatment and learning strategies, especially for university students who are undergoing distance learning.

Various studies that offer solutions in the form of decision support systems for each problem that requires accuracy in determining the solution. Wolo, Pasend and Roberth solved the problem of distributing Raskin to the right residents in the Uneng City Village area by using a decision support system. The algorithm used is the Simple Additive Weight (SAW). The decision-making process is seen from several criteria including occupation, income, number of dependent children, condition of the house, and building area. The result is that the distribution of Raskin assistance is right on target (Wolo et al., 2019).

Research conducted by Yunisya and Sopandi (Yunisya & Sopandi, 2020) states that the adaptive learning method is very appropriate to use in learning in this covid-19 era. Each student is faced with a situation where they have to learn online from home with all the possible problems of each. In their research, students with special needs such as blind people need to get more attention than others. With adaptive learning, teachers can provide appropriate treatment to students who feel they need more help than others.

3. Methods

3.1 Needs Analysis

Needs analysis was carried out by conducting a survey of the needs of students and lecturers in carrying out teaching and learning activities using the distance learning model. The unit that is considered to be the target of implementation for the use of this system is Informatics Education Study Program at Universitas Sebelas Maret. The research sample is students and lecturers there.

In this DSS application, the SAW algorithm is implemented using four core elements in adaptive learning, namely individual characteristics, individual performance, personal development, and adaptive adjustment (Peng et al., 2019). Furthermore, these four elements are further elaborated into several criteria which are then used as weight parameters in the SAW algorithm. The description of the weighting criteria can be seen in Table 1.

Table 1. SAW weighting criteria

Criteria Name	**Element**	**Type**
Motivation	Individual characteristics	Benefit
Interest	Individual characteristics	Benefit
Competence	Individual performance	Benefit
Activity	Individual performance	Benefit
Understanding time	Individual performance	Cost
Busyness	Personal development	Cost
Facility	Adaptive adjustment	Benefit

The application systematically provides recommendations for learning strategies that need to be given personally to each student. Table 2 shows recommendations for follow-up or personal learning strategies and their weights.

Table 2. Recommended learning strategies

Learning Strategies	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**
Enrichment	3	4	5	3	3	3	3
Emotional approach	1	2	4	3	2	1	4
Digital module giving	3	2	3	2	1	3	5
Physical module giving	3	5	3	2	1	2	1
Demonstration	3	3	4	5	3	5	4
Conceptual	2	5	4	2	5	2	5
Process assessment	5	3	2	4	4	2	4

3.2 System Design and Build

The system was constructed by using the PHP programming language. System development was carried out with a collaborative strategy between developers using Git. Software Development Life Cycle (SDLC) uses the Spiral model. The spiral model combines the iterative concept of the prototype model and the systematic aspects taken from the waterfall model (Bhosale T, 2014).

The architecture of this system consists of three main parts, namely external system, virtual server and end-user. The following is an explanation related to architectural design from Figure 1. Furthermore, Table 3 is an explanation of the function of each system component.

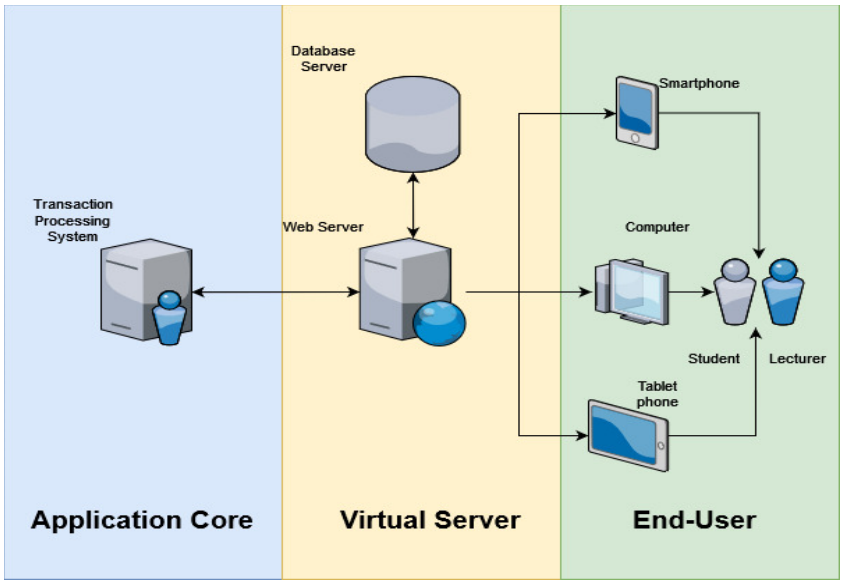

Figure 1. Design of decision support system application architecture

Table 3. Functions of system components

Component name	Location	Function
Transaction Processing System	Application Core	Means of input data and parameters needed by the system
Web Server	Virtual Server	Web service provider as a bridge between external data and applications used by end users
Database server	Virtual Server	Act as application data store. Data storage using MySQL.
Data viewing device (web browser)	End-User	As an interface between the user and the system. Displaying data on student learning outcomes and their recommendations

3.3 System Test

Testing was performed by monitoring the accuracy of the recommendations given with actual conditions. Testing is based on expert opinion in the field of education. The error tolerance used is only 5%. The error in question is if there are students who are in normal conditions but are notified that they need a special approach.

3.4 System Evaluation

System evaluation is an important process in order to realize a system that is truly able to support data needs to provide recommendations for teaching strategies on adaptive learning in the era of distance learning. The evaluation was carried out using a SUS (System Usability Scale)-based questionnaire aimed at users, namely teaching staff at the Informatics Education Study Program, Universitas Sebelas Maret.

The SUS evaluation questionnaire contains 10 questions that have been adapted to the standards of experts (Suharsih et al., 2021). Table 4 shows the original question from SUS-based evaluation.

Table 4. List of SUS-based questions

No	Question
1	I think that I would like to use this product frequently
2	I found the product unnecessarily complex
3	I thought the product was easy to use
4	I think that I would need the support of a technical person to be able to use this product.
5	I found that the various functions in this product were well integrated.
6	I thought there was too much inconsistency in this product.
7	I would imagine that most people would learn to use this product very quickly.
8	I found the product very cumbersome to use.
9	I felt very confident using the product.
10	I needed to learn many things before I could get going with this product.

Each question points is a text-based answer option. To facilitate the data analysis process, the answer options were translated into numerical weights. Table 5 shows the weight of each respondent's answer options based on the Likert scale.

Table 5. Weight of answer options

Answer options	Abbreviations	Score
Strongly disagree	SD	1
Disagree	D	2
Neutral	N	3
Agree	A	4
Strongly agree	SA	5

After collecting data from respondents, the data were calculated. There are several rules in calculating the SUS score (Sanjaya et al., 2021). The following are the rules when calculating the score on the questionnaire:

- For each odd numbered question, the score of each question obtained from the user's score will be deducted by 1.
- For each question with an even number, the final score is obtained from a score of 5 minus the question score obtained from the user.
- The SUS score is obtained from the sum of the scores for each question which is previously multiplied by 2.5.

The rules for calculating scores apply to 1 respondent. For further calculations, the SUS score of each respondent is sought for the average score by adding up all scores and dividing by the number of respondents. Here's the formula for calculating the sus score:

$$\bar{x} = \frac{\sum x}{n}$$

Description:

$\bar{x}$ = Average score

$\sum x$ = Sum of SUS score

n = number of respondents

3.5 Conclusion Drawing

The study ended with drawing conclusions. The conclusion was drawn based on the results of the evaluation of the application that was tested in the Informatics Education Study Program, Universitas Sebelas Maret. The results obtained at this stage are a straightforward statement regarding whether the application has criteria that are not good, not good, good enough or very good according to the SUS standard in Table 6 below (Online et al., 2021).

Table 6. Classification of criteria based on SUS score

SUS Score	Grade	Grade interpretation
> 80.3	A	Excellent
68 – 80.3	B	Good
68	C	Okay
51 – 68	D	Poor
< 51	F	Awful

5. Results and Discussion

5.1 System Analysis and Design

Before the application starts to be built, several application design concepts are designed in such a way that it can accommodate interactions between applications and users. The system workflow is designed using flow charts to make it easier for interested parties to understand the application business process flow. The application flow chart can be seen in Figure 2.

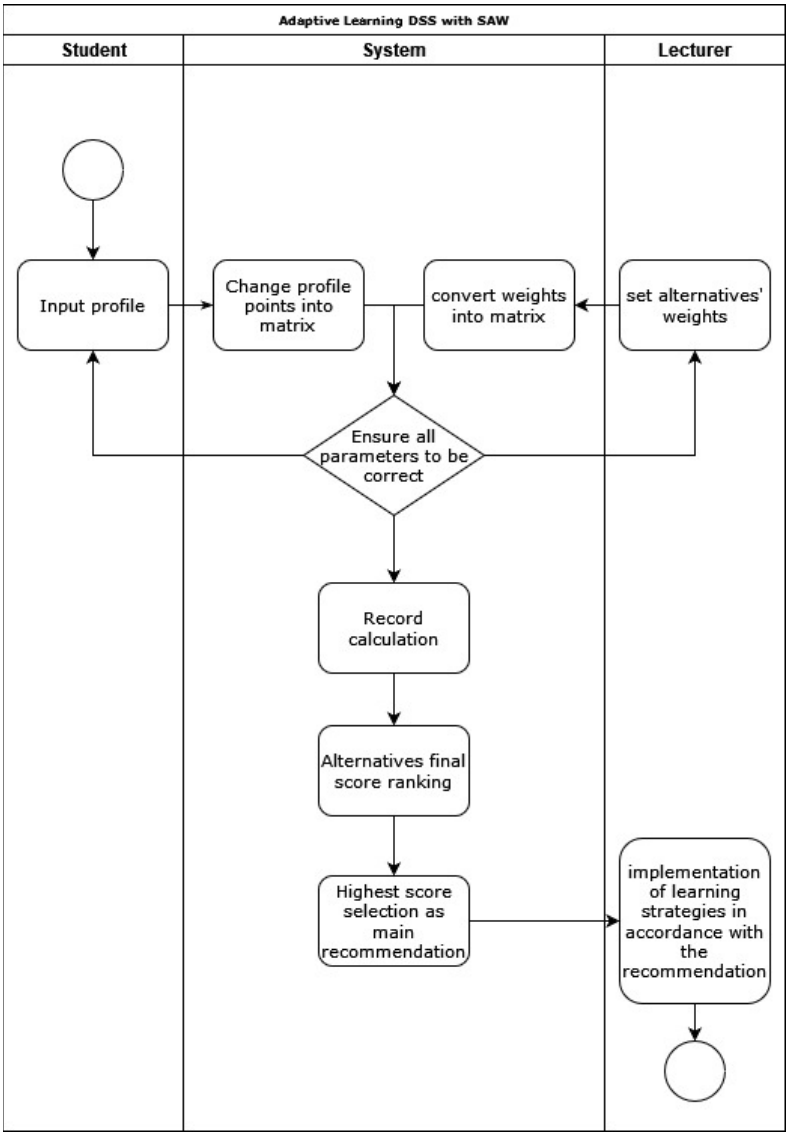

Figure 2. Application business process flowchart

The design of the application interface is formed through a mockup that contains the layout design of the application elements. Making this mockup aims to reduce errors in the placement of application elements, such as buttons, tables, and text. Figure 3 is a mockup design of a decision support system application.

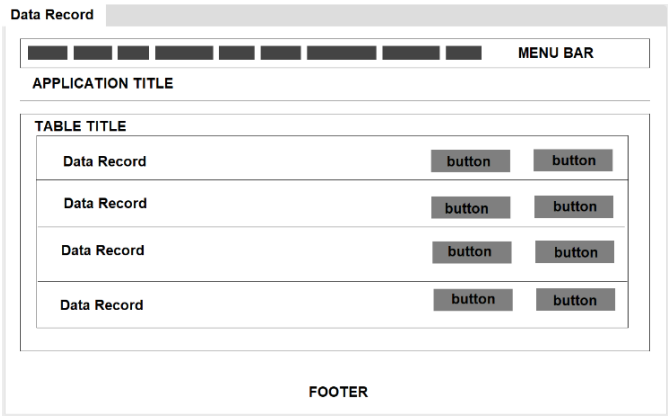

Figure 3. Application interface mockup design

Guided by the problem constraints, mockups and system flow diagrams, the application is made using PHP programming with the CodeIgniter framework. The database used is the MariaDB engine. Once built, the application is then ready to be published by installing it on a Virtual Private Server.

5.2 System Implementation

The finished application was tested on teaching staff and students in the Informatics Education, Universitas Sebelas Maret Surakarta. Web-based applications make it easy for users to be able to access anytime and anywhere. Due to the region where the application will be mostly used, the labels written within the application are in Bahasa Indonesia.

The process of running the system begins with inputting profile data from each student who takes courses from the sample lecturer. Input of student profile data is done using a questionnaire with a Likert scale with a value between 1 to 4. Figure 4 shows the appearance of the application interface on the student profile criteria page.

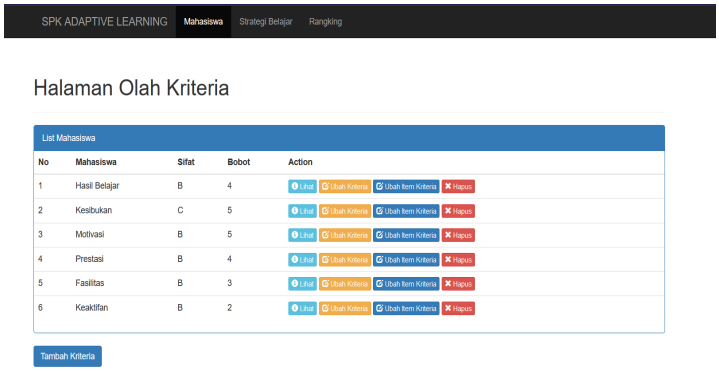

Figure 4. Student profile criteria page interface

By default, the application has six learning strategies with pre-calculated weights as shown in Table 2. Details of learning strategies and their weights can be accessed through the learning strategies page. The learning strategy page interface and its weights can be shown in Figure 5.

Even though the strategies and weights are predetermined, users (lecturers) can adjust them according to their own personalization. This is so that the essence of adaptive learning can be implemented optimally.

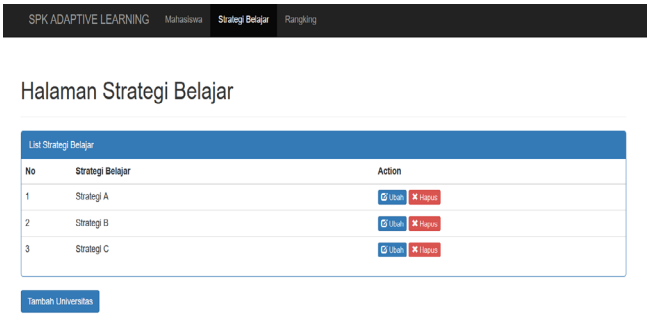

Figure 5. Learning strategy page interface

The last step in the process of giving this recommendation is to calculate the weight of the student criteria with the learning strategies they have. The result of the calculation is in the form of a score for each strategy, where the highest score is the option which will then be recommended as an appropriate follow-up to the student concerned. Figure 6 is an application interface display on the calculation page for the ranking of learning strategies.

Figure 6. The learning strategy ranking page calculation interface

5.3 System Evaluation

The system that has been tested on four lecturers of the Informatics and Computer Engineering Education study program is evaluated using a SUS-based questionnaire. SUS or System Questionnaires were given to the lecturer via Google Form. The raw results of the questionnaire can be described through Table 7 below.

Table 7. Raw results of SUS evaluation

Question	Lecturer 1	Lecturer 2	Lecturer 3	Lecturer 4
Q1	5	4	5	3
Q2	2	2	1	4
Q3	3	5	5	2
Q4	2	3	2	5
Q5	4	4	5	4
Q6	2	2	2	3
Q7	4	5	4	2
Q8	2	2	2	3
Q9	4	4	4	2
Q10	2	3	1	5

Based on the answers obtained from the questionnaire, all the results are then analyzed by using the SUS rules. It's formula can be written as follow.

$$SUS\ Score = ((R1 - 1) + (5 - R2) + (R3 - 1) + (5 - R4) + (R5 - 1) + (5 - R6) + (R7 - 1) + (5 - R8) + (R9 - 1) + (5 - R10)) * 2.5)$$

Following scores gathering and calculation, it was then recapitulated by finding the average percentage value from each total score. Table 8 shows the results of the recapitulation of all scores from SUS assessment and Figure 7 represents the average point from each questions.

Table 8. Recapitulation results of SUS

Question	Lecturer 1	Lecturer 2	Lecturer 3	Lecturer 4
Q1	4	3	4	2
Q2	3	3	4	1
Q3	3	4	4	1
Q4	3	2	3	0
Q5	3	3	4	3
Q6	3	3	3	2
Q7	3	4	3	1
Q8	3	3	3	2
Q9	3	3	3	1
Q10	3	2	4	0
SubTotal	**31**	**30**	**34**	**13**
Total (subtotal * 2.5)	**78**	**75**	**85**	**33**

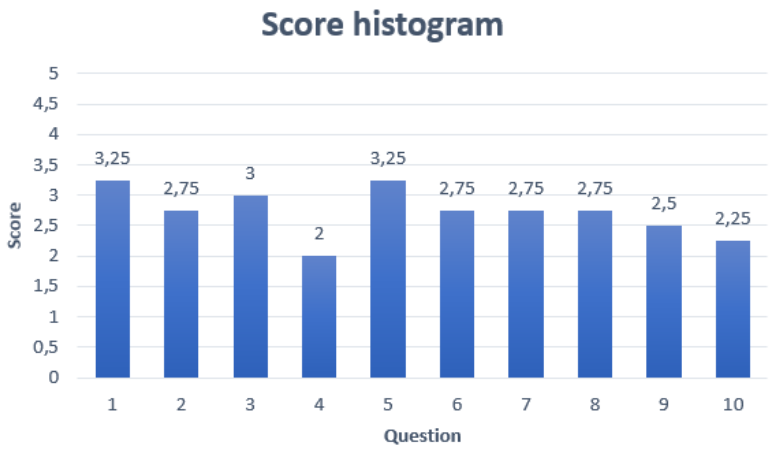

Figure 7. Score histogram of each questions point average

The summary value from total scores gathered from table 7 is 111 which is then calculated to find the average. The average from these scores is 78. From Figure 8, It is clear that the question number 4 got the lowest score. This value means that the user still needs technical assistance from the support team in using the application. Question number 1 and 5 received score of 3,25. From these numbers, it can be seen that user may be using this application in the next chance and they might think that the algorithm quite well embedded into the application. To explain the results more clearly, Figure 8 display the position of the application SUS score.

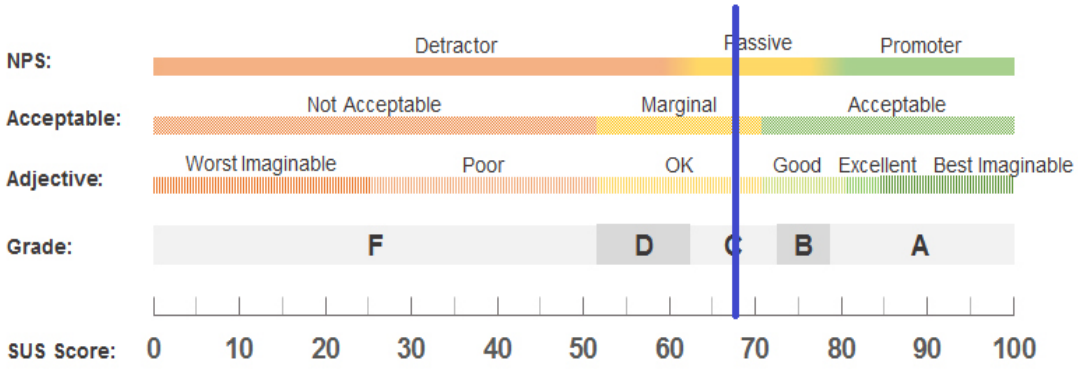

Figure 8. Position of application SUS Score

From Figure 9, it can be seen that the application's SUS score is 78. Therefore, it is included in the category of OK and indicated as grade “C”. The okay category means the adjective rating of the usability of this application into an absolute rating is just okay. It means that even though there are some positive acceptance from the user, but the negative commends are also has a fairly high score.

Furthermore, the NPS score result is Passive as shown in Figure 9. The purpose of the predicate is that the application is not good enough to be easily recognized by the user. It may cause the application to take a long time to be recognized by the target user. The application must be given a more detailed explanation and has an interface that makes it easy for people to use it

However, the acceptance value of the application is at a marginal level, which means the application is acceptable but needs improvement. It can be concluded that the application of decision support systems application for the selection of learning strategy recommendations in the adaptive learning method can be applied even if only on a small scale.

6. Conclusion

The decision support system application for the selection of learning strategy recommendations on the adaptive learning method was successfully implemented and received a fairly good response. This is evidenced by the acquisition of an average score of 68 from the SUS questionnaire given to a sample of 4 lecturers of the Informatics Education study program, Universitas Sebelas Maret. Through these results, the author will make up the user interface and user experience to help end-user to easily understand how to use the application. Long-term development of this application is expanding the scope of application to a wider scale, namely in elementary and middle schools.

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Biography

Raqael Fisabillah Ramadhan is currently a student at Universitas Sebelas Maret majoring in informatics and computer engineering education, before he became a student at Sebelas Maret University, he studied at 7 Depok Junior High School between 2013-2015, attended Vocational High School 1 Depok between 2015 -2017, became a finalist for the Indosat Ooredoo Wireless Innovation Contest in 2017 with the eduqa application which is used as a management platform for schools, worked at the International Global Network event organizer as a UX Programmer between 2017-2018 and helped manage several international events such as Asia Model United Nations (AWMUN), Youth Excursion (YOUTEX) and Global Goals MUN while at the International Global Network, besides that he has also worked at a software house called Ionbit Indonesia 2019 as DevOps, in 2020 as a backend programmer, and in 2021 as chief operating officer. He has worked on several projects from the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN), RISTEK-BRIN, and ASTRA while working at Ionbit Indonesia. His main areas of expertise are programming with PHP and javascript, server automation deployment, and continuous integration/continuous dlivery with amazon web service or google cloud platform.

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