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Implementation of a Combination of Rank Reciprocal and Additive Ratio Assessment Approaches for 3D Printer Selection

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Abstract

With the wide selection of 3D printers available on the market, the challenge arises for consumers and businesses to choose the device that best suits their specific needs. To determine the choice, the decision-maker must know one by one the specifications of the 3D printer to be purchased, which results in making difficult decisions and requiring a long time. This research aims to implement a combination of the Rank Reciprocal and additive ratio assessment (ARAS) approaches to make it easier to determine decisions for selecting a 3D printer. The Reciprocal Rank approach provides weight values by utilizing the reciprocal or inverse principle. Meanwhile, the ARAS approach is used to obtain the best alternative by evaluating alternative rankings based on their utility function. From the case studies that have been carried out, the highest to lowest utility values are Anycubic 4Max Pro (A2) getting a score of 0.8289, Creality Ender-3 Pro (A1) getting a score of 0.6174, Anet 3D Printer ET4 Pro (A3) getting a score of 0.5510, and Mingda Magician X2 (A4) getting a score of 0.5116. The output produced by the system in the case study carried out produces the same value as the manual calculation, meaning that the ARAS method calculation in the system is declared valid. Based on usability testing, it got a score of 90%, which shows the system is suitable for use.

Keywords: 3D Printer; Additive Ratio Assessment; ARAS Method; Decision Support System; Rank Reciprocal

1. INTRODUCTION

In an era of rapid digitalization, 3D printing has emerged as a revolutionary technology that has the potential to transform a variety of industries, from manufacturing to medicine to education. The advantages of 3D printing, including mass customization, reduced waste, and the ability to print designs of complexity that are impossible to create with traditional methods, have made this technology one of the pioneers of the Industry 4.0 era [1]. However, with the wide variety of 3D printer options available on the market, the challenge arises for consumers and businesses to choose the device that best suits their specific needs. This decision becomes more complex because each printer may offer a different combination of advantages and limitations. On the other hand, mistakes in 3D printer selection can lead to significant financial losses and a waste of resources [2]. To determine the choice, the decision-maker must know one by one the specifications of the 3D printer to be purchased and compare them with his needs. This results in making difficult decisions and requiring a long time. Therefore, a system is needed that can support decision-making in selecting the most suitable 3D printer for a particular purpose. Decision support systems are computer-based systems that are used to support decision-making processes in complex and unstructured situations [3]. Decision support systems combine data from various sources, analytics, and simulation models to assist decision makers in making informed decisions [4].

Research related to the selection of devices such as computers and printers has been carried out by previous researchers using various methods. The first research concerns the development of a decision support system for choosing the best laptop by applying the SAW (Simple Additive Weighting) approach [5]. This method obtains the best alternative through normalization and weighted addition to evaluate alternatives. The next research, like the previous research, develops a decision support system for choosing the best laptop, but the researchers use the SMART (Simple Multi Attribute Ratting Technique) approach [6]. The SMART approach derives the best alternative by comparing different alternatives, taking into account the relative importance of each attribute, and combining these assessments into one overall utility value for each alternative. The next research is about using the AHP (Analytical Hierarchy Process) method to choose the best Personal Computer [7]. The AHP method works by setting priorities and making the best decisions by breaking down problems into a hierarchical structure. Different from subsequent research, this research develops a decision support system for selecting the best printer using the Weighted Product (WP) approach [8]. This approach uses the multiplication principle to connect attribute ratings, where each attribute must be given a weight or relative importance value that reflects its contribution to the overall decision. However, several previous studies did not explain the determination of the weight for each criterion. The weight of each criterion is determined by the decision-maker without using special techniques. Apart from that, in previous research, conflicting criteria were not resolved by using certain methods.

The difference between this research and the research that has been described is that in this research the criteria weights were determined using the Rank Reciprocal approach and in resolving conflicts or differences between criteria the ARAS approach was used. Apart from that, this research focuses on developing a decision support system for choosing a 3D printer. The Reciprocal Rank method is used to determine weight values through reciprocal normalization where the criteria are ordered based on their priority [9]. Meanwhile, the ARAS approach is used to evaluate and rank alternatives based on their utility function [10]. The advantage of the ARAS method is that it can handle qualitative and quantitative

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criteria, making it possible to carry out a comprehensive evaluation of alternatives [11]. This approach considers different criteria measurement units, so that conflict problems between criteria can be resolved [12].

The aim of this research is to implement a combination of the Rank Reciprocal and Additive Ratio Assessment (ARAS) approaches to determine a 3D printer so that it is easy to make decisions and can produce fast and correct decisions. The decision support system that is built is based on a website, so users can easily use and access it. The criteria used in this case study include: printer accuracy, technology used, price, materials used, and printer speed.

2. RESEARCH METHODOLOGY

2.1 Research Stages

Research stages are a series of systematic steps carried out by researchers in order to achieve goals and solve existing problems [13]. The aim of the research stage is to ensure that the research process takes place using the correct methods, thereby producing valid data and relevant recommendations [14]. The research steps used in this research are presented in Figure 1.

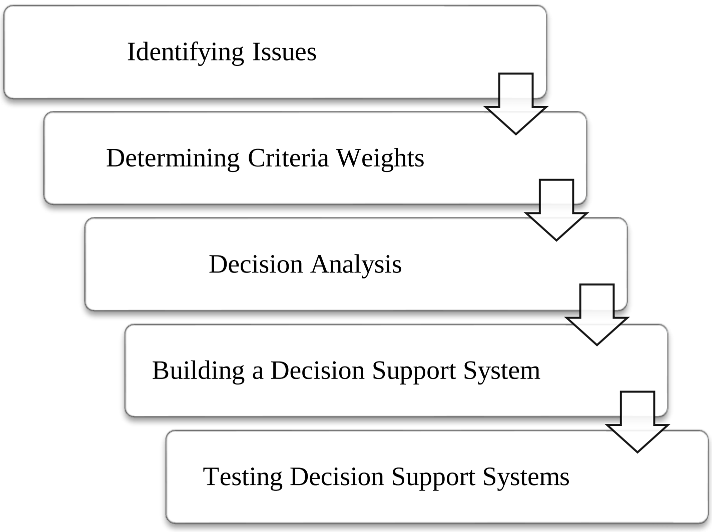

Figure 1. Research Steps

The chart shown in Figure 1 contains the steps carried out in this research. In detail, these steps are as follows:

1) Identifying Issues
This step is related to defining, recognizing, and articulating existing problems that do not need to be resolved and require a solution [15]. The problems in choosing a 3D printer in this research are based on the results of observations and interviews. Based on the results of problem identification, it was found that the main problem in choosing a printer is that the decision takes a long time and makes it difficult for decision-makers to make their choice. This is because, due to the increasing popularity of 3D printers, various brands and models have started flooding the market. Each 3D printer has its own specifications, features, advantages, and limitations. For this reason, we need software that can make it easier to recommend 3D printers easily and precisely.
2) Determining Criteria Weights
The criteria used in this research are based on expert knowledge contained in website articles [16]. These criteria are usually: printer accuracy, technology used, price, materials used, and printer speed. After the criteria are determined, the next step is to determine the weight of the criteria using the Rank Reciprocal approach. The Rank Reciprocal approach is used to rank or sort alternatives based on preferences or weights given by the user [9]. At this stage, the criteria weight values will be obtained based on calculations using the Rank Reciprocal method.
3) Decision Analysis
To solve decision problems in this research, the Additive Ratio Assessment (ARAS) approach was used. The ARAS approach has the ability to evaluate and rank alternatives based on their utility function [10]. This method can handle conflicting criteria and consider different units of measurement, making it a valuable tool for decision-makers.
4) Building a Decision Support System
This stage involves the coding stage, where a software developer translates the software design or specifications into computer code that can be executed by a computer [17]. In this research, a decision support system was built based on a website using a code editor, namely Atom, and the database MySQL.
5) Testing Decision Support Systems
This stage functions to ensure that the software being built is able to work correctly, in accordance with predetermined requirements, and meets the desired quality standards [18]. The test technique applied in this research is usability

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Page 115−124
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testing. Usability testing is an evaluation method used to measure the extent to which a product or system can be used effectively and efficiently by end users [19]. This test is taken from the usability aspects of ISO 9126, which consist of sub-criteria including understandability, learnability, operability, and attractiveness. In this research, a questionnaire was prepared, which was then filled out by users to assess the decision support system based on its usability.

2.2 Reciprocal Rank Weighting Method

Determining criteria weights is an important step in decision making because criteria weights are used for the evaluation or comparison process of options [20]. The Rank Reciprocal weighting method is one of the techniques used in decision support systems to give weight to the criteria used in the decision making process [9]. This method focuses on the relative ranking of criteria that have been determined by the user. In Rank Reciprocal, users are asked to provide relative rankings on these criteria. This method utilizes the principle of reciprocity or inverse, which means that an alternative with a higher ranking will get a higher score, while an alternative with a lower ranking will get a lower score [9]. To get the weight value in the Rank Reciprocal approach, it can be calculated using equation (1).

$$w_j = \frac{1/j}{\sum_{k=1}^{n} 1/k} \quad (1)$$

where w_j is the weight value for each criterion, j refers to the priority ranking of the criteria, and k is the priority order of the criteria.

2.3 Additive Ratio Assessment (ARAS) Method

The Additive Ratio Assessment (ARAS) method is a multiple-criteria decision-making (MCDM) technique that was first proposed by Zavadskas and Turskis [21]. It is used to solve MCDM problems by evaluating and ranking alternatives based on their utility function [10]. The ARAS method is particularly useful for dealing with MCDM problems that involve non-commensurable and conflicting criteria [12]. It can handle both qualitative and quantitative information, making it a versatile method for decision-making [11]. The advantage of the ARAS method is that it can handle qualitative and quantitative criteria, making it possible to carry out a comprehensive evaluation of alternatives [21]. This approach considers different units of measurement for criteria, which can be challenging in some multi-criteria problems [22]. In addition, the ARAS method is able to handle conflicting criteria and obtain alternative priorities based on their utility functions [23].

The process in calculating the ARAS approach consists of several stages, the following are the stages in completing the ARAS approach decision:

1) Determine the criteria values, weights, alternatives and optimum values.
   This step begins with determining the criteria, level of importance or weight, and the alternatives to be selected. Then, the next stage is determining the optimum value for each attribute. To determine the optimum value (X_{0j}), it is obtained by looking at the type of criteria, where there are two criteria, namely benefit or cost. The benefit type refers to criteria that prioritize maximum value, while the cost type refers to criteria that prioritize minimum value. If the criterion is benefit, then use equation (2), and if the criterion is cost, then use equation (3).

   $$X_{0j} = \frac{Max}{1} \quad (2)$$

   $$X_{0j} = \frac{Min}{1} \quad (3)$$

   where X_{0j} refers to the optimum value of criterion j.
2) Develop a decision matrix
   The decision matrix is prepared by including all attributes, including the optimum value obtained from the previous process. The decision matrix is prepared based on equation (4).

   $$X_{ij} = \begin{bmatrix} x_{01} & x_{0j} & \cdots & x_{0n} \\ x_{11} & x_{1j} & \cdots & x_{1n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{n1} & x_{mj} & \cdots & x_{mn} \end{bmatrix} \quad (4)$$

   where m refers to the number of alternatives and refers to the number of criteria. X_{ij} refers to the performance value of alternative i against criterion j, and X_{0j} refers to the optimum value of criterion j.
3) Normalize the attributes and arrange them in a normalized matrix.
   This stage will carry out normalization for each existing attribute to get a uniform assessment for each attribute, then arrange them into a normalized matrix. If the criterion is benefit, then the normalization uses equation (5), and if the criterion is cost, then the normalization uses equation (6).

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$$x_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{5}$$

$$x_{ij} = \frac{1}{x_{ij}^{*}};\ x_{ij}^{*} = \frac{X_{ij}}{\sum_{i=1}^{m} X_{ij}} \tag{6}$$

4) Perform weighted normalization and arrange them in a weighted normalized matrix.
In order to create a weighted normalized matrix, this process multiplies the normalized attributes by their weights. This process is implemented using equation (7).

$$D_{ij} = x_{ij} \times w_{ij} \tag{7}$$

5) Find the optimal value of each attribute.
The next step is to find the optimum value obtained through calculations using equation (8).

$$S_i = \sum_{j=1}^{n} D_{ij} \tag{8}$$

where S_i refers to the optimum value for each alternative.

6) Calculate the utility value of each attribute.
After the Si value is obtained, it is then used as a reference to obtain the utility value for each criterion. This utility value is used to determine the best alternative, where the highest value is the best option. To get the utility value, you can calculate it using equation (9).

$$K_i = \frac{S_i}{S_0} \tag{8}$$

where K_i refers to the utility value of each option, while Si and So indicate the optimum value of each alternative.

3. RESULT AND DISCUSSION

To solve the problem of deciding to choose a 3D printer, start by determining the criteria used as a reference for choosing the best option. The criteria used in this research are based on expert knowledge contained in website articles. These criteria are usually: printer accuracy, technology used, price, materials used, and printer speed. Once the criteria have been set, the next step is to determine the value range and conversion value for each criterion used. The values for each criterion, along with the conversion values, are presented in Table 1.

Tabel 1. Criteria and Conversion Value

Criteria Code	Criterion Name	Criterion Value	Value Conversion
C1	Printer Accuracy	< 60 mikron	1
		>= 60 mikron and < 100 mikron	2
		>= 100 mikron and < 140 mikron	3
		>= 140 mikron	4
C2	Technology Used	Selective Laser Sintering (SLS)	1
		Digital Light Processing (DLP)	2
		Stereolithography (SLA)	3
		Filament Deposition Method (FDM)	4
C3	Price	< 3,500,000	1
		>= 3,500,000 and < 5,000,0000	2
		>= 5,000,000 and < 6,500,0000	3
		>= 6,500,000	4
C4	Materials Used	< 2 Jenis Material	1
		>= 2 Jenis Material and < 4 Jenis Material	2
		>= 4 Jenis Material and < 6 Jenis Material	3
		>= 6 Jenis Material	4
C5	Printer Speed	< 50 mm/s	1
		>= 50 mm/s and < 100 mm/s	2
		>= 100 mm/s and < 150 mm/s	3
		>= 150 mm/s	4

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Page 115−124
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Table 1 presents the criteria used, which consist of a range of values and value weights for each criterion. The next stage is to determine the weight value for each criterion. Before calculating the weight value, the type of criteria is also determined, whether benefit (looking for the maximum value) or cost (looking for the minimum value). To determine the value for each weight, the Rank Reciprocal approach is used. Rank Reciprocal is an approach used to rank or sort alternatives based on preferences or weights given by the user. This approach uses a reciprocal or inverse technique where the alternative with a higher ranking will get a higher score, while the alternative with a lower ranking will get a lower score. The decision maker will give a priority value to each existing alternative, where the criteria that are considered more important have a higher priority. In the case study in this research, the types of criteria and order of priority are shown in Table 2.

Table 2. Order of Priority for Each Criteria

Code Criteria	Criterion Name	Type Criteria	Priority
C1	Printer Accuracy	Cost	1
C2	Technology Used	Benefit	2
C3	Price	Cost	3
C4	Materials Used	Benefit	4
C5	Printer Speed	Benefit	5

Table 2 shows the order of priority or level of importance for each criterion, which is used as a reference for calculating the weight value using the Rank Reciprocal approach. To get the value of each weight, equation (1) is used. Following is the calculation process:

$$w_1 = \frac{1/_1}{(1/_1) + (1/_2) + (1/_3) + (1/_4) + (1/_5)} = 0.4380$$

$$w_2 = \frac{1/_1}{(1/_1) + (1/_2) + (1/_3) + (1/_4) + (1/_5)} = 0.2190$$

$$w_3 = \frac{1/_1}{(1/_1) + (1/_2) + (1/_3) + (1/_4) + (1/_5)} = 0.1460$$

$$w_4 = \frac{1/_1}{(1/_1) + (1/_2) + (1/_3) + (1/_4) + (1/_5)} = 0.1095$$

$$w_5 = \frac{1/_1}{(1/_1) + (1/_2) + (1/_3) + (1/_4) + (1/_5)} = 0.0876$$

After the value for each weight has been calculated using the Rank Reciprocal approach, the value is entered into the table as shown in Table 3.

Table 3. Results of Weight Values Using the Reciprocal Rank Approach

Code Criteria	Criterion Name	Type Criteria	Value Weight
C1	Printer Accuracy	Cost	0.4380
C2	Technology Used	Benefit	0.2190
C3	Price	Cost	0.1460
C4	Materials Used	Benefit	0.1095
C5	Printer Speed	Benefit	0.0876

Table 3 shows the values for each weight through Rank Reciprocal calculations. The next step is to determine the alternative that will be selected. These alternatives include: Creality Ender-3 Pro (A1), Anycubic 4Max Pro (A2), Anet 3D Printer ET4 Pro (A3), and Mingda Magician X2 (A4). Then, these alternatives are given a value based on existing criteria according to the specifications of each product. The resulting values for each alternative in this case study are presented in Table 4.

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ISSN 2580-8389 (Media Online)
Page 115−124
https://ejurnal.pdsi.or.id/index.php/bids/index
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Table 4. Value of Each Alternative

Code	Alternative Name	Kriteria				
		C1	C2	C3	C4	C5
A1	Creality Ender-3 Pro	100 mikron	FDM	3,490,000	5 Types of Materials	50 mm/s
A2	Anycubic 4Max Pro	50 mikron	SLA	5.600.000	3 Types of Materials	180 mm/s
A3	Anet 3D Printer ET4 Pro	100 mikron	FDM	4,790,000	4 Types of Materials	150 mm/s
A4	Mingda Magician X2	100 mikron	FDM	4,690,000	4 Types of Materials	60 mm/s

Table 4 shows the results of giving alternative values to the criteria according to the specifications of the 3D printer. Next, the results of the assessment are converted into values to make calculations easier. The value conversion is carried out based on Table 1. The value for each alternative after the value conversion is carried out is presented in Table 5.

Table 5. Value Conversion Results for Each Alternative

Code	Alternative Name	Kriteria				
		C1	C2	C3	C4	C5
A1	Creality Ender-3 Pro	3	4	1	3	2
A2	Anycubic 4Max Pro	1	3	3	2	4
A3	Anet 3D Printer ET4 Pro	3	4	2	2	4
A4	Mingda Magician X2	3	4	2	2	2

Table 5 shows the value of each alternative for which the value conversion was carried out. To find the best alternative using the ARAS approach, start by determining the Xo value or optimum value for each attribute. The general value is also determined based on the type of criteria; if the criterion is benefit, then use equation (2), and if the criterion is cost, then use equation (3). Based on Table 2, the benefit criteria are criteria C2, C4, and C5. Meanwhile, cost criteria include criteria C1 and C3. Then, the conversion results in Table 5 become values for each attribute in the matrix. Then the optimum value (X0) is produced, namely {1; 4; 1; 3; 4}. The values of all attributes and the optimum values that have been obtained are then entered into the matrix based on equation (4). The following are the results of the initial decision matrix:

$$X = \begin{bmatrix} 1 & 4 & 1 & 3 & 4 \\ 3 & 4 & 1 & 3 & 2 \\ 1 & 3 & 3 & 2 & 4 \\ 3 & 4 & 2 & 2 & 4 \\ 3 & 4 & 2 & 2 & 2 \end{bmatrix}$$

After the decision matrix has been prepared, the next step is to normalize each attribute and arrange them into a normalized decision matrix. For normalization, equation (5) is used for each attribute for the benefit criteria, and equation (6) is used for the cost criteria. The calculation process to obtain normalization for each attribute is as follows:

$$X_{01} = \frac{1}{1 + 0.33 + 1 + 0.33 + 0.33} = 0.3333$$

$$X_{11} = \frac{0.33}{1 + 0.33 + 1 + 0.33 + 0.33} = 0.1111$$

$$X_{21} = \frac{1}{1 + 0.33 + 1 + 0.33 + 0.33} = 0.3333$$

$$X_{31} = \frac{0.33}{1 + 0.33 + 1 + 0.33 + 0.33} = 0.1111$$

$$X_{41} = \frac{0.33}{1 + 0.33 + 1 + 0.33 + 0.33} = 0.1111$$

This stage is carried out until all attributes have been normalized, or up to attribute X_{45}. If all attributes have been normalized, they are then arranged into a normalized decision matrix as follows:

$$X_{ij} = \begin{bmatrix} 0.3333 & 0.2105 & 0.3000 & 0.2500 & 0.2500 \\ 0.1111 & 0.2105 & 0.3000 & 0.2500 & 0.1250 \\ 0.3333 & 0.1579 & 0.1000 & 0.1667 & 0.2500 \\ 0.1111 & 0.2105 & 0.1500 & 0.1667 & 0.2500 \\ 0.1111 & 0.2105 & 0.1500 & 0.1667 & 0.1250 \end{bmatrix}$$

The next process is to obtain weighted normalized attribute values and then arrange them into a weighted normalized decision matrix. To get the weighted normalized value, equation (7) is used, with the weight value referring to the results of weight calculations using the Rank Reciprocal approach in Table 3. The following is the calculation process to get normalized attribute values with their weights:

$$D_{01} = 0.3333 \times 0.4380 = 0.1467$$

$$D_{11} = 0.1111 \times 0.4380 = 0.0489$$

$$D_{21} = 0.3333 \times 0.4380 = 0.1467$$

$$D_{31} = 0.1111 \times 0.4380 = 0.0489$$

$$D_{41} = 0.1111 \times 0.4380 = 0.0489$$

This stage is carried out until all attributes have been weighted normalized, or up to attribute D_{45}. If all attributes have been normalized with their weights, they are then arranged into a weighted normalized decision matrix as follows:

$$D_{ij} = \begin{bmatrix} 0.1467 & 0.0463 & 0.0420 & 0.0275 & 0.0225 \\ 0.0489 & 0.0463 & 0{,}0420 & 0.0275 & 0.0113 \\ 0.1467 & 0.0347 & 0.0140 & 0.0183 & 0.0225 \\ 0.0489 & 0.0463 & 0.0210 & 0.0183 & 0.0225 \\ 0.0489 & 0.0463 & 0.0210 & 0.0183 & 0.0113 \end{bmatrix}$$

Then, continue by calculating the optimal value (S_i) for each alternative using equation (8). The calculation steps can be seen in the following discussion:

$$S_0 = 0.1467 + 0.0463 + 0.0420 + 0.0275 + 0.0225 = 0.2850$$

$$S_1 = 0.0489 + 0.0463 + 0.0420 + 0.0275 + 0.0113 = 0.1760$$

$$S_2 = 0.1467 + 0.0347 + 0.0140 + 0.0183 + 0.0225 = 0.2362$$

$$S_3 = 0.0489 + 0.0463 + 0.0210 + 0.0183 + 0.0225 = 0.1570$$

$$S_4 = 0.0489 + 0.0463 + 0.0210 + 0.0183 + 0.0113 = 0.1458$$

After the optimal value (S_i) is obtained, the final step is to find the utility value (K_i) through equation (9). The calculation process can be seen in the following steps:

$$K_1 = \frac{0.1760}{0.2850} = 0.6174$$

$$K_2 = \frac{0.2362}{0.2850} = 0.8289$$

$$K_3 = \frac{0.1570}{0.2850} = 0.5510$$

$$K_4 = \frac{0.1458}{0.2850} = 0.5116$$

The highest utility value (K_i) is the best option. After all utility values (K_i) are obtained, they are then arranged into rankings from highest to lowest, as presented in Table 6.

Table 6. Ranking of Utility Values

Alternative Code	Alternative Name	Utility Value	Ranking
A2	Anycubic 4Max Pro	0.8289	1
A1	Creality Ender-3 Pro	0.6174	2
A3	Anet 3D Printer ET4 Pro	0.5510	3
A4	Mingda Magician X2	0.5116	4

It can be seen in Table 6 that the highest to lowest utility values are Anycubic 4Max Pro (A2) getting a score of 0.8289, Creality Ender-3 Pro (A1) getting a score of 0.6174, Anet 3D Printer ET4 Pro (A3) getting a score of 0.5510, and Mingda Magician X2 (A4) obtaining a score of 0.5116. This means that in this case study, the Anycubic 4Max Pro (A2) alternative is the best option.

The results of the analysis and modeling that have been carried out are then realized in the form of a decision support system through the coding stage. In this research, a decision support system was built based on a website using a code editor, namely Atom, and the database MySQL. The decision support system for selecting a 3D printer is equipped with a login form to access the system. After the user has successfully logged in, enter the main menu interface. On the main menu, a dashboard will be displayed containing the main menus of the system and graphs of the ARAS method calculation results. The main menu interface form in this decision support system is presented in Figure 3.

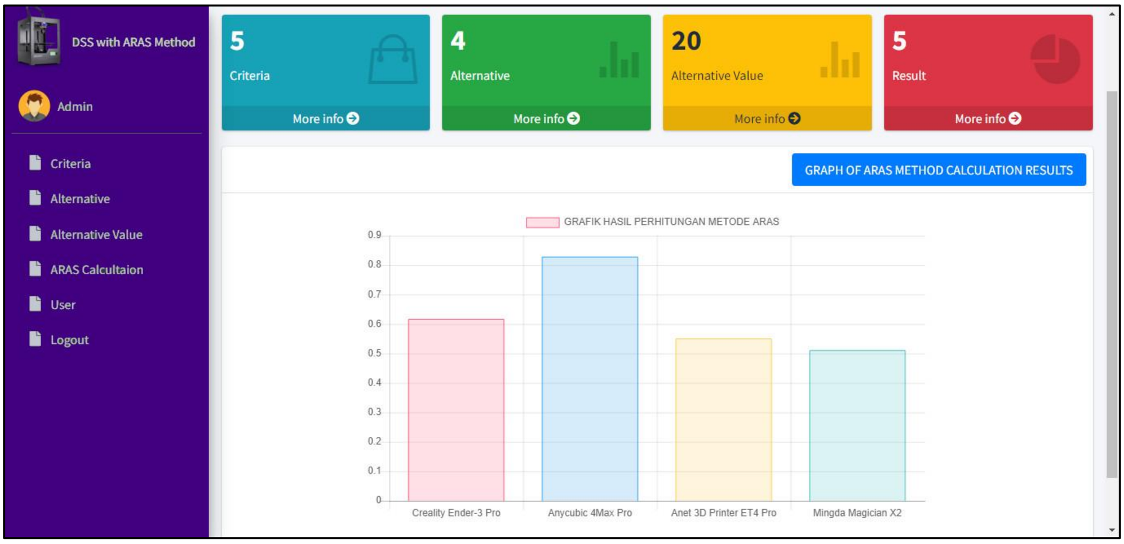

Figure 3. Developed Decision Support System Dashboard User Interface

Figure 3 is the system's main menu interface, where in this form the user can select existing features and see the results of the system's selected recommendations through a graph of the calculation results. To be able to start selecting a 3D printer, the user can input criteria data, alternative data, and alternative value data. After the data has been managed, the user can select a 3D printer. As an example, the form for alternative data input is visualized in Figure 4.

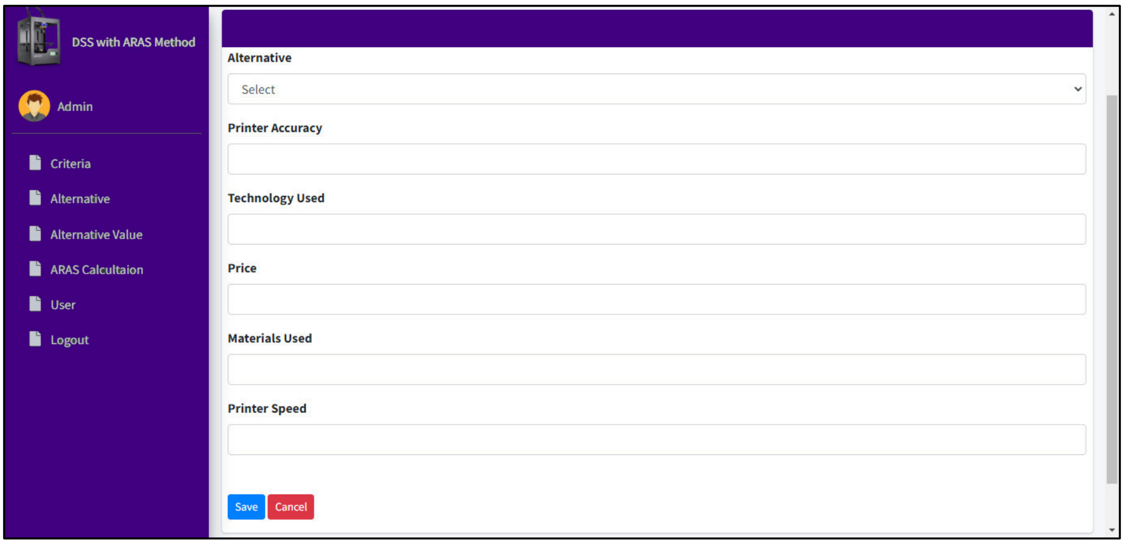

Figure 4. Alternative Value Data Input Form Interface

Figure 4 shows the form interface for inputting alternative data, where the user will give a value to the alternative based on existing criteria. After the alternative value data has been input, the best alternative results can be seen in the ARAS Calculation menu. This feature will show the steps or process for implementing the ARAS approach. Apart from that, this feature also displays a ranking of alternatives from highest to lowest utility value. The interface for the ARAS calculation feature is visualized in Figure 5.

Optimum Value and Utility Value

No	Alternative	Printer Accuracy	Technology Used	Price	Materials Used	Printer Speed	Optimum Value (S_i)	Utility Value (K_i)
-	Weight	44 % (Cost)	22 % (Benefit)	14 % (Cost)	11 % (Benefit)	9 % (Benefit)		
	A0	0.146666666667	0.0463157894736	0.042	0.0275	0.0225	0.28498245614	
1	Creality Ender-3 Pro	0.0488888888888	0.0463157894736	0.042	0.0275	0.01125	0.175954678362	0.617422843305
2	Anycubic 4Max Pro	0.146666666667	0.0347368421052	0.014	0.0183333333334	0.0225	0.236236842105	0.828952228515
3	Anet 3D Printer ET4 Pro	0.0488888888888	0.0463157894736	0.021	0.0183333333334	0.0225	0.157038011696	0.551044488222
4	Mingda Magician X2	0.0488888888888	0.0463157894736	0.021	0.0183333333334	0.01125	0.145788011696	0.511568373965

Rangking

No	Alternative	Utility Value
1	Anycubic 4Max Pro	0.828952228515
2	Creality Ender-3 Pro	0.617422843305
3	Anet 3D Printer ET4 Pro	0.551044488222
4	Mingda Magician X2	0.511568373965

Figure 5. Output of ARAS Method Calculation Results

Figure 5 shows the output of the calculation process using the ARAS approach. If you look at the output results of the ARAS method calculations from the case studies that have been carried out, it produces values that are no different from the manual calculation results. This means that the output produced by the system is valid.

Following system development, usability testing is conducted to make sure the program is appropriate for its intended usage. Understandability, learnability, operability, and attractiveness are the sub-criteria that are employed in usability assessment. Users who choose investing applications are asked to complete questionnaires as part of this testing process. The Guttman scale, which only has two answer choices (agree and disagree), is used as a measurement scale. This attempts to elicit from consumers extreme responses. Twenty respondents will complete the ten questions on the questionnaire. The results of this usability testing are visualized in graphic form presented in Figure 6.

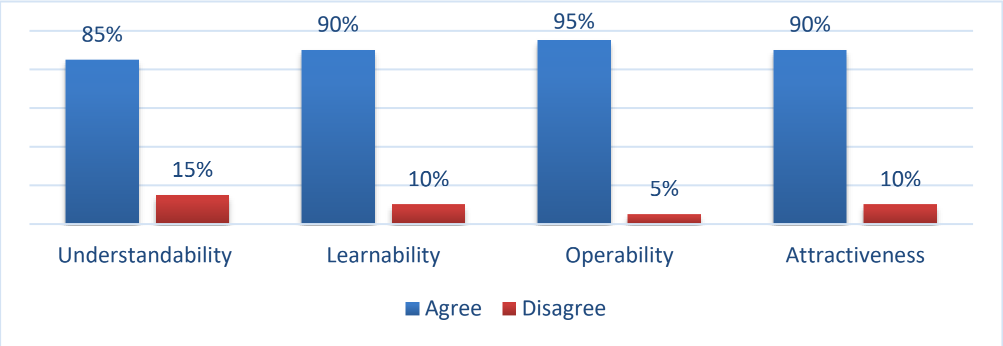

Figure 6. Usability Testing Graph

The usability testing results shown in Figure 6 show that respondents agreed to the sub-criteria of understandability of 85%, learnability of 90%, operability of 95%, and attractiveness of 90%. If the average value is calculated, a usability testing value of 90% is obtained. Next, the usability testing results obtained are transformed into an assessment that is guided by the following grouping of values: "Good", the value is between 76% and 100%; “Fair”, the value is between 56% and 75%; “Not Good”, the value is between 40% and 55%; and “Not Good”, less than 40% [24]. From this grouping, the usability testing results of the decision support system for selecting the 3D printer to be built are in the "Good" group. This means that the system is suitable for use because it is considered to have the functionality desired by users.

4. CONCLUSION

In this research, the Rank Reciprocal and Additive Ratio Assessment (ARAS) approach has been implemented in a decision support system for choosing a 3D printer. The Rank Reciprocal approach provides weight values using the reciprocal or inverse principle based on priority order. Meanwhile, in carrying out the analysis to determine the best alternative, the ARAS approach is used, where the best alternative will be evaluated by ranking the alternatives based on their utility function. Based on the case studies that have been carried out, the highest to lowest utility value results are obtained, namely Anycubic 4Max Pro (A2) getting a score of 0.8289, Creality Ender-3 Pro (A1) getting a score of 0.6174, Anet 3D Printer ET4 Pro (A3) getting a score of 0.5510, and Mingda Magician X2 (A4) getting a score of 0.5116. The results generated by the case study's decision support system are identical to those obtained by hand computations. This indicates that ARAS's installation on the system may be deemed legitimate. Apart from that, the usability testing obtained an average score of 90%. This indicates that the system is deemed to contain the functionality that users have requested, making it appropriate for usage. For further research, there are several suggestions that can be used as a reference for improvement. Determining weights using Rank Reciprocal is susceptible to non-objectivity in determining rankings, so it needs to be combined with a fuzzy logic algorithm to get more precise values. Apart from that, in this research using conversion values, it is necessary to determine the appropriate value in assessing alternatives against existing criteria.

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