Decision Analysis of Laptop Selection with the Analytical Hierarchy Process (AHP) Method

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ABSTRACT – Technology has become a basic need, such as a laptop. Some laptop manufacturers compete to create the best specification of laptop that suits their target market. Many brands and types of laptops sold on the market also make consumers feel confused. The purpose of this study is to determine the best alternatives and laptop specifications that ITS FSAD students preferred when using the AHP method. The data used in this research is primary data from questionnaires distributed to 31 students of the Faculty of Science and Data Analytics (FSAD) of the Sepuluh Nopember Institute of Technology (ITS) on October 10–17, 2022. All criteria levels have a Consistency Ratio (CR) value of less than 0.1. That means the preferences of the respondents are constant. The alternative rankings that are preferred by respondents are ASUS, LENOVO, HP, and ACER. In criteria level 2, respondents prefer RAM greater than 8GB, a processor greater than Intel i5, SSD type internal storage, and a price less than a million rupiah. While in criteria level 1, price is the most preferred by respondents. Based on these four alternatives, the price is less than ten million rupiah and SSD type internal storage is more preferred by respondents.

Keywords– Analytical Hierarchy Process (AHP), Consistency Ratio (CR), Laptop, Matrix, Weights

I. INTRODUCTION

A. Backgrounds

Technology is one thing that can't be separated from life in the current modern era. There are lots of activities that require a laptop for technological support. Laptops are computer-like items that are more flexible because they can be used anywhere. The laptop's components are the same as those on computers, but they are generally lighter and smaller in size, which means they can be put in a bag easily. Nowadays, laptops can be considered one of the basic needs of society, both to support the course of their education and their respective jobs.

The development of advanced technology also affects the development of laptops in terms of types, specifications, functions, and prices. This makes laptop manufacturers compete to create the best products that suit their target market because the laptops needed for each level of education and different types of work are also not the same. Some examples of specifications that are considered by potential consumers in general are the size of the laptop, Random Access Memory (RAM), processor, battery life, internal memory, and laptop design. On the other hand, the many brands and types of laptops sold on the market also make potential consumers feel confused, because choosing the right laptop according to consumer needs is not easy, especially when it comes to adjusting to their budget. There are still many potential consumers who often buy laptops with specifications that do not match their needs. For example, there is a student who is going to buy a laptop with high specifications for graphic design even though he is an accounting student who is not familiar with design matters, unless he has a passion for design in addition to his college major.

Based on some of the problems above, the authors are interested in conducting research and analysis related to the decision-making system for choosing a laptop for students of the Faculty of Science and Data Analytics (FSAD) at Institut Teknologi Sepuluh Nopember (ITS) Surabaya. The title that has been determined by the author of this study is "Decision Analysis of Laptop Selection with the Analytical Hierarchy Process (AHP) Method." According to Ivan J. Aziz (2010:65), the AHP method itself does have advantages over several other methods because it can solve complex and unstructured problems by organizing the groups into a hierarchy. Therefore, the author conducted this analysis to find out what kinds of laptop specifications and alternatives are in demand by ITS Surabaya FSAD students.

B. Problems

The problems in this study are as follows.

1) What are the alternative laptop specifications that ITS FSAD students prefer?
2) What is the best laptop alternative with these specifications for ITS FSAD students to buy?

C. Goals

The goals of this study are as follows.

1) To know the alternative laptop specifications that ITS FSAD students prefer.
2) To determine the best laptop specifications alternative for ITS FSAD students to purchase.

D. Benefits

The benefits of this study are as follows.

1) Can provide the right alternative solution in the process of selecting a laptop that suits the needs of potential

consumers.

2) Can expand understanding and knowledge of decision-making systems with the Analytical Hierarchy Process (AHP) method.

II. LITERATURE REVIEW

A. Decision Making

Decision-making is a method for choosing one from several available alternatives. Decision-making is not easy because there are many considerations for every possibility that exists, so literature study and further analysis are needed before making the best decision. The purpose of decision-making is to solve an existing problem by finding the best solution. Several processes must be followed in decision-making. There is the problem-finding stage, the problem-solving stage (state of nature), and the decision-making stage (payoff). Over time, the decision-making stage is continuously improved to promote a more systematic thinking concept. The following is a tabulation of opinion stages in decision-making according to Herber A. Simon, Richard I. Levin, and Sir Francis Bacon [1].

Table 2.1 Decision making steps

Herber A. Simon Opinions	Richard I. Levin Opinions	Francis Bacon Opinions
Observing the environment and looking for conditions that need to be improved	Observating stage	Formulating and defining the problem
Finding, developing and analyzing possible alternatives	Analyzing and problem recogniting stage	Collecting relevant information
Selecting a specific alternative from all available alternatives	Model developing stage	Looking for alternative actions
Evaluating the selected options	Choosing data stage	Alternative analyzing
	Formulating and testing stage	Choosing the best alternative
	Problem solving	Implementing the decisions and evaluating the results

B. Descriptive Statistics

Descriptive statistics is a type of statistical knowledge that studies how to collect, compile, summarize, and present data [2]. Descriptive statistics will describe the data in a form that is easier to read and understand. The function of this method is limited to providing a description or general description of the object's characteristics. The results of these descriptive statistics can be summarized in the form of tables and/or visualized in the form of appropriate diagrams or graphs. In this study, pie charts and bar charts were used to visualize the data.

A pie chart is a diagram presented in the form of a circle that is divided into several areas. Usually, the presentation of a pie chart is in the form of a proportion or percentage of the data studied. A circle will show all the parts that add up to 100%

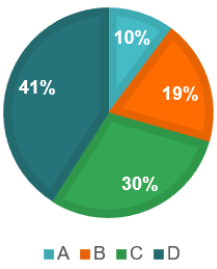


Figure 2.1 Example of Pie Chart

A bar chart is a diagram that shows data using vertical or horizontal bars that have a height or length that indicates the frequency of the data. Bar charts are used to present data for comparison purposes between one object and another. This chart shows the information through vertical or horizontal bars with separate bars and the same width of bars. Here is an example of a bar chart, both vertical and horizontal.

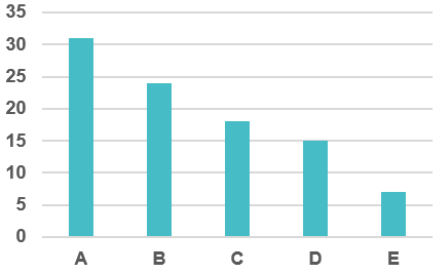


Figure 2.2 Example of Vertical Bar Chart

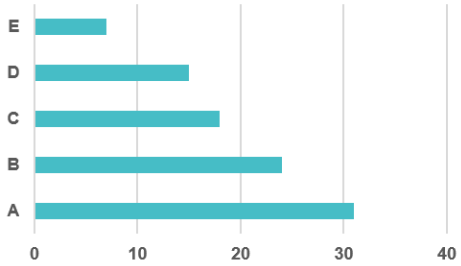


Figure 2.3 Example of Horizontal Bar Chart

C. Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process, or AHP, is a method of making decisions in a more complex system. The AHP method can simplify complex decision-making into simpler ones by changing the system into a simpler hierarchical system so that calculation analysis, both qualitatively and quantitatively, can be carried out systematically by considering several expected criteria [3]. The AHP method uses pairwise comparisons between two alternatives so that it can be seen which alternative is more likely to be chosen. This comparison is made using a numerical preference scale to describe the level of tendency of the chosen alternative compared to other alternatives [4]. The steps in using AHP for decision-making are as follows [5].

1. Identify the problem
2. Develop a hierarchical structure

In this step, each selection will be organized using a hierarchical structure. Each selection has sub-choices that can also be further considered. The following is an example of the hierarchical structure used in the AHP method.

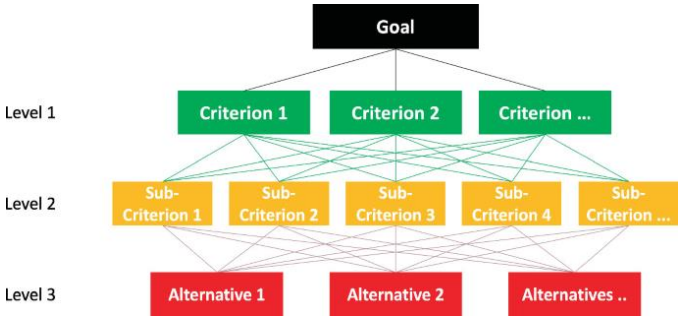


Figure 2.4 Hierarchy Structure

3. Create a pairwise comparison matrix

The structure of a pairwise comparison matrix with criteria is shown below.

Table 2.2 Pairwise comparison matrix structure

Criterion	A_1	A_2	A_3	…	A_n
A_1	a_{11}	a_{12}	a_{13}	…	a_{1n}
A_2	a_{21}	a_{22}	a_{23}	…	a_{2n}
A_3	a_{31}	a_{32}	a_{33}	…	a_{3n}
…	…	…	…	…	…
A_n	a_{n1}	a_{n2}	a_{n3}	…	a_{nn}

where,

A_i = i-th criterion

a_{ij} = The tendency toward choice obtained from the priority scale

Table 2.3 Priority Scale

Priority Scale	Description
1	The two criteria are equally important
3	One criterion is a little more important
5	One of the more important criteria
7	One criterion is very important
9	One of the absolute criteria is more important
2,4,6,8	When in doubt between two adjacent values

4. Do pairwise comparisons

The next step is to calculate the consistency measure using weights. The weight, in this case, is the average of each row. Table 2.3 is an example of the consistency measure calculation steps.

Table 2.4 Consistency measure calculation

Factor	A_1	A_2	A_3	…	A_n	Weight	Consistency measure

A_1	a_{11}	a_{12}	a_{13}	…	a_{1n}	W_1	CM_1
A_2	a_{21}	a_{22}	a_{23}	…	a_{2n}	W_2	CM_2
A_3	a_{31}	a_{32}	a_{33}	…	a_{3n}	W_3	CM_3
…	…	…	…	…	…	…	…
A_n	a_{n1}	a_{n2}	a_{n3}	…	a_{nn}	W_4	CM_n

where,

$$W_i = \frac{1}{n}\sum_{j=1}^{n} a_{ij} \quad (1)$$

$$CM_i = \frac{1}{W_i}\sum_{j=1}^{n} a_{ij}\, W_j \quad (2)$$

5. Calculate the eigenvector values for each matrix
   Calculate the eigenvector values in the comparison matrix using the following formula.

$$\lambda = \frac{1}{n}\sum_{i=1}^{n} CM_i \quad (3)$$

6. Calculate the consistency ratio
   The consistency index value is needed for calculating the consistency ratio in the comparison matrix. The consistency index equation is as follows:

$$CI = \frac{\lambda - n}{n-1} \quad (4)$$

Then, the consistency ratio equation is as follows.

$$CR = \frac{CI}{RI} \quad (5)$$

where,
RI = *Random index* that depends on the values of n.
If $CR < 0.1$, the analysis process is acceptable and can be continued at the decision-making stage. However, the analysis process must be repeated by reviewing the existing data, The review can be done by asking the respondent whether it is true that the data was obtained based on the respondent's choice or not. If it turns out that the data does not match the respondent's choice, the data can be changed according to the existing reality and then a pairwise comparison analysis can be performed again with the updated data.

D. Laptop

An alphanumeric keyboard and screen make up a compact, portable personal computer (PC) known as a laptop, laptop computer, or notebook computer. The screen is normally installed on the inside of the upper lid of laptops, while the keyboard is often mounted on the inside of the lower lid. Regarding the usage of laptops in higher education, numerous studies have been conducted on a variety of topics, including general use, communication, attitudes of students toward learning, student achievement, and distractions. According to Demb, Erickson, and Hawkins-Wilding (2004), 16% of all laptop usage involved typing papers and taking notes. According to Arend's (2004) research, most laptop use was for extracurricular activities, including completing group projects, utilizing software to write papers, and conducting internet searches. According to McVay, Snyder, and Graetz (2005), students reported utilizing their laptops on average for five hours per day, with 36% of that time going toward educational pursuits [6]. There are several alternative laptop brands for students, namely as follows:

1. ASUS
2. ACER
3. HP
4. LENOVO

III. METHODOLOGY

A. Data Sources

The data used in this study is primary data. Primary data was obtained by distributing questionnaires to 31 students of the Faculty of Science and Data Analytics (FSAD) of the Sepuluh Nopember Institute of Technology (ITS) on October 10–17, 2022, using the Google Forms platform. The following is a breakdown of the respondents in each department of the Faculty of Science and Analytics.

Table 3.1 Number of respondens from each departments

Department	Total Respondent
Physics	5
Chemistry	6
Biology	4
Statistics	6
Mathematics	6
Actuarial Science	4

B. Research Variables

The research variables used are level 1, 2, and 3 criteria listed in the following table.

Table 3.2 Research Variables

Criteria Level 1	Criteria Level 2	Criteria Level 3
RAM	<= 8 GB	ASUS

		ACER
		HP
		LENOVO
	> 8 GB	ASUS
		ACER
		HP
		LENOVO
Processor	Equivalent to Intel i3	ASUS
		ACER
		HP
		LENOVO
	Equivalent to Intel i5	ASUS
		ACER
		HP
		LENOVO
	Better than Intel i5	ASUS
		ACER
		HP
		LENOVO
Internal Storage	HDD	ASUS
		ACER
		HP
		LENOVO
	SSD	ASUS
		ACER
		HP
		LENOVO
Price	<= 10 million	ASUS
		ACER
		HP
		LENOVO
	> 10 million	ASUS
		ACER
		HP
		LENOVO

C. Hierarchy of Criteria Level 1, 2, and 3 (Alternatives)

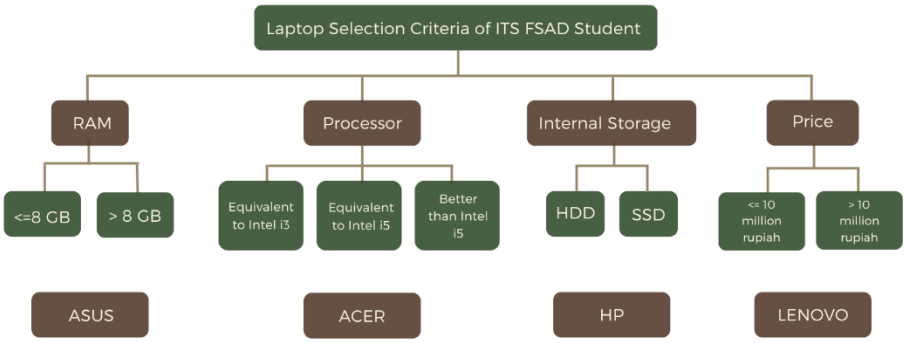


Figure 3.1 Hierarchy Structure of Criteria Level 1, 2, and 3 (Alternatives)

D. Step of Analysis

The analysis steps used in this research are as follows.

1. Defining the problem or topic to be analyzed
2. Defining alternative or initial decision criteria
3. Defining uncertain events in each alternative initial decision
4. Defining alternative decision criteria
5. Determining the limits of the research and the sample size
6. Determining a descriptive statistical analysis from the profiles of the respondents who supported the research
7. Determining weight calculations and analysis using the AHP method

a. Creating a pairwise comparison matrix from survey results for criteria 1, 2, and 3
b. Normalizing the pairwise comparison matrix for criteria 1, 2, and 3
c. Calculating consistency measure (CM)
d. Calculating consistency index (CI)
e. Determine the random index (RI) to be used
f. Calculating consistency ratio (CR)
g. Summarizing the results of the partial weight calculation
h. Calculating weights for level 3 criteria
i. Calculating weights for level 2 criteria
j. Calculating weights for level 1 criteria
k. Analyzing level 3 criteria
l. Analyzing the ranking of the criteria at levels 2 and 3
m. Analyzing respondents' perceptions of each alternative

8. Make conclusions and suggestions

IV. RESULTS AND DISCUSSIONS

A. Descriptive Statistics

To find out the respondents' characteristics from this study, pie charts and bar charts can be used. The pie chart can be used to see the proportion of respondents' gender.

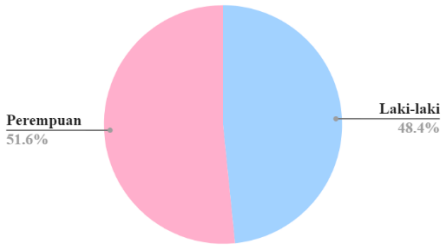


Figure 4.1 Pie Chart of Respondents' Gender

Figure 4.1 shows that the proportion of respondents by gender is almost the same. It's only different by 1 person. Of a total of 31 people, 15 respondents were male and 16 were female. Then, here is a bar chart to see a comparison between the respondents' departments.

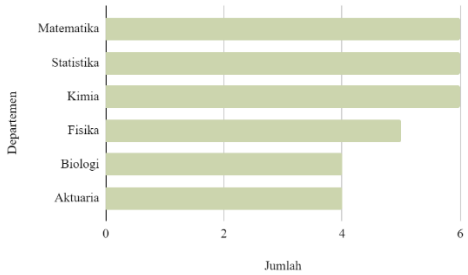


Figure 4.2 Bar Chart of Respondents' Department

Figure 4.2 shows that most of the respondents' departments were the Departments of Mathematics, Statistics, and Chemistry, which each had six people. This calculation is obtained based on the number of each student quota in the department and compared to the total student quota at the ITS Faculty of Science and Data Analytics (FSAD) and then multiplied by the initial target of respondents, which is 30.

B. Analysis Hierarchy Process (AHP)

The AHP method is used to make decisions on what kind of laptop is most suitable for students in the ITS Faculty of Science and Data Analytics. Based on the answers of 31 respondents from the survey, the results of the pairwise comparison matrix for criteria level 1 are as follows.

Table 4.1 Pairwise Comparison Matrix Criteria Level 1

	RAM	PROCESSOR	INTERNAL STORAGE	PRICE
RAM	1.0000	0.4423	3.0232	0.3765
PROCESSOR	2.2611	1.0000	4.8705	0.6040
INTERNAL STORAGE	0.3308	0.2053	1.0000	0.3876
PRICE	2.6564	1.6555	2.5797	1.0000

In the next step, the comparison matrix above will be normalized. After normalization, calculations were performed to

obtain the average value for each row, consistency measure (CM), consistency index (CI), and consistency ratio (CR). Here are the results of the calculation.

Table 4.2 Normalized Pairwise Comparison Matrix Criteria Level 1

	RAM	PROCESSOR	INTERNAL STORAGE	PRICE	WEIGHT	CM
RAM	0.1600	0.1339	0.2635	0.1590	0.1791	4.2009
PROCESSOR	0.3619	0.3027	0.4245	0.2551	0.3361	4.2381
INTERNAL STORAGE	0.0529	0.0622	0.0872	0.1637	0.0915	4.0685
PRICE	0.4251	0.5012	0.2248	0.4223	0.3934	4.2237

Table 4.3 Value of CI, RI, and CR for Criteria Level 1

CI	RI	CR
0.0609	0.9	0.0677

Table 4.3 shows that the value of the consistency ratio is 0.0677, which is less than 0.1. So, it can be concluded that the preferences of the respondents are consistent. The next step is to calculate the pairwise comparison matrix, determine the normalization pairwise comparison matrix, and calculate the value of the consistency measure (CM), consistency index (CI), and consistency ratio (CR) for criteria level 2.

Table 4.4 Pairwise Comparison Matrix of RAM Subcriteria

	≤8 GB	>8 GB
≤8 GB	1.0000	0.8136
>8 GB	1.2291	1.0000

Table 4.5 Normalized Pairwise Comparison Matrix of RAM Subcriteria

	≤8 GB	>8 GB	WEIGHT	CM
≤8 GB	0.4486	0.4486	0.4486	2.0000
>8 GB	0.5514	0.5514	0.5514	2.0000

Table 4.6 Value of CI, RI, and CR for RAM Subcriteria

CI	RI	CR
0.0000	0.0000	0.0000

Based on Table 4.6, the value of RAM subcriteria CR is 0 because the value of RI with $n = 2$ is 0. That value is less than 0.1, so it can be concluded that the preferences of the respondents about laptop RAM are consistent.

Table 4.7 Pairwise Comparison Matrix of Processor Subcriteria

	Equivalent to Intel i3	Equivalent to Intel i5	Better Than Intel i5
Equivalent to Intel i3	1.0000	0.2227	0.2472
Equivalent to Intel i5	4.4907	1.0000	0.4384
Better Than Intel i5	4.0452	2.2810	1.0000

Table 4.8 Normalized Pairwise Comparison Matrix of Processor Subcriteria

	Equivalent to Intel i3	Equivalent to Intel i5	Better Than Intel i5	WEIGHT	CM
Equivalent to Intel i3	0.1049	0.0636	0.1467	0.1050	3.0274
Equivalent to Intel i5	0.4709	0.2854	0.2601	0.3388	3.1117
Better Than Intel i5	0.4242	0.6510	0.5933	0.5562	3.1535

Table 4.9 Value of CI, RI, and CR for Processor Subcriteria

CI	RI	CR

0.0488	0.5800	0.0841

Based on Table 4.9, the value of processor subcriteria CR is 0.0841, which means that the value is less than 0.1. So, it can be concluded that the preferences of the respondents about laptop processor are consistent.

Table 4.10 Pairwise Comparison Matrix of Internal Storage Subcriteria

	HDD	SSD
HDD	1.0000	0.2297
SSD	4.3542	1.0000

Table 4.11 Normalized Pairwise Comparison Matrix of Internal Storage Subcriteria

	HDD	SSD	WEIGHT	CM
HDD	0.1868	0.1868	0.1868	2.0000
SSD	0.8132	0.8132	0.8132	2.0000

Table 4.12 Value of CI, RI, and CR for Internal Storage Subcriteria

CI	RI	CR
0.0000	0.0000	0.0000

Based on table 4.12, the value of internal storage subcriteria CR is 0 because the value of RI with $n = 2$ is 0. That value is less than 0.1, so it can be concluded that the preferences of the respondents about laptop internal storage are consistent.

Table 4.13 Pairwise Comparison Matrix of Price Subcriteria

	≤10 million rupiah	>10 million rupiah
≤10 million rupiah	1.0000	1.3553
>10 million rupiah	0.7378	1.0000

Table 4.14 Normalized Pairwise Comparison Matrix of Price Subcriteria

	≤10 million rupiah	>10 million rupiah	WEIGHT	CM
≤10 million rupiah	0.5754	0.5754	0.5754	2.0000
>10 million rupiah	0.4246	0.4246	0.4246	2.0000

Table 4.15 Value of CI, RI, and CR for Price Subcriteria

CI	RI	CR
0.0000	0.0000	0.0000

Based on table 4.15, the value of price subcriteria CR is 0 because the value of RI with $n = 2$ is 0. That value is less than 0.1, so it can be concluded that the preferences of the respondents about laptop prices are consistent. The next step is to calculate the pairwise comparison matrix, determine the normalization pairwise comparison matrix, and calculate the value of the consistency measure (CM), consistency index (CI), and consistency ratio (CR) for criteria level 3. Here is the comparison matrix of alternative subcriteria at criteria level 3.

Table 4.16 Pairwise Comparison Matrix of RAM Subcriteria 1 Alternative

	ASUS	ACER	HP	LENOVO
ASUS	1.0000	1.8545	1.2593	0.8068
ACER	0.5392	1.0000	0.7429	0.5665
HP	0.7941	1.3461	1.0000	0.6365
LENOVO	1.2395	1.7653	1.5711	1.0000

Table 4.17 Pairwise Comparison Matrix of RAM Subcriteria 2 Alternative

	ASUS	ACER	HP	LENOVO
ASUS	1.0000	2.1554	1.1287	0.8996

ACER	0.4639	1.0000	0.6754	0.5692
HP	0.8860	1.4806	1.0000	0.6825
LENOVO	1.1116	1.7570	1.4652	1.0000

Table 4.18 Pairwise Comparison Matrix of Processor Subcriteria 1 Alternative

	ASUS	**ACER**	**HP**	**LENOVO**
ASUS	1.0000	1.8323	0.9883	0.9682
ACER	0.5458	1.0000	0.6259	0.5048
HP	1.0118	1.5978	1.0000	0.6922
LENOVO	1.0328	1.9811	1.4446	1.0000

Table 4.19 Pairwise Comparison Matrix of Processor Subcriteria 2 Alternative

	ASUS	**ACER**	**HP**	**LENOVO**
ASUS	1.0000	2.3859	1.2631	0.9732
ACER	0.4191	1.0000	0.5559	0.4439
HP	0.7917	1.7988	1.0000	0.6762
LENOVO	1.0276	2.2528	1.4789	1.0000

Table 4.20 Pairwise Comparison Matrix of Processor Subcriteria 3 Alternative

	ASUS	**ACER**	**HP**	**LENOVO**
ASUS	1.0000	2.2691	1.4852	1.0768
ACER	0.4407	1.0000	0.7165	0.4539
HP	0.6733	1.3956	1.0000	0.7969
LENOVO	0.9286	2.2030	1.2548	1.0000

Table 4.21 Pairwise Comparison Matrix of Internal Storage Subcriteria 1 Alternative

	ASUS	**ACER**	**HP**	**LENOVO**
ASUS	1.0000	1.9700	1.4350	0.9680
ACER	0.5076	1.0000	0.8723	0.5599
HP	0.6968	1.1464	1.0000	0.6138
LENOVO	1.0331	1.7862	1.6293	1.0000

Table 4.22 Pairwise Comparison Matrix of Internal Storage Subcriteria 2 Alternative

	ASUS	**ACER**	**HP**	**LENOVO**
ASUS	1.0000	2.5392	1.7890	1.3537
ACER	0.3938	1.0000	0.6716	0.4746
HP	0.5590	1.4889	1.0000	0.6269
LENOVO	0.7387	2.1070	1.5951	1.0000

Table 4.23 Pairwise Comparison Matrix of Price Subcriteria 1 Alternative

	ASUS	**ACER**	**HP**	**LENOVO**
ASUS	1.0000	2.6477	1.3959	1.1608
ACER	0.3777	1.0000	0.9330	0.6192
HP	0.7164	1.0718	1.0000	0.6066
LENOVO	0.8615	1.6151	1.6486	1.0000

Table 4.24 Pairwise Comparison Matrix of Price Subcriteria 2 Alternative

	ASUS	ACER	HP	LENOVO
ASUS	1.0000	1.9039	1.5420	1.1436
ACER	0.5252	1.0000	0.6221	0.4684
HP	0.6485	1.6076	1.0000	0.6895
LENOVO	0.8745	2.1347	1.4503	1.0000

In the next step, the comparison matrix above will be normalized. After normalization, calculations were performed to obtain the average value for each row, consistency measure (CM), consistency index (CI), and consistency ratio (CR). Here are the summary results of the calculation.

Table 4.25 Summary Calculaton of Criteria Level 3

Criteria Level 1	Criteria Level 2	Criteria Level 3	Weight	CM	CI	RI	CR
RAM	≤8 GB	ASUS	0.2835	4.0071	0.0023	0.9000	0.0026
		ACER	0.1673	4.0048			
		HP	0.2195	4.0076			
		LENOVO	0.3297	4.0082			
	>8 GB	ASUS	0.2940	4.0154	0.0048	0.9000	0.0053
		ACER	0.1573	4.0106			
		HP	0.2346	4.0170			
		LENOVO	0.3141	4.0144			
Processor	Equivalent to Intel i3	ASUS	0.2940	4.0154	0.0035	0.9000	0.0039
		ACER	0.1573	4.0106			
		HP	0.2346	4.0170			
		LENOVO	0.3141	4.0144			
	Equivalent to Intel i5	ASUS	0.3095	4.0029	0.0011	0.9000	0.0013
		ACER	0.1342	4.0028			
		HP	0.2344	4.0037			
		LENOVO	0.3219	4.0041			
	Better than Intel i5	ASUS	0.3290	4.0045	0.0015	0.9000	0.0017
		ACER	0.1469	4.0033			
		HP	0.2221	4.0042			
		LENOVO	0.3020	4.0059			
Internal Storage	HDD	ASUS	0.3104	4.0044	0.0013	0.9000	0.0014
		ACER	0.1703	4.0032			
		HP	0.2018	4.0040			
		LENOVO	0.3175	4.0035			
	SSD	ASUS	0.3683	4.0053	0.0014	0.9000	0.0015
		ACER	0.1392	4.0035			
		HP	0.1989	4.0024			
		LENOVO	0.2937	4.0052			
Price	≤10 million rupiah	ASUS	0.3449	4.0469	0.0116	0.9000	0.0128

	ACER	0.1640	4.0275			
	HP	0.1979	4.0353			
	LENOVO	0.2932	4.0290			
>10 million rupiah	ASUS	0.3238	4.0112	0.0030	0.9000	0.0034
	ACER	0.1499	4.0055			
	HP	0.2200	4.0089			
	LENOVO	0.3063	4.0106			

Table 4.25 provides information about weight, CM, CI, RI, and CR of criteria level 3. First, the CR value for alternative RAM subcriteria for ≤8 GB and >8 GB subcriteria is 0.026 and 0.0053, which means that both values are less than 0.1. It can be concluded that the preferences of the respondents about alternative RAM subcriteria are consistent. Second, the CR values of alternative processor subcriteria equivalent to Intel i3, equivalent to Intel i5, and better than Intel i5 are 0.0039, 0.0013, and 0.0017, which means that all values are less than 0.1. It can be concluded that the preferences of the respondents about rhe alternative processor subcriteria are consistent. Third, the CR values of the alternative internal storage subcriteria HDD and SSD are 0.0014 and 0.0015, respectively, which means that both values are less than 0.1. It can be concluded that the preferences of the respondents about alternative internal storage subcriteria are consistent. Finally, the CR value of alternative price subcriteria for ≤10 million and >10 million sub-criteria is 0.0128 and 0.0034, which means that both values are less than 0.1. It can be concluded that the preferences of the respondents about alternative price subcriteria are consistent.

The next step is to calculate the partial weights for the criteria at level 1, level 2, and alternatives. The partial widths are obtained from the average row normalized matrix. The partial weight is to be used to calculate the level 3 weight value with the following calculation results:

Table 4.26 Partial Weight and Weight Level 3

Criteria Level 1	Partial Weight 1	Criteria Level 2	Partial Weight 2	Alternatives	Partial Weight 3	Weight 3
RAM	0.1791	RAM ≤8 GB	0.4486	ASUS	0.2835	0.0228
				ACER	0.1673	0.0134
				HP	0.2195	0.0176
				LENOVO	0.3297	0.0265
		RAM >8 GB	0.5514	ASUS	0.2940	0.0290
				ACER	0.1573	0.0155
				HP	0.2346	0.0232
				LENOVO	0.3141	0.0310
PROCESSOR	0.3361	Equivalent to Intel i3	0.1050	ASUS	0.2784	0.0098
				ACER	0.1554	0.0055
				HP	0.2490	0.0088
				LENOVO	0.3171	0.0112
		Equivalent to Intel i5	0.3388	ASUS	0.3095	0.0352
				ACER	0.1342	0.0153
				HP	0.2344	0.0267
				LENOVO	0.3219	0.0366
		Better than Intel i5	0.5562	ASUS	0.3290	0.0615
				ACER	0.1469	0.0275
				HP	0.2221	0.0415
				LENOVO	0.3020	0.0564
	0.0915	HDD	0.1868	ASUS	0.3104	0.0053

				ACER	0.1703	0.0029
				HP	0.2018	0.0034
				LENOVO	0.3175	0.0054
INTERNAL STORAGE				ASUS	0.3683	0.0274
		SSD	0.8132	ACER	0.1392	0.0104
				HP	0.1989	0.0148
				LENOVO	0.2937	0.0218
				ASUS	0.3449	0.0781
		≤10 million rupiah	0.5754	ACER	0.1640	0.0371
				HP	0.1979	0.0448
				LENOVO	0.2932	0.0664
PRICES	0.3934			ASUS	0.3238	0.0541
		>10 million rupiah	0.4246	ACER	0.1499	0.0250
				HP	0.2200	0.0368
				LENOVO	0.3063	0.0512

The following is the result of the level weight calculation that is shown in Table 4.27.

Table 4.27 Weight Level 1 and Weight Level 2

Criteria Level 1	Weight 1	Criteria Level 2	Weight 2
RAM	0.1791	≤ 8 GB	0.0803
		> 8 GB	0.0988
PROCESSOR	0.3361	Equivalent to Intel i3	0.0353
		Equivalent to Intel i5	0.1139
		Better than Intel i5	0.1869
INTERNAL STORAGE	0.0915	HDD	0.0171
		SSD	0.0744
PRICES	0.3934	≤10 million rupiah	0.2264
		>10 million rupiah	0.1670

Column Weight 1 in Table 4.27 shows that the laptop prices have the greatest weight. So, it can be concluded that price is the preferred criteria for respondents when choosing a laptop. The second place is the processor, RAM, and internal storage. While at criteria level 2 on the RAM subcriteria, respondents prioritize >8 GB RAM over ≤8 GB RAM. Respondents prefer Intel i5 processors over other options. Within the internal storage subcriteria, respondents prioritize SSD over HDD. Finally, at price subcriteria, respondents prioritize ≤ 10 million rupiah over >10 million rupiah.

Table 4.28 Rank Total Weight Alternatives

Alternatives	Total of Weight	Rank
ASUS	0.3232	1
ACER	0.1526	4
HP	0.2176	3
LENOVO	0.3066	2

Based on Table 4.28, the best laptop alternative is the ASUS, with a weight of 0.3232. Then, followed by LENOVO with a weight of 0.3066, HP with a weight of 0.2176, and ACER with a weight of 0.1526. After that, there are some results of the criteria level 3 weight analysis for the four alternatives available in this research.

Table 4.29 Weight Level 3 Alternative ASUS

ASUS Alternatives		
Category	**Subcategory**	**Weight 3**
RAM	≤ 8 GB	0.0228
	> 8 GB	0.0290
PROCESSOR	Equivalent to Intel i3	0.0098
	Equivalent to Intel i5	0.0352
	Better than Intel i5	0.0615
INTERNAL STORAGE	HDD	0.0053
	SSD	0.0274
PRICES	≤ 10 million	0.0781
	> 10 million	0.0541

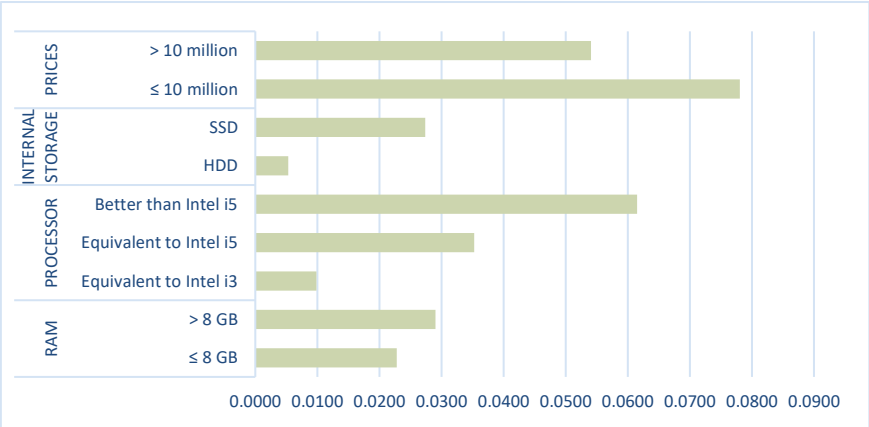


Figure 4.3 Respondent's Perceptions of ASUS Alternatives

Based on Figure 4.3, the respondents' preferences for ASUS laptops are those with the following specifications: RAM greater than 8GB, a processor greater than an Intel i5, SSD type internal storage, and a price less than ten million rupiah.

Table 4.30 Weight Level 3 Alternative ACER

ACER Alternatives		
Category	**Subcategory**	**Weight 3**
RAM	<= 8 GB	0.0134
	> 8 GB	0.0055
PROCESSOR	Equivalent to Intel i3	0.0153
	Equivalent to Intel i5	0.0275
	Better than Intel i5	0.0029
INTERNAL STORAGE	HDD	0.0104
	SSD	0.0371
PRICES	<= 10 million	0.0371
	> 10 million	0.0250

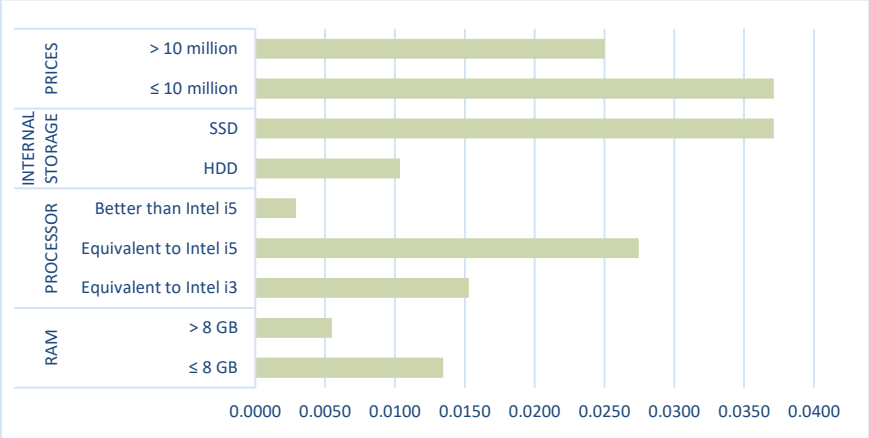


Figure 4.4 Respondent's Perceptions of ACER Alternatives

Based on Figure 4.3, the respondents' preferences for ACER laptops are those with the following specifications: RAM lower than or equal to 8GB, a processor equivalent to an Intel i5, SSD-type internal storage, and a price less than ten million rupiah.

Table 4.31 Weight Level 3 Alternative HP

HP Alternatives		
Category	**Subcategory**	**Weight 3**
RAM	<= 8 GB	0.0176
	> 8 GB	0.0232
PROCESSOR	Equivalent to Intel i3	0.0088
	Equivalent to Intel i5	0.0267
	Better than Intel i5	0.0415
INTERNAL STORAGE	HDD	0.0034
	SSD	0.0148
PRICES	<= 10 million	0.0448
	> 10 million	0.0368

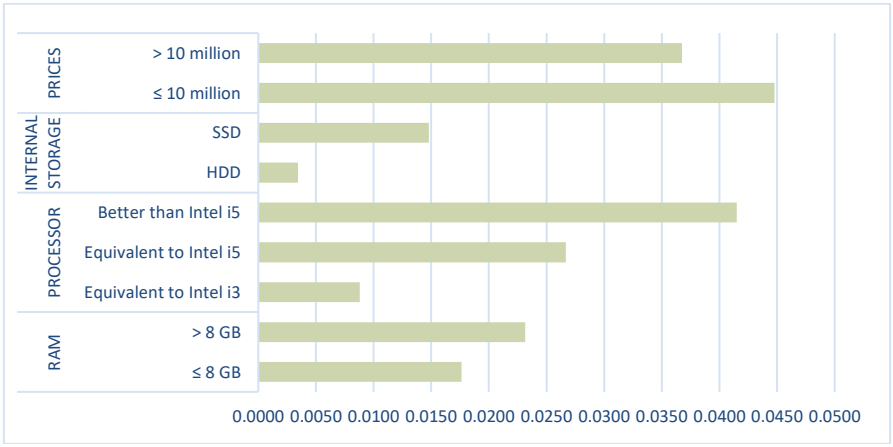


Figure 4.5 Respondent's Perceptions of HP Alternatives

Based on Figure 4.3, the respondents' preferences for HP laptops are those with the following specifications: RAM greater than 8GB, a processor greater than an Intel i5, SSD type internal storage, and a price less than ten million rupiah.

Table 4.32 Weight Level 3 Alternative LENOVO

LENOVO Alternatives		
Category	Subcategory	Weight 3
RAM	<= 8 GB	0.0265
	> 8 GB	0.0310

PROCESSOR	Equivalent to Intel i3	0.0112
	Equivalent to Intel i5	0.0366
	Better than Intel i5	0.0564
INTERNAL STORAGE	HDD	0.0054
	SSD	0.0218
PRICES	<= 10 million	0.0664
	> 10 million	0.0512

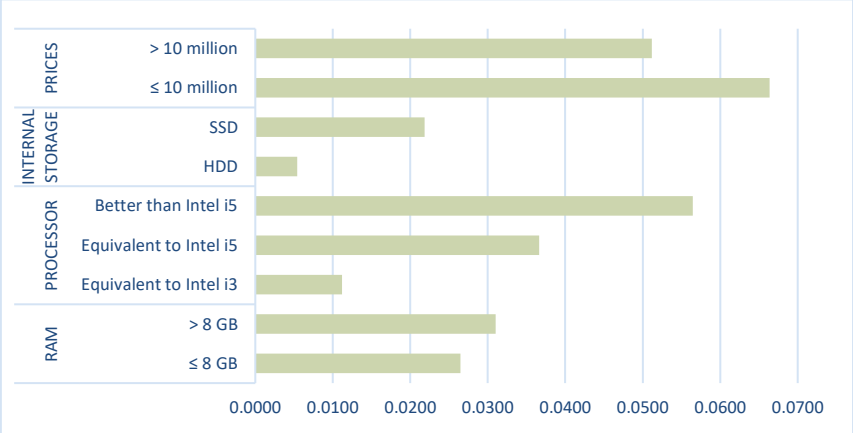


Figure 4.6 Respondent's Perceptions of LENOVO Alternatives

Based on Figure 4.3, the respondents' preferences for HP laptops are those with the following specifications: RAM greater than 8GB, a processor greater than an Intel i5, SSD type internal storage, and a price less than ten million rupiah. Overall, from the four alternatives, the price of less than ten million rupiah is preferred by the respondents.

V. CONCLUSIONS AND SUGGESTIONS

Based on the analysis, it can be concluded that all criteria levels have a Consistency Ratio (CR) value less than 0.1. This value shows that the preferences of the respondents are constant. The alternative rankings that were preferred by respondents are ASUS, LENOVO, HP, and ACER. Respondent's preferences in criteria level 2 are: RAM greater than 8GB, a processor greater than Intel i5, SSD type internal storage, and a price less than ten million rupiah. While in criteria level 1, price is more preferred by respondents than RAM, processor, and internal storage. The analysis of respondents perceptions of each alternative shows that respondents prefer RAM greater than 8GB, a processor greater than Intel i5, SSD type internal storage, and a price less than ten million rupiah for ASUS, HP, and LENOVO. For an ACER laptop, respondents prefer RAM less than 8GB, processor that equivalent to Intel i5, SSD type internal storage, and a price less than ten million rupiah. Based on these four alternatives, it can be concluded that prices less than ten million rupiah and SSD-type internal storage is more preferred by respondents. Suggestions for the authors on the next research are to pay more attention to the respondent sampling process and be more careful in analyzing and conducting literature studies.

REFERENCES

[1] D. Sunarko, "Study Decision Tree/Pohon Keputusan Sebagai Sebuah Alat Bantu Pendukung Sistem Dalam Proses Pengambilan Keputusan Penjualan pada CV.Khan Setia Utama, Pondok Cabe-Depok," *Jurnal Ilmiah Teknologi dan Informasi ASIA*, 2002.

[2] R. E. Walpole, R. H. Myers, S. L. Myers and K. Ye, Probability & Statistics for Engineers & Scientists, Ninth Edition., United States of America: Pearson Education Inc, 2012.

[3] T. L. Saaty, "Decision Making with The Analytic Hierarchy Process," 2008.

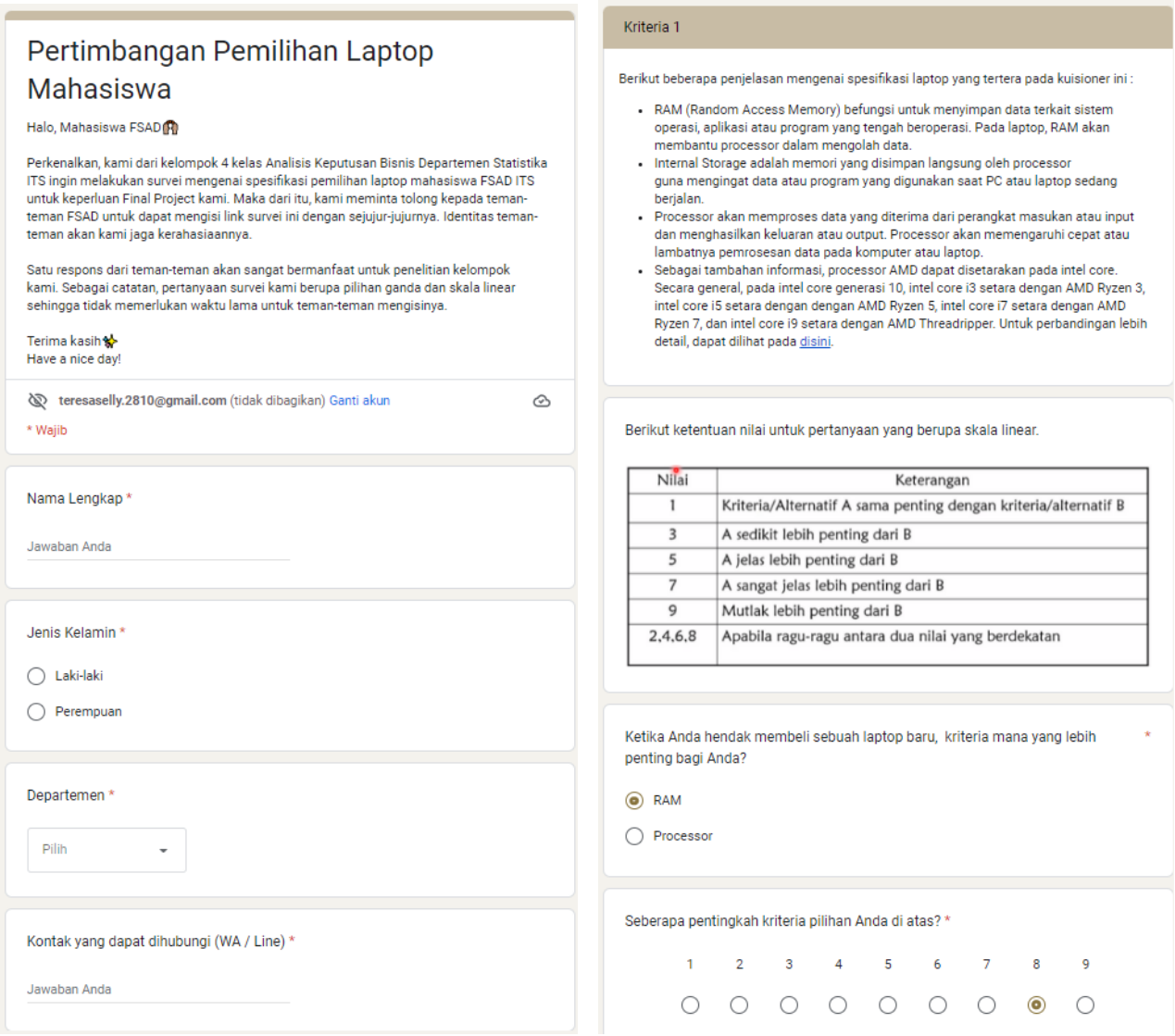
[4] B. Nabi and M. Tavakkoli, "Selection of Wastewater Treatment Process Based on The Analytical Hierarchy Process and Fuzzy Analytical Hierarchy Process Methods," 2011.

[5] O. Erol, "An Energy Source Policy Assessment Using Analytical Hierarchy Process," 2012.

[6] L. Sharon and R. Kay, "Assessing Laptop Use in Higher Education Classrooms: The Laptop Effectiveness Scale (LES)," *Australasian Journal of Educational Technology*, 2010.

APPENDIX

Appendix 1 Overview of The Questionnaire



Pertimbangan Pemilihan Laptop Mahasiswa

Halo, Mahasiswa FSAD

Perkenalkan, kami dari kelompok 4 kelas Analisis Keputusan Bisnis Departemen Statistika ITS ingin melakukan survei mengenai spesifikasi pemilihan laptop mahasiswa FSAD ITS untuk keperluan Final Project kami. Maka dari itu, kami meminta tolong kepada teman-teman FSAD untuk dapat mengisi link survei ini dengan sejujur-jujurnya. Identitas teman-teman akan kami jaga kerahasiaannya.

Satu respons dari teman-teman akan sangat bermanfaat untuk penelitian kelompok kami. Sebagai catatan, pertanyaan survei kami berupa pilihan ganda dan skala linear sehingga tidak memerlukan waktu lama untuk teman-teman mengisinya.

Terima kasih
Have a nice day!

teresaselly.2810@gmail.com (tidak dibagikan) Ganti akun

* Wajib

Nama Lengkap *

Jawaban Anda

Jenis Kelamin *

Laki-laki

Perempuan

Departemen *

Pilih

Kontak yang dapat dihubungi (WA / Line) *

Jawaban Anda

Kriteria 1

Berikut beberapa penjelasan mengenai spesifikasi laptop yang tertera pada kuisioner ini :

- RAM (Random Access Memory) befungsi untuk menyimpan data terkait sistem operasi, aplikasi atau program yang tengah beroperasi. Pada laptop, RAM akan membantu processor dalam mengolah data.
- Internal Storage adalah memori yang disimpan langsung oleh processor guna mengingat data atau program yang digunakan saat PC atau laptop sedang berjalan.
- Processor akan memproses data yang diterima dari perangkat masukan atau input dan menghasilkan keluaran atau output. Processor akan memengaruhi cepat atau lambatnya pemrosesan data pada komputer atau laptop.
- Sebagai tambahan informasi, processor AMD dapat disetarakan pada intel core. Secara general, pada intel core generasi 10, intel core i3 setara dengan AMD Ryzen 3, intel core i5 setara dengan dengan AMD Ryzen 5, intel core i7 setara dengan AMD Ryzen 7, dan intel core i9 setara dengan AMD Threadripper. Untuk perbandingan lebih detail, dapat dilihat pada disini.

Berikut ketentuan nilai untuk pertanyaan yang berupa skala linear.

Nilai	Keterangan
1	Kriteria/Alternatif A sama penting dengan kriteria/alternatif B
3	A sedikit lebih penting dari B
5	A jelas lebih penting dari B
7	A sangat jelas lebih penting dari B
9	Mutlak lebih penting dari B
2,4,6,8	Apabila ragu-ragu antara dua nilai yang berdekatan

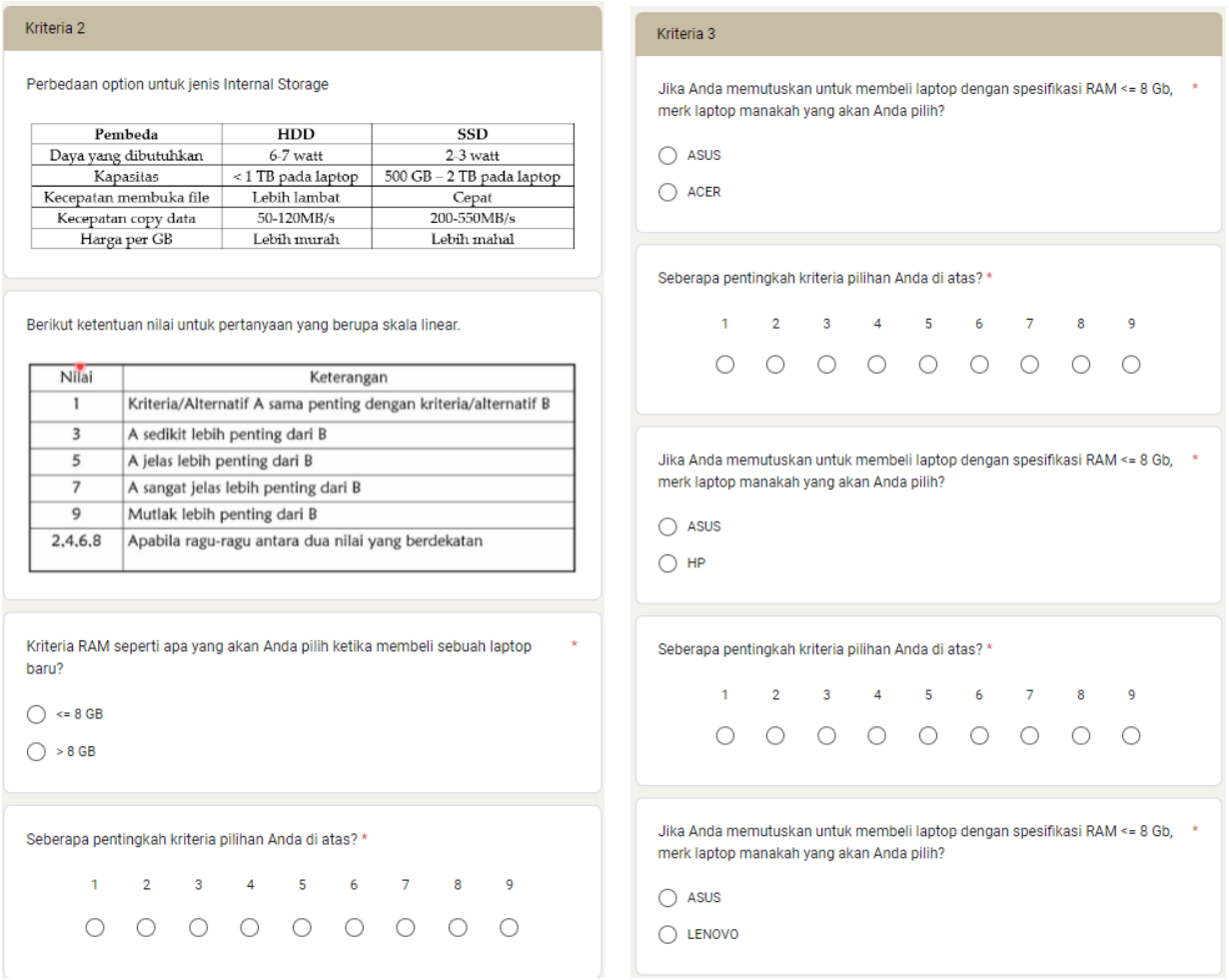
Ketika Anda hendak membeli sebuah laptop baru, kriteria mana yang lebih penting bagi Anda? *

RAM

Processor

Seberapa pentingkah kriteria pilihan Anda di atas? *

1 2 3 4 5 6 7 8 9



Kriteria 2

Perbedaan option untuk jenis Internal Storage

Pembeda	HDD	SSD
Daya yang dibutuhkan	6-7 watt	2-3 watt
Kapasitas	< 1 TB pada laptop	500 GB – 2 TB pada laptop
Kecepatan membuka file	Lebih lambat	Cepat
Kecepatan copy data	50-120MB/s	200-550MB/s
Harga per GB	Lebih murah	Lebih mahal

Berikut ketentuan nilai untuk pertanyaan yang berupa skala linear.

Nilai	Keterangan
1	Kriteria/Alternatif A sama penting dengan kriteria/alternatif B
3	A sedikit lebih penting dari B
5	A jelas lebih penting dari B
7	A sangat jelas lebih penting dari B
9	Mutlak lebih penting dari B
2,4,6,8	Apabila ragu-ragu antara dua nilai yang berdekatan

Kriteria RAM seperti apa yang akan Anda pilih ketika membeli sebuah laptop baru? *

<= 8 GB

> 8 GB

Seberapa pentingkah kriteria pilihan Anda di atas? *

1 2 3 4 5 6 7 8 9

Kriteria 3

Jika Anda memutuskan untuk membeli laptop dengan spesifikasi RAM <= 8 Gb, merk laptop manakah yang akan Anda pilih? *

ASUS

ACER

Seberapa pentingkah kriteria pilihan Anda di atas? *

1 2 3 4 5 6 7 8 9

Jika Anda memutuskan untuk membeli laptop dengan spesifikasi RAM <= 8 Gb, merk laptop manakah yang akan Anda pilih? *

ASUS

HP

Seberapa pentingkah kriteria pilihan Anda di atas? *

1 2 3 4 5 6 7 8 9

Jika Anda memutuskan untuk membeli laptop dengan spesifikasi RAM <= 8 Gb, merk laptop manakah yang akan Anda pilih? *

ASUS

LENOVO

Appendix 2 Normalized Matrix of RAM Subcriteria 1 Alternative

	ASUS	ACER	HP	LENOVO
ASUS	0.2799	0.3108	0.2754	0.2681
ACER	0.1509	0.1676	0.1624	0.1882
HP	0.2223	0.2256	0.2187	0.2115
LENOVO	0.3469	0.2959	0.3435	0.3323

Appendix 3 Normalized Matrix of RAM Subcriteria 2 Alternative

	ASUS	ACER	HP	LENOVO
ASUS	0.2889	0.3372	0.2644	0.2855
ACER	0.1340	0.1564	0.1582	0.1806
HP	0.2559	0.2316	0.2342	0.2166
LENOVO	0.3211	0.2748	0.3432	0.3173

Appendix 4 Normalized Matrix of Processor Subcriteria 1 Alternative

	ASUS	ACER	HP	LENOVO
ASUS	0.2785	0.2858	0.2435	0.3059
ACER	0.1520	0.1560	0.1542	0.1595
HP	0.2818	0.2492	0.2464	0.2187
LENOVO	0.2877	0.3090	0.3559	0.3159

Appendix 5 Normalized Matrix of Processor Subcriteria 2 Alternative

	ASUS	ACER	HP	LENOVO
ASUS	0.3088	0.3208	0.2939	0.3146
ACER	0.1294	0.1345	0.1293	0.1435
HP	0.2445	0.2419	0.2327	0.2186
LENOVO	0.3173	0.3029	0.3441	0.3233

Appendix 6 Normalized Matrix of Processor Subcriteria 3 Alternative

	ASUS	ACER	HP	LENOVO
ASUS	0.3287	0.3304	0.3333	0.3236
ACER	0.1448	0.1456	0.1608	0.1364
HP	0.2213	0.2032	0.2244	0.2395
LENOVO	0.3052	0.3208	0.2816	0.3005

Appendix 7 Normalized Matrix of Internal Storage Subcriteria 1 Alternative

	ASUS	ACER	HP	LENOVO
ASUS	0.3089	0.3338	0.2907	0.3081
ACER	0.1568	0.1694	0.1767	0.1782
HP	0.2152	0.1942	0.2026	0.1954
LENOVO	0.3191	0.3026	0.3300	0.3183

Appendix 8 Normalized Matrix of Internal Storage Subcriteria 2 Alternative

	ASUS	ACER	HP	LENOVO
ASUS	0.3715	0.3559	0.3539	0.3918
ACER	0.1463	0.1402	0.1328	0.1374
HP	0.2077	0.2087	0.1978	0.1814
LENOVO	0.2745	0.2953	0.3155	0.2894

Appendix 9 Normalized Matrix of Price Subcriteria 1 Alternative

MATRIKS 13	ASUS	ACER	HP	LENOVO
ASUS	0.3383	0.4180	0.2804	0.3428
ACER	0.1278	0.1579	0.1874	0.1828
HP	0.2424	0.1692	0.2009	0.1791
LENOVO	0.2915	0.2550	0.3312	0.2953

Appendix 10 Normalized Matrix of Price Subcriteria 2 Alternative

MATRIKS 14	ASUS	ACER	HP	LENOVO
ASUS	0.3281	0.2865	0.3342	0.3464
ACER	0.1723	0.1505	0.1348	0.1419
HP	0.2127	0.2419	0.2167	0.2089
LENOVO	0.2869	0.3212	0.3143	0.3029