Employee Enrollment Decision Support System Using Analytical Hierarchy Process and Promethee Methods

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Abstract—Perseroan Terbatas (PT) Sumber Berkat Anugerah is one of the companies engaged in spare parts, vehicle accessories, home audio, and others. The stages of prospective employees' enrollment in this company are still done manually, which causes many problems, such as the long processing time for the selection and the occurrence of human error during data saving. Based on the problems that occur, the Human Resources Department (HRD) wants a decision support system for new employees' enrollment, which is expected to solve the problems that occur and produce a better and more accurate calculation result. This system was designed and built using the Analytical Hierarchy Process (AHP) method, which has advantage in determining priority weights and Promethee method that has advantage in the alternative rating process. The result of this system is the prospective employees ranking sorted from the highest to the lowest. The system has been built and tested by comparing the manual calculation results with the calculation results generated by the system. Usability testing on the system was done using the Usefulness, Satisfaction, and Ease of use (USE) Questionnaire and it can be concluded that the results of overall system user satisfaction have reached 85.2%.

Keywords—Analytical Hierarchy Process; Decision Support System; employee enrollment; Promethee.

I. INTRODUCTION

EMPLOYEES are workers who do work and provide their work to employers who work, where the results of their work are in accordance with the profession or work based on their livelihood. In line with that according to Law No. 14 of 1969 concerning the main workforce, labor is every person who is capable of doing work both inside and outside the employment relationship to produce services or goods to meet the needs of the community [1].

Perseroan Terbatas (PT) Sumber Berkat Anugerah is one of the companies engaged in Parts and accessories for four-wheeled vehicles, two-wheeled vehicles, and industrial vehicles and home audio such as speakers, home theater, and others.

According to Human Resources Department (HRD) Manager of PT Sumber Berkat Anugerah before becoming a permanent employee, prospective new employees must go through a process of receiving employees by going through several stages; namely, prospective employees applying for work can send curriculum vitae via email or send directly to the office. Prospective employees who register via job vacancies can send curriculum vitae according to the web procedure. Furthermore, the HRD Department will ask prospective employees to come to the office to fill out personal data forms as well as take a series of tests such as basic ability tests, technical tests, psychological tests, and several stages of interviews with related sections. After all stages are completed, the HRD Department will provide an assessment of the results of the steps that have been carried out manually by prospective employees by calculating the weight of the criteria according to that stage. This system aims to get the right and qualified employees to work optimally [2].

The stages of acceptance of prospective employees in this company are still manual, which still causes many problems. One of the problems that occur in the process of receiving new prospective employees is the calculation of the value of the selection of prospective employees usually takes a long time and the occurrence of human error when storing data of new prospective employees. Therefore we need a decision support system using methods that are expected to be able to correct the problems that occur and can produce better and more accurate calculations than the system with manual calculations [2].

Many methods can be used in decision support systems. These methods can also be combined into two methods. One combination of methods that can be used in decision support systems is a combination of Analytical Hierarchy Process (AHP) and Promethee methods.

The AHP method can be combined with Promethee to obtain good and objective recommendations. The combination of these two methods makes use of the advantages of each method. AHP has advantages in determining weight and hierarchy of criteria, while Promethee has advantages in the alternative ranking process using different preference and weight functions. In other

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words, Promethee does not support the determination of weights and hierarchy of criteria and does not have guarantee or protection of consistency when determining weights such as AHP. Meanwhile, AHP is also not as optimal as Promethee in calculations and ratings [3].

Based on the background of the problems described above, this study implements the AHP and Promethee method to build an acceptance decision support system for new prospective employees at PT Sumber Berkat Anugerah. The AHP method is used to calculate the weight of the criteria and the Promethee method used to generate rankings of prospective employees who are accepted to work at PT Sumber Berkat Anugerah. After the system is completed, the system will be tested and evaluated to find out whether the system is running according to its needs or functions.

The organization of this paper is as follows. In the next section, some related works will be described briefly, followed by the explanation of AHP, Promethee, and USE Questionnaire in Section III-V consecutively. In Section VI, the research methodology and implementation results will be given and some conclusion remarks will end the organization of this paper in Section VII.

II. Related Works

There were many researches had been done by notable researchers regarding the use of Analytical Hierarchy Process (AHP) and Promethee methods in solving many different cases. Sennaroglu and Celebi for example, they have used AHP integrated Promethee and Vikor methods to select the best military airport location in Turkey [4]. Segura et al. have developed a collaborative management tool of ecosystem services in natural parks based on AHP and Promethee methods [5]. Moreover, Oliveira et al. have applied and evaluated the integrated AHP-Promethee methods in vehicle painting plans in an automobile assembly plant [6]. Another study worth to mention here is the usage of AHP-Promethee methods in maintenance strategy selection for critical shipboard machinery system which has been publicized by Animah and Shafiee in the early 2019 [7]. The common result from all the studies is that the AHP-Promethee methods have successfully implemented and could produce a better decision result compare with other types of multi-criteria decision analysis.

III. Analytical Hierarchy Process

Decision Support System is a computer-based information system that provides interactive information support for managers and business practitioners during the decision making process [8].

The Analytical Hierarchy Process (AHP) method was developed in the early 1970s by Thomas L. Saaty, a Mathematician from the University of Pittsburg. AHP is designed to rationally capture people's perceptions that are very closely related to certain problems through procedures designed to arrive at a preference scale among various alternative sets. This analysis is intended to make a model of a problem that does not have a structure, usually set to solve measurable problems (quantitative), problems that require opinion (judgment) as well as in complex or unforeseen situations, in situations where statistical data is very minimal or absent at all and only qualitative in nature based on perception, experience or intuition [9].

The steps in the AHP method presented by Saaty are as follows [10], [11].

a. Determine the criteria used.
b. Defines the hierarchy structure of the problem to be solved, begins with a general goal, followed by sub-objectives, and possible alternatives at the lowest level.
c. Make a paired comparison matrix that describes the relative contribution or influence of each element to its objectives or the criteria above it.
d. Defines pairwise comparisons of the matrix, so that the total number of evaluations is $n\,x\,[\frac{n-1}{2}]$ with n is the number of elements compared. The comparison value of each criterion uses the value of the pair comparison scare which can be seen in Table I.

Table I
Pairwise Comparison Scale [12][13]

Intensity of Interest	Information
1	Both elements are equally important
3	One element is slightly more important than the other
5	One element is more important than the other
7	One element is clearly more important than the other
9	One element is absolutely important than the other elements
2,4,6,8	Values between two values are considered close consideration (Compromise values)

e. Calculates the results of the Comparison Value after entering the comparison value

$$C_{row,}\,C_{col} = \frac{1}{C_{col,}\,C_{row}} \quad (1)$$

f. Make a Normalization Matrix

$$C_{row,}\,C_{col} = \frac{Comparison\ Matrix\ Value}{Column\ total\ of\ Comparison\ Matrix} \quad (2)$$

g. Calculate the Criteria Priority Weight

$$C_n = \frac{Row\ total\ of\ Comparison\ Matrix}{Number\ of\ Criteria} \quad (3)$$

h. Make a Consistency Test Matrix

$$C_{row,}\,C_{col} = Comparison\ Matrix \times C_n \quad (4)$$

i. Calculate Lamda from each criterion

$$\lambda = \frac{\Sigma Row\ value\ of\ Consistency\ Test}{Priority\ Weight} \quad (5)$$

j. Calculate $\lambda\ max$ (Lamda Max)

$$\lambda\,\max = \frac{\Sigma\lambda}{n} \quad (6)$$

k. Calculate Consistency Index Value (CI)

$$CI = \frac{\lambda\ max - n}{n-1} \quad (7)$$

l. Calculate Value of Consistency Ratio (CR)

$$CR = \frac{CI}{Random\ Index\ (RI)} \quad (8)$$

If CR ≤ 0.1, then the process can be proceed. Else if CR > 0.1, then the process must be repeated because there is no consistency.

m. Repeat the steps above for all levels of the hierarchy.
n. Calculate the Eigenvalues of each paired comparison matrix. The Eigenvalues is the weight of each element for priority setting. The calculation is done by summing the value of each column of the matrix, divide each result value from the column by the column total, and add the values of each row then calculate the average.
o. Examining the consistency of the hierarchy, if it is not consistent, the assessment must be repeated.

IV. PROMETHEE

Promethee stands for Preference Ranking Organization Method for Enrichment Evaluation is an outranking method that offers a flexible and simple way for users (decision makers) to analyze multi-criteria problems [14].

Calculation of direction of preference is considered based on index value [15]:

a. The formula of Leaving flow:

$$\varphi^{+}(a) = \frac{1}{n-1}\sum_{x \in A} \varphi(a,x) \quad (9)$$

b. The formula of Entering flow:

$$\varphi^{-}(a) = \frac{1}{n-1}\sum_{x \in A} \varphi(x,a) \quad (10)$$

c. Formula Net flow:

$$\varphi(a) = \varphi^{+}(a) - \varphi^{-}(a) \quad (11)$$

where:

$\varphi(a,x)$ = show preference that alternative a is better than alternative x.
$\varphi(x,a)$ = show preference that alternative x is better than alternative a.
$\varphi^{+}(a)$ = Leaving flow
$\varphi^{-}(a)$ = Entering flow
$\varphi(a)$ = Net flow

Following are the steps of the Promethee Method [16].

1. Provide an assessment for each alternative based on criteria,
2. Determine the type of preference,
3. Calculation in pairs between alternatives based on the type of preference criteria to obtain the minimization value of H (d),
4. Calculate the minimization value of H (d) with Eigen (the weight of the criteria from the AHP calculation),
5. Calculate the value of leaving flow, entering flow, net flow,
6. Sorts the alternative priority rankings (ranking).

V. USE QUESTIONNAIRE

USE *Questionnaire* was developed by Arnold Lund and colleagues at Ameritech, U.S West Advanced Technologies. USE stands for Usefulness, Satisfaction, and Ease of use. The factors that contribute to the Ease of use parameters can be divided into two, namely Ease of learning and Ease of Use [17].

The USE questionnaire package is as follows [17].

Usefulness

1. It helps me be more effective.
2. It helps me be more productive.
3. It is useful.
4. It gives me more control over the activities in my life.
5. It makes the things I want to accomplish easier to get done.
6. It saves me time when I use it.
7. It meets my needs.
8. It does everything I would expect it to do.

Ease of Use

9. It is easy to use.
10. It is simple to use.
11. It is user-friendly
12. It requires the fewest steps possible to accomplish what I want to do with it.
13. It is flexible
14. Using it is effortless.
15. I can use it without written instructions.
16. I do not notice any inconsistencies as I use it.
17. Both occasional and regular users would like it.
18. I can recover from mistakes quickly and easily.
19. I can use it successfully every time.

Ease of Learning

20. I learned to use it quickly.
21. I easily remember how to use it.
22. It is easy to learn to use it.
23. I quickly became skillful with it.

Satisfaction

24. I am satisfied with it.
25. I would recommend it to a friend.
26. It is fun to use.
27. It works the way I want it to work.
28. It is wonderful.
29. I feel I need to have it.
30. It is pleasant to use.

The questionnaire was made in the form of five points using a Likert scale [10]. Likert scale is a scale used to measure attitudes, opinions, and perceptions of a person or group of people about social phenomena [18]. Likert Scale measurement values can be seen in Table II.

TABLE II
LIKERT SCALE MEASUREMENT [17]

Respondent's answer	Score
Strongly Agree (SA)	5
Agree (A)	4
Neutral (N)	3
Disagree (D)	2
Very Disagree (VD)	1

The results of the questionnaire data were then analyzed to obtain the percentage eligibility score.

After getting the results of the feasibility percentage in the form of quantitative values from the previous calculation, then the value is converted to a qualitative scale of five with a Likert scale. Convert percentages to statements as in Table III [19].

TABLE III
PERCENTAGE INTERPRETATION [19]

Percentage	Statement
0% - 20%	Very bad
21% - 40 %	Bad
41% - 60%	Enough
61% - 80%	Good
81% - 100%	Very good

VI. RESEARCH METHODOLOGY AND RESULTS

The research method used in the design of the decision support system for the recruitment of new employees using the AHP and Promethee methods with a case study of PT Sumber Berkat Anugerah, namely literature review, user requirements, system design, system programming, testing and evaluation, consultation and documentation.

The decision support system built is a web-based system with PHP, HTML, and MySQL languages. This decision support system is used by the user and admin; the user is the HR department staff while the admin is the HR department manager. Users and admins have the same sidebar menu, which is the prospective employees' data menu, the data weighting criteria menu, the prospective employees selection menu, the menu changes the password and the Navbar menu, namely credits menu and help menu. However, in the admin, there is one menu that can only be accessed by the admin, i.e., the user menu. Fig.1 shows the general system flowchart.

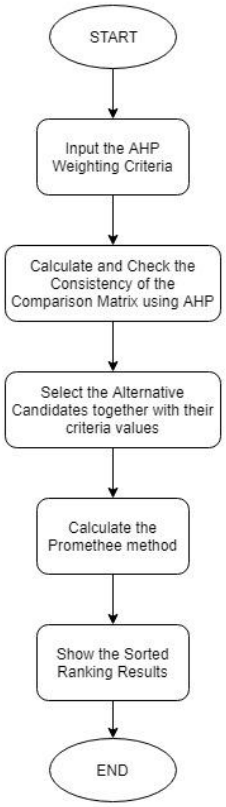

Figure 1. The system's flowchart

Implementation of this decision support system is done using the programming language PHP, HTML, Codeigniter Framework, MySQL Database, and Jquery. The following is the implementation results of the decision support system for the recruitment of new employees by using the AHP and Promethee methods.

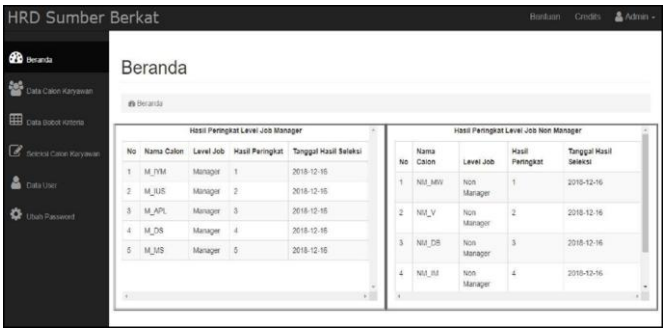

Figure 2. Admin Homepage

Fig. 2 is the admin home page. There is a home menu, prospective employee data menu, data weighting criteria menu, prospective employee selection menu, user data menu, password change menu, credits menu, help menu, and log out.

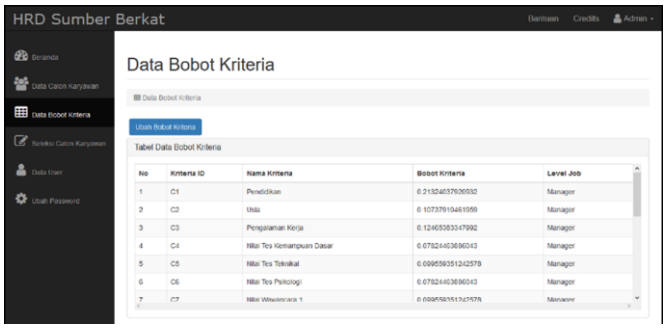

Figure 3. AHP Weight Criteria page

Fig. 3 is the AHP weight criteria page. On this page, there is a change weight criteria button that will display the page change the weight of the AHP criteria. On this page, there are also criteria data weight table that contains the criteria for ID, criteria name, criteria weight, and job level.

Fig. 4 is a page showing the changing of AHP criteria weight. This page can only be accessed by the admin and contains a form to change the criteria weight. Admin must provide an assessment of each criterion. There is a save button that functions to calculate the weight and save it to the database and the back button to return to the data page weights the AHP criteria.

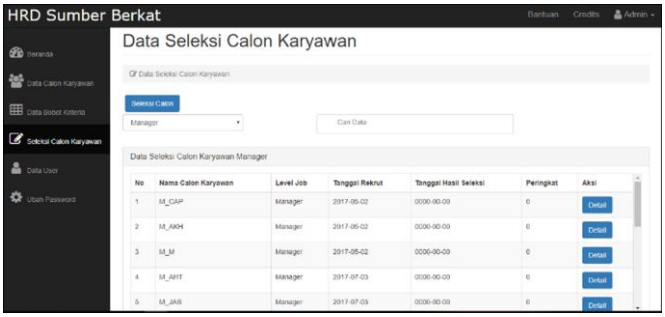

Figure 5. Prospective Employee Selection page

Fig. 5 is the prospective employee selection data page for admin. On this page, there is a candidate selection button that

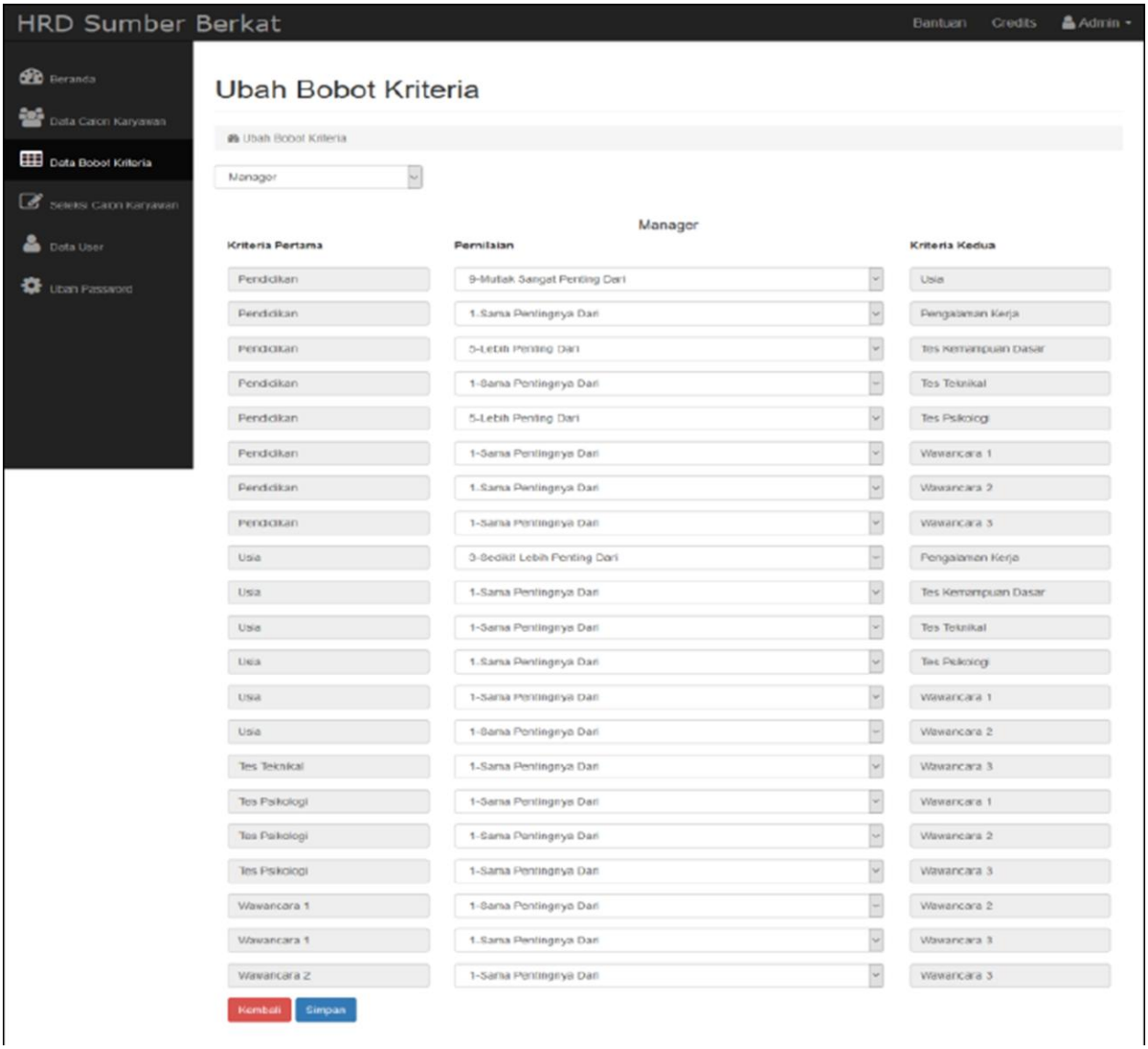

Figure 4. Changing on the AHP Weight Criteria page

serves to display data search pages for prospective employees to be selected. Under the candidate selection button, there is a dropdown to select the job level for prospective employees consisting of managers and non-managers.

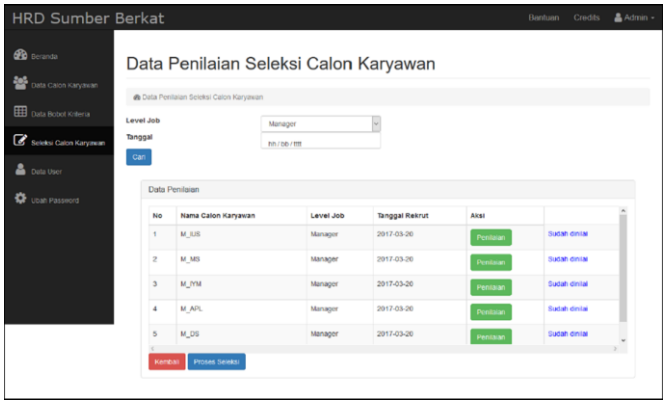

Figure 6. Prospective Employee Data Assessment page

Fig. 6 is a page for the assessment of prospective employees. There are data on prospective employees who have been searched for and an assessment button that serves to display a prospective employee's data assessment page. On this page, there is also a selection process button that serves to process all prospective employee data that has been assessed to be calculated using the Promethee method and directs it back to the prospective employee selection data page.

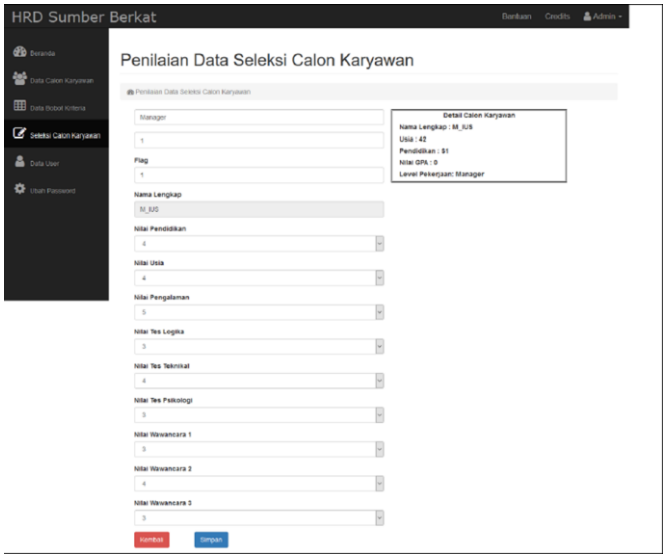

Figure 7. Prospective Employee Assessment Criteria page

Fig. 7 is a prospective employee assessment criteria page. On this page, there is a form to assess the criteria for each prospective employee. Next to the form is brief information from prospective employees.

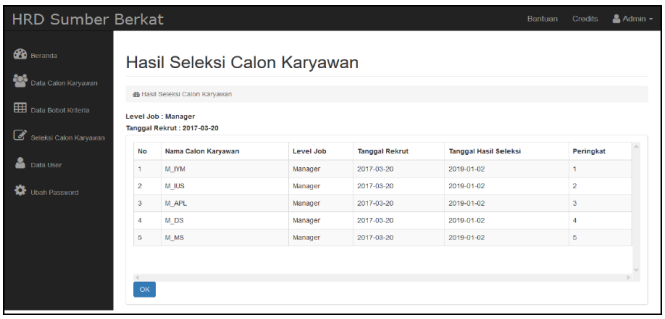

Figure 8. Employee Selection Results page

Fig. 8 is the employee selection results page. On this page, there are prospective employee data along with the rankings of prospective employees. Under the prospective employee selection data, there is an "ok" button that will lead to the prospective employee selection detail data page.

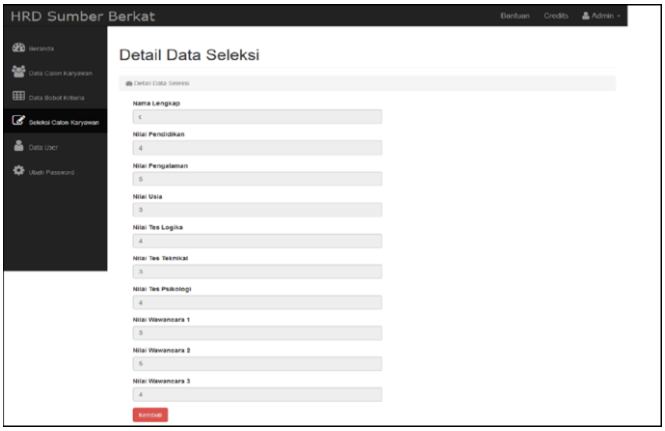

Figure 9. Employee Selection Results Detail page

If the user clicks the "ok" button, a more detailed page of the selected employee candidate will be shown as can be seen in Fig. 9. The criteria values a prospective candidate has that will affect the calculation results will be shown here. There is also a "back" button to go back to the employee selection results page as depicted in Fig. 8.

Usability testing on the decision support system for new employees acceptance with the AHP and Promethee methods is done by using the USE Questionnaire. This testing was carried out by six HRD department personnel consisting of one HRD manager and five staff using a Likert Scale measurement. The results of the questionnaire recapitulation can be seen in Table IV.

TABLE IV
RECAPITULATION OF USE QUESTIONNAIRE

Questions	Answer				
	VD	D	N	A	SA
1	0	0	0	2	4
2	0	0	0	4	2
3	0	0	0	2	4
4	0	0	0	4	2
5	0	0	0	2	4
6	0	0	0	3	3
7	0	0	0	4	2
8	0	0	0	3	3
9	0	0	0	6	0
10	0	0	0	6	0
11	0	0	0	3	3
12	0	0	0	4	2
13	0	0	0	4	2
14	0	0	0	2	4
15	0	1	1	4	0
16	0	0	3	2	1
17	0	0	2	4	0
18	0	0	0	5	1
19	0	0	0	5	1
20	0	0	1	2	3
21	0	0	0	2	4
22	0	0	0	4	2
23	0	0	0	2	4
24	0	0	0	3	3
25	0	0	0	4	2
26	0	0	0	5	1
27	0	0	1	3	2
28	0	0	3	2	1
29	0	0	2	3	1
30	0	0	0	5	1
Score	**0**	**1**	**13**	**104**	**62**

The results of the scores from the USE Questionnaire recapitulation that have been obtained will be calculated using the Likert Scale, referring to Table II. The results of the scores obtained are then calculated as the overall system user satisfaction, as shown in Fig. 10.

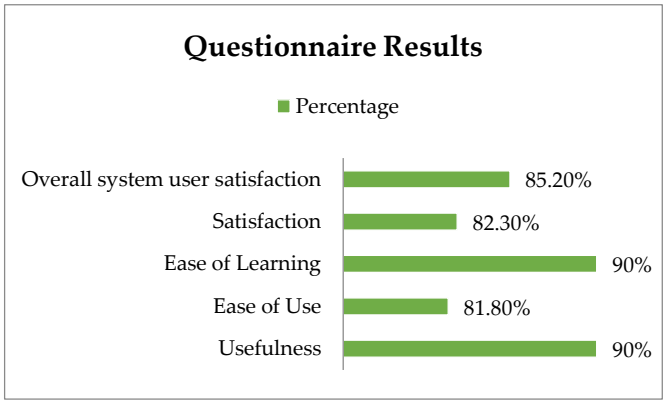

Figure 10. Questionnaire Percentage results

Usefulness aspect gets a percentage of 90% which interpreted as Very Good, Ease of Use gets a percentage of 81.8% which interpreted as Very Good, Ease of Learning gets 90% percentage which interpreted as Very Good, and Satisfaction gets a percentage of 82.3% which interpreted as Very Good. For the overall system, user satisfaction gets 85.2%, which interpreted as Very Good.

VII. CONCLUSION

Based on the research that has been done, it can be concluded that the decision support system for employees' enrollment acceptance using AHP and Promethee methods at PT Sumber Berkat Anugerah was successfully designed and built. This decision support system can display the results of AHP calculation criteria weights based on the criteria given by HRD of PT Sumber Berkat Anugerah and display the results of sorted Promethee calculations based on the weight criteria which were obtained from the previous AHP calculation. The acceptance test was done using the USE Questionnaire to test the usability of the system by six HRD staff from PT Sumber Berkat Anugerah consisting of one HRD Manager and five HRD staff. From the results of the USE Questionnaire, overall system user satisfaction reached 85.2% and can be concluded that this system is very useful, easy to learn, easy to use, and users feel very satisfied because this decision support system really helps speed up HRD in the process of accepting prospective new employees.

Suggestions that can be given for the development of decision support system for prospective employees' enrollment using AHP and Promethee method are to create a system where users can modify the required criteria so that the system can be used by users in other companies, and data export feature can be added.

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