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Group decision support system model to determine supervisor lecturers for student creativity programs

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ABSTRACT

A group decision support system (GDSS) model was created in this study by implementing the weighted product (WP) method and the borda method to determine prospective assistant or supervisor lecturers for student creativity programs (PKMs) that are routinely carried out every year at the Sriwijaya State Polytechnic. This study applies 5 criteria, including i) education level, ii) academic position, iii) group tenure, iv) lecturer certification, and v) achievement in the field of three pillars of higher education. The decision-makers in this study consisted of the head of the department (DM–1), the secretary of the department (DM–2), and the head of the study program (DM–3) where they carried out the decision-making process in groups. The WP method is used to make preferences independently of the decision-makers to determine the best alternative based on predetermined criteria. The borda method is currently used to aggregate the decision-makers to obtain the final result in the form of an alternative ranking. The results of this study are sufficient to be used as a reference in determining the supervisor lecturer for PKM activities at the Department of Computer Engineering, State Polytechnic of Sriwijaya.

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1. INTRODUCTION

Higher education is an ever-changing environment, so its sustainability depends on the ability to adapt to these changes [1]. The student creativity program (PKM) is a manifestation of the implementation of the Tridharma of Higher Education launched by the Directorate General of Higher Education in 2021. This program is one of the efforts to grow, accommodate, and realize creative and innovative ideas for students. The impact of this activity is the improvement in student and university achievement in ranking at the Ministry of Education and Culture [2]. To support the activities of the PKM, the Sriwijaya State Polytechnic at the department level appointed several lecturers to assist students in preparing proposals for proposed activities, writing techniques, and implementing activities. For this reason, an objective mechanism in determining the candidate for supervisor lecturers for activities is very much needed to obtain optimal results. Some of the criteria that become the basis for determining suitable lecturer candidates to become activity supervisors include education level, academic position, group tenure, lecturer certification, and the lecturer's achievement in the activities of the three pillars of higher education.

To increase the objectivity of decision-making, the decision-making approach is carried out in groups [3]. The group decision-making process occurs when each individual is characterized by his or her perceptions, attitudes, and motivations. According to Costa [4] decision making is a fairly complex problem to be solved, and produce a ranking of the selected alternatives [5]. Integration and combination of several models can improve the performance of decision-making systems [6]. This is related to accuracy and computational processing [7]. Decision support systems have been widely applied in various fields, including in the field of education which is used to determine scholarship grantees [8], in the field of human resource management it is used for employee performance appraisal [9], even in the political field, this kind of decision support system used to determine political parties in general elections [10].

Several studies on group decision support systems (GDSS) were conducted by Azmi *et al.* [11] where they developed a GDSS model for supplier selection using a combination of analytic hierarchy process (AHP), technique for order preference by similarity to ideal solution (TOPSIS), and Borda methods. This study sets 6 criteria to determine the best supplier, namely price, quality, delivery, location, inventory, and flexibility. The combination of these 3 methods has resulted in a GDSS model that is quite adequate to determine the best supplier ranking. Another GDSS research was also conducted by Meidelfi *et al.* [12] who combined the SAW and Borda methods to determine the final project's topic. This study sets 4 criteria and 10 topics in model testing. The decision-makers, in this case, consist of 2 lecturers as evaluators of research topics. The research has succeeded in producing a sequential list of recommended research topics.

Research conducted by Saputra *et al.* [13] using the weighted product (WP) method aims to determine the ideal cloud computing service. This study establishes as many as 11 criteria used in the consideration of decision making and 6 alternatives that can be selected in cloud computing services. This research has resulted in the best ranking in determining cloud computing services. The use of the WP method is also used in measuring employee performance by Aminudin *et al.* [14]. In this study, 5 criteria were used, consisting of attendance, behavior, experience, discipline, and teamwork. This study determines 5 alternatives to test the model and produce a ranking in the form of the order of the best employee performance.

The WP method is also used by Arifin and Mintamanis [15] to determine the thesis supervisor. This study sets as many as 10 criteria in determining the decision, while the alternatives used in testing the model are only 3 alternatives. However, this research has succeeded in proving that the WP method can be used in the multiple criteria decision-making model. As the output, this research can produce the best ranking for thesis supervisor candidates. Research conducted by Supriyono and Sari [16] also uses the WP method to determine house selection. This study establishes 11 criteria which are categorized into 2 groups, namely cost, and benefit. The alternatives used in model testing consist of 3 alternatives. This research has produced a list of recommended house rankings.

Decision making with a multicriteria decision making approach has been implemented in a study conducted by Bire *et al.* [17] using a fuzzy AHP and native AHP approach to determine tourist attractions in the city of Kupang. Both of these approaches produce equally good outputs in the decision-making process. However, the fuzzy AHP approach gives better results in calculations. This study uses 9 criteria in determining the best alternative. Likewise, research by Pattnaik *et al.* [18] uses fuzzy multi criteria decision making (MCDM) and TOPSIS approaches to determine alternative life insurance in India. There are 10 criteria used to determine the best alternative. This study also uses a sensitivity analysis approach to ensure the effectiveness of the developed model.

Research conducted by Fanghua and Guanchun [19] developed a fuzzy multi-criteria group decision-making (FMCGDM) model to carry out environmental risk analysis of watersheds. This study conducted tests using 5 criteria and 3 alternatives, and involved 4 decision makers. Research shows optimal results in weight loads. Other research on the topic of multi-criteria decision-making was also carried out by Meshram and Agrawal [20] which places more emphasis on the aspects of risk analysis and the confidence of an attribute being considered. Research conducted by Zou and Qiu [21] implementing fuzzy borda for watershed management. Research on group decisions was also carried out by Dewi *et al.* [22] using the TOPSIS approach and the Borda method. This model is implemented in a mobile application to make it easier for tourists to visit tourist destinations in the city of Malang.

According to research conducted by Lestari *et al.* [23] comparing 2 aggregation methods, namely the Borda method and Copeland, the results show that the Borda method is better than Copeland. Likewise in terms of processing speed, Borda method is faster than Copeland. This research is organized as follows. Section 2 describes the methodology and architecture of model. Section 3 describes the research results, and discussion. Section 4 contains conclusions.

2. METHOD

This study aims to build a GDSS model using the WP and Borda methods. Both of these methods are used to improve the quality of the results of decision making. This segment reviews in more detail the two methods.

2.1. Architecture system design of group decision support system

Figure 1 is the architecture of the developed model. In this architecture, the GDSS model developed consisted of 3 decision-makers, namely the head of the department (DM–1), the secretary of the department (DM–2), and the head of the study program (DM-3). This modeling stage starts from individual preferences by each decision-maker using the WP method to generate a ranking of alternatives. Furthermore, after the ranking results from each decision-maker are obtained, the ranking is calculated using the Borda points to produce the final ranking of the recommendation process using the GDSS.

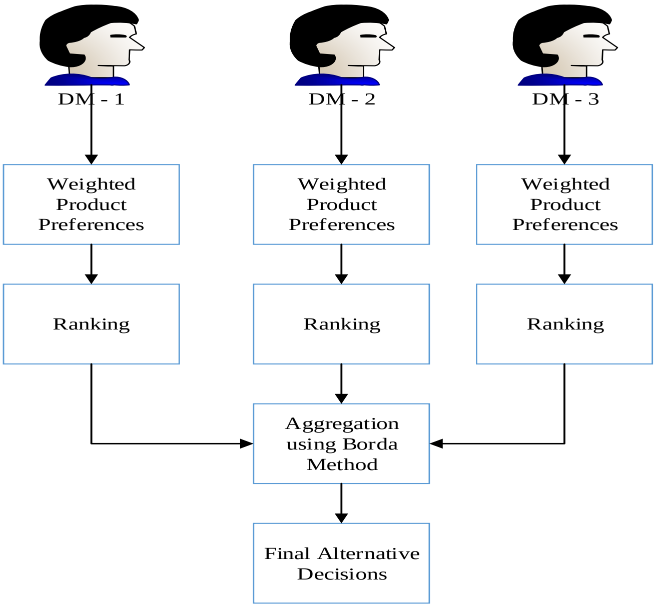

Figure 1. System architecture of GDSS

2.2. Weighted product method

WP is a method of making multiple criteria decisions that are used to solve cases that have data with many attributes [24]. The WP method uses multiplication to connect attribute ratings where the rating of each attribute must be raised first with the weight of the attribute concerned [3]. In general, several steps to perform calculations using the WP method are as follows:

– Determination of the criteria used as the basis in determining the decision. The criteria are symbolized by Ci, where i is the number of criteria determined to be used as a reference in decision making.
– Determine the suitability rating for the criteria. This is done by creating a decision matrix, and ranking the suitability of each criterion.
– Determination of the normalized weight value.

W is the weight of each criterion that will be calculated. The formula for finding the value of W is:

$$W_j = \frac{w_j}{\sum w_j} \tag{1}$$

After this calculation, the value of W will be ranged 0 to 1 where the total of all W is 1. Then, W is multiplied by 1 for the attribute worth benefit, and W is multiplied by -1 for the attribute worth the cost.

– Calculating preference values for alternatives as vector S

The preference value for the alternative is calculated based on (2):

$$S_i = \prod_{j=1}^{n} X_{ij}^{W_j} \tag{2}$$

Description:
S : preference alternative
w : criterion weight
X : criterion value
i : alternative i to n

j : criterion
– Calculating the relative preference value as vector V

Vector V is the result of a preference for each alternative. In (3) is the formula used to calculate the value of V.

$$V_i = \frac{\prod_{j=1}^{n} x_{ij}^{w_j}}{\prod_{j=1}^{n} x_{ij^*} w_j} \tag{3}$$

After the value of V is obtained, then it is sorted by the largest value of V.
– Ranking the value of the vector V

At this stage, it will be known which alternative has the highest Vi value which is the result of the decision and is the best alternative.

2.3. Borda method

The principle of the Borda method is to do alternative voting by weighting the value on each alternative ranking [23], [25]. The alternative that has the top rank is given the highest score, and so on in descending order where lower values are given to the rank below it until the lowest rank is given a value of 0 (zero) or 1 [26]. The Borda method is one of the aggregation methods that are quite effective in GDSS applications [27]-[30]. Even [23] mentions that the Borda method can be used to rank the sparsity data. On the other hand, according to [31] Borda method is done by sorting all alternatives from the largest value to the smallest value with a value of 0.

3. RESULTS AND DISCUSSION

In this study, the problem discussed in the decision-making to determine the assistant lecturer for PKM activities, at the Sriwijaya State Polytechnic. The following are the steps involved in the decision-making process. The implementation of these two methods will be explained in more detail.

3.1. Independent assessment by decision makers using the weighted product method

The stages in performing calculations independently by decision-makers are executed using the WP method. The decision-makers consisted of the DM-1, the DM-2, and the DM-3 at the Computer Engineering Department of the Sriwijaya State Polytechnic. The initial step taken is to determine the criteria and the value of the weight of the criteria as a reference in decision making. Table 1 presents the criteria and the weight of the criteria defined.

Table 1. Criteria and criteria weight

Criteria	Description	Category	Criteria weight
C1	Education level	Benefit	5
C2	Academic position	Benefit	4
C3	Group tenure	Benefit	5
C4	Lecturer certification	Benefit	3
C5	Achievement in the field of three pillars of higher education	Benefit	5

Criteria C1 to C4 will have the same value trend between decision-makers (DM). This is because the data is standard and does not require objective expert judgment from each decision-maker. Meanwhile, the C5 criteria will have varied values from each decision-maker given it will be based on the perceptions of each decision-maker. This variable value depends on the point of view of the decision makers based on the performance achievements of each alternative on the C5 criteria, because there is no standard reference based on certain values such as in criteria C1 to C4, where each criterion has a value that becomes reference.

3.2. Determine the criteria scale

The data obtained in this study is qualitative so that it requires a scale value of each criterion to facilitate the calculation process. Table 2 is the scale for the C1 criteria for education level. Table 3 is a criterion scale for lecturers' academic positions. Table 4 is the criteria scale for group tenure, and Table 5 presents the criteria scale for lecturer certification which only contains information on certified and uncertified.

Meanwhile, Table 6 contains information that tends to be subjective from decision-makers whose content depends on the perception of each decision-maker. Table 6 is related to the performance of each lecturer based on higher education tridharma activities. Each lecturer has a different performance in the fields of teaching, research, community service, and supporting activities in higher education. So, there are no parameters that are set specifically. So that each lecturer is likely to get a varied score, depending on the preferences of the decision makers.

Table 2. Criteria scale of education level

No.	Qualification	Scale
1	S2-Master	1
2	S3-Doctor	2

Table 3. Criteria scale of academic position

No.	Qualification	Scale
1	Instructor	1
2	Lecturers	2
3	Senior Lecturers	3
4	Assoc. Professors	4
5	Professors	5

Table 4. Criteria scale of group tenure

No.	Qualification	Scale
1	0-5 years	1
2	6-10 years	2
3	11-15 years	3
4	16-20 years	4
5	> 20 years	5

Table 5. Criteria scale of lecturer certification

No.	Qualification	Scale
1	Uncertified	1
2	Certified	2

Table 6. Criteria scale of achievement in the field of three pillar's of higher education

No.	Qualification	Scale
1	Very poor	1
2	Poor	2
3	Enough	3
4	Good	4
5	Very good	5

3.3. Entering alternative data

Tables 7-9 are the distribution of preference data from decision-makers (DM-1, DM-2, and DM-3). The alternative data tested into the model are 10 alternatives and are distributed for each of the 5 criteria. This data is lecturer data from the D3 computer engineering study program, in the Department of Computer Engineering at the Sriwijaya State Polytechnic. In this model the lecturer's name is not presented in detail using the name, but uses initials in the form of A1, A2,…, A10.

Table 7. Data preference from DM-1

No.	Alternatives	C1	C2	C3	C4	C5
1	A1	1	4	4	2	4
2	A2	1	4	3	2	4
3	A3	1	4	4	2	4
4	A4	1	4	3	2	4
5	A5	1	3	3	2	5
6	A6	1	2	3	2	4
7	A7	1	3	3	2	3
8	A8	2	2	3	1	4
9	A9	1	2	3	2	2
10	A10	1	3	2	2	3

Table 8. Data preference from DM-2

No.	Alternatives	C1	C2	C3	C4	C5
1	A1	1	4	4	2	5
2	A2	1	4	3	2	5
3	A3	1	4	4	2	3
4	A4	1	4	3	2	4
5	A5	1	3	3	2	5
6	A6	1	2	3	2	5
7	A7	1	3	3	2	3
8	A8	2	2	3	1	3
9	A9	1	2	3	2	2
10	A10	1	3	2	2	3

Table 9. Data preference from DM-3

No.	Alternatives	C1	C2	C3	C4	C5
1	A1	1	4	4	2	5
2	A2	1	4	3	2	5
3	A3	1	4	4	2	4
4	A4	1	4	3	2	5
5	A5	1	3	3	2	4
6	A6	1	2	3	2	4
7	A7	1	3	3	2	3
8	A8	2	2	3	1	4
9	A9	1	2	3	2	3
10	A10	1	3	2	2	4

3.4. Calculating the normalization weight value

This weight is calculated using (1) following the weight criteria in Table 1 so that the weight normalization is obtained as follows:

W=(5, 4, 3, 3, 5)
W1=5/(5+4+3+3+5)=0.25
W1=4/(5+4+3+3+5)=0.20
W1=3/(5+4+3+3+5)=0.15
W1=3/(5+4+3+3+5)=0.15
W1=5/(5+4+3+3+5)=0.25

Furthermore, it is ensured that the accumulated value of this weight is equal to 1 as follows:

w1+w2+w3+w4+w5=1
0.25+0.20+0.15+0.15+0.25=1

Table 10 is the result of the normalization of the weights of the criteria that have been defined in Table 1 obtained by using (1). The normalized value of Wj also has the same value, because all criteria categories are in the form of benefits, so they are multiplied by 1. If the criteria category is cost, then it is multiplied by -1.

Table 10. Normalization of weight criteria

Criteria	Wj	Wj normalized
C1	0,25	0,25
C2	0,20	0,20
C3	0,15	0,15
C4	0,15	0,15
C5	0,25	0,25
∑	1,00	

3.5. Calculating vector S

Vector S is calculated by referring to (2). In calculating the S vector, the categories of cost and benefit criteria are considered. The cost category will be negative and the benefit value will be positive. Referring to Table 1, it can be seen that all categories are positive so that the normalized Wj is also positive. Tables 11-13 are the results of the calculation of the S vector from the decision-makers. For example, vector S is obtained by using (2) where the information contained in Table 11 can be described as follows:

$S1 = (1^{0.25}) (4^{0.20}) (4^{0.15}) (2^{0.15}) (4^{0.25}) = 2.5491$
$S2 = (1^{0.25}) (4^{0.20}) (3^{0.15}) (2^{0.15}) (4^{0.25}) = 2.4415$
$S3 = (1^{0.25}) (4^{0.20}) (4^{0.15}) (2^{0.15}) (4^{0.25}) = 2.5491$
$S4 = (1^{0.25}) (4^{0.20}) (3^{0.15}) (2^{0.15}) (4^{0.25}) = 2.4415$
$S5 = (1^{0.25}) (3^{0.20}) (3^{0.15}) (2^{0.15}) (5^{0.25}) = 2.4372$
$S6 = (1^{0.25}) (2^{0.20}) (3^{0.15}) (2^{0.15}) (4^{0.25}) = 2.1254$
$S7 = (1^{0.25}) (3^{0.20}) (3^{0.15}) (2^{0.15}) (3^{0.25}) = 2.1450$
$S8 = (2^{0.25}) (2^{0.20}) (3^{0.15}) (1^{0.15}) (4^{0.25}) = 2.2780$
$S9 = (1^{0.25}) (2^{0.20}) (3^{0.15}) (2^{0.15}) (2^{0.25}) = 1.7873$
$S10 = (1^{0.25}) (3^{0.20}) (2^{0.15}) (2^{0.15}) (3^{0.25}) = 2.0184$

Table 11. Preference vector S from DM-1

Alternatives	$C1^\wedge W_j$	$C2^\wedge W_j$	$C3^\wedge W_j$	$C4^\wedge W_j$	$C5^\wedge W_j$	Si
A1	1.0000	1.3195	1.2311	1.1096	1.4142	2.5491
A2	1.0000	1.3195	1.1791	1.1096	1.4142	2.4415
A3	1.0000	1.3195	1.2311	1.1096	1.4142	2.5491
A4	1.0000	1.3195	1.1791	1.1096	1.4142	2.4415
A5	1.0000	1.2457	1.1791	1.1096	1.4953	2.4372
A6	1.0000	1.1487	1.1791	1.1096	1.4142	2.1254
A7	1.0000	1.2457	1.1791	1.1096	1.3161	2.1450
A8	1.1892	1.1487	1.1791	1.0000	1.4142	2.2780
A9	1.0000	1.1487	1.1791	1.1096	1.1892	1.7873
A10	1.0000	1.2457	1.1096	1.1096	1.3161	2.0184
					∑Si	22.7724

Table 12. Preference vector S from DM-2

Alternatives	$C1^W_j$	$C2^W_j$	$C3^W_j$	$C4^W_j$	$C5^W_j$	Si
A1	1.0000	1.3195	1.2311	1.1096	1.4953	2.6954
A2	1.0000	1.3195	1.1791	1.1096	1.4953	2.5815
A3	1.0000	1.3195	1.2311	1.1096	1.3161	2.3722
A4	1.0000	1.3195	1.1791	1.1096	1.4142	2.4415
A5	1.0000	1.2457	1.1791	1.1096	1.4953	2.4372
A6	1.0000	1.1487	1.1791	1.1096	1.4953	2.2474
A7	1.0000	1.2457	1.1791	1.1096	1.3161	2.1450
A8	1.1892	1.1487	1.1791	1.0000	1.3161	2.1199
A9	1.0000	1.1487	1.1791	1.1096	1.1892	1.7873
A10	1.0000	1.2457	1.1096	1.1096	1.3161	2.0184
					∑Si	22.8457

Table 13. Preference vector S from DM-3

Alternatives	$C1^W_j$	$C2^W_j$	$C3^W_j$	$C4^W_j$	$C5^W_j$	Si
A1	1.0000	1.3195	1.2311	1.1096	1.4953	2.6954
A2	1.0000	1.3195	1.1791	1.1096	1.4953	2.5815
A3	1.0000	1.3195	1.2311	1.1096	1.4142	2.5491
A4	1.0000	1.3195	1.1791	1.1096	1.4953	2.5815
A5	1.0000	1.2457	1.1791	1.1096	1.4142	2.3050
A6	1.0000	1.1487	1.1791	1.1096	1.4142	2.1254
A7	1.0000	1.2457	1.1791	1.1096	1.3161	2.1450
A8	1.1892	1.1487	1.1791	1.0000	1.4142	2.2780
A9	1.0000	1.1487	1.1791	1.1096	1.3161	1.9779
A10	1.0000	1.2457	1.1096	1.1096	1.4142	2.1689
					∑Si	23.4077

3.6. Calculating vector V

Based on (3), the V vector is calculated by dividing the value of the Si vector by the total number of Si vectors. Tables 14-16 are the results of V vector calculations from decision-makers. Looking at the results of the calculations in Table 11, the value of ∑Si is 22.7724. The value of Vi as shown in Table 14 is obtained from:

V1 = S1/∑Si
= 2.5491/22.7724
= 0.111939
V2 = S1/∑Si
= 2.4415/22.7724
= 0.107211
V3 = S1/∑Si
= 2.5491/22.7724
= 0.111939
V4 = S1/∑Si
= 2.4415/22.7724
= 0.107211
V5 = S1/∑Si
= 2.4372/22.7724
= 0.107024
V6 = S1/∑Si
= 2.1254/22.7724
= 0.093333
V7 = S1/∑Si
= 2.1450/22.7724
= 0.094193
V8 = S1/∑Si
= 2.2780/22.7724
= 0.100032
V9 = S1/∑Si
= 1.7873/22.7724
= 0.078483
V10 = S1/∑Si
= 2.0184/22.7724
= 0.088635

Table 14. Preference's vector v from DM-1

Alternatives	Vi	Ranking
A1	0.111939	1
A2	0.107211	3
A3	0.111939	2
A4	0.107211	4
A5	0.107024	5
A6	0.093333	8
A7	0.094193	7
A8	0.100032	6
A9	0.078483	10
A10	0.088635	9

Table 15. Preference's vector v from DM-2

Alternatives	Vi	Ranking
A1	0.118361	1
A2	0.113362	2
A3	0.104171	5
A4	0.107211	3
A5	0.107024	4
A6	0.098687	6
A7	0.094193	7
A8	0.093090	8
A9	0.078483	10
A10	0.088635	9

Table 16. Preference's vector v from DM-3

Alternatives	Vi	Ranking
A1	0.118361	1
A2	0.113362	2
A3	0.111939	4
A4	0.113362	3
A5	0.101217	5
A6	0.093333	9
A7	0.094193	8
A8	0.100032	6
A9	0.086856	10
A10	0.095244	7

Table 17 is the final result of the decision-makers, in the form of ranking with the highest weight to the lowest weight generated from the WP method. Table 18 is the result of giving Borda points from the preferences of each decision-maker. Furthermore, the final results of ranking in the GDSS in the form of the most recommended alternative order are presented in Table 19. This is indicated by the highest Borda score, as can be seen in Table 19.

Table 17. Decision maker evaluation results

Ranking	DM-1	DM-2	DM-3
A1	A1	A1	A1
A3	A2	A2	A3
A2	A4	A4	A2
A4	A5	A3	A4
A5	A3	A5	A5
A8	A6	A8	A8
A7	A7	A10	A7
A6	A8	A7	A6
A10	A10	A6	A10
A9	A9	A9	A9

Table 18. Borda voting results

Alternatives	DM-1	DM-2	DM-3	Values
A1	9	9	9	27
A2	7	8	8	23
A3	8	5	6	19
A4	6	7	7	20
A5	5	6	5	16
A6	2	4	1	7
A7	3	3	2	8
A8	4	2	4	10
A9	0	0	0	0
A10	1	1	3	5

Table 19. Borda ranking

Ranking	Alternatives	Score
1	A1	27
2	A2	23
3	A4	20
4	A3	19
5	A5	16
6	A8	10
7	A7	8
8	A6	7
9	A10	5
10	A9	0

Based on Table 19, the ranking is obtained in the order A1 has a score of 27, A2 has a score of 23, and so on. The alternative A1 score of 27 is obtained from the score of the Borda model from decision maker 1, decision maker 2, and decision maker 3 of 9 points. Likewise alternative A2 gets a weight of 23 from decision maker 1 of 7, and decision maker 2 and decision maker 3 each of 8. This is an advantage of the developed model, so the best alternative is the result of the aggregation of each decision maker.

The results of the calculation of the weights of the Borda model have provided a single weight from several weights obtained from the decision makers. This can provide a level of confidence in the results of the decision-making process. The selected alternative is the best alternative out of 3 decision makers based on predetermined criteria. Furthermore, the implementation in software using a web-based application obtained the same results as the calculations described in the previous discussion as can be seen in Figure 2. This provides important information that the developed model and the software that is applied to a web-based environment can be used as a tool for management in higher education to determine lecturers to accompany students' creativity programs.

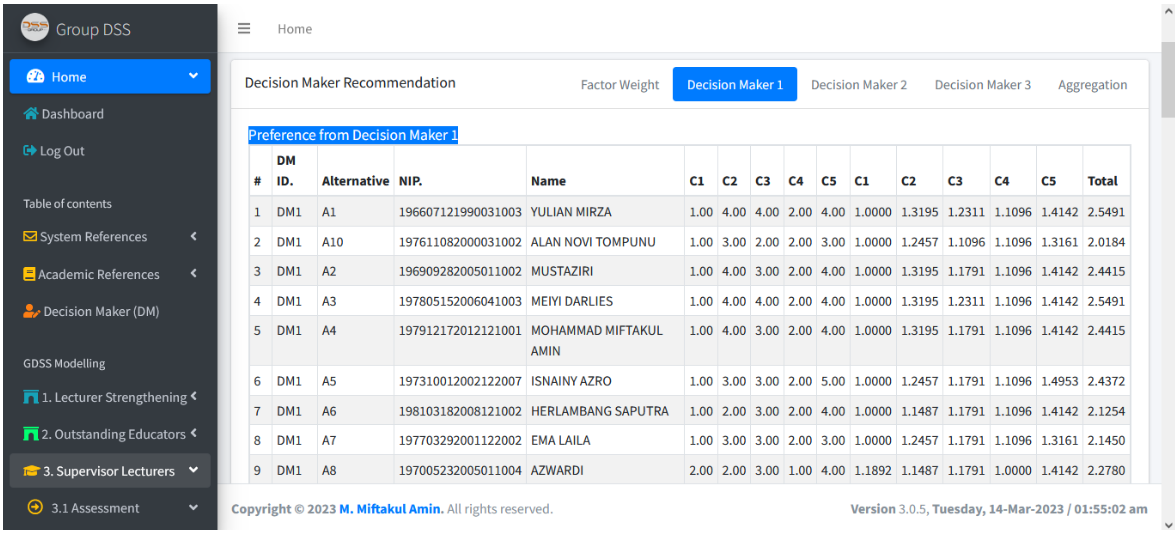

Figure 2. Implementation of GDSS using web based application

4. CONCLUSION

Knowing the results and discussions that have been described, it can be argued that the combination of the WP and Borda methods can be used as a model in making the GDSS. The recommendations generated by the GDSS can be used as a reference by decision-makers in the Computer Engineering Department of the Sriwijaya State Polytechnic, which consists of the DM–1, the DM–2, and the DM–3. This method can be used to determine suitable lecturer candidates to accompany PKM activities. To improve the performance of the GDSS model that has been built, several other methods can be chosen to make preferences independently by decision-makers, as well as aggregation in groups.

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