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PROJECT-BASED LEARNING PERFORMANCE MEASUREMENT USING VIKOR METHOD AND RANK ORDER CENTROID

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Abstract: Project-Based Learning is a type of learning that is quite widely recommended today, especially in vocational type institutions where the learning is effective in the aim of involving students with direct learning content. The process of evaluating project-based learning on project teams in the performance assessment of each team to rank the order of best performance of all teams is still assessed based on subjective assessments. To overcome these problems, in this study the performance measurement of the project-based learning team by applying the VIKOR method and Rank Order Centroid in conducting assessments with test samples, namely in the Introduction to Database course. The test results obtained based on the calculation of VIKOR and Rank Order Centroid, namely PBL-TRPL01 Team 1 as the best alternative by obtaining based on variations of testing the VIKOR index value with values v=0.4, v=0.5, and v=0.6. Thus, it can be seen that the VIKOR and Rank Order Centroid methods can be applied to the calculation process of measuring team performance in project-based learning.

Keywords: decision Support System; project-based learning; rank order centroid; VIKOR

Abstrak: Pembelajaran Berbasis Proyek merupakan jenis pembelajaran yang cukup banyak direkomendasikan di masa kini khususnya pada institusi berjenis vokasional. Pembelajaran tersebut efektif dalam tujuan melibatkan para peserta didik dengan konten pembelajaran secara langsung. Proses evaluasi pembelajaran berbasis proyek pada tim proyek dalam penilaian performa dari masing-masing tim untuk memeringkatkan urutan performa terbaik dari seluruh tim masih dinilai berdasarkan penilaian secara subyektif. Untuk mengatasi persoalan tersebut, pada penelitian ini pengukuran performa tim *project-based learning* dengan menerapkan metode VIKOR dan *Rank Order Centroid* dalam melakukan penilaian dengan sampel pengujian yaitu pada mata kuliah Pengantar Basis Data. Hasil pengujian yang diperoleh berdasarkan perhitungan VIKOR dan *Rank Order Centroid* yaitu bahwa alternatif PBL-TRPL01 Tim 1 sebagai alternatif terbaik dengan peroleh berdasarkan variasi pengujian nilai indeks VIKOR. Maka dengan demikian, dapat diketahui bahwa metode VIKOR dan *Rank Order Centroid* dapat diterapkan pada proses perhitungan pengukuran performa tim pada pembelajaran berbasis proyek.

Kata kunci: pembelajaran berbasis proyek; rank order centroid; sistem pendukung keputusan; VIKOR

INTRODUCTION

Project-based learning is authentic learning which is also one of the effective learning models in the aim of engaging students with direct learning content [1]. For that reason, project-based learning is now recommended by many educational institutions as a best learning practice, especially vocational type educational institutions. Project-based learning provides an excellent experience for learners and can be used to understand ongoing learning not only

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textually, but contextually in the real world [2]. This is reflected in the steps of project-based learning based on these stages, starting from *Driving Questions*, designing project work plans, scheduling project work, then teachers directly monitor the performance and progress of student projects, as well as assessing and evaluating learning outcomes [3].

Likewise what happened at the Batam State Polytechnic which in recent years has applied learning patterns to students with project-based learning mechanisms that previously applied conventional learning patterns. The project-based learning pattern that has been applied is that students as students at the beginning of the semester will be grouped into several groups / teams and each group will be assigned a topic / project title with different cases with each team will be evaluated by the Project Manager and lecturers of courses related to the project. Performance appraisals from each team to rank the best performance order of all teams are still assessed based on subjective proportions of scores. In this study, the author tried to test the assessment and ranking process of the performance of the project-based learning project team using objective calculations mathematically. One way is to apply the rules for calculating ratings by using rating calculations with the calculation rules of the Decision Support System.

Decision Support System itself is a medium that can be used for decision makers in overcoming complex and unstructured problems [4], so as to increase the effectiveness of decisions taken from users [5],[6]. The DSS methods that are commonly used include Simple Additive Weighting (SAW), ELECTRE, TOPSIS, MOORA, VIKOR, AHP, Weighted Product (WP), SMART, SMARTER, and so on [7],[8]. One of the DSS methods is *VIsektriterijumsko KOMpromisno Rangiranje* (VIKOR) which is one of the methods used on *Multi Attribute Decision Making* (MADM) By using the closest solution/alternative approach as an approach to deal solutions in ranking [9].

Some of the previous studies related to the research to be carried out are as follows. The results of research from Lubis et al (2022) assessed marketplace sites with VIKOR and Centroid Rank Order with Shoopee as the best alternative by obtaining an index value of 1[9]. The results of research by Wibowo by applying Fuzzy AHP-VIKOR for marketplace selection with the result that Shopee is proposed to be the best alternative [10]. The results of research from Sari, et al 2020 are implementing Vikor to complete the selection of Medan service ambassador events by producing rankings for all alternatives involved and determining the ideal compromise solution [11]. The results of research from Dewi, et al. in 2021, Vikor was applied to solve the problem of providing credit to multi-purpose cooperatives with the result that Vikor has a low risk of error in making decisions [12]. In a study conducted by Sari, et al. in 2021, Vikor in the formation of a medical team at the PTP-VI Berangir Clinic, it was concluded that Vikor could provide accurate decision-making results [13]. Research from Umam et al, determination of Regional Superior Product Priorities Using VIKOR with the result that VIKOR can help determine regional superior products and can increase the income of these products in predetermined areas [14]. Research from Siregar et al, Multi-Attribute Decision Making with VIKOR Method for Any Purpose Decision. VIKOR is considered to be an effective

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and easy-to-use method for all types of data [15]. Research from Pratama et al, Selection of Outstanding Students in Junior High School with VIKOR and TOPSIS. From 13 experimental results, TOPSIS was found to have a higher accuracy rate than VIKOR, which was 80% [16]. The results of the VIKOR method research can determine participants who are eligible to receive funding for uninhabitable houses and rank effectively [17]. The results of VIKOR's research can help decision making to shape values into the best alternatives. The assessment in the research that has been carried out uses 4 competency criteria, each using VIKOR [18].

The weighting of criteria is also very important needed in solving problems using MADM, so here the author uses the weighting method *Rank Order Centroid* (ROC) with technique assigns weight to each criterion according to the ranking based on the priority level of the specified criteria [5].

This study aims to examine the calculation of the decision support system for ranking project team performance in project-based learning using the VIKOR and combined with Rank Order Centroid where the results of this research are expected to provide objective results in determining the ranking of project team performance measurement in project-based learning.

METHOD

In carrying out this research on the stages carried out starting from the initial stage to the final stage with detailed explanations as follows:

Identify the Problem

At this stage identify the actual problem and what elements are needed to solve the problem of performance measurement in a team or project-based learning group.

Data Collection

Data collection is carried out by observation and literature study to obtain the necessary data and assessment formulation of the criteria to be used.

Formulation of VIKOR Method & Rank Order Centroid

To solve problems in carrying out the performance measurement process in teams or project-based learning work groups by applying the VIKOR and Rank Order Centroid (ROC) so as to facilitate the process of making decisions quickly and precisely.

VIKOR (*VIsektriterijumsko KOMpromisno Rangiranje*) comes from Serbian which is used for ranking to see the ideal solution in the ranking. The main objective is to generate compromise solutions by ranking alternative value results and conflicting criteria with reference to feasible plans or close to ideal plans. The following is the calculation in the VIKOR [18][19][20]:

Create an F matrix from the data used with the following format:

$$F = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} C_{x1} & C_{x1} & \dots & C_{xn} \\ X_{11} & X_{12} & \dots & X_{1n} \\ \vdots & \vdots & \dots & \vdots \\ X_{m1} & X_{m2} & \dots & X_{m2} \end{bmatrix} \quad (1)$$

Where Ai is an alternative from i=1 to n and Cxn is the criterion from j=1 to *m*. The preparation of matrix A can be seen in the following equation.

Next steps, Calculates the normalization of the matrix by following the following equation:

$$R_{ij} = \frac{(f_i^*) - (f_{ij})}{(f_i^*) - (f_i^-)} \quad (2)$$

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Information:

R_{ij} = matrix normalization value
f_{ij} = Sample data value *i* criterion *j*
f_i^* = best value in a criterion
f_i^- = worst value in a criterion

Multiplies the normalized matrix value by the criterion weighted value obtained in the previous step.

$$Weight\ Normalization = (W_i \times R_{ij}) \quad (3)$$

Information:

W_i = Weight of each criterion *j*
R_{ij} = Alternative element *i* to criterion *j*

Calculate *the utility measures* of each alternative using the following equations and equations.

$$S_i = \sum_{j=1}^{n} w_j \frac{(f_i^*)-(f_{ij})}{(f_i^*)-(f_i^-)} \quad (4)$$

$$R_i = MAX_j \left[w_j \frac{(f_i^*)-(f_{ij})}{(f_i^*)-(f_i^-)} \right] \quad (5)$$

Information:

S_i = Utility value (S) of each alternative
R_i = Regret value (R) of each alternative

Calculates the VIKOR index of each alternative by using the following equation:

$$Q_i = v\left[\frac{S_i - S^*}{S^- - S^*}\right] + 1(1-v)\left[\frac{R_i - R^*}{R^- - R^*}\right] \quad (6)$$

Information:

Q_i = Ranking results
S^- = max S_i and S^+ = min S_i
R^- = max R_i and R^+ = min R_i
v = VIKOR Index Value

In *Rank Order Centroid* calculates priority based on each criterion, and assigns weights according to priority order [21]. Then determine the priority, the formula is that the highest value is the highest priority value compared to other values [22]. ROC can be expressed as follows [9]:

$$\text{If, } Cr1 \geq Cr2 \geq Cr3 \ldots \geq Crn \quad (7)$$
$$\text{Then, } W1 \geq W2 \geq W3 \ldots \geq Wn \quad (8)$$

In formula (7) it is intended that the order of priority of the importance value of the criterion (*Cr*) while in formula (8) is the order of the value of weight (*W*) based on the priority of the importance value of the criterion.In general, ROC weighting is formulated as follows [4]:

$$Wk = \frac{1}{K} \sum_{i=1}^{K} \left(\frac{1}{i}\right) \quad (9)$$

Where *W* is the criterion weighting value, k is the number of criteria and i is the alternative value. The ROC technique can give weight in each criterion based on the priority level according to a predetermined assessment rating.

Implementation and Testing

At this stage, the results and discussion of the VIKOR and ROC methods are described, resulting in accurate ranking and objective assessment.

Conclusion

This final phase is to make conclusions based on the calculation results by applying the VIKOR and ROC methods and answering all the problems contained in the research.

RESULT AND DISCUSSION

The data used in this study was obtained based on the results of the *Self-Assessment* presentation at the end of the even semester of the 2022/2023 academic year from each *Project Based Learning* Team for elements of the Database Programming course in the D4 Software Engineering Technology study program, Batam State Polytechnic. In Table 1 the following is information on the criteria used in this study:

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Table 1. Criteria Data

Code	Criterion	Information
C1	Database Normalization	Understanding of the concept and application of database normalization techniques
C2	Advanced Query	Understanding of concepts and application of advanced queries to the database manipulation process
C3	Client-Server	Understanding the concept and application of access rights management and client-server concepts to the database operation process on several different devices
C4	Non Relational Database	Understanding the concept and application of non-relational databases to database operations
C5	Application Programming Interface (API)	Understanding the concept and application of the basic concepts of Application Programming Interface to database operations
C6	Team Leader	Assessment for the Group Leader in coordinating his group during project work
C7	Team Emotional Closeness	The level of emotional closeness of all group members during project work

Then the weighting of criteria is done by the Rank Order Centroid (ROC) weighting method where each attribute has a priority, and the weight value of each attribute is based on priority. The results of the ROC weight value in this study are based on the standards used, as shown in Table 2.

Table 2. ROC Weight Value

Code	Priority	ROC Weight
C1	2	$\frac{0+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}+\frac{1}{6}+\frac{1}{7}}{7} = 0.228$
C2	1	$\frac{1+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}+\frac{1}{6}+\frac{1}{7}}{7} = 0.370$
C3	3	$\frac{0+0+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}+\frac{1}{6}+\frac{1}{7}}{7} = 0.156$
C4	6	$\frac{0+0+0+0+0+\frac{1}{6}+\frac{1}{7}}{7} = 0.044$
C5	7	$\frac{0+0+0+0+0+0+\frac{1}{7}}{7} = 0.020$
C6	4	$\frac{0+0+0+\frac{1}{4}+\frac{1}{5}+\frac{1}{6}+\frac{1}{7}}{7} = 0.109$
C7	5	$\frac{0+0+0+0+\frac{1}{5}+\frac{1}{6}+\frac{1}{7}}{7} = 0.073$

Then in the assessment of the criteria for each team is assessed based on categories or rating scales with the rating scale having their respective rating scale values. The importance of the rating scale used can be seen in Table 3.

Table 3. Value Weight Importance

Scale	Rate Value
Very very good (VVG)	6
Very well (VW)	5
Good (G)	4
Pretty good (PG)	3
Not Good (NG)	2
Very Not Good (VNG)	1

Then in Table 4, the following is alternative data, which in this case is a list of *student project-based learning* teams assigned in the even semester of 2022/2023 with a total of 20 teams in the Class of 2022.

Table 4. Alternative Data

Code	Alternative
A1	PBL-TRPL01 Tim 1
A2	PBL-TRPL01 Tim 2
A3	PBL-TRPL01 Tim 3
A4	PBL-TRPL01 Tim 4
A5	PBL-TRPL02 Tim 1
A6	PBL-TRPL02 Tim 2
A7	PBL-TRPL02 Tim 3
A8	PBL-TRPL02 Tim 4
A9	PBL-TRPL03 Tim 1
A10	PBL-TRPL03 Tim 2
A11	PBL-TRPL03 Tim 3
A12	PBL-TRPL03 Tim 4
A13	PBL-TRPL04 Tim 1
A14	PBL-TRPL04 Tim 2
A15	PBL-TRPL04 Tim 3
A16	PBL-TRPL04 Tim 4
A17	PBL-TRPL05 Tim 1
A18	PBL-TRPL05 Tim 2
A19	PBL-TRPL05 Tim 3
A20	PBL-TRPL05 Tim 4

Then in Table 5, which displays the results of the criteria assessment on each alternative data with an assessment format based on the conversion of scale values based on the value of the matching rating of criteria against alternatives.

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Table 5. Match Rating Value

Code	C1	C2	C3	C4	C5	C6	C7
A1	5	5	6	6	6	6	6
A2	4	5	6	4	4	5	5
A3	2	3	4	2	2	5	6
A4	3	4	3	4	2	6	5
A5	4	4	5	4	5	5	6
A6	5	5	5	4	4	6	6
A7	2	2	4	4	4	4	6
A8	5	6	5	5	5	6	2
A9	5	5	6	5	5	5	6
A10	4	4	4	4	4	4	6
A11	4	4	4	4	4	4	4
A12	2	4	3	3	2	5	3
A13	4	5	5	5	5	5	6
A14	4	5	5	5	5	5	5
A15	4	4	4	4	4	5	6
A16	4	4	4	4	4	5	5
A17	1	1	1	1	1	1	1
A18	3	4	5	4	2	2	1
A19	4	4	4	4	4	5	4
A20	1	2	1	1	1	1	1

The first step is to adjust the conversion result data match rating value from the criteria obtained in each alternative data and to find the maximum and minimum values, then normalize the weight by multiplying the matrix normalization result by the calculated weight seen in Table 6.

Table 6. Weight Normalization Results

Code	C1	C2	C3	C4	C5	C6	C7
A1	0	0	0	0	0	0	0
A2	0.057	0	0	0.018	0.008	0.022	0.015
A3	0.171	0.185	0.062	0.035	0.016	0.022	0
A4	0.114	0.093	0.094	0.018	0.016	0	0.015
A5	0.057	0.093	0.031	0.018	0.004	0.022	0
A6	0	0	0.031	0.018	0.008	0	0
A7	0.171	0.278	0.062	0.018	0.008	0.044	0
A8	0	0	0.031	0.009	0.004	0	0.058
A9	0	0	0	0.009	0.004	0.022	0
A10	0.057	0.093	0.062	0.018	0.008	0.044	0
A11	0.057	0.093	0.062	0.018	0.008	0.044	0.029
A12	0.171	0.093	0.094	0.026	0.016	0.022	0.044
A13	0.057	0	0.031	0.009	0.004	0.022	0
A14	0.057	0.093	0.062	0.018	0.008	0.044	0.029
A15	0.057	0.093	0.062	0.018	0.008	0.044	0.029
A16	0.057	0.093	0.062	0.018	0.008	0.044	0.029
A17	0.228	0.37	0.156	0.044	0.02	0.109	0.073
A18	0.114	0.093	0.031	0.018	0.016	0.087	0.073
A19	0.057	0.093	0.062	0.018	0.008	0.044	0.029
A20	0.228	0.278	0.156	0.044	0.02	0.109	0.073

After normalizing the weight, the next step is to calculate the *utility and* regret measure with Equations (3) and (4). The results of *utility* and *regret measure* calculations can be seen in Table 7.

Table 7. Utility and Regret Measure Calculation Results

Code	Utility	Regret Measure
A1	0	0
A2	0.119	0.057
A3	0.491	0.185
A4	0.348	0.114
A5	0.224	0.093
A6	0.057	0.031
A7	0.58	0.278
A8	0.102	0.058
A9	0.035	0.022
A10	0.281	0.093
A11	0.31	0.093
A12	0.465	0.171
A13	0.123	0.057
A14	0.31	0.093
A15	0.31	0.093
A16	0.31	0.093
A17	1	0.37
A18	0.432	0.114
A19	0.31	0.093
A20	0.908	0.278

The next step is to calculate the value of the VIKOR index using varying *v* values, namely 0.4, 0.5, and 0.6 to see if there is a difference from the ranking is generated. Then the results of calculating and ranking the VIKOR index on the alternatives used can be seen in Table 8.

Table 8. Ranking of Alternatives Based on VIKOR Index Value

Code	Rank			Average
	v = 0.4	v = 0.5	v = 0.6	
A1	1	1	1	1
A2	5	5	5	5
A3	17	17	17	17
A4	14	14	14	14
A5	7	7	7	7
A6	3	3	3	3
A7	18	18	18	18
A8	4	4	4	4
A9	2	2	2	2
A10	8	8	8	8
A11	13	13	13	13
A12	16	16	16	16
A13	6	6	6	6
A14	12	12	12	12
A15	11	11	11	11
A16	10	10	10	10
A17	20	20	20	20
A18	15	15	15	15
A19	9	9	9	9
A20	19	19	19	19

Table 8 is the result of alternative ranking, can be seen that PBL-TRPL01 Team 1 as the first rank based on the VIKOR Index test value varies. Then based on testing of varying v values, the average results of alternative ratings also obtain stable results from each v value test so that the final rating of each alternative becomes easier to rank. Thus, it can be seen that the VIKOR and ROC have been successfully applied to the calculation process of measuring group / team performance in project-based learning.

CONCLUSION

Based on the results of the testing conducted in the method applied in this research case, it was concluded that the application of the VIKOR method and Rank Order Centroid in the process of calculating group / team performance measurement in project-based learning was able to produce a ranking of the order of team / group performance in accordance with the criteria and the weight of the criteria used using objective criteria weights from the calculation of Rank Order Centroid. The research conducted by the author can be an evaluation for the future that for group / team performance measurement in project-based learning can still be developed and reviewed in determining the criteria used and the weight of objective criteria used can also be used based on other criteria weighting methods.

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