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Selection of Educational Software Tools based on AHP and TOPSIS

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***Abstract*— Several software packages are available for the smooth-running of an educational system. However, making the choice for most-appropriate software can be very tasking. This may require the meeting of the school's management team to take quality decisions based on some given criteria. As a result, conflicts may arise if standard multicriteria decision methods are not applied in the selection process. This current research focuses on the application of AHP and TOPSIS methods to select the most relevant software among three options for use in a high school. Five members of the management team evaluated the various criteria and conducted pair-wise comparisons to determine the weights using AHP. The choices were further ranked based on the TOPSIS method. The result showed SMS C as the best choice for the school, with a TOPSIS ranking score of 0.730044.**

Keywords*— Analytic Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), School Management Software (SMS), Multicriteria Decision Making (MCDM)

I. INTRODUCTION

School authorities are constantly involved in several activities to efficiently manage the educational processes within their domain. These activities range from admissions to class work and results-computation among others. The educational system is gradually transcending from paper works to digital processes. Therefore, to improve the performance of the school administration, many school authorities opt-out a school management software to smoothly automate some of the important educational processes. School management software is a collection of relevant application programs that organizes the school processes into a well-structured system to effectively give the staff and students an interesting educational experience. There are various educational software packages available nowadays, with each of them having its uniqueness. Therefore, selecting suitable software for a specific school can be quite demanding. The application of a multicriteria decision making (MCDM) method is a good way to make an optimal choice in the selection process. MCDM methods include but are not limited to Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), ELimination Et Choix Traduisant la REalitè (ELECTRE), Best-Worst Method (BWM) [1] [2], Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE). There are no specific rules to be followed when making a choice at MCDM [3]. This work applies AHP and TOPSIS in the selection of suitable school management software for an educational system.

II. A REVIEW OF RELATED WORKS

AHP is MCDM tool that can be applied in a wide range of fields [4]. AHP was originally developed by Thomas L., Saaty in the 1970s and has been used in various fields to make decisions. A multicriteria analysis for supplier selection in a university using AHP was performed by [5]. The selection was conducted based on flexibility, delivery, variety, quality and cost. The developed model can evaluate and monitor the performances of various suppliers for the procurement department of the institution. In [4], the factors affecting the choice of retail pharmacies in Bangladesh while purchasing the drugs from various pharmaceutical companies were prioritized. Six factors were identified and then analyzed through analytic hierarchy process (AHP) to quantify the qualitative factors through a standard scale.

AHP was also used by [6] to develop a framework that selects suppliers for qualitative dairy products in Indonesia. The criteria for the analysis were based on quality, quantity, delivery, warranty, and pricing. In 2019, [7] proposed a hybrid decision-making approach based on Analytic Hierarchy Process (AHP) and Dempster-Shafer Theory (DST) to evaluate and select a new product. AHP and DST were used in weight determination to improve accuracy and objectivity.

Furthermore, AHP was applied by [8] in the selection of an optimal Electronic Toll Collection (ETC) method. Three ETC technologies were analyzed based on five criteria and their result provides an intelligent guide for toll selection in Nigeria. In addition, the application of AHP was used to establish a multicriteria-based equipment selection framework for sustainability in the context of the Malaysian construction industry. The resultant procurement index helps decision-makers in the process of the acquisition of sustainable construction equipment in Malaysia [9]. AHP and ELECTRE methods were used by [10] to evaluate and select a suitable hospital management software. Their result showed the cost criterion to be the most important criterion in the decision-making process.

In [11], Fuzzy TOPSIS was used to quantify data and prioritize criteria for enterprise information security architecture. AHP and TOPSIS were integrated by [12] to determine the most appropriate tomography equipment.

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AHP was used to determine the weights while TOPSIS was applied to evaluate the purchase options.

A multi-criteria decision approach was applied by [13] to select the best college coaches. In their work, the AHP was applied to find the best coaches from different sports and to rank these coaches while TOPSIS method was used to test the correctness and effectiveness of the model. The work of [14] AHP and TOPSIS independently to assess the performance of some financial institutions and to determine the best performing organization for a period of four years. In [15], an experiment was conducted on employee placement using several MCDM methods. Their results gave an accuracy of 95% using TOPSIS method. They concluded that when there are many criteria, the accuracy is reduced using AHP.

III. METHODOLOGY

A. Analytic Hierarchy Process (AHP)

AHP organizes criteria and alternatives into levels of hierarchy to enable experts to make easy comparisons among several variables [16]. In the AHP method, an important indicator is the number of criteria. This affects the consistency of the result because more than seven criteria lead to an increase in inconsistency [17]. The AHP mathematical methods are shown in equations (1) and (2).

– Define the value of the criteria, that is, the judgment matrix, C, on the scale 1–9.

– Calculate normalized matrix using Equation (1):

$$X_{i,j} = \frac{C_{ij}}{\sum C_{ij}} \tag{1}$$

where *Cij* is the criteria value; $\sum C_{ij}$ *is the* column sum.

– Calculate priority vector using Equation (2):

$$W_{i,j} = \frac{\sum X_{i,j}}{n} \tag{2}$$

where $\sum X_{i,j}$ is the normalized matrix column sum; and *n* is the number of criteria.

When applying AHP method, it is important to involve experts in the evaluation process so that the values obtained can be re-used in future [18]. The decision process is done using Saaty's scale of preference as seen in Table I.

TABLE I. Scale of Comparison [19]

Scale	Degree of Preference
1	Equal significance
3	Moderate significance of a factor over the other
5	Strong significance
7	Very strong significance
9	Ultimate importance
2, 4, 6, 8	Estimates for inverse comparison

B. Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

The principle used in TOPSIS is that the chosen alternative must have the closest distance from an ideal best solution and furthest from an ideal worst solution from a geometric point of view using the Euclidean distance to determine the relative proximity of an alternative with the optimal solution. The positive ideal solution, V_i^+, is defined as the sum of all the best attainable values for each attribute, while the negative ideal solution, V_i^-, consists of all the worst values achieved for each attribute [15] [20].

TOPSIS considers both the distance to an ideal best solution, S_i^+, and the distance to an ideal worst solution, S_i^-, by taking the proximity relative to the positive ideal solution. Based on a comparison of the relative distance, an alternative priority arrangement, P_i, can be achieved. This method is used to solve practical decision-making problems. Because the concept is simple and easy to understand, computing is efficient and has the ability to measure the relative performance of decision alternatives. The steps for TOPSIS are seen below.

Step 1: Vector normalization is done using equation 3.

$$\overline{x_{ij}} = \frac{x_{ij}}{\sqrt{\sum_{ji}^{n} x_{ij}^2}} \tag{3}$$

where x_{ij} represents the performance values of each cell.

Step 2: Multiply the corresponding weights by the normalized values to obtain the weighted normalized decision values, V_{ij}.

Step 3: Determine the values for the ideal best and ideal worst for each criterion. For non-beneficial factors, lower values are the ideal best, while the higher values are the ideal worst. For beneficial factors, the higher values are the ideal best, while the lower values are the ideal worst. V_j^+ indicates the ideal best solution. V_j^- indicates the ideal worst solution.

Step 4: Calculate the Euclidean distance from the ideal best (S_i^+) and the ideal worst (S_i^-). They are expressed in equations 4 and 5.

$$S_i^+ = \left[\sum_{j=1}^{m}\left(V_{ij} - V_j^+\right)^2\right]^{0.5} \tag{4}$$

$$S_i^- = \left[\sum_{j=1}^{m}\left(V_{ij} - V_j^-\right)^2\right]^{0.5} \tag{5}$$

Step 5: Calculate the performance score, P_i. It is expressed as seen in equation 6.

$$P_i = \frac{S_i^-}{S_i^+ + S_i^-} \tag{6}$$

The performance score is between 0 and 1. The closer it is to 1, the more optimal the solution is.

Step 6: Rank the alternatives.

IV. RESULTS AND DISCUSSION

This research uses AHP and TOPSIS to select the appropriate software among three proposed school management software (SMS) based on the following factors.

- Component: The software is expected to handle admissions, fees, class assessment, academic activities and relationship management for the school.
- Cost: This factor is to be considered to fit in into the estimated budget of the school without negatively affecting the turnover. It includes the initial cost, running cost and maintenance cost.
- Ease of use: The software is expected to be user-friendly, easy to navigate, have an attractive GUI, and have access to support.
- Maturity: Software should be known for its capability to handle school management activities.

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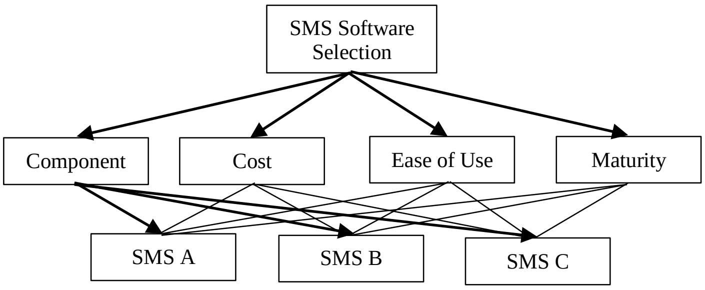

Fig. 1. Hierarchy Structure for the Software Selection

The above factors are arranged into a hierarchical tree to determine their weights using AHP as shown in figure 1. Five members of the management team made the decision using the scale of comparison shown in Table 1. The judgement matrix is shown.

$$C = \begin{bmatrix} 1 & \frac{1}{3} & 3 & 5 \\ 3 & 1 & 5 & 7 \\ \frac{1}{3} & \frac{1}{5} & 1 & 3 \\ \frac{1}{5} & 7 & \frac{1}{3} & 1 \end{bmatrix}$$

Six comparisons were done with a consistency ratio of 4.6%. The resultant weights of the process can be seen in Table II.

Table II. AHP Weights for Selection Factors

Criteria	Priority	Rank
Cost	0.262	2
Component	0.565	1
Ease of Use	0.118	3
Maturity	0.055	4

Based on the outcome of the AHP analysis, it can be seen that the Component criterion has the highest threshold, with a weight of 0.565. This implies that Component factor is most important when considering the selection of a school management software. The obtained weights are further applied to select the most suitable software for the school. The judgement is consistent because the value of the consistency ratio is less than 10%. Fig. 2 shows the graph of the criteria weights.

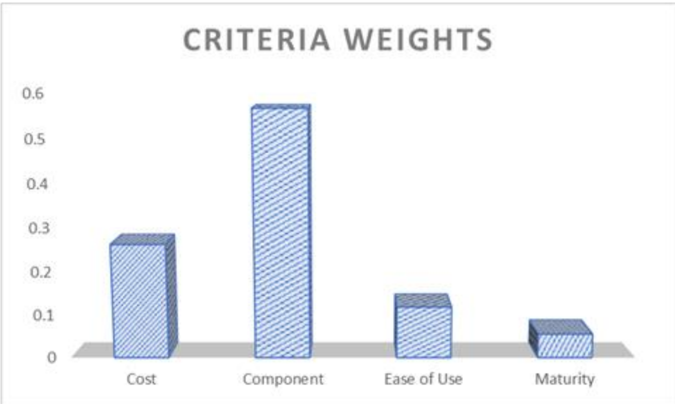

Fig. 2. Weights of Selection Criteria

Furthermore, TOPSIS is applied to rank the three SMS alternatives. The resultant matrices and ranking are shown in Tables III, IV and V.

TABLE III. TOPSIS Weighted Normalized Decision Matrix

	COST	COMPONENT	EASE	MATURITY
SMS A	0.250412	0.374180391	0.06071	0.044610891
SMS B	0.071546	0.299344313	0.080947	0.026766534
SMS C	0.028619	0.299344313	0.06071	0.017844356

TABLE IV. Ideal Best and Ideal Worst Matrix

Ideal Best	0.028619	0.374180391	0.080947	0.044610891
Ideal Worst	0.250412	0.299344313	0.06071	0.017844356

TABLE V. Summary of Final TOPSIS Analysis

Options	S_i^+	S_i^-	$S_i^+ + S_i^-$	P_i	Rank
SMS A	0.222715	0.079479	0.302194	0.263006	3
SMS B	0.0881	0.180228	0.268328	0.67167	2
SMS C	0.082015	0.221793	0.303808	0.730044	1

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As shown in Table V above, the best choice is SMS C with a score of 0.730044 because of its closeness to 1. The closer the performance score is to 1, the more excellent the outcome is.

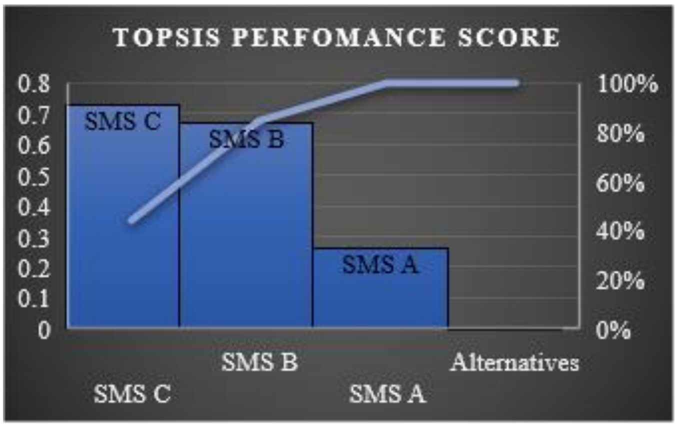

Fig. 3. TOPSIS Performance Score for the SMS

V. CONCLUSION

Based on the result of this study, it can be seen that software selection process should not be handled casually but should be done using suitable MCDM methods such as AHP and TOPSIS. The component factor is of utmost importance when making decision for an ideal school management software. The weights for the criteria were obtained using AHP while the actual ranking of the software was done through TOPSIS. Therefore, the hybrid approach yields an excellent result with performance score of 0.730044.

VI. REFERENCES

[1] J. Rezaei, "A Concentration Ratio for Non-Linear Best Worst Method," *International Journal of Information Technology & Decision Making,* 2020, 19(3), pp. 891-907.

[2] P. Dragan, E. Fatih, E., C. Goran, and A. A. Melfi, "Application of Improved Best Worst Method (BWM) in Real-World Problems" MDPI journal, 2020, doi:10.3390/math8081342 www.mdpi.com/journal/mathematics

[3] R. G. Maria, B. Fabrizio, and C. A. Anthea, "Methodology for the Selection of Multi-Criteria Decision Analysis Methods in Real Estate and Land Management Processes," MDPI, Basel, Switzerland, 2018, (http://creativecommons.org/licenses/by/4.0/)

[4] E. Farzana, M. Afia, A. Shahriyar, and K. Mustafiz, "Pharmaceutical Product Selection: Application of AHP," International Journal of Business and Management, 2017, Vol. 12, No. 8; 2017 ISSN 1833-3850 E-ISSN 1833-8119

[5] D. R. Babak, and E. K. Turan, "Selecting the best supplier using analytic hierarchy process (AHP) method," African Journal of Business Management, 2012, DOI: 10.5897/AJBM11.2009

[6] C. A. Putri, B. Imam, and A. Dewanti, "Supplier Selection Using Analytical Hierarchy Process at PT. Indolakto" JURNAL SAINS DAN SENI ITS, 2017, Vol. 6, No. 1 ISSN: 2337-3520 (2301-928X Print)

[7] W. Chong, Z. Zijiao, and Z. Wei, "A Group Decision-Making Approach Based on DST and AHP for New Product Selection under Epistemic Uncertainty," Hindawi Mathematical Problems in Engineering, 2019, https://doi.org/10.1155/2019/4635374

[8] F. A. Thompson, F. M. Aliu, and K. O. Akinyokun, "Selection of a Suitable Electronic Toll Collection System," European Journal of Computer Science and Information Technology, 2020, Vol.8, No.2, pp.1-9.

[9] M. Waris, S. Panigrahi, A. Mengal, M. Soomro, N. Mirjat, M. Ullah, Z. Azlan, and A. Khan, "An Application of Analytic Hierarchy Process (AHP) for Sustainable Procurement of Construction Equipment: Multicriteria-Based Decision Framework for Malaysia," Mathematical Problems in Engineering (Hindawi), 2019. https://doi.org/10.1155/2019/6391431

[10] A. A. Mohammad, S. Shahaboddin, & L. Y. Por, "Using multi-attribute decision-making approaches in the selection of a hospital management system," Technology and Health Care, 2018, DOI 10.3233/THC-170947 IOS Press

[11] S. J. Farzaneh, & N. Akbar, "Ranking Criteria of Enterprise Information Security Architecture Using Fuzzy TOPSIS," International Journal of Computer Science & Information Technology (IJCSIT), 2016, Vol 8, No 5. DOI:10.5121/ijcsit.2016.8504 45

[12] M. A. O. Barrios, F. De Felice, K. P. Negrete, B. A. Romero, Y. Arenas, and A. Petrillo, "An AHP-TOPSIS Integrated Model for Selecting the Most Appropriate Tomography Equipment," International Journal of Information Technology & Decision Making, 2016, 15(04), pp. 861-885.

[13] L. Jin-qiu, Y. Xiao-ming, S. Wenjie, and L. Sheng, "An AHP (Analytic Hierarchy Process)/FCE (Fuzzy Comprehensive Evaluation)-Based Multi-Criteria Decision Approach for Looking for the Best All Time College Coaches," International Journal on Computational Sciences & Applications (IJCSA), 2014, Vol.4, No.3, DOI:10.5121/ijcsa.2014.4308 77

[14] S. Aditi, K. Gurjeet, and B. Jatin, "A comparative analysis of PROMETHEE, AHP and TOPSIS aiding in financial analysis of firm performance," International Conference on Information Technology and Knowledge Management, 2018, pp. 145–150. DOI: 10.15439/2018KM39 ISSN 2300-5963 ACSIS, Vol. 14

[15] M. Widianta, T. Rizaldi, D. Setyohadi, and H. Riskiawan, "Comparison of Multi-Criteria Decision Support Methods (AHP, TOPSIS, SAW & PROMETHEE) for Employee Placement," International Joint Conference on Science and Technology (IJCST), 2017, doi :10.1088/1742-6596/953/1/012116

[16] M. M. Kablan, "Decision support for energy conservation promotion: An analytic hierarchy process approach," Energy Policy, 2004, 2004:32(10):11511158. https://doi.org/10.1016/S03014215(03)00078-8

[17] T. L. Saaty and M. S. Ozdemir, "Why the magic number seven plus or minus two," Mathematical and Computer Modelling, 2003, 2003:38(3–4):233–244. https://doi.org/10.1016/S0895-7177(03)90083-5

[18] Z. Beate, Z. Lauma, B. Lauma, K. Antra, K. Aset, & B. Dagnija, "Multi-Criteria Decision Analysis Methods Comparison," Environmental and Climate Technologies, 2020, vol. 24, no. 1, pp. 454–471 https://doi.org/10.2478/rtuect-2020-0028

[19] T. L. Saaty, and L. G. Vargas, Prediction, Projection and Forecasting. Kluwer Academic Publishers, Dordrecht, 1991, 251 pp.

[20] A. Afshari, M. Majid, & M. Rosnah, "Simple Additive Weighting approach to Personnel Selection Problem," International Journal of Innovation, Management and Technology, 2010, Vol. 1, No. 5