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Decision making with analytical hierarchy process algorithm and prototype model for exemplary teachers

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ABSTRACT

The selection process for exemplary teachers in vocational schools in Bekasi City has so far been carried out subjectively without a structured system, relying on internal meetings and daily notes, thus causing problems of transparency, accuracy, and efficiency. To overcome this, this study developed an online decision support system (DSS) that makes use of the analytical hierarchy process (AHP) algorithm to create an objective and measurable selection method based on five criteria: discipline, travel costs, personality, teaching administration, and learning achievement. Quantitative methods were applied by collecting data through questionnaires and observations, while the system prototype was designed through the stages of problem analysis, design, implementation, and evaluation. The AHP algorithm was used to process the decision matrix, benefit-cost-based normalization, weighting, and pairwise comparisons, with a consistency test (CR =0.044) ensuring the reliability of the results. This system successfully identified Didi Saputra, S.Pdi., as the best exemplary teacher with the highest preference value (0.92), while providing a significant impact in the form of increased accuracy (reducing subjective bias), transparency (clear ranking reports), and efficiency (faster selection process). The research findings demonstrate the effectiveness of AHP as a structured solution for exemplary teacher selection, with potential for adoption by other educational institutions and sustainability through a web-based system.

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1. INTRODUCTION

Schools have structures that have certain positions, interact with each other, and carry out roles as expected according to their positions [1]–[3]. Educational decision-making related to all potentials optimally starting from education staff, students, learning processes, educational facilities, and finances [4], teachers are no exception. Teachers are professional educators who are tasked with educating, teaching, evaluating students, guiding, training, and assessing [5]. Teachers are role models in the world of education who act as educators, mentors, assessors, and role models for the students they teach [6], [7]. Selecting exemplary teachers is important to ensure students receive effective, quality instruction. In selecting exemplary teachers at School Bekasi City, there is no system that can assist the school in calculating exemplary teacher assessments. To determine an exemplary teacher, the principal usually holds a meeting with several deputy

principals. The deputy principal will help determine the exemplary teacher by looking at the teacher's attendance and the teacher's daily notes. Students were asked to give thorough explanations of why they felt that, as well as any suggestions for improvement, and acknowledgment as an outstanding educator in the report on teaching and learning [8]. Decisions involve many intangibles that need to be considered. In order to do something, decisions must be measured along with real, objective things. The things involved in the measurement must also be evaluated to see how well they serve the decision maker's goals [9], [10]. Then the results obtained in selecting [11] exemplary teachers will be written on a piece of paper, which is vulnerable to damage or loss because there is no system-based report that can store the ranking of exemplary teachers. The absence of a decision support system (DSS) can cause the process of selecting exemplary teachers to be less efficient and accurate in its calculations. What then happens is that the absence of a clear report on the ranking of exemplary teachers means that other teachers cannot know who is considered exemplary, giving rise to ambiguity and a lack of transparency in this process. To overcome the problems that have been explained, a system is needed that can assist in the process of selecting exemplary teachers, which will be determined by the school principal. The selection of exemplary teachers in a school is still said to be subjective, with the appointment of a leader or principal without or accompanied by support from objective data. Decision support system are computer-based systems that support decision- making activities by providing flexible tools to decision-makers [12]. DSS have been traditionally identified as useful IT tools in a variety of fields, including the context of cultural heritage [13], [14]. One of the most suitable DSS methods for giving employee (teachers) award is to apply [15], [16] the analytical hierarchy process (AHP) algorithm.

The DSS research trend can be seen in Figure 1 using VOSviewer. To demonstrate that the AHP method remains effective for DSS research, the researchers presented the results of several studies in the form of a curve graph using Python, as seen in Figure 2. Based on Figures 1 and 2, DSS research using the AHP method was conducted on schools in Bekasi City.

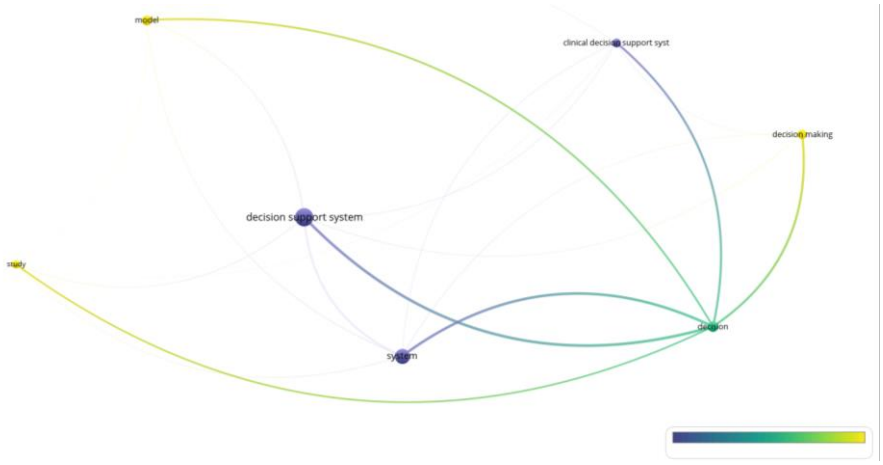

Figure 1. Viosviewer provides research on decision support systems

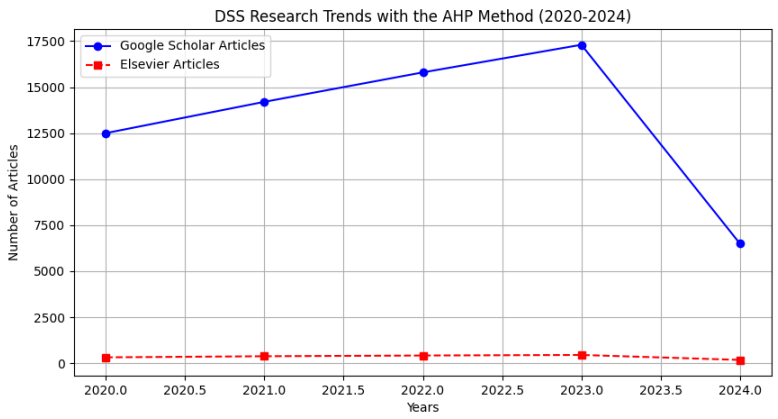

Figure 2. DSS research trends with the AHP method (2020-2024)

2. METHOD

Research conducted at one of the vocational schools in Bekasi City. With the investigation focus on a problem in selecting exemplary teachers at vocational schools in Bekasi City, namely still relying on data which can be said to be subjective (vague/biased), so it is necessary to carry out and develop research in selecting exemplary teachers based on objective (transparent) data. Professional conceptualization as a teacher is feeling themselves as teachers from the perspective of interpreting their experiences [17]. This research was carried out using a quantitative approach based on a questionnaire according to prototype test results on a web-based system design. Regardless of how many factors are involved in making the decision, the AHP method only requires to compare a pair of elements [18] or criteria to obtain a consistency ratio (CR) value. When making a decision, users can utilize these equations to forecast the CR by integrating them into AHP software [19]. The AHP combines the qualitative and quantitative analysis, flexible and systematical to deal with different kinds of problems [20]. The AHP method [21] consists of several steps, including defining a hierarchical decision structure, performing a comparison of criteria and alternatives using fuzzy numbers, calculating fuzzy synthetic values, and then prioritizing criteria and alternatives [22]. AHP is a technique for analyzing complex decisions, involving individual weighted calculations through pairwise comparisons [23]. Research in this school aims to answer the problem that occurs, namely selecting exemplary teachers based on data, as in the research flow in Figure 3.

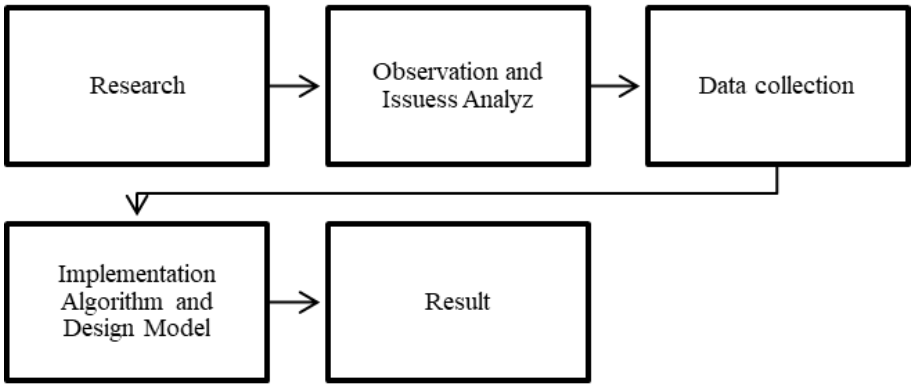

Figure 3. Research flow

The research method carried out by the researcher is a quantitative approach, which explains a picture with the support of data obtained from respondents. The survey and questionnaire were designed with students' needs, requirements, and preferred level of quality for online learning [24]. To carry out this approach, the researcher used system development with a prototype model, namely the problem analysis stage, design and implementation stage, and evaluation stage to obtain the expected system and simulate it with respondents in a prototype. The prototype model [25] is a software development method that is widely used because developers and customers can interact with each other during the application creation process [26]. With the prototyping technique, developers can create a prototype first before developing the actual system [27].

3. RESULTS AND DISCUSSION

This study uses a descriptive-quantitative approach to develop a web-based system with the AHP algorithm to select the exemplary teachers. Observations at a vocational school in Bekasi showed that the previous selection process only relied on attendance and social interaction without objective calculations, so a more structured system is needed. Therefore, research into this issue is necessary so that teachers can carry out their teaching activities with a sense of responsibility.

In the data collection stages the researchers used literature study, observation, and interviews [28]–[30], to obtain a list of teachers who were used as samples for this research. These criteria are positive values for consideration, including the economic and financial capabilities of the scholarship recipient, academic grades from the level of education, and other achievements [31]. The study aimed to determine the best-fit model for keeping quality teachers factored by exemplary teacher characteristics, interpersonal reactivity, and organizational climate [32]. However, in this study there are 5 criteria in

determining exemplary teachers, namely discipline, travel costs, personality, teaching administration, and learning achievements. The list of teachers used as sample tests for the AHP algorithm is shown in Table 1.

Table 1. Decision matrix

Alternatives	C1	C2	C3	C4	C5
Amirullah, M.Pd.	4	1	5	5	4
Auditya A. Dharmala, S.Pd.	3	3	4	4	4
Cindy Yunita,S.S.	4	3	4	4	4
Didi Saputra,S.Pdi.	5	1	5	5	5
Eka Sasnata, S.T.	3	1	5	5	5
Faiz Rifki, S.T.	4	2	4	5	4
Kintan A. Lestari, A.Md.	3	3	4	4	4
Komariyatul Badriyah, S.Pd.	5	1	5	4	4
Mujahidin, S.Pd.	3	2	4	5	4
Musfi'ah, S.Pd.	3	2	4	4	4
Sabilah N. Muawanah, S.Pd.	4	1	4	4	4
Sunarni S. Pd.	4	2	5	3	4
Sunarto, S.T.	4	1	5	5	5
Susan Kamelia, S.Pd.	3	3	4	4	4

In the AHP algorithm, it is explained that there are 5 determining aspects, namely decision matrix and normalization matrix, weighted normalization matrix, criteria pairwise comparison matrix, the CR. And in determining exemplary teachers, a measuring tool for assessment is made based on criteria so that alternatives (teachers) get criteria values that will be processed first in the form of normalization. After determining the normalization value, the weighted normalized value will be determined. by adopting selection models based on selection research in other disciplines [33], there are 5 criteria for determining an exemplary teacher in a school, as explained and Table 2 and with 5 stages of the AHP algorithm.

Table 2. Matrix of weight

Code	Criteria	Type	Weight
C1	Dicipline	Benefit	0.25
C2	Travel cost	Cost	0.2
C3	Personality	Benefit	0.2
C4	Admnistration teacher	Benefit	0.15
C5	Learning achievements	Benefit	0.2

3.1. Decision matrix

In the decision matrix (X), several criteria and benefits, and costs from Table 1 will be explained so that the decision matrix X can be obtained as an initial step in determining the normalization matrix. The decision matrix is as per the (1).

$$X = \begin{vmatrix} A_{C1} & A_{C2} & A_{C3} & A_{C4} & A_{C5} \\ B_{C1} & B_{C2} & B_{C3} & B_{C4} & B_{C5} \\ C_{C1} & C_{C2} & C_z & C_{C4} & C_{C5} \end{vmatrix} \quad (1)$$

from Table 1, the decision matrix is obtained as shown in Figure 4,

$$X = \begin{bmatrix} 4 & 5 & 5 & 5 & 4 \\ 3 & 3 & 4 & 4 & 4 \\ 4 & 3 & 4 & 4 & 4 \\ 5 & 5 & 5 & 5 & 5 \\ \dots & \dots & \dots & \dots & \dots \\ 3 & 3 & 4 & 4 & 4 \end{bmatrix}$$

Figure 4. Decision matrix (X)

3.2. Normalization matrix

In this normalization matrix, it can be said that the 2nd stage is with the following formula,

$$r_{ij} = \frac{x_{ij}}{max\ (x_j)} \quad (2)$$

$$r_{ij} = \frac{\min\ (x_j)}{x_{ij}} \quad (3)$$

AHP explains the normalization of the 2-formula matrix as the (2) and (3) by looking at the benefit and cost. In (2) explains the value of benefit, while (3) explains the value of cost. Then, a normalization matrix table (R) as shown in Table 3 is produced as calculated using the (2) and (3),

Table 3. Normalization matrix (R)

Alternative	C1	C2	C3	C4	C5
Amirullah, M.Pd.	0.8	0.6	1	1	0.8
Auditya A. Dharmala, S.Pd.	0.6	1	0.8	0.8	0.8
Cindy Yunita, S.S.	0.8	1	0.8	0.8	0.8
Didi Saputra, S.Pdi.	1	0.6	1	1	1
…	…	…	…	…	…
Susan Kamelia, S.Pd.	0.6	1	0.8	0.8	0.8

From the explanation above, the normalized benefit and cost matrix is as follows
Benefit (2).
The maximum value of criterion 1 (C1) is 5, then
A1 =4:5=0.8
A2 =3:5=0.6
…
A14 =3:5=0.6
Cost (3)
The minimum value of criterion 1 (C2) is 3, then
A1 =3:5=0.6
A2 =3:3=1
…
A14 =3:3=1

3.3. Weighted normalization matrix (V)

For the weighted automatic as per the (4), by looking at Table 4, the following values are obtained,

$$v_{ij} = w_j \,.r_{ij} \quad (4)$$

Table 4. Weighted normalization matrix (V)

Alternative	C1	C2	C3	C4	C5	Sum	Rank
Amirullah, M.Pd.	0.20	0.12	0.20	0.15	0.16	0.83	5
Auditya A. Dharmala, S.Pd.	0.15	0.20	0.16	0.12	0.16	0.79	9
Cindy Yunita, S.S.	0.20	0.20	0.16	0.12	0.16	0.84	4
Didi Saputra, S.Pdi.	0.25	0.12	0.20	0.15	0.20	0.92	1
Eka Sasnata, S.T.	0.15	0.12	0.20	0.15	0.20	0.82	6
Faiz Rifki, S.T.	0.20	0.15	0.16	0.15	0.16	0.82	6
Kintan A. Lestari, A.Md.	0.15	0.20	0.16	0.12	0.16	0.79	9
Komariyatul Badriyah, S.Pd.	0.25	0.12	0.20	0.12	0.16	0.85	3
Mujahidin, S.Pd.	0.15	0.15	0.16	0.15	0.16	0.77	12
Musfi'ah, S.Pd.	0.15	0.15	0.16	0.12	0.16	0.74	14
Sabilah Nurul Muawanah, S.Pd.	0.20	0.12	0.16	0.12	0.16	0.76	13
Sunarni S. Pd.	0.20	0.15	0.20	0.09	0.16	0.80	8
Sunarto, S.T.	0.20	0.12	0.20	0.15	0.20	0.87	2
Susan Kamelia, S.Pd.	0.15	0.20	0.16	0.12	0.16	0.79	9

to determine the weighted normalized matrix is by using (4)
Dicipline (C1)

A1=0.8x0.25=0.2
A2=0.6x0.25=0.15
…
A14=0.6x0.25=0.15
Travel cost (C2)
A1=0.6x0.2=0.12
A2=1x0.2=0.2
…
A14=1x0.2=0.2

Then, Vij = C1 + … + C5, and the highest V value is obtained from Didi Saputra, S.Pdi., with a V value of 0.92, as evidenced by the values of C1=0.25, C2=0.12, C3=0.20, C4=0.15, and C5=0.20. From the normalized weight value above, it is concluded that the number of alternatives from each criterion then obtained a value that is close to the value of 1 from the weighted normalization matrix value from Table 5, which is Didi Saputra, S.Pdi., with a V value =0.92. However, the V value above must look at the suitability and consistency of the pairwise comparison matrix values of the criteria.

3.4. Pairwise comparison matrix

The (5) shows how to formulate the pairwise comparison matrix for the criteria.

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n} \frac{(A.w)_i}{w_i} \quad (5)$$

Then the value of the weighted criteria pairwise comparison is obtained as in Table 5. As for determining the eigenvector value, then adding up the respective criteria values, we obtain C1=6.42, C2=5.13, C3=5.13, C4=3.85, C5=4.80.

Table 5. Criteria pairwise comparison matrix

Criteria	C1	C2	C3	C4	C5
C1	1.00	0.80	0.80	0.60	0.80
C2	1.25	1.00	1.00	0.75	1.00
C3	1.25	1.00	1.00	0.75	1.00
C4	1.67	1.33	1.33	1.00	1.00
C5	1.25	1.00	1.00	0.75	1.00

3.5. Consistency ratio

To ensure the consistency between the criteria and alternative values, it is better to calculate the CR, which must find the Eigenvector value from the comparison of alternatives and criteria as seen in the previous Table 5. To obtain the CR value, by paying attention to the consistency index (CI) value obtained from the Saaty formula, if there are 5 criteria, then the RI value is 1.12 [34], then determine the weight eigenvector value, as below:

λ_{max} = (6.42x0.25) + (5.13x0.2) + (5.13x0.2) + (3.85x0.15) + (4.80x0.2) x1:5=5.20

Then, look for CI, as in the (6),

$$CI = \frac{\lambda_{max}-n}{n-1} \quad (6)$$

CI =5.20–5:4=0.049

Then, look for CR, as in the (7),

$$CR = \frac{CI}{RI} \quad (7)$$

CR =0.049:1.12≈0.044

Then the matrix consistency is obtained, in the form of CR =0.044<0.1 in several of the matrices above. The design model for selecting exemplary teachers in schools is outlined as presented in Figure 5.

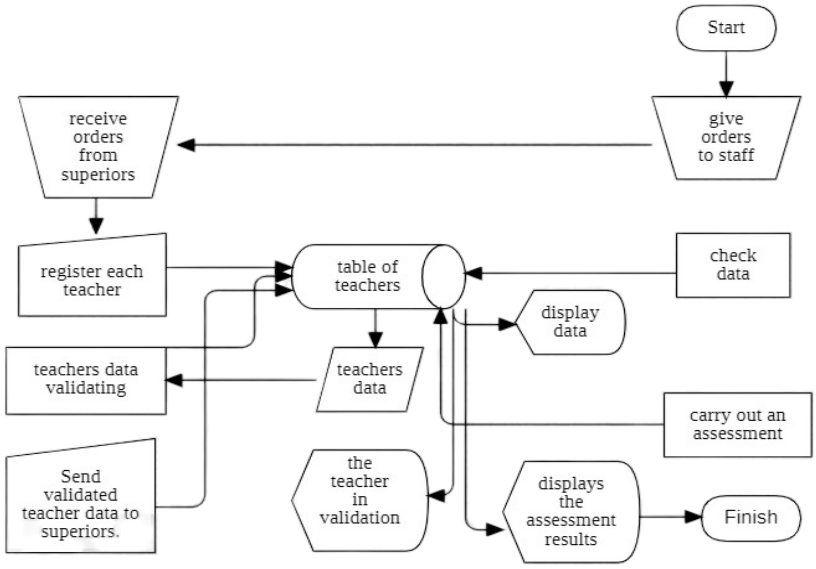

Figure 5. Model prototype design

4. CONCLUSION

This study successfully developed a web-based DSS with the AHP algorithm for the selection of exemplary teachers in vocational schools in Bekasi City, which was able to overcome the problem of subjectivity in the previous selection process. This system effectively identified the best teacher, namely Didi Saputra, S.Pdi., with a preference value of 0.92, based on five objective criteria: discipline, travel costs, personality, teaching administration, and learning achievement. The results of the consistency test (CR =0.044) showed the reliability of the AHP method in structured decision-making. The implementation of this system has a significant impact in the form of increasing selection accuracy through a quantitative approach, process transparency through clear digital reports, and operational efficiency by drastically reducing selection time. In addition, this system is replicable and can be adapted by other educational institutions with similar needs. The success of this study not only provides a concrete solution to the problem of selecting exemplary teachers but also opens up opportunities for the development of similar systems for various strategic decision-making needs in the world of education. The advantages of a web-based system guarantee sustainability and ease of development in the future, as well as being a foundation for improving the quality of education through an objective and transparent data-driven approach.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
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Norhafizah Ismail		✓			✓					✓		✓		
Wiwit Apriyadi		✓				✓		✓		✓				
Agus Riyanto		✓				✓		✓		✓				
Indra Marta Rusmana		✓				✓		✓		✓				

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee.

DATA AVAILABILITY

Data supporting the findings of this study are available at vocational schools Binakarya Mandiri, Bekasi City, West Java, Indonesia.

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