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Smart Group Decision Making on Leadership Style Identification Using Bayes Theorem

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Abstract. The un-synergistic criteria's of the candidate and the organization's vision and mission became the main problem. The subjectivity of certain group tended to bring the frustration hence it provoked the emergence of conflict interests. In order to cover such issues, this paper proposed the blending of an expert system using Bayes theorem and Group Decision Making in identifying the candidate's leadership style. The analysis was conducted in a series of activities through the development of knowledge base, inference engines, weighting, experts' alliance, decision tree diagram, intersection independent and mean sample calculation. As a result, eleven numbers of leadership styles were theoretically identified thus confirmed and weighted by experts. In addition, the correlation between the leadership style and organizational vision and mission was analyzed. The leaders' assessments were perceived by the candidate itself and supported team members. The calculation of estimated values proposed the percentage of candidate leadership style identification. This provided a smart group decision making in recommending organizational decision-makers towards the fit proper elected leader based on the situation. To automate the calculation, prototype assessment software was produced and tested. Black-box and User Acceptance Test found that this application was successfully applied in identifying the leadership style for future leaders.

Keywords: Bayes theorem · Multiple perspectives · Leader election · Leader assessment

1 Introduction

Leadership could be regarded as a process either individual or groups' activities in achieving the ultimate organization's goals through the creation of managing risks, administrative, regulation, creating harmony and maintains commitment within groups [1]. A leader in a nonprofit organization was responsible in generating innovative and effective management in the pursuit of success, motivating and triggering the

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productivity of knowledge members thus the leadership styles, principles and practices towards the achievement of effective leadership became substantial [2, 3]. Moreover, the lacking fund in nonprofit organization enforced a leader to move towards increasing the diversity of funding sources to sustain the missions. A leader in a nonprofit organization played a significant role in inspiring, motivating, encouraging, and drivers of social changes [4]. Leadership style supported and coached the development of team builders through the close relationship between leaders and members, trusts and leader respects, wherewith impact on the production of decision making [5]. Vision and mission are considered as a strategic management process that plays a significant role in achieving the organizational goals thus impact on the performance of an organization. A leader takes a part in translating vision and mission into the day to day activities as well as key drivers on operational of members' work and team buildings [6, 7]. Therefore, the leadership style regarding the characteristics features carries weight on the creation of organizational culture towards the formulation and accomplishment of vision and mission. The emergence of conflicts in leaders' election was unavoidable as well as the political interference. Thus the objectivity of leadership style that meets to members' need, visions and mission are neglected. Effective leaders engage in the process of leadership assessment [8]. The contribution of the supported group as instead of self-assessment in gauging the leadership skills and competencies provides an unprejudiced decision on the leaders. Therefore, leadership competence and the potential need to be measured in recognizing their strength and identify areas toward the target for future growth. Formal procedures presume that collective decision making can be enhanced through the systematic approach in terms of group decision making. Group decision making aids decision-makers in facing fuzzy preferences for alternative and individual judgment towards the optimal solution [9].

In the computer science field, many techniques and algorithms have been applied in group decision making to ensure the election of leaders is efficacious and fairness. It is including Bayes Theorem, Decision tree, K-Mean Clustering, Support Vector Machine, Linear Regression, Learning Vector Quantization, K-Nearest Neighbors, Adaboost, and Random Forest [10], and [11]. Several comparative studies had been conducted to make an evidence of the best theory. Nevertheless, the applicability of the recommended techniques in supporting decision making is pointed out by the requirement of data analysis and proposed weights embedded to provide better results. Bayes theorem is one of the techniques that widely used and explored by researchers. The application of it in forecasting, pattern recognition, diagnostics, natural language processing, and classification problems increased the utilization of this method in many platforms. These above showed the capabilities of Bayes theorem in minimizing several errors in calculation and make them distorted from the real probabilistic results [12]. The Bayes rules in decision making are strong evidence could improve the quality and efficiency of decisions. Thus, the evolvement of it in Multi-Attribute Decision Making (MADM), as well as group decision-makers, became a challenge.

This paper tried to study the application of expert system using Bayes theorem in group decision making. Answering the research question on how a smart group decision-making system designed to solve the election problems. The smart leader assessment presented the identification of an appropriate leadership style based on the calculation of quantitative criteria's from multiple perspectives. As a limitation, a case

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study for the election of the Students Association Leader was conducted through the development of a smart system. Herein, the experts' justification, the lectures, and the colleagues' were asked their contribution in objectively assessing the candidate leaders. These multiple perspectives advanced the complexity of performing alternative priorities which were analyzed based on organizational vision and mission. As a result, the distinguishing of candidate leadership style was presented. This recommendation suggested the decision-makers in selecting the candidate and perceived the management capabilities of the candidate towards organizational success. Therefore, the conflict and political interest amongst candidates can be minimized and the elected leader is voted based on the quality of leadership management capabilities according to the organizational objectives.

2 Literature Review

2.1 Leadership Style

There are many different perspectives in viewing the characteristics of leaders. The shifted from traditional-based theories into situational theory impacts the determination of leadership skills and leader characteristics [13]. As reviews on leadership theories, the principles of styles are defined into eleven types including H1-Democratic, H2-Environmental oriented, H3-Human-oriented, H4-Transactional, H5-Service-oriented, H6-Charismatic, H7-Transformational, H8-Bureaucratic, H9-Task-oriented, H10-Autocratic, and H11-Laissez-faire [14] (See Table 1). The characteristics of the above style are described as sixty-seven criteria symbolized into E1–E67 [15]. Democratic (H1) is explained as the leaders who are including team members in the decision-making process, encouraging and motivating the creativity of team members, and highly engaging team members in the organizational day to day activity. Environmental oriented (H2) leaders support any kinds of environmentally action-oriented movements, the harmonious environment through ecologically friendly services, the application of environmental laws, and raises environmental awareness. Human-oriented (H3) is the opposite of task-oriented. This style involves supporting people in team members that require high participation of leaders and provide input on decision making thus a high level of communication performed. Transactional (H4) leaders start when the team members accept a job from leaders and return the payment for their effort and compliance. Service-oriented (H5) leaders care about the team member needs, constantly adjust, acclimate, and assert the strategies thus successfully accomplish for organizational survival and development. Charismatic (H6) is a leadership style that inspires and motivates the team members to move forward, pursuing the member's passion and commitment towards the goal achievement, high dependency on the leader, and the feelings of invincibility of leaders. Transformational (H7) style focuses on the performance and connection between leaders and team members, increasing of motivation, morality, and fulfilling their potential for goal achievement. Bureaucratic (H8) leaders ensure the procedures are followed precisely. Task-oriented style (H9) can be described as autocratic that leaders make decisions without consulting their team members. Task-driven leadership requires the leaders to a deep

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understanding of task productivity, roles, performance goals and deadlines, and motivated task to succeeding. Autocratic (H10) is kinds of style where leaders have full power over members, cut off the idea from members, provide quick decisions, act immediately upon decisions, provide incredibly efficient, and best used in a crises situation. Laissez-faire (H11) describes leaders who abdicate the responsibilities and complete freedom on members, provides the team members with resources and advice, and allows the job autonomy.

Table 1. Reviews of articles according to the proposed Leadership Style identification model

References	Method	Leadership style proposed	Case study
[13]	Styles and Principles of Educational Leadership	H10, H8, H6, H1, H11, H4	Management Education in Nigeria
[14]	Leadership theories and style	H4, H7	General Concept
[1]	Leadership theories and style	H10, H4, H8, H6, H7, H1, H11.	Management Education in India
[2]	Leadership Style affect group dynamics	H10, H1, H11,	Outdoor recreation students at Lakehead University
[4]	Authentic leadership development	H5, H6, H7, H3, H2, H9	University of Nebraska-Lincoln
[5]	The partial least squares method	H7, H6	Nonprofit organizations in Mexican Case

2.2 Bayes Theorem

Bayes theorem as one of the probabilistic models has been widely used in data analysis to evaluate decisions for decision making. One of the main is by determining the probability of belief from the numbers of decision-makers' inquiries and measuring the advantages of evidence values thus provides the numbers of the likelihood for the uncertain situation [16]. Bayes theorem is capable of combining new evidence and existing evidence as well as subjective probability and reviewing the previous one based on the information trace. This indicates that Bayes theorem is not only an ordinary calculus and measurement system. The uncertainty measured and probabilities are considered by Bayes theorem as shown in Eq. 1 where E_1, E_2, …, E_m are double evidence and H_1, H_2, …, H_m are a double hypothesis.

$$p(H_i|E_1E_2\ldots E_m) = \frac{p(E_1E_2\ldots E_m|H_i) \times p(H_i)}{\sum_{k=1}^{n} p(E_1E_2\ldots E_m|H_k) \times p(H_k)} \quad (1)$$

In this paper, the combination of the experts perceives as well as multiple perspectives have been considered by combining the probability estimation in uncertainty situation. Thus, the analysis of probability assessments will be calculated from different

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sources into a single estimation using Bernoulli's probability formula [17]. This independently explains the context of the dichotomous perceptual decision by considering estimated on the experts' weights through the combination of ecological validity and subjective reliability. The probability estimation for multiple experts is determined in Eqs. 2 and 3.

$$\frac{pq}{[pq + (1-p)(1-q)]} \tag{2}$$

where:

p is the probability estimation of expert 1, and q as the estimation of expert 2.

In order to analyze the probability intersection between leadership style and vision and mission, Eq. 3 is applied.

$$\mathrm{P}(\mathrm{A} \cap \mathrm{B}) = \mathrm{P}(\mathrm{A}) \cdot \mathrm{P}(\mathrm{B}) \tag{3}$$

where:

A is defined as the probability estimation of vision and mission from the department, and B as the estimation from faculty.

The calculation of the mean sample is conducted to easily understand the central tendency from multiple observations. The following mean sample formula can be depicted in Eq. 4.

$$\overline{X} = \frac{X_1 + X_2 + X_3 + \ldots + X_n}{n} \tag{4}$$

where:

X_1, X_2, … X_n is a random independent variable and n is a number of random variables.

3 Methodology

As a methodology, several activities are listed (see Fig. 1). Data collection was gotten hold of by reviewing the leadership theories, Bayes theorem and its application in decision making. To strengthen the theoretical foundation, interviews and observation were conducted with regards to students' affairs process in five departments of Faculty science and technology, UIN Suska Riau viz., Informatics Engineering (IF), Electrical Engineering (EE), Industrial Engineering (IE), Information System (IS) and Applied Mathematics (AM). Dean, deputy dean of students' affairs, head of the department, head of students association in faculty level, head of students association in department level, and team members of students association became target respondents in multiple viewing on the election process, the organizational needs, the objective, and goals. As an expert judgment, two experts from management leadership field were interviewed and knowledgeable transferred into knowledgebase development.

The analyses were performed through the development of knowledge base, inference engines, a combination of experts weighting, and decision tree diagrams. Herein,

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the calculation of probability values in leadership styles, criteria as indicators, vision and mission was carried out using Bayes theorem. Due to the complexity of multiple perspectives in group decision making, the estimation was figured out by applying the intersection independent formula in Eqs. 2 and 3. Intersection provided the dissections of probability values of leadership style over vision and mission in department and faculty level.

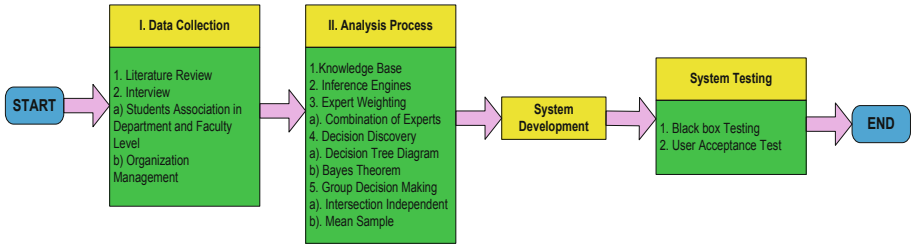

Fig. 1. Research procedure

Furthermore, the mean sample was then estimated based on the calculation of probability values from numbers of users involved in leaders' assessment. As a result, the appropriate leadership styles were identified and ranked. The recommendations were given as corrective action to aid decision-maker in making decisions in leader election.

To automate the analysis process, prototype software of leader election system was developed. The root process and calculation were worked out by the system. Twenty users from each department (2 candidates, 2 lectures, and sixteen colleagues) for totally one hundred respondents from the faculty were asked their leader assessment by answering the questionnaires. The questionnaire was made in "Yes" and "No" questions formatted based on the flow of forward chaining procedure and Bayes calculation. Black box testing and user acceptance test was performed in ensuring the capability of this system in measuring the leadership election and providing fit proper leader as well as the recommended leadership style.

4 Result and Analysis

4.1 Knowledge Base Development

The knowledge base was developed by analyzing the correlation between sixty-seven indicators (E1–E67) and eleven leadership style (H1–H11). Herein, H1 was described by fifteen criteria; H2 in ten indicators; H3 in 8 indicators; H4 in fourteen indicators; H5 in 8 indicators; H6 in 9 indicators; H7 in eleven indicators; H8 in 9 indicators; H9 was in 6 indicators; H10 was in fourteen indicators, and finally, H11 provided twelve indicators. In order to explain the knowledge base in forms of rule-based, the decision tree diagrams were generated (see Fig. 2).

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Forward chaining procedure was followed as inference engines traced from up to down iteration. The example of the rule base as follows

The rule for H9: Task Orientation Style IF E1 AND E2 AND E3 AND E45 AND E46 AND E47.

This rule-based was intelligently generated in reliance on the users' answers during the leader assessment.

4.2 Expert Weighting

The analysis went forward into the leadership style and indicators' weighting by two experts. The probability values of indicators were estimated as well as subjective probability value against the hypothesis. It ranges from 0 to 1 which indicates the significant level of the indicator. Meanwhile, the probability values of experts weighing on leadership style (H1–H11) and 67 indicators (E1–E67) were distracted at Table 2 based on Eq. 1. Moreover, two experts were also given their probability values weighing on the correlation between organizational vision and mission of 5 departments (IF, EE, IE, IS, AM) and the leadership style.

To obtain a single subjective probability from multiple experts, Eqs. 2 and 3 are applied. Meanwhile, the probability value of experts' intersection between departments' vision and mission and leadership style was explained in Table 3. The mean score was provided as the calculation remark of intersection and Bayes probability values as referring to Eqs. 3 and 4.

Table 3 in mean score column identified the list of leadership style which accommodated the department's vision and mission. For example, Department Informatics Engineering (IF) provided the mean score ranging from the lowest in 1,084 to the highest 1, 44175. It meant that Human-oriented (H3) and Transformation (H7) styles became the most recommended of leadership style in this department. It was followed by Service-oriented (H5), Environmental-oriented (H2), Democratic (H1), Task-oriented (H9), Bureaucratic (H8), Laissez-faire (H11), Transactional (H7), Charismatic (H6), and Autocratic (H10) as the less one.

Referring to the input of leaders' assessment, the calculation of group decision making for 100 respondents was carried out. Equations 1, 2, 3 and 4 were initiated. The consideration of experts' weight enriched the multiple perspectives calculation in identifying the leadership style of the candidate. As a result, the decision-makers have suggested whether the candidate fitted into the flawless leaders as in the particular department.

4.3 Prototype System Leadership Style Identification

The architecture system development can be depicted (see Fig. 3). The System Interface was designed to accommodate the leader assessment form in forms of expert system-question and answer platform. The questionnaire was performed in accordance with the knowledge base rules and weights development. As a result, the list of the candidate leadership style was then ranked and identified its concordance with the expert recommendation. In order to test the functionality of the application, the Expert

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Judgement, Black box and User Acceptance Test (UAT) were conducted. It found that the system application is running well and provided the analysis and result as the expert knowledge transferred.

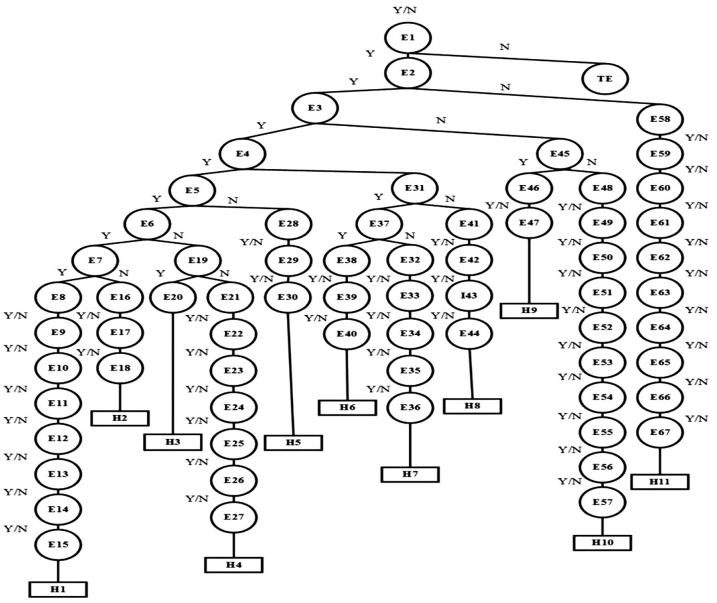

Fig. 2. Decision tree diagrams

Table 2. Probability hypothesis on indicators

$p(E_i\|H_i)$	Probability	Hypothesis										
		i = 1	i = 2	i = 3	i = 4	i = 5	i = 6	i = 7	i = 8	i = 9	i = 10	i = 11
$p(E_1\|H_i)$	Expert One	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
	Expert Two	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
$p(E_2\|H_i)$	Expert One	0,6	0,5	0,5	0,2	0,5	0,2	0,6	0,2	0,4	0,5	0,3
	Expert Two	0,6	0,4	0,4	0,3	0,4	0,2	0,6	0,3	0,5	0,4	0,4
$p(E_3\|H_i)$	Expert One	0,8	0,4	0,4	0,3	0,4	0,3	0,6	0,4	0,4	0,5	0
	Expert Two	0,8	0,3	0,5	0,2	0,3	0,2	0,7	0,3	0,3	0,5	0
…	…	…	…	…	…	…	…	…	…	…	…	…
	…	…	…	…	…	…	…	…	…	…	…	…
$p(E_{47}\|H_i)$	Expert One	0	0	0	0	0	0	0	0	0	0	0,8
	Expert Two	0	0	0	0	0	0	0	0	0	0	0,8

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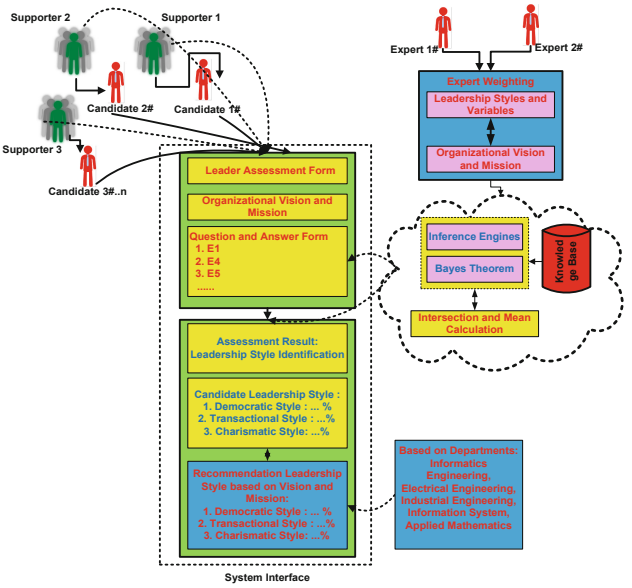

Fig. 3. Leadership style system architecture

Table 3. Probability intersection on hypothesis and mean score

Leadership Style	Department hypothesis					Probability mean score				
	IF	EE	IE	IS	AM	IF	EE	IE	IS	AM
H1	0,819	0,819	0,819	0,8463	0,8372	1,4095	1,4095	1,4095	1,42315	1,4186
H2	0,8366	0,799	0,846	0,846	0,846	1,4183	1,3995	1,423	1,423	1,423
H3	0,8835	0,9021	0,8835	0,9021	0,8928	1,44175	1,45105	1,44175	1,45105	1,4464
H4	0,6132	0,6132	0,6132	0,6132	0,584	1,3066	1,3066	1,3066	1,3066	1,292
H5	0,873	0,8633	0,873	0,8924	0,8924	1,4365	1,43165	1,4365	1,4462	1,4462
H6	0,5312	0,5184	0,5312	0,5056	0,48	1,2656	1,2595	1,2656	1,2528	1,24
H7	0,9935	0,9025	0,874	0,90025	0,8835	1,44175	1,45125	1,4365	1,45125	1,44175
H8	0,7304	0,7304	0,7304	0,7138	0,7138	1,3652	1,3652	1,3652	1,3569	1,3569
H9	0,748	0,748	0,7565	0,748	0,765	1,374	1,374	1,37825	1,374	1,3825
H10	0,168	0,165	0,165	0,18	0,195	1,084	1,084	1,0825	1,09	1,0975
H11	0,6688	0,6424	0,6688	0,6776	0,6424	1,335	1,3212	1,3344	1,3388	1,3212

5 Conclusion

Bayes theorem has been successfully applied in smartly identifying the leadership style in leader election. A group decision making, as well as multiple perspectives of the leader assessment process, turned over a complex decision making into unsophisticated adaptive problem-solving in the absence of respondents' vote. Two experts weighting towards the leadership styles and its relation to organizational vision and mission found the level significance of it based on the organizational situation. Thus, the assessment

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values became more immaculate not just in follow up respondents' vote as well as experts judgment confirmation.

Intersection independence and mean values calculation enriched the complexity of leadership style identification as an alternative priority. The recommendation of leadership style aids the decision-makers in making the right decision for leader election. Therefore, the quality of decisions was a guarantee, more objective, could minimize political intervention and ensuring the fit proper elected leader based on the situation. Moreover, the candidate leaders can measure his capabilities, skills, and knowledge-based upon organizational needs. To automate the calculation, the prototype system leadership style identification has been successfully developed and tested. It showed the significant tool in aiding the leader election process.

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