Decision Support System for Managing and Determining International Class Program

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Abstract

Indonesian higher education today is faced with serious challenges that will threaten the existence of some universities. An increasing international competition will require that universities take a progressive approach to attract enough students to ensure their survival. One way the universities must improve is in the quality of their administration management. While universities in Indonesia do not compare well internationally, steps can be taken to improve the quality. There are potential lessons to be learned from corporate experience in quality control management. Decision-making in the field of academic resource planning involves extensive analysis of many data originating from multiple systems. Academic resource planning management is concerned with management resources in order to effectively support the university's educational framework (such as offered degrees, enrolment and retention, resources teaching, course structure and curriculum). We propose a methodology for managing and determining the proposed International class based on many criteria of academic performance in university. The approach has been implemented as a decision support system allowing evaluation of various criteria and scenarios. The system combines two different methods in decision support system: Analytical hierarchy Process (AHP) and linear weightage model, the proposed model uses the AHP pairwise comparisons and the measure scale to generate the weights for the criteria which are much better and guarantee more fairly preference of criteria. Applying the system as decision-support facility for the management has resulted in significant acceleration of planning procedures and implementation, raised the overall effectiveness with respect to the underlying methodology and ultimately enabled more efficient academic administration.

I. INTRODUCTION

Entering an age of rapid economic growth, it is common for Universities to elevate their existing universities to World Class stature or to becoming World Class universities. This issue is heard from President of Universities all the way to ministers of education. There are several approach that Indonesian universities can focus on in response to these challenges; but first and foremost a there needs to be a realization that a university is also a business and therefore reform strategy needs to focus on market principles. Making efforts to attract more foreign students will be necessary. In order to attract international students, Indonesian universities are going to have to make greater efforts in improving the quality of their course offerings and move towards a new paradigm of world Class University. Although the terminology of World Class University has been used widely in discussion about academic institutions, there has been little attempt to define the term carefully. The definition of what makes a University become a world class university is subjective. By definition, a world class university is one on which there is widespread agreement of an international reputation, that it is one of the best in the world. The lack of an absolute set of performance criteria and measures may mean that world class will always be positional. Indeed, even when criteria are used to rank and measure university performance, they are incomplete and difficult to measure, and the ones that do exist are not very powerful predictors, especially for universities in non-English speaking countries. The subjective nature of world class status means that institutions will attempt to address those dimensions that are considered in assessing reputations and that are visible.

Internationalization has increasingly becoming an important aspect for a university. Historically, by their very nature of producing commonly valid knowledge, universities are accepted as international organizations [1]. Hence, the need to understand internationalization of the university becomes more important. Until recent time the literature has mainly focused on rationales of internationalization and forces of internationalization [2-4], and approaches to internationalize [5-7]. Although internationalization in most cases is a comprehensive change process, the literature has failed to explain how exactly the process nature. As a result, many universities are trying to internationalize without holding a comprehensive change approach and unaware or ignorant of the rich literature which may help them successfully accomplish the internationalization process. Although the economic rationale of internationalization has commonly been highlighted in the literature there are other rationales as well. Several authors

argued that internationalization has ***political*** [6], economic [3, 4, 6, 7], academic [8-10], and cultural/social rationales [3, 4]. Different approaches to accomplish internationalization in universities can be achieved using an open systems understanding [5-7, 11]. In other words, these approaches reflect the idea that the organizations exist in a dynamic environment and they need to respond effectively to the developments in their environment for their survival. Four basic approaches to internationalize consist of: activity approach (developing or joining exchange programs, bringing international student body), competency approach (change in the knowledge, skills, interests, values, and attitudes of different groups of in the organization), ethos approach (developing a culture and climate which facilitates internationalization) and process approach (developing an international aspects not only into academic aspects of the organization but also managerial aspect) [6]. These approaches indicate that the universities are pursuing multiple strategies in order to internationalize. Nevertheless, these strategies are not mutually exclusive but interconnected to each other. As a result, the majority of universities are trying to build an international dimension by experimenting, trial and error, imitation, and the like. An analysis of an internationalization process in a business school showed that the school formally defined (plan) a limited number of academic and managerial dimensions at the onset of the change program of internationalization (*i.e.*, finance, switch of teaching language, marketing strategy). On the other hand, the school continuously modified these formally defined dimensions (*i.e.*, change strategy, human resources aspects of the process) and developed new dimensions as a result of emergent needs (*i.e.*, modifying the admission process, developing student services, internationalizing the teaching content, *etc*.)[12].

Academic resource planning is a highly complex administrative procedure based on extensive analysis of the entire data related to the educational framework, such as teaching resources, offered degrees, course structure and curricula, enrolment and retention, etc. “State-of-the-art” decision-making within most universities around the globe has the form of an argumentative pie-cutting barely backed up by any solid quantitative analysis. However, the emergence of advanced information technologies has altered the operational environment of universities world-wide offering them an opportunity to move on towards more systematic and efficient management of their assets. Accurate computational model, comprehensible methodology, complete and consistent data basis and a friendly output presentation are of paramount importance for advanced decision support. Frequently experienced problems include

unavailability of the data in an appropriate form and lack of tools and approaches for its evaluation. From the early days of information systems administrative academic processes such as effective resource distribution, teaching personnel management, automation of student admission and registration, student performance, retention and dismiss, to name the major ones, have been among the "hottest" educationalist issues. In the 80-ies the academic decision theory focused mainly on formulating the general principles and approaches of the model-based decision support systems (DSS) for academic environments [13] [14]. Various academic DSS for resource allocation [15], performance assessment [16], course scheduling [17], admission policy [18], advising [19], and student profile evolution [20] have previously been proposed, while in the 90-ies apparently encouraged by the overall advancement of information technology. The goal of our research is to contribute to the next generation of academic DSS based on managing and determining proposed international class. Decision-making is supported primarily by means of information presentation and by providing options for its explorative analysis. Our DSS targets to support the administrative task of planning the university's educational strategy in choosing proposed International class. Decision-makers are able to evaluate various criteria and generate decision with the input data. Our contribution is basically twofold: 1) to propose the new methodology for managing the educational resources and 2) to determine the best proposed study program as International class. The paper is structured as follows: Section 2 introduces the proposed new methodology, in Section 3 we analyze and discuss on the implementation issues; we conclude by a summary of our contribution and future research aspects are discussed in Section 5. In order to provide some tentative answers, we have organized the paper in the following way.

II. METHODOLOGY

Linear Weightage Model

This model is mostly depending upon Higher Education Management's judgment as they have to assign weights to the criteria that involve in decision making process. In most cases there are some criteria considered as more important than others, such as number of international student body, number of professor with the highest degree in their field, number of journal in accredited publication produce by staff in the last 5 years. Higher Education Managements

should assigned weight to each individual criterion in order to determine the relative importance of each one. These weights play a vital role in decision making process and extremely affect the final decision. First of all Higher Education Management has to identify all criteria that involve in the certain process before performing any other steps. After identifying all the criteria related to study program selection decision, Higher Education Management has to determine threshold for each criterion. In fact, threshold can be divided into two types, i.e. maximum and minimum. To establish a threshold to criterion, decision maker should classify all criteria into two groups. The first group known as "Larger is better" while the other known as "Smaller is better". average graduation rate GPA, Number of professors with the highest degree in their fields, and test scores of students on university TOEFL test can be categories a "Larger is better" and the threshold for this type of criteria must be minimum. On the other hand, most of the qualitative criteria can be considered as "Smaller is better" such as acceptance rate and job waiting time for fresh graduate.

Once the attribute is considered as maximum type of thresholds, formula 1 should be used.

$$V_{\max} = \frac{Max - \text{Study Program}}{Max - Min} \quad (1)$$

where

V max = study program that has maximum type of threshold with respect to a particular attribute/criterion.

Study Program= specific study program that is considered at the time.

Max = maximum value of particular attribute/criteria among all study program proposed

Min = minimum value of the same attribute among the whole study program.

In the other case when the attribute is classified under the minimum type of threshold, formula 2 is the only option for calculating the study program's value.

$$V_{\min} = \frac{\text{study program} - \min}{\max - \min} \quad (2)$$

where

Vmin = study program that has minimum type of threshold with respect to a particular attribute/criterion.

Study Program= specific study program that is considered at the time

Max = maximum value of a particular attribute/criterion among all study programs.

Min = minimum value of the same attribute among the whole study programs.

The idea of using formula 1 and formula 2 is extremely valuable because they provide a method that enables the comparisons among decision criteria. Usually decision criteria have different units of measure so any comparisons among those criteria are not logically acceptable. By using the data normalization concepts which represented in formula 1 and formula 2, all the criteria will be having weights instead of variety of measurement units and then the comparisons can simply be made.

When all values of the criteria matrix are calculated, series of calculations should be achieved by multiplying weights W_i of criteria by the whole values X_i within the matrix. The total score should also be calculated using formula 3 for each study program which represents the study program's scores. The final decision table includes a total score for each study programs and the one who gains the highest score is recommended as the best study programs over all.

$$Total\ Score = \sum W_i X_i \Big/ \sum W_i \qquad (3)$$

2. Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) was originally designed by [21] to solve complicated multi-criteria decision problem, beside that AHP is appropriate whenever a target is obviously declared and a set of relevant criteria and alternatives are offered [22]. AHP has been proposed for study program selection problem to support Higher Education manager through the decision making activity, which aims to select the right Study program to be promoted as International class. AHP is a popular model to aggregate multiple criteria for decision making [23]. In AHP the problems are usually presented in a hierarchical structure and the Higher Education Management is guided throughout a subsequent series of pairwise comparisons to express the relative strength of the elements in the hierarchy. In general the hierarchy structure encompasses of three levels, where the top level represents the goal, and the lowest level has the study

program under consideration. The intermediate level contains the criteria under which each study program is evaluated. The final score obtain for each study program across each criterion is calculated by multiplying the weight of each criterion with the weight of each study program. The study program which has got the highest score is suggested as the best study program and Higher Education Management may consider that one as the best decision choice for International class.

3. The Proposed Hybrid Model

Based on the previous discussion about both models, there is an urgent need for new model that can support the study program selection decision and offer a powerful tool which can ultimately produce satisfactory results. This paper intends to achieve this objective by proposing new hybrid model. This new model concentrates on avoiding all the shortcomings mentioned above. It combines two different aspects from both AHP and linear weightage model. The new model uses the measurement scale of AHP model to determine to which degree each single criterion is preferred in comparison with others. Once the pairwise comparisons have been made, decision maker can obtain the weights of whole criteria when specify the relative preference of criteria. The next step in the proposed model is to assign thresholds to all criteria considering "Larger is better" or "Smaller is better".

Calculate the values for each single cell in the criteria matrix which depends upon specifying the thresholds of criteria first. Regarding thresholds and the data of study programs the decision table matrix can be created. Calculation of the whole values in the decision table matrix has to be produced by considering the two formulae. If the threshold is maximum then formula 1 should be used, otherwise formula 2 is applied for minimum threshold. When the whole cells that represent each study program across only criteria will be filled with a certain value in the decision table matrix, then each column will multiply by the column of criteria weights and obtain the new values of these cells. Now each column represents one of the competitive study programs, the last step in the proposed model is to compute the sum of each column to get the final scores of all study programs. The highest score indicates to the best study program and that study program will be recommended as the most appropriate study program among the competitors.

III. ANALYSIS AND DISCUSSION

First column in Table 1 shows the criteria of the selection study program which are average graduation rate (GPA). These criteria involve in the study program selection process are eleven different criteria which describe each study program that has been proposed to open International Class in the following year. The eleven criteria for determining International class are average graduation rate GPA (A), average freshman retention rate (B), Number of professors with the highest degree in their fields (C), test scores of students on university Acceptance test (D), test scores of students on university TOEFL test (E), proportion of enrolled freshmen who were in the top 10 percent of their high school classes (F), number of joining exchange programs (G), number of international student body (H), acceptance rate (I), Job waiting time for fresh graduate time (J), and Proportion of permanent academic staff and student body (K). The rest of the columns represent the six proposed study programs. P1 in the third column refers to study program1 and P2 in the next column refers to study program 2 and so on till P6 which refers to study program 6.

Table 1 Criteria and Program Study

Attribute	Measurement unit	p1	P2	P3	P4	P5	P6
average graduation rate GPA (A)	Number	3.12	3.2	3.35	3.15	2.95	3.05
average freshman retention rate (B)	Percentage	86%	89%	90%	95%	88%	80%
Number of professors with the highest degree in their fields (C)	Number	5	6	4	4	5	7
test scores average of students on university Acceptance test (D)	Number	475	490	500	515	486	479
test scores average of students on university TOEFL test (E)	Number	490	450	464	470	465	460
proportion of enrolled freshmen who were in the top 10 percent of their high school classes (F)	percentage	25%	20%	15%	10%	12%	18%
number of joining exchange programs (G)	Number	2	3	2	1	2	4
Number of international student body (H)	Number	10	3	2	1	5	7
acceptance rate (I)	Percentage	20%	24%	15%	30%	23%	28%
Job waiting time for fresh graduate (J)	Month	6	7	5	10	12	4
Proportion of permanent academic staff and student body (K)	number	0.05	0.07	0.08	0.065	0.045	0.055

Applying the proposed model to study program selection decision implies that all the steps above have to be followed. Accordingly, the preference criteria matrix was obtained which compare each criterion to the others and Table 2 depicts the preference criteria matrix and gives

a glimpse of Higher Education Management judgment and preference of criteria in a form of pairwise comparisons.

Table 2 Preference Criteria Matrix

Criteria	A	B	C	D	E	F	G	H	I	J	K
A	1.00	3.00	0.20	3.00	3.00	3.00	0.33	0.14	5.00	1.00	0.33
B	0.33	1.00	0.14	0.33	0.20	1.00	0.20	0.14	0.33	0.33	0.20
C	5.00	7.00	1.00	5.00	5.00	7.00	3.00	1.00	7.00	5.00	3.00
D	0.33	3.00	0.20	1.00	1.00	3.00	0.20	0.14	5.00	3.00	0.20
E	0.33	5.00	0.20	1.00	1.00	5.00	1.00	0.33	0.20	5.00	1.00
F	0.33	1.00	0.14	0.33	0.20	1.00	0.33	0.14	1.00	5.00	0.20
G	3.00	5.00	0.33	5.00	1.00	3.00	1.00	1.00	5.00	7.00	1.00
H	7.00	7.00	1.00	7.00	3.00	7.00	1.00	1.00	5.00	5.00	1.00
I	0.20	3.00	0.14	0.20	5.00	1.00	0.20	0.20	1.00	3.00	0.14
J	1.00	3.00	0.20	0.33	0.20	0.20	0.14	0.20	0.33	1.00	0.14
K	3.00	5.00	0.33	5.00	1.00	5.00	1.00	1.00	7.00	7.00	1.00
Sum	21.53	43.00	3.90	28.20	20.60	36.20	8.41	5.30	36.87	42.33	8.22

A and J, B and F, C and H, D and E, F and I have an equal preference of criteria that's why the cell across each two of them is filled with ones. On other hand, G is more important than A so the cell which represents A across G in the second row and four columns is filled with 0.33 according the AHP measure scale, and thus when compare G to A it should be 3 because it's the opposite comparison. The same concept is followed to fulfill all the pairwise comparisons.

The next step is to obtain the weight for each criterion by normalized the data in Table 2. Three procedures applied to preference criteria matrix and immediately the weights will be calculated.

1. Sum the elements in each column.
2. Divide each value by its column total.
3. Calculate row averages.

Performing of the previous mathematical calculation yields the normalized matrix of criteria as illustrated in Table 3. The average weights of rows are computed in the last column to indicate the weights of the criteria.

Table 3. The average weights

	A	B	C	D	E	F	G	H	I	J	K	Weight
A	0.046	0.070	0.051	0.106	0.146	0.083	0.040	0.027	0.136	0.024	0.041	0.070
B	0.015	0.023	0.037	0.012	0.010	0.028	0.024	0.027	0.009	0.008	0.024	0.020
C	0.232	0.163	0.257	0.177	0.243	0.193	0.357	0.189	0.190	0.118	0.365	0.226
D	0.015	0.070	0.051	0.035	0.049	0.083	0.024	0.027	0.136	0.071	0.024	0.053
E	0.015	0.116	0.051	0.035	0.049	0.138	0.119	0.063	0.005	0.118	0.122	0.076
F	0.015	0.023	0.037	0.012	0.010	0.028	0.040	0.027	0.027	0.118	0.024	0.033
G	0.139	0.116	0.086	0.177	0.049	0.083	0.119	0.189	0.136	0.165	0.122	0.125
H	0.325	0.163	0.257	0.248	0.146	0.193	0.119	0.189	0.136	0.118	0.122	0.183
I	0.009	0.070	0.037	0.007	0.243	0.028	0.024	0.038	0.027	0.071	0.017	0.052
J	0.046	0.070	0.051	0.012	0.010	0.006	0.017	0.038	0.009	0.024	0.017	0.027
K	0.139	0.116	0.086	0.177	0.049	0.138	0.119	0.189	0.190	0.165	0.122	0.135
Sum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

From the Table 3, the weight for the A criterion is 0.070 while the weight of B criterion is 0.020 and so on. The next step in the proposed model is to compute the criteria value matrix using the previous formulae relying upon the thresholds which have already been determined earlier. Once the threshold of a certain criterion is maximum type, thus formula1 should be applied to compute the value of that criterion with respect to all suppliers.

Table 4 Criteria' Values Matrix

Criteria	Treshold	p1	p2	p3	p4	p5	p6
A	min	3.120	3.200	3.350	3.150	2.950	3.050
B	min	0.860	0.890	0.900	0.950	0.880	0.800
C	min	5.000	6.000	4.000	4.000	5.000	7.000
D	min	475.000	490.000	500.000	515.000	486.000	479.000
E	min	490.000	450.000	464.000	470.000	465.000	460.000
F	min	0.250	0.200	0.150	0.100	0.120	0.180
G	min	2.000	3.000	2.000	1.000	2.000	4.000
H	min	10.000	3.000	2.000	1.000	5.000	7.000
I	max	0.200	0.240	0.150	0.300	0.230	0.280
J	Max	6.000	7.000	5.000	10.000	12.000	4.000
K	Min	0.050	0.070	0.080	0.065	0.045	0.055

The last step in the proposed model is to compute the final score of each study program by multiplying each column in table 3 by the corresponding weights of attributes from table 4. Then get the sum of each column and the sum represents the score of each single study program. Table 5 depicts the final scores of study programs. The most important thing is regarding the

final results, the study program which has the highest score is suggested as the best study program for the proposed hybrid model.

Table 5 Final Decision Matrix

Criteria	Treshold	p1	p2	p3	p4	p5	p6	weight
A	min	0.425	0.625	1	0.5	0	0.25	0.0698917
B	min	0.4	0.6	0.6666667	1	0.5333333	0	0.0196842
C	min	0.3333333	0.6666667	0	0	0.3333333	1	0.2257585
D	min	0	0.375	0.625	1	0.275	0.1	0.0531824
E	min	1	0	0.35	0.5	0.375	0.25	0.075653
F	min	1	0.6666667	0.3333333	0	0.1333333	0.5333333	0.0327909
G	min	0.3333333	0.6666667	0.3333333	0	0.3333333	1	0.1254512
H	min	1	0.2222222	0.1111111	0	0.4444444	0.6666667	0.1831496
I	max	0.6666667	0.4	1	0	0.4666667	0.1333333	0.0518202
J	max	0.75	0.625	0.875	0.25	0	1	0.0272127
K	min	0.1428571	0.7142857	1	0.5714286	0	0.2857143	0.1354056
Value		0.520541	0.506591	0.426866	0.229817	0.280518	0.605312	

In accordance with the results generated by the proposed hybrid model, P6 has the highest score of 0.605312 in comparison with the rest of study programs. As a result, the proposed hybrid model would recommend P6 as the best study program among all competitors.

IV. CONCLUSION

The proposed hybrid model derived from both Linear Weightage and AHP models. AHP is considered as one of the most accurate and optimal models that can support study program selection process. Thus the proposed model is considered as a robust tool that can assist Higher Education Management in the activity of study program selection. In addition, the proposed model saves time because there are only a few computations to be done. Also it saves effort due to its simplicity, and that will strongly accelerate the study program selection decision as well as improving the whole business processes within organizations in turn.

Other advantage of the proposed model is avoiding the limitation in the linear weightage model which assigning the weights of criteria directly by Higher Education Management. The

proposed model uses the AHP pairwise comparisons and the measure scale to generate the weights for the criteria which are much better and guarantee more fairly preference of criteria. Thus the proposed model overcomes the absolute dependency on human judgment as in the case of Linear Weightage model. In conclusion, the proposed model can be considered as a powerful model for study program selection problem. It fully integrates the advantages of both linear weightage model and AHP approach in addition to maintaining the shortcomings of them. Hence mathematical models are contributing more in managerial decisions. Future research of this analysis can be conducted using more complex criteria and using other approach.

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