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# Decision support system for managing and determining international class program: Ga and AHP approach

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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. The present study is aimed at achieving an alternative method, a hybrid model for managing and determining the proposed International class based on many criteria of academic performance in university. The model 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. Findings show that 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.*

**Keywords:** *administration management, academic administration, quality control management, decision support, analytical hierarchy process, linier weightage model*

## 1. 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 approaches that Indonesian universities can focus on in response to these challenges; but first and foremost there needs to be a realization that a university is also a business form 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 universities. 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 becomes a world class university is subjective. By definition, a world class university is one in 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 the world class status 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 the 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 (Kerr, 1990). 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 (Kehm, 2003, Yelland, 2000, Callan, 2000), and approaches to internationalize (Howe, 1998, Knight, 1999, Denman, 2001). Although internationalization in most cases is a comprehensive change process, the literature has failed to explain how exactly the process proceeds. 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 (Knight, 1999), economic (Callan, 2000, Knight, 1999, Yelland, 2000, Denman, 2001), academic (Healey, 1998, Hay, 2000, Haigh, 2002), and cultural/social rationales (Callan, 2000, Yelland, 2000). Different approaches to accomplish internationalization in universities can be achieved using an open systems understanding (Howe, 1998, Knight, 1999, McBurnie, 2000, Denman, 2001). In other words, the organizations exist in a dynamic environment and they need to take action 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) (Knight, 1999). 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 (Kondakci, 2005).

## **2. Method**

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

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decision support. Frequently experienced problems include unavailability of data in an appropriate form and a 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 (Kassicieh, 1986) (Turban, 1988). Various academic DSS for resource allocation (Franz, 1981), performance assessment (Deniz, 2001), course scheduling (Deris, 1997), admission policy (Elimam, 1991), advising (Murray, 1995 ), and student profile evolution (Borden V.M., 1998) have previously been proposed, while in the 90-ies apparently encouraged by the overall advancement of information technology.

The goal of the present study 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. The proposed DSS is targeted 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. The expected research 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 present report is structured as follows: Section 1 describes background of the research; Section 2 covers the rationale; Section 3 introduces the proposed new methodology; Section 4 presents analyses and discusses the implementation issues; and Section 5 concludes in a summary of possible contribution and future research aspects.

### **Grey Analysis**

Prof. Deng Julong first proposed grey system theory with the publication of his article "The Control Problems of Grey System" (Ju-Long, 1982) in an international journal in March 1982. After more than a decade of elaboration by Prof. Deng and other domestic and foreign grey system researchers, grey system theory had grown increasingly mature, and had been applied to ten or more fields, including life science, agriculture, environmental protection, electricity, and manpower. The grey relational analysis is a kind of method by which the related degree of every factor in the system is analyzed. The basic idea of this method is to judge the related degree by dynamic developing situation of the system. In this paper, the problem of evaluating the *e-government* website quality is regarded as a grey multi-objectives decision-making problem, and a grey relational evaluation model of the comprehensive situation is set up and studied practically.

#### **Setting Up the Eigenvalue Matrix**

Suppose the number of the *e-government* website is  $m$ , and the number of the website quality indicators is  $n$ , then a  $m \times n$  eigenvalue matrix is set up.

$$[X] = \begin{Bmatrix} X_1 \\ X_2 \\ \vdots \\ X_m \end{Bmatrix} = \begin{Bmatrix} X_1(1) & X_1(2) & \cdots & X_1(n) \\ X_2(1) & X_2(2) & \cdots & X_2(n) \\ \vdots & \vdots & \cdots & \vdots \\ X_m(1) & X_m(2) & \cdots & X_m(n) \end{Bmatrix} \quad (1)$$

In formula (1),  $x(k)$  means the value of the number  $i$  *e-government* website and the number  $k$  website quality indicators. Usually, two kinds of quality indicators are included, which are the maximum type indicator (the bigger the better), the minimum type indicator (the smaller the better).

#### Standardized Transformation

Usually, it is difficult to compare between different kinds of indicators because of the different dimension. Therefore, the standardized transformation to these indicators must be done. Two formulas can be used to do this as follows:

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$$X_i = \frac{[X_i(k) - \min X_i(k)]}{[\max X_i(k) - \min X_i(k)]} \quad (2)$$

$$X_i = \frac{[\max X_i(k) - X_i(k)]}{[\max X_i(k) - \min X_i(k)]} \quad (3)$$

Formula (2) is suitable for the maximum type indicator, Formula (3) is suitable for the minimum indicator.

### The Calculation and Analysis of the Grey Relational Degree

The grey relational degree can be calculated by steps as follows: Firstly, the absolute difference of the compared series and the referential series should get by the following

$$\Delta X_i(k) = |X_0(k) - X_i(k)| \quad (4)$$

and the maximum and the minimum should be find out. Secondly, choose the value of  $p$ . Here, the constant  $p$ . is the distinguishing coefficient of the grey relation, and its function is to adjust the comparative environment. In practical application, we usually suppose  $p = 0.5$ . Finally, calculate the relational coefficient and relational degree by formulas as follows:

$$\xi_{i_k} = \frac{(\Delta_{\min} + \rho \Delta_{\max})}{(\Delta_i(k) + \rho \Delta_{\max})} \quad (5)$$

$$r_i = \sum [w(k) \times \xi_i(k)] \quad (6)$$

$w(k)$  in Formula (5) is the proportion of the number  $k$  quality indictor to the total quality indictors. Different people can assign different weight to the same indicator, and it means that the importance of the same indictor is different to different quality assurance person. But the sum of  $w(k)$  is 100%. The result by using Formula (5) can be used to measure the comprehensive quality situation of the e-government website.

### Analytical Hierarchy Process

Analytic Hierarchy Process (AHP) was originally designed to solve complicated multi-criteria decision problem (Saaty, 1980). In addition to this, AHP is appropriate whenever a target is obviously declared and a set of relevant criteria and alternatives are offered (Ozden, 2005). AHP has been proposed for study program selection problem to support Higher Education managers 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 (Kevin, 2008). 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.

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Generally, AHP has the following steps:

- a. Employ a pair-wise comparison approach. Fundamental scale for pair-wise comparisons developed to solve this problem (Saaty, 1980). The pair-wise comparison matrix  $A$ , in which the element  $a_{ij}$  of the matrix is the relative importance of the  $i^{th}$  factor with respect to the  $j^{th}$  factor, could be calculated

$$\text{as } A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad (4)$$

- b. There are  $n(n-1)/2$  judgments required for developing the set of matrices in step 1. Reciprocals are automatically assigned to each pair-wise comparison, where  $n$  is the matrix size.
- c. There are  $n(n-1)/2$  judgments required for developing the set of matrices in step 3. Reciprocals are automatically assigned to each pair-wise comparison, where  $n$  is the matrix size.
- d. Hierarchical synthesis is now utilized to weight the eigenvectors according to weights of criteria. The sum is for all weighted eigenvectors corresponding to those in the next lower hierarchy level.
- e. Having made all pair-wise comparisons, consistency is identified by using the eigenvalue  $\lambda_{\max}$ , to calculate the consistency index. The largest eigenvalue,  $\lambda_{\max}$ , will be

$$\lambda_{\max} = \sum_{j=1}^n a_{ij} \frac{W_j}{W_i} \quad (5)$$

where:

$\lambda_{\max}$  is the principal or largest eigenvalue of positive real values in a judgment matrix;  $W_j$  is the weight of  $j^{th}$  factor

$W_i$  is the weight of  $i^{th}$  factor.

- f. Consistency test. Each pair-wise comparison contains numerous decision elements for the consistency index (CI), which measures the entire consistency judgment for each comparison matrix and the hierarchy structure. CI and consistency ration (CR) is utilized to assess the consistency of the comparison matrix. The CI and CR are defined as

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

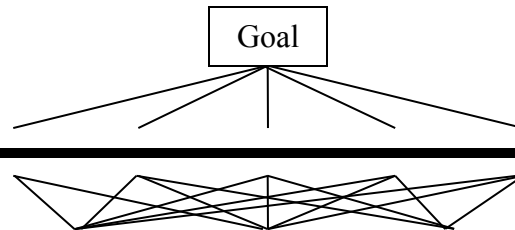
- g. Where  $n$  is the matrix size.

$$CR = \quad (7)$$



- h. where the judgment consistency can be checked by taking the CR of CI with the appropriate value. The CR is acceptable if it does not exceed 0.10. The CR is  $> 0.10$ , the judgment matrix is inconsistent. To acquire a consistent matrix, judgments should be reviewed and improved.

Figure 1. AHP Model of Best Study Program

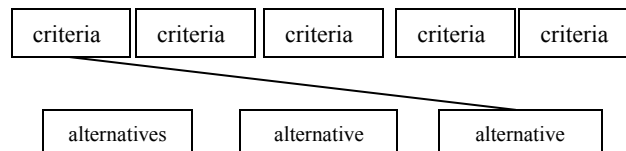


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The Fundamental Scale for judgments is shown in Table 1.

Table 1  
*The Fundamental Scale for Making Judgments*

1	Equal
2	Between Equal and Moderate
3	Moderate
4	Between Moderate and Strong
5	Strong
6	Between Strong and Very Strong
7	Very Strong
8	Between Very Strong and Extreme
9	Extreme
Decimal judgments, such as 3.5, are allowed for fine tuning, and judgments greater than 9 may be entered, though it is suggested that they be avoided.	

**The Proposed Hybrid Model**

Based on the previous discussion about both models, there is an urgent need for a 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 grey relational analysis. 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”.

Calculation of the values for each single cell in the criteria matrix 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 2 should be used, otherwise formula 3 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.

### **Sample Data**

In order to get the data for this study, artificial data are used consisting of six study programs as a candidate for opening international classes in Yogyakarta State University. One reason for the inclusion of artificial data in such experiments is that the parameters of the models underlying the data can be much better controlled for artificial data when compared with real data and it is generally much easier to generate artificial data than to search for real data sets with varying criteria set up in this research. By doing such an approach it was felt that measures of 'best practices' could emerge.

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### 3. Findings and Discussion

The discussion of the data analyses is based on Table 2. The first column in Table 2 shows the criteria of the selection study program. These criteria involved 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 program 1 and P2 in the next column refers to study program 2 and so on till P6 which refers to study program 6.

Table 2  
*Criteria and Program Study*

<b>Attribute</b>	<b>Measurement unit</b>	<b>P1</b>	<b>P2</b>	<b>P3</b>	<b>P4</b>	<b>P5</b>	<b>P6</b>
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

After determining the criteria and obtaining the courses data that will be assessed, the next step of the evaluation process is calculating the weight of each study program. This research uses Grey Relational Analysis (GA) as the used model for calculating the weights.

Table 3 presents transformation results and reference values for the weighting of the study program that are based on GA model.

Job waiting time for fresh graduate time (J) and acceptance rate (I) can be categorized as "smaller is better" and the threshold for the type of criteria that must be maximum. Whereas average freshman retention rate (B), average graduation rate/GPA (A), 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), the proportion of permanent academic staff and student body (H), the proportion of permanent academic staff and student body (K) are

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considered as " bigger is better "and the limit for this species is minimal. In this study, a total of six courses and eleven selection criteria included in the computation. Codes for sixth courses are X1, X2, X3, X4, X5, X6, while X0 is the maximum value of the reference. Then, the reference value before the transformation process of the courses are (3:35, 0.95, 7, 515, 490, 0:25, 4, 10, 0:15, 4, 0:08). Formula (2) and (3) can be used to standardize the process of transforming data so that results can be showed in Table 3.

Table 3  
*Data of Study Programs Based on the Criterion after the Transformation Process*

	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>	<b>G</b>	<b>H</b>	<b>I</b>	<b>J</b>	<b>K</b>
X0	1	1	1	1	1	1	1	1	1	1	1
X1(P1)	0.43	0.40	0.33	0.00	1.00	1.00	0.33	1.00	0.67	0.75	0.14
X2(P2)	0.63	0.60	0.67	0.38	0.00	0.67	0.67	0.22	0.40	0.63	0.71
X3(P3)	1.00	0.67	0.00	0.63	0.35	0.33	0.33	0.11	1.00	0.88	1.00
X4(P4)	0.50	1.00	0.00	1.00	0.50	0.00	0.00	0.00	0.00	0.25	0.57
X5(P5)	0.00	0.53	0.33	0.28	0.38	0.13	0.33	0.44	0.47	0.00	0.00
X6(P6)	0.25	0.00	1.00	0.10	0.25	0.53	1.00	0.67	0.13	1.00	0.29

Calculating the absolute difference between value in the criteria and reference value can be done using formula (4) and the results shown in the Table 4.

Table 4  
*Absolute Difference between Values in the Criteria and Reference Values*

$\Delta x_1$	0.58	0.60	0.67	1.00	0.00	0.00	0.67	0.00	0.33	0.25	0.86
$\Delta x_2$	0.38	0.40	0.33	0.63	1.00	0.33	0.33	0.78	0.60	0.38	0.29
$\Delta x_3$	0.00	0.33	1.00	0.38	0.65	0.67	0.67	0.89	0.00	0.13	0.00
$\Delta x_4$	0.50	0.00	1.00	0.00	0.50	1.00	1.00	1.00	1.00	0.75	0.43
$\Delta x_5$	1.00	0.47	0.67	0.73	0.63	0.87	0.67	0.56	0.53	1.00	1.00
$\Delta x_6$	0.75	1.00	0.00	0.90	0.75	0.47	0.00	0.33	0.87	0.00	0.71

If the  $p$  value is determined to be  $p = 0.5$ , then the value of the gray relational coefficient can be obtained by using the formula (5) and the results are shown in Table 5.

Tabel 5  
Grey Relational Coefficients

§1(P1)	0.47	0.45	0.43	0.33	1.00	1.00	0.43	1.00	0.43	0.40	0.37
§2(P2)	0.57	0.56	0.60	0.44	0.33	0.60	0.60	0.39	0.56	0.44	0.64
§3(P3)	1.00	0.60	0.33	0.57	0.43	0.43	0.43	0.36	0.33	0.36	1.00
§4(P4)	0.50	1.00	0.33	1.00	0.50	0.33	0.33	0.33	1.00	0.67	0.54
§5(P5)	0.33	0.52	0.43	0.41	0.44	0.37	0.43	0.47	0.52	1.00	0.33
§6(P6)	0.40	0.33	1.00	0.36	0.40	0.52	1.00	0.60	0.79	0.33	0.41

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In formula (6), weight  $w$  (k) for each indicator criteria may differ depending on the evaluator's point of view. Based on the AHP-based assessments, the given values of  $w$  (A) = 0070,  $w$  (B) = 0020,  $w$  (C) = 0226, (D) = 0053,  $w$  (E) = 0076,  $w$  (6) = 0033,  $w$  (7) = 0125,  $w$  (8) = 0183,  $w$  (9) = 0052,  $w$  (10) = 0027, and  $w$  (11) = 0135. The process of calculating weights for each criterion based on the AHP is shown in Table 6.

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 6  
*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.

- a. Sum the elements in each column.
- b. Divide each value by its column total.
- c. Calculate row averages.

Performing of the previous mathematical calculation yields the normalized matrix of criteria as illustrated in Table 7. The average weights of rows are computed in the last column to indicate the weights of the criteria.

Table 7  
*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

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From Table 7, 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 formula 1 should be applied to compute the value of that criterion with respect to all suppliers.

Table 8  
*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 8. Then get the sum of each column and the sum represents the score of each single study program. Table 9 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 9  
*Final Decision Matrix*

Criteria	Treshold	p1	p2	p3	p4	p5	p6	Weight
A	min	0.465	0.571	1.000	0.500	0.333	0.400	0.070
B	min	0.455	0.556	0.600	1.000	0.517	0.333	0.020
C	min	0.429	0.600	0.333	0.333	0.429	1.000	0.226
D	min	0.333	0.444	0.571	1.000	0.408	0.357	0.053
E	min	1.000	0.333	0.435	0.500	0.444	0.400	0.076
F	min	1.000	0.600	0.429	0.333	0.366	0.517	0.033
G	min	0.429	0.600	0.429	0.333	0.429	1.000	0.125
H	min	1.000	0.391	0.360	0.333	0.474	0.600	0.183
I	max	0.429	0.556	0.333	1.000	0.517	0.789	0.052
J	max	0.400	0.444	0.364	0.667	1.000	0.333	0.027
K	min	0.368	0.636	1.000	0.538	0.333	0.412	0.135
value		0.585	0.529	0.516	0.478	0.437	0.668	
		2	3	4	5	6	1	

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. Combination of Grey Analysis and AHP method for assessing the study programs can be used for assigning the weights of the criteria that involved in the decision making process. Weight for the alternative was taken from the GA process and the weights for these criteria were taken from the AHP. Applying the evaluation model between GA and AHP approach for the evaluation of study programs has resulted in a significant reduction of computation and improve the speed and effectiveness of the procedure and finally enable a more efficient process compared with other methods.

#### **4. Conclusion and Suggestion**

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The proposed hybrid model IS derived from both Grey Analysis 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.

Another advantage of the proposed model is avoiding the limitation in the Grey Relational Analysis which assigns 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 judgments as in the case of Grey Relational Analysis. In conclusion, the proposed model can be considered as a powerful model for study program selection problem. It fully integrates the advantages of both the Grey Relational Analysis 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 approaches.

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