Selection of a student for All Round Excellence Award using fuzzy AHP and TOPSIS methods

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Abstract

The aim of the study is developing a fuzzy decision model to select a student from an Engineering college who is eligible for *All Round Excellence Award* for the year 2004-05 by taking subjective judgments of decision makers into consideration. Here Fuzzy Analytic Hierarchy Process (FAHP) approach and (Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS) methods are proposed. The weights of the criteria by decision makers are determined by FAHP method and the ranking of the alternative branches from which a student is selected are determined by TOPSIS method. A numerical example is taken to demonstrate these processes.

Key words : *AHP, Multi Criteria Decision Making, Fuzzy AHP*

I INTRODUCTION

For most of the decisions, we either approach the problem from a holistic point of view in which we simply choose the best, or we somehow break the decision down in to components in order to

i) Better understand the problem we are faced with and / or

ii) Communicate with someone else why a particular course of action was chosen.

Holistic approach in decision making to some extent works out but major decisions, one needs a more scientific/logical approach to decision making.

Determination and evaluation of the criteria for selection of a student for "All round Excellence Award" can be affected by the expert opinions and the conditions of the decision making platform. Thus, deterministic scale or crisp values can produce misleading consequences sometimes. For example, some pessimistic people may not give any point more than four, or some optimistic people may easily give 5 even if it does not deserve it. These situations generate fuzziness within the decision making process, so fuzzy AHP method can handle these deviations concerning this fuzziness. Analytical Hierarchy Process (AHP) is one of the best ways for deciding among the complex criteria structure in different levels. Fuzzy AHP is an extension of classical AHP method when the fuzziness of the decision makers is considered.

The AHP is also a method for ranking decision alternatives and selecting the best one among them when the decision maker has multiple criteria to evaluate alternatives. According to Saaty, an AHP matrix can be considered reasonably consistent if its CR is not more than 0.1. It has been shown in the literature that these solutions perform poorly with respect to other error criteria like least square error (LSE) even for moderately inconsistent matrices (CR > 0.1). This may be due to the fact that the methods that rely on the eigen vector approach requires solving the crisp linear equations and near approximate solutions are often ignored. The uncertainty in the preference judgments essentially gives rise to uncertainty in the ranking of alternatives as well leading to difficulty in determining consistency of preferences. Hence there is a necessity of Fuzzy AHP in such problems.

II LITERATURE

Many methods for generating weights have been proposed in Multi Criteria decision Analysis. Saaty T.L (1980) proposed AHP method as a decision-making aid to solve unstructured problems in economics, social and management sciences. Saaty

T.L and Luis G. Vargas (1987) investigated the effect of uncertainty in judgment on the stability of the rank order of alternatives. Wang et al (2005) developed a method of consistency test to check whether an interval comparison matrix is consistent or not. Van Laarhoven and Pedrycz (1983)proposed the first studies that applied fuzzy logic principle to AHP in which triangular fuzzy numbers (TFN's) are used to model the pair-wise comparisons. Wei Cuiping et al (2008) suggested to check whether the Fuzzy comparison matrix is consistent or not by means of the kernals of fuzzy numbers. Kousalya et al(2006) discussed the problem of Student absenteeism in engineering colleges using AHP. Saaty(1980) explained AHP in his book Analytic Hierarchy Process. Saaty T.L., L.G. Vargas (1984),used Comparison of eigenvalue, logarithmic leastsquares and least squares methods in estimating ratios. Saaty .T. L and Luis G. Vargas(1987) showed the uncertainty and rank order in the analytic hierarchy process.Van Laarhoven.P.J.M., W. Pedrycz(1983) used the method of a fuzzy extension of Saaty's priority theory .Wang, Y.M., Yang, J.B. and Xu, D.L. (2005) discussed the interval weight generation approaches based on consistency test .Wei Cuiping, Fan Lili and Zhang Yuzhong (2008)gave a note on the Consistency of a Fuzzy Comparison Matrix. Xu R., X. Zhai(1996)described Fuzzy logarithmic least squares and a ranking method in analytic hierarchy process.Wang Y M and Elhag T.M.S (2006) explained Fuzzy TOPSIS method based on alpha level sets along with an application to bridge risk assessment. Wang Y J and Lee H-S.(2007), "discussed generalising TOPSIS for fuzzy multiple criteria group decision making. Ertugral I and karakasoglu N.,(2007) has given performance evaluation of Turkish cement firms with fuzzy Analytical Hierarchy process and TOPSIS methods. Serkan Balli and Serdar Korukoglu(2009) has given selection of operating sytem using Fuzzy AHP and TOPSIS Methods. Kousalya et al (2011) has discussed comparative Performance of Averaging Methods and Stochastic Vector Methods in Analytical Hierarchy Process problems. Kousalya et al(2012) has discussed Selection of a student for All Round excellence award using Multi criteria decision making approach.

III METHODOLOGY

The following steps are involved in any decision making process.

i) Define the problem of interest and gather relevant data
ii) Formulate a Mathematical model to represent the problem.
iii) Develop a computer-based procedure for deriving solutions to the problem from the model.
iv) Test the model and refine it as needed. Prepare for ongoing application of the model as prescribed by management.
v) Implement.

3.1Establishment of a structural Hierarchy

A complex decision is to be structured in to a hierarchy descending from an overall objective to various criteria, sub criteria till the lowest level. The overall goal of the decision is represented at the top level of the hierarchy. The criteria and the sub criteria, which contribute to the n, are represented at the intermediate levels. Finally the decision alternatives are laid down at the last level of the hierarchy. According to Saaty (2000), a hierarchy can be constructed by creative thinking, recollection and using people's perspectives.

3.2 Establishment of comparative judgments

Once the hierarchy has been structured, the next step is to determine the priorities of elements at each level. A set of comparison matrices of all elements in a level with to respect to an element of the immediately higher level are constructed. The pair wise comparisons are given in terms of how much element A is more important than element B. The preferences are quantified using a nine – point scale that is shown in Table 1.

3.3 Fuzzy AHP method

Algorithm of FAHP method:

Let $X=\{x_1,x_2,x_3,\ldots, x_m\}$ be an object set and $G=\{g_1,g_2,g_3,\ldots,g_n\}$ be a goal set. According to this method, each object is taken and extent analysis for each goal performed respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs.

$M^1_{gi}, M^2_{gi}, \ldots, M^m_{gi}$. i= 1, 2, 3…, n Where M^j_{gi}, (j=1, 2, 3,…m) all are Triangular Fuzzy Numbers

Step 1: The value of fuzzy synthetic extent with respect to the i^th^ object is defined as

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} \quad \text{------ (1)}$$

To obtain $\sum_{j=1}^{m} M_{gi}^{j}$, perform the fuzzy addition operation of m extent values for a particular matrix such that

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right)$$

-------------------- (2)

and to obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}$, perform fuzzy addition operation of M_{gi}^{j},(j=1,2,3,…m) values such that

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right)$$

---------------------- (3) and then compute the inverse of the vector above, such that

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right)$$

-------------------- (4)

Step 2: As $\tilde{M}_1 = (l_1, m_1, u_1)$ and $\tilde{M}_2 = (l_2, m_2, u_2)$ are two TFNs, the degree of possibility of $\tilde{M}_2 = (l_2, m_2, u_2) \geq \tilde{M}_1 = (l_1, m_1, u_1)$ is defined as

$$V(\tilde{M}_2 \geq \tilde{M}_1) = \sup_{y \geq x} \left[\min\left(\mu_{\tilde{M}_1}(x), \mu_{\tilde{M}_2}(y) \right) \right]$$

-------------------------- (5)

This can be equivalently expressed as follows

$$V(\tilde{M}_2 \geq \tilde{M}_1) = hgt(\tilde{M}_2 \cap \tilde{M}_1) = \mu_{\tilde{M}_2}(d)$$

$$= \begin{cases} 1, & \text{if } m_2 \geq m_1 \\ 0, & \text{if } l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{otherwise} \end{cases}$$

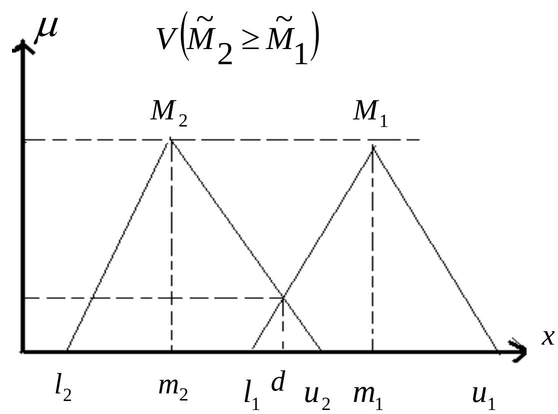

Fig1: Intersection between M_1 and M_2

Step 3: The degree of possibility for convex fuzzy number to greater than k convex fuzzy number M_i (i=1, 2, 3….n) can be defined by

$$V(M \geq M_1, M_2, M_3 \ldots M_K)$$
$$= V\left[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and } (M \geq M_3) \text{ and} \ldots (M \geq M_k) \right]$$

$$V(M \geq M_1, M_2 \ldots M_k) = \min V(M \geq M_i), i = 1,2,3\ldots k \quad \text{------------ (6)}$$

assume that

$$d'(A_i) = \min V(S_i \geq S_k) \text{ for } k = 1,2,3, \ldots n; k \neq i$$

Then the weight vector is given by

$$W' = \left(d'(A_1), d'(A_2), d'(A_3), \ldots\ldots d'(A_n) \right)^T$$

-- (7) Where A_i (i =1, 2, 3….n) are n elements.

Step 4: Via normalization, the normalized vectors are given by

$$W = \left(d(A_1), d(A_2), d(A_3), ... d(A_n)\right)^T \text{ -------- (8)}$$

where W is non-fuzzy number.

3.4 TOPSIS Method

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is one of the useful techniques which is very simple and easy to implement when one goes for an easy weighting technique. AHP provides a decision hierarchy and requires pair wise comparison among criteria. Hence detailed knowledge of the criteria in the decision hierarchy is required to make informed decisions while using AHP[18]TOPSIS method was first proved by Hwang and Yoon[10]. According to this technique , the best alternative would be the one which is nearest to the positive ideal solution and farthest from the negative ideal solution[1]. The positive ideal solution is one that maximizes the cost criteria and minimizes the benefit criteria[29,30]. Hence the positive ideal solution consists of all best values attainable of criteria and negative ideal solution consists of all worst values attainable of criteria. In this study, TOPSIS method is used for determining the final ranking of the alternative branches of engineering with regard to the Excellence award.

Step1 : Decision matrix is normalized as

$$r_{ij} = \frac{w_{ij}}{\sqrt{\sum_{j=1}^{J} w_{ij}^2}}$$

j= 1,2,3…J, i=1,2,3,….n---------(9)

Step2 : Weighted normalized decision matrix is formed.

$v_{ij} = w_{ij} * r_{ij}$, j= 1,2,3…J, i= 1,2…n

Step3 : Positive ideal solutions (PIS) and negative ideal solutions (NIS) are determined :

$A^* = \{ v_1^*, v_2^*, \ldots v_n^* \}$ Maximum values

$A^- = \{v_1^-, v_2^- \ldots . V_n^- \}$ Minimum values

Step 4 : The distance of each alternative from PIS and NIS are calculated :

$$d_{ij}^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2} \quad ,j=1,2,\ldots J$$

----------(10)

$$d_{ij}^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \quad i=$$

1,2…..J ------------(11)

Step 5 : The closeness coefficient of each alternative is calculated :

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-} \quad i=1,2,\ldots J \text{ ----(12)}$$

Step 6 : By comparing CC1 values the ranking of alternatives are determined.

IV EXAMPLE

A numerical example is considered here. In this, the main goal is to select a student for All Round Excellence award. Here seven criteria which are favorable to the main objective are selected and weighted according to decision maker. Five alternative branches are selected in selecting one student of a branch for the final Award. The physical significance of their alternative branches is given as follows.

4.1 Physical Significance of criteria

Attendance: The students' attendance has to be above 75% throughout four-year period in all the semesters.

Academics: The students' academic record should be consistently above 70% in all the Semesters throughout four-year period.

Co-curricular activities: A student has to participate in co-curricular activities like Paper presentation, debates, Group Discussions or quizzes etc, either in inter college or Intra College and need to win some prizes.

Extra curricular activities: A student has to participate in extra-curricular activities like Indoor games, Outdoor games which are held in intra college or inter college and need to win some prizes.

Cultural activities: A student has to participate in cultural activities like Singing or choreography which are held in Intra College or Inter College and need to win some prizes.

General behavior: A student is required to be honest and need to maintain good relationship with his / her peers and with teachers.

Departmental activities: A student need to participate in the activities conducted by the department and need to posses certain managerial skills and need to coordinate different activities/events held in the department.

Next we move to pair wise comparisons of the lower level and lastly to the pair wise comparisons of the lowest level .The elements to be compared pair wise are the engineering branches with respect to how much better one is than the other in satisfying each criterion in level 2.Thus there will be fifteen 5 x 5 matrices of judgments. To understand these judgments, a brief description of the engineering branches is follows.

EEE: This branch consists of students who are good at academics, attendance and Co-Curricular activities. Their participation is comparatively less in Extra Curricular activities when compared to other branch students.

ECE: The students of this branch are highly motivated and hence have good academic records and attendance. Their general behavior is good. The departmental activities are conducted well. Though their participation in Extracurricular activities and Cultural activities is less, compared to other branch students, they are good at Co Curricular activities.

ICE: This branch consists of students who are less motivated and hence poor in academics and attendance. Their relationship with teachers and peers is not good when compared with other branch students. They are good at Extracurricular activities , cultural activities and are able to manage events well in their departments.

CSE: The students of this branch are good in academics and attendance as students of EEE. The relationship with peers is not good. They are good in Extra Curricular activities and Co curricular activities. They manage events well as students of EEE and ECE.

MECH: The students of this branch are less motivated and hence are not good in academics and attendance. They are good at Extra Curricular activities and Cultural activities, but not good at Co Curricular activities. Their relationship with teachers and peers is not very good.

After the fuzzy pair wise comparison matrix is formed, weights of all criteria and sub criteria are determined by the help of FAHP. According to FAHP method, Synthesis Values are calculated first. From Table 3 synthesis values with respect to main goal are calculated as shown below.

$S_{c1}=(13,23,33) \otimes (1/114.33,1/76.47,1/44.77)$
$=(0.114,0.301, 0.737)$

$S_{c2}=(2.89,3.4,5.67) \otimes (1/114.33,1/76.47,1/44.77)$
$=(0.025,0.044,0.127)$

$S_{c3}=(6.2,12.33,19) \otimes (1/114.33,1/76.47,1/44.77)$
$=(0.054,0.161,0.424)$

$S_{c4}=(3.74,6.2,10.33) \otimes (1/114.33,1/76.47,1/44.77)$
$=(0.033,0.081,0.231)$

$S_{c5}=(4.54,6.87,10.33) \otimes (1/114.33,1/76.47,1/44.77) =(0.040,0.090,0.231)$

$S_{c6}=(9,17,25) \otimes (1/114.33,1/76.47,1/44.77)$
$=(0.079,0.222,0.558)$

$S_{c7}=(5.4,7.67,11) \otimes (1/114.33,1/76.47,1/44.77)$
$=(0.047,0.1,0.246)$

These fuzzy values are compared by using Eq.(3.10) and the following values are obtained.

$V(S_{C1}\geq S_{C2})=1$, $V(S_{C1}\geq S_{C3})=1$, $V(S_{C1}\geq S_{C4})=1$,$V(S_{C1}\geq S_{C5})=1$, $V(S_{C1}\geq S_{C6})=1$, $V(S_{C1}\geq S_{C7})=1$,

$V(S_{C2}\geq S_{C1})=1$, $V(S_{C2}\geq S_{C3})=1$,$V(S_{C2}\geq S_{C4})=0.72$, $V(S_{C2}\geq S_{C5})=0.65$, $V(S_{C2}\geq S_{C6})=1$, $V(S_{C2}\geq S_{C7})=1$,

$V(S_{C3}\geq S_{C1})=0.69$, $V(S_{C3}\geq S_{C2})=1$, $V(S_{C3}\geq S_{C4})=1$, $V(S_{C2}\geq S_{C5})=1$, $V(S_{C2}\geq S_{C6})=0.85$, $V(S_{C2}\geq S_{C7})=1$,

$V(S_{C4}\geq S_{C1})=0.35$, $V(S_{C4}\geq S_{C2})=1$,$V(S_{C4}\geq S_{C3})=0.69$, $V(S_{C4}\geq S_{C5})=0.95$, $V(S_{C4}\geq S_{C6})=1$, $V(S_{C4}\geq S_{C7})=1$,

$V(S_{C5}\geq S_{C1})=0.36$, $V(S_{C5}\geq S_{C2})=1$, $V(S_{C5}\geq S_{C3})=0.71$, $V(S_{C5}\geq S_{C4})=1$, $V(S_{C5}\geq S_{C6})=0.54$, $V(S_{C5}\geq S_{C7})=1$,

$V(S_{C6}\geq S_{C1})=0.85$, $V(S_{C6}\geq S_{C2})=1$, $V(S_{C6}\geq S_{C3})=1$, $V(S_{C6}\geq S_{C4})=1$, $V(S_{C6}\geq S_{C5})=1$, $V(S_{C6}\geq S_{C7})=1$,

Table 1: Pair wise comparison scale

TFN	Inverse TFN	Definition	Explanation
(1,1,1)	(1,1,1)	Equal importance	Two elements contribute equally to the property
(1,3,5)	(1/5,1/3,1)	Moderate importance of one over another	Experience and judgment slightly favor one over the other
(3,5,7)	(1/7,1/5,1/3)	Essential or strong importance	Experience and judgment strongly favor one over another
(5,7,9)	(1/9,1/7,1/5)	Very strong importance	An element is strongly favored and its dominance is demonstrated in practice.
(7,9,11)	(1/11,1/9,1/7)	Extreme importance	The evidence favoring one element over another is one of the highest possible order of affirmation

Table 2: Table of opinions of Criteria

	C1	C2	C3	C4	C5	C6	C7
C1	(1,1,1)	(3,5,7)	(1,3,5)	(3,5,7)	(3,5,7)	(1,1,1)	(1,3,5)
C2	(1/7,1/5,1/3)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)	(1/5,1/3,1)	(1/7,1/5,1/3)	(1,1,1)
C3	(1/5,1/3,1)	(1,3,5)	(1,1,1)	(1,3,5)	(1,3,5)	(1,1,1)	(1,1,1)
C4	(1/7,1/5,1/3)	(1,3,5)	(1/5,1/3,1)	(1,1,1)	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)
C5	(1/7,1/5,1/3)	(1,3,5)	(1/5,1/3,1)	(1,1,1)	(1,1,1)	(1/5,1/3,1)	(1,1,1)
C6	(1,1,1)	(3,5,7)	(1,1,1)	(1,3,5)	(1,3,5)	(1,1,1)	(1,3,5)
C7	(1/5,1/3,1)	(1,1,1)	(1,1,1)	(1,3,5)	(1,1,1)	(1/5,1/3,1)	(1,1,1)

$V(S_{C7} \geq S_{C1})=0.39$, $V(S_{C7} \geq S_{C2})=1$, $V(S_{C7} \geq S_{C3})=0.76$, $V(S_{C7} \geq S_{C4})=1$, $V(S_{C7} \geq S_{C5})=1$, $V(S_{C7} \geq S_{C6})=0.58$

Then the priority weights are calculated by using Eq.(3.11) as follows

$d^1(C_1)= \min(1,1,1,1,1,1) = 1$

$d^1(C_2)= \min(1,1,0.72,0.65,1,1) = 0.65$

$d^1(C_3)= \min(0.69,1,1,1,0.85,1) = 0.69$

$d^1(C_4)= \min(0.35,1,0.69,0.95,1,1) = 0.35$

$d^1(C_5)= \min(0.36,1,0.711,0.54,1) = 0.36$

$d^1(C_6)= \min(0.85,1,1,1,1,1) =0.85$

$d^1(C_7)= \min(0.39,1,0.76,1,1,0.58) = 0.39$

Hence we can obtain the priority weights from $W^1 =(1,0.65,0.69,0.35,0.36,0.85,0.39)$.

The above vector can be normalized and the priority weights with respect to the main goal are calculated as follows:

$W^1 =(0.363216, 0.236091, 0.250619, 0.127126, 0.130758 , 0.308734, 0.141654)$

In a similar way, the weights of sub criteria and priority values of the alternative branches are calculated. These priority values of alternative branches for each sub criteria are shown in table 3.Normalization is done as shown in the first step of TOPSIS method .Then weighted normalized matrix is formed by multiplying each value with their weights. All weighted values that form each sub criterion are aggregated. Then these values which are aggregated and the weights of each main criterion are multiplied to form Table 4.

Table 3:Priority values of sub criteria

Sub criteria	A1	A2	A3	A4	A5
C1	0.0060	0.64790	0.0137	0.4141	0.0137
C2	0.3651	0.4103	0.2790	0.2256	0.1436
C31	0.3823	0.4581	0.0093	0.3005	0.1700
C32	0.3083	0.4602	0.0506	0.3037	0.1933
C33	0.3669	0.3669	0.1775	0.3552	0.2793
C41	0.2643	0.4264	0.1193	0.3368	0.2387
C42	0.3589	0.4376	0.0568	0.3063	0.2013
C51	0.4335	0.3208	0.1820	0.4335	0.4335
C52	0.3265	0.3698	0.1809	0.3934	0.3934
C61	0.4583	0.4583	0.2016	0.4583	0.2016
C62	0.4472	0.4472	0.4472	0.4472	0.4472
C63	0.0000	0.0000	0.0000	0.0000	1.0000
C71	0.3216	0.3874	0.1472	0.3216	0.3061
C72	0.4075	0.3138	0.1834	0.3423	0.1834

Table 4: Total Weights of main criteria

	C1	C2	C3	C4	C5	C6	C7
A1	0.0022	0.0862	0.2650	0.0792	0.0993	0.2795	0.1032
A2	0.2353	0.0968	0.2067	0.1098	0.0903	0.2795	0.0993
A3	0.0050	0.0658	0.0595	0.0224	0.0474	0.2003	0.0468
A4	0.1504	0.0532	0.2404	0.0817	0.1081	0.2795	0.0940
A5	0.0050	0.0339	0.1610	0.0559	0.1081	0.2003	0.0693

From TOPSIS method ,Positive and Negative Ideal solutions are determined by taking the maximum and minimum values for each criterion:
A^* ={0.2353, 0.0968, 0.2650, 0.1098, 0.1081, 0.2795, 0.1032}
A^- ={0.0022, 0.0339, 0.0595, 0.0224, 0.04747, 0.2003, 0.0468}

Then the distance of each alternative from PIS and NIS with respect to each criterion are calculated with the help of Eq.(11) and (12)
d_i^*={0.2353, 0.0582, 0.3222, 0.1024, 0.2658} and
d_i^- ={0.2196, 0.2960, 0.0320, 0.2421, 0.1070}
Finally the rankings of the alternative branches are performed using step 5 of TOPSIS method. The ranks of these alternatives aren't calculated as step 6 of TOPSIS method and are tabulated in the Table5.

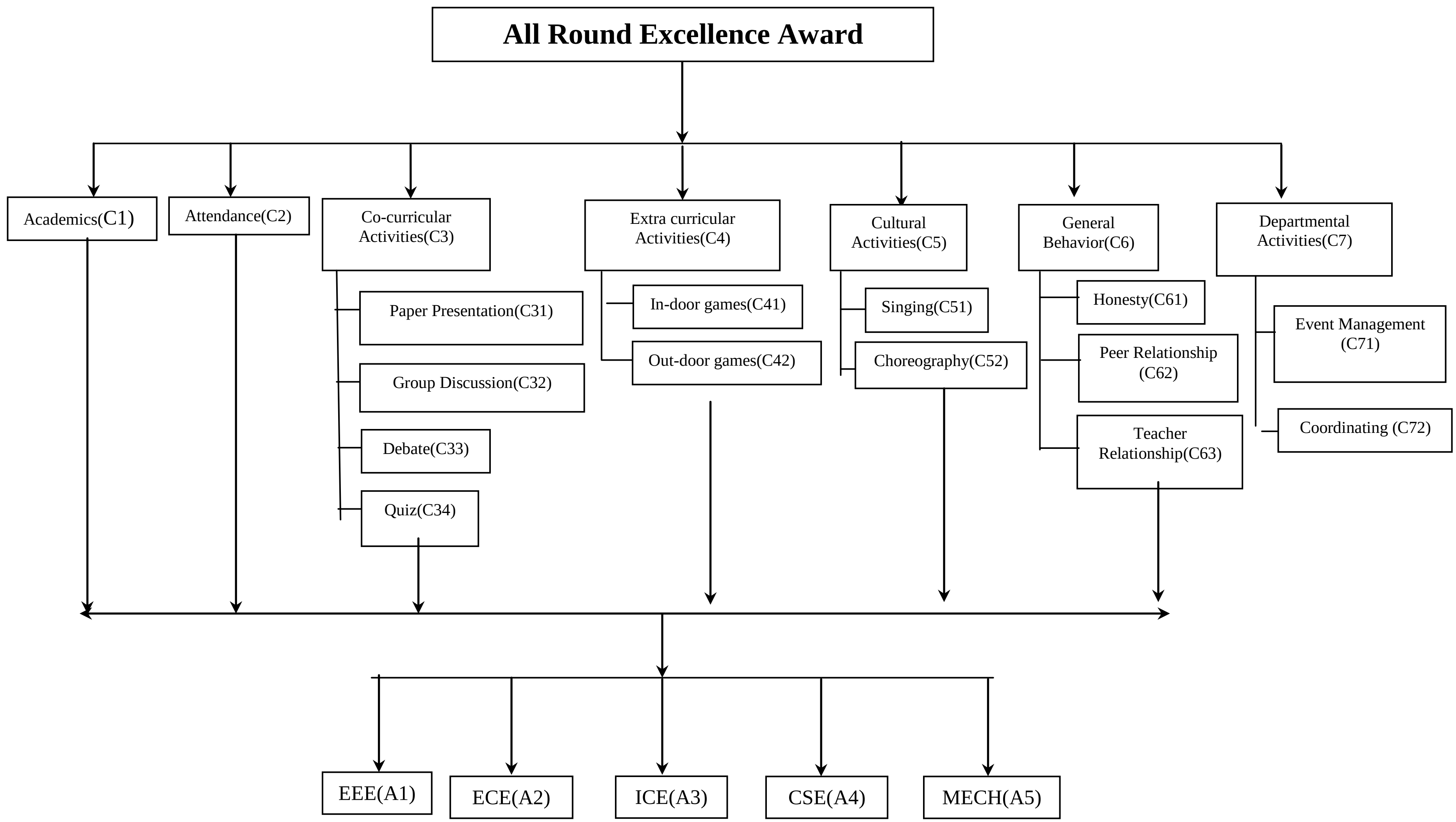

Figure: 1 Hierarchical decomposition of criteria, sub criteria and alternatives

Table5: Rankings of the alternative branches

Alternative Branches	CC_i	Ranks
EEE	0.4827	3
ECE	0.8356	1
ICE	0.0905	5
CSE	0.7027	2
MECH	0.2870	4

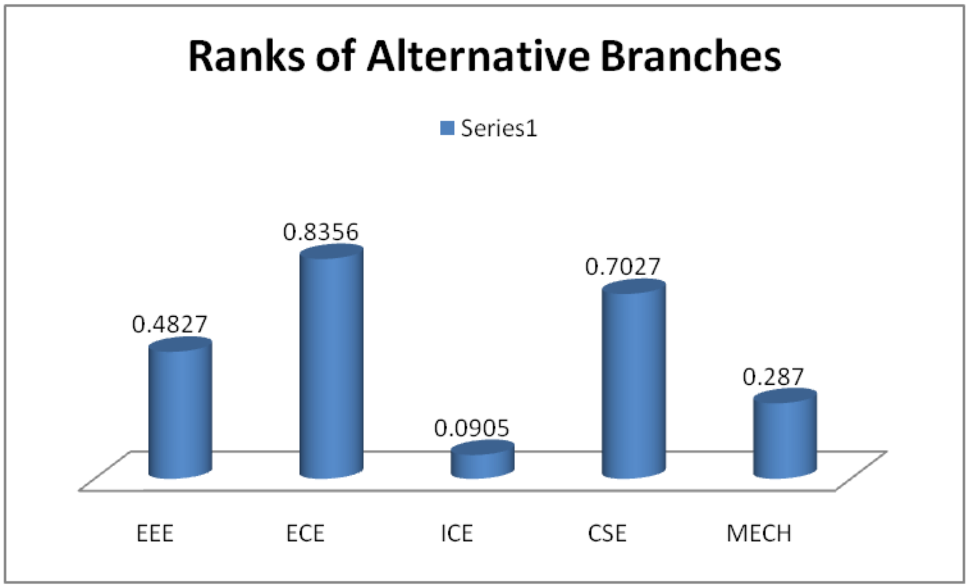

Figure: 2 Ranks of alternatives (five engineering branches)

5. Conclusions& Scope

The student of ECE gets the All Round Excellence Award as he/she gets the highest score as shown in Figure 2. The student of CSE branch is equivalently good who performed better than EEE students.
The present study is taken for a small sample (one college) and it could be extended to a very large sample of many colleges and also at University level. Group decision making can be performed.

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