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Fuzzy analytical network process logic for performance measurement system of e-learning centers of Universities

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Abstract

This paper proposes an efficient performance measurement system to evaluate the excellence of e-learning centers of Universities. The proposed system uses the analytic network process (ANP) as an effective multi-criteria decision making (MCDM) method and its fuzzy mode to respond to uncertainties in judgements. This system also needs a targeted and systematic criteria set which is collected through comprehensive literature studies and experiences of faculty members. The performance of e-learning centers can then be systemically measured and managed by finding the relationship between these criteria, comparing the pairwise of criteria together and gaining their importance under uncertainty. In this paper, eight main criteria and twenty-five sub criteria is identified by a comprehensive survey on a statistical community consist of faculty members, staff and students of e-learning centers. Based on the results, the criteria for measuring University performance are mainly "student, teacher, educational content, communication, research, scheduling, continuous improvement and infrastructure." From the results of the final weights obtained, the "master's attitude toward the course" is most important in measuring performance. The sub-criterion of "attracting student participation by the master" has the next important place as well. The subcategory of the need for learning, the interest of interference in education, and the future prospects of the student future are in the subsequent degree of importance.

Keywords: Performance measurement, uncertainty multi criteria decision making (MCDM, e-learning, analytical network process (ANP)

1- Introduction

Measuring the performance of the organization is recognized as one of the important management functions and is also a key tool that determines whether output are in line with what was planned or should have been achieved (Balabonienca & Vecerskienah, 2014). This management task is the process of information collecting, analyzing and reporting and tries to make a relationship between planning, decision, practice and results (Micheli & Mari, 2014). The importance and competitive advantages of performance measurement systems are proven today to guarantee survival in world-class competition (Dewangan & Godse, 2014).

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The benefits of performance evaluation can be summarized as follows: Providing performance feedback - Creating enormous synergy - Understanding consumer needs - Controlling the current location, showing the path, providing feedback - Reviewing the effectiveness of the organization's strategies (Micheli & Mari, 2014).

Different definitions are used to measure performance and generally it is a strategic process (indicative of the way forward) in an organization (Rahimi, 2006) .Several empirical studies have shown that the process of measuring performance is profitable (Cavalluzzoa & Ittne, 2004) and if poorly done, it is not only ineffective but also harmful and destructive. Therefore, this concept is considered as an experience, not a technical process (Micheli & Mari, 2014). While measuring performance with a process-based and consistent perspective, it leads to trust and development assistance (Rahimi, 2006) .Performance measurement can be called a complex process that evaluates performance (Heydari et al, 2016).

An efficient performance measurement system has the following characteristics: clear and identifiable criteria and indicators, measurable indicators, achievable goals, outcome-oriented, time-oriented, and, in general, an appropriate system, Growth and development, improves evaluated capacities and fosters prosperity (Heydari et al, 2016). Moreover, designing a performance evaluation system has some principles that are summarized as follows: the measurement plan should provide multi-dimensional performance; the design must focus on measuring the performance of different stages of creativity; the design must be effectively and satisfy the expectations of stockholders; the plan should be easy to use and applied; and finally the plan should support the cause and effect relationship between the measurements (Dewangan & Godse, 2014). Measures and performance evaluations in private organizations are widely used, while in the academic sectors, is relatively new (Balaboniene & Vecerskiene, 2015). The main mission of Universities is raising the level of education and they play an important role for establishment of knowledge-based and information-based sectors and creating a perfect image of a country (Balaboniene & Vecerskiene, 2015). By improving the performance of Universities (or any organizations), resources can be used efficiently and the productivity indices can be highly improved. In response to growing demands and willingness for higher education in Iran, the academic institutions turned to online learning as the newest development in distance education by establishment of E-learning centers. E-learning can be viewed as the delivery of course content via electronic media such as Internet, Intranets, Extranets, satellite broadcast, audio/video tape, interactive TV and CD-ROM. E-centers also need to be informed about their performance and evaluating the efficiency and effectiveness of past actions and managing the values delivered to students, professors and other stockholders. Therefore, the main purpose of this research is to design an efficient system for measuring the performance of Universities and e-learning centers using the multi-criteria decision making (MCDM) methods. MCDMs, due to their inherent usefulness for making complex decisions and wide applicability in real-life, have widely been studied and continued to draw attention from researches (Soon, 2012) and (Asghari Zadeh & Mohamed poor, 2007). These approaches are further emphasized when this is not enough available information for decision making and there are several criteria (Zebardast, 2010).

The designed performance measurement system in this paper needs a targeted and systematic criteria set and there is interdependence among them (like many real-world cases). In 1996, Professor Thomas Al-Saaty developed an approach named analytic network process (ANP) that takes into account existing dependencies and allows the use of feedback systems in communications. ANP is an effective instrument to deal with MCDM because of its clarity in concept. The weight of the criteria and the desirability of alternatives are obtained through judgment of individuals and pairwise benchmark comparisons (Yousif & Shaout, 2016). Some of positive points of this method are:

- To apply qualitative and quantitative criteria simultaneously
- Ability to calculate inconsistency in judgments
- Expresses the complex relationship between decision elements and network structure.
- The network includes criteria, sub-criteria, alternatives
- Flexibility and simplicity

In reality, only part of the decision data can be precisely measured and the experts' judgments may be associated with uncertainty. Most of the performance indicators in a measurement system are associated with uncertainty, and it may cause the vague judgments of decision makers in traditional ANP techniques (Yousif & Shaout, 2016). When the decision maker does not know the probability of occurrence of the results; he decides in conditions of uncertainty. Although experts who use their mental abilities to make comparisons, it should be noted that there is no possibility of a reflection of the style of human thinking. The use of fuzzy numbers is more consistent with verbal and sometimes vague human phrases (Habibi, Izadyar, & Sarafrazi, 2014). Therefore, the fuzzy network analysis process can simulate the process of decision making in the human mind better than the traditional network analysis process (Abdollahian, Abdollahian, & Abodollahian, 2012). Summary of the other related studies on performance measurement of Universities is shown in table 1.

Table 1. Related studies on performance measurement of Universities (literature review)

Article issue	Method	Case study	Refrences
Critical factors affecting learner satisfaction in e-learning and a six-dimensional integrated model including learner, instructor, lesson, technology, design, and environment.	Hypotheses test	---	(Sun et al, 2008)
The critical success factors for admitting e-learning and categorized the vital factors of performance into four categories of instructor, student, information technology and University support.	Confirmatory factor modeling approach	e-learning students	(Selim, 2007)
The performance of the electronic center	Combination of fuzzy analytical hierarchy process and critical factors of success.	Tehran University	(Jam Barazmi & Hossein zadeh, 2011)
Social responsibility in the annual causes of Universities by investigating three areas including: environmental performance, economic performance and social performance (which is divided into four parts: labor practices and decent work, human rights, society, product responsibility).	Content analysis of annual performance reports and descriptive statistics	Lithuanian public Universities	(Dagiliene & Mykolaitiene, 2015)
The characteristics of the performance measurement of Universities by noting the strategy, vision, mission and goals of the University	Review article	---	(Balabonienca & Vecerskienah, 2014)
Fuzzy logic computational model for performance evaluation	Fuzzy AHP and fuzzy TOPIS.	Sudanese Universities	(Yousif & Shaout, 2016)
assessing the performance of Universities	BSC	---	(Heydari et al, 2016)
Evaluation and ranking of Universities by investigating their technology, human resource, scientific disciplines and their level, results of the research activities, the overall level of the University in the scientific community, the number of articles from the University and the amount of financial resources absorbed in in research Projects.	Studying the different Universities sch as american Universities, chinies Universities and other	Iran Universities	(Hosein pour, 2016)
Provided a framework for assessing the performance of Universities.	Triple helix model	Cyprus	(Kapetaniou & Hee Lee, 2016)

The literature of the network analysis process and its fuzzy logic are very extensive due to its wide application. In 2009, Sehat et al. Used a network analysis process to analyze the strengths, weaknesses, opportunities and threats of Iranian insurance (Sehat & Parizadi, 2009). In 2010, Zebardast has used the network analysis process for urban and regional planning (Zebardast, 2010). In 2011, Abdullain et al. Used the fuzzy network analysis process to prioritize the entrepreneurial skills indexes (Abdollahian et al, 2012). Tesfamariam et al. addressed the issue of environmental risk decision making using the process of fuzzy hierarchy analysis (Tesfamariam & Sadiq, 2006). In 2008, Degevrein et al. Used a network analysis model to identify the behavioral failure behavior in the workplace (Degevrein et al, 2008). In the year 2012, Richtta et al. Investigated the use of fuzzy hierarchy process to evaluate and select a notebook (Richetta & Thurachon, 2012). In the year 2012, Buyukozkabn et al. also evaluated green suppliers with a fuzzy network analysis approach (Büyüközkan & Çifçi, 2012). Wang et al. ranked and evaluated maneuverability by using the fuzzy network analysis process (Wang, Liu, & Cai, 2015). Yuksel et al in 2015, combined the fuzzy network analysis process and the balanced scorecard to evaluate the incumbent companies (Yüksel & Dag˘deviren, 2010).

Finally, this paper tries to present a new system for performance measurement of E-learning centers by exploring a complete set of key attributes and designing an evaluation process using fuzzy ANP.

2- Proposed performance measure system (PMS) methodology

The proposed methodology is designed based on a huge survey on different performance measurement system in literature and different approaches of performance management like ISO quality management system, performance pyramid system, balanced scorecard system, Business Process, Medori and Steeple framework, Management By Objectives (MBO), EFQM and etc. These approaches try to make a relationship between plans and reality results and they are mostly used in an efficient performance measurement system as a process of information collecting, analyzing and reporting. The proposed methodology tries to cover this process in three main phases as figure 1 and satisfy the main principals of designing a performance evaluation system as follows:

- Focusing on clear criteria and indicators, achievable goals, providing a multi-dimensional performance, satisfying the expectations of stockholders and etc. via phase 1 of proposed methodology that in which a significant number of criteria and sub criteria are identified via a group of experts in the form of different questionnaires and a huge survey on different metrics in the literature.
- Supporting the cause and effect relationship between the measurements via phase 2 of methodology. This phase uses the multi attribute decision making approaches (MADMs) due to their great benefits for analyzing the systems with multiplicity of criteria, the relations between criteria and the difficulties of measurement, huge number qualitative criteria, mental judgments and etc. Among the number of approaches explored in the literature of MADMs, the analytical network process (ANP) as a comprehensive approach is employed due to its inherent excellence to takes into account the existing dependencies and relationships between different elements, discover the decision-makers' preferences and allow the use of feedback systems in communications. Moreover, in order to be further representative of real-life situations, the proposed PMS uses the fuzzy mode of ANP because most of the indicators in a measurement system and the experts' judgments may be associated with uncertainty and only part of the decision data can be precisely measured.

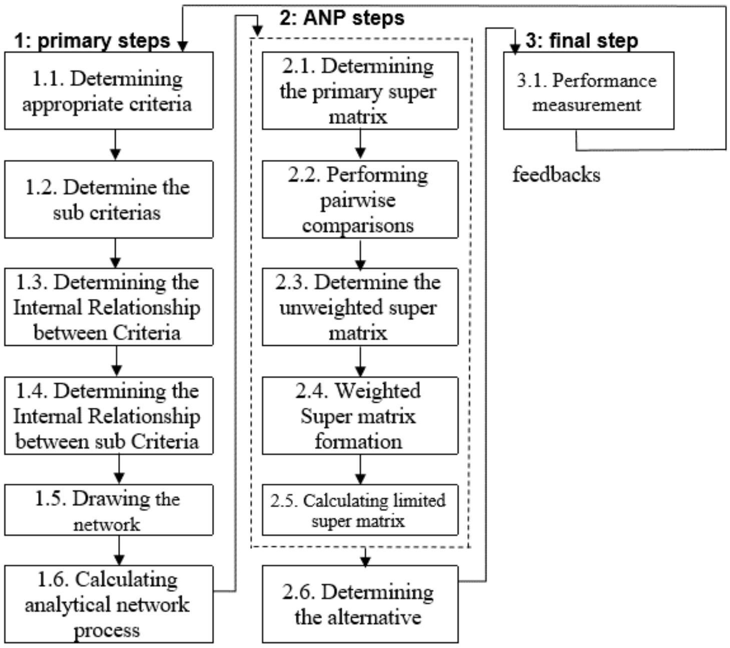

Fig 1. Steps of designing performance measurement system (PMS)

- Phase 3 of proposed approach creates an outcome-oriented & time-oriented model and tries to evaluate the system within a predefined time periods based on the most important evaluation criteria (phase 2) and providing feedback for growth and development, improving the evaluated capacities and etc.

Phase 1, 2 and 3 of the proposed methodology as Figure 1 include the following Actions:

- Actions 1.1 and 1.2 Identify a set of required criteria and sub-criteria by a huge survey on different metrics for measuring Universities' performance in the literature and they were developed and approved by a group of experts (6 faculty members of University) via a questionnaire
- Actions 1.3 and 1.4 make the relationship between the criteria and sub-criteria as internal relationship matrices.
- Action 1.5 create the network diagram according to the approved criteria and sub-criteria, the matrix of internal relations and the internal relationship matrix of sub-criteria.
- Action 1.6 includes ANP steps which are continued in phase 2 of figure 1 (Saaty T. , 2001), (Motaki & Kamach, 2017).
- Action 2.1forms the primary super matrix on the abovementioned network diagram.
- Action 2.2 proceed the pairwise comparisons under preferences of decision makers/experts.
- Action 2.3 creates the unweighted super matrix containing the local priorities.
- Action 2.4 calculates the weighted Super matrix by normalizing the above unweighted matrix..
- Action 2.5 coverts the weighted super matrix into a limit matrix. Weighted super matrix can be transformed into the limit super matrix by raising itself to powers until the matrix coverages.
- Action 2.6 tries to find the best alternative.
- Action 3.1 employs the proposed PMS using ANP steps and provides the report and feedback.

As mentioned before, the experts' judgments may be associated with uncertainty and the suitable approach should be considered in the proposed PMS. Professor Lotfi Zadeh, an Iranian scientist at the University of Berkeley in 1965, first introduced a fuzzy theory that tended to rationalize uncertainty due to inaccuracy and ambiguity. Fuzzy logic can be used for multiple management systems, including decision making, policy making, planning, and modeling. Since knowledge can be expressed more naturally using fuzzy sets, so most decision-making and engineering issues can be expressed more simply. In this approach the linguistic variables are used and it tried to convert them to fuzzy numbers. The linguistic variables and corresponding fuzzy numbers are given in Table 2 (Tesfamariam & Sadiq, 2006) and (Habibi et al, 2014).

Table 2. Fuzzy numbers used for making pairwise comparisons

Fuzzy scale	Relative importance	Definition
(1,1,1)	$\tilde{1}$	Equal importance
(1,2,3)	$\tilde{2}$	Intermediate value
(2,3,4)	$\tilde{3}$	Weak importance
(3,4,5)	$\tilde{4}$	Intermediate value
(4,5,6)	$\tilde{5}$	Essential or strong importance
(5,6,7)	$\tilde{6}$	Intermediate value
(6,7,8)	$\tilde{7}$	Demonstrated importance
(7,8,9)	$\tilde{8}$	Intermediate value
(8,9,9)	$\tilde{9}$	Extreme importance

The fuzzy numbers shown in this table are triangular fuzzy numbers as $\tilde{F}$ = (*l*, *m*, *u*) where, the value of *m* is the most probable value of a fuzzy number. After completing the matrix comparison and collecting expert opinions, since there are more than one questionnaire, the group decision making approach is used and the corresponding geometric mean are taken. The formula for calculating the geometric mean is given by the formula (1).

$$\tilde{a}_{ij} = \left(l_{ij}.m_{ij}.u_{ij}\right) = (\prod_{i=1}^{n} a_{ijk})^{1/n} \quad (1)$$

Where *n* is the number of decision makers (experts) and $\tilde{a}_{ij}$ is the fuzzy matrix element for decision makers and $\tilde{A} = [a_{ij}]$ is the final matrix produced in accordance with formula (2) (Saaty & Tran, 2007).

$$\tilde{A}=\begin{bmatrix} (1.1.1) & (l_{12}.m_{12}.u_{12}) & (l_{1n}.m_{1n}.u_{1n}) \\ (1/u_{12}.1/m_{12}.1/l_{12}) & (1.1.1) & (l_{2n}.m_{2n}.u_{2n}) \\ \vdots & \vdots & \vdots \\ (1/u_{1n}.1/m_{1n}.1/l_{1n}) & (1/u_{2n}.1/m_{2n}.1/l_{2n}) & (1.1.1) \end{bmatrix} \quad (2)$$

Where $a_{ii} = 1$ and $a_{ij} > 0$ (Bozóki, & Rapcsák,, 2008).

In order to evaluate the reliability of the pairwise comparison questionnaire, which was completed by the experts and the result was matched with the matrix $\tilde{A}$, the inconsistency of the questionnaire should be calculated. The inconsistency rate for each of the crisp matrix tables of the questionnaire could easily computed by the concept of classical AHP and eigenvectors. To calculate the fuzzy matrix inconsistency, a method called "Gougus" and "Boucher" is used, which is as follows (Pilevari, Hasanzadeh, & Shahriari, 2016), (Esmaeili, Seyedi, & ranban, 2013).In this approach one Matrix called M is formed by each middle value of fuzzy numbers of $\tilde{A}$as formula (3).

$$M = m_{ij} = [a_{ijm}] \quad (3)$$

The lower bounds (*l*) and the upper bound (*u*) of the fuzzy numbers of the matrix $\tilde{A}$ are also taken geometrically and placed in a matrix called G. The method of computing the geometric average is as formulas (4) and (5).

$$g_{ij} = \sqrt[2]{(l_{ij} \times u_{ij})} \quad (4)$$

$$G = [g_{ij}] \quad (5)$$

For each of the matrixes of M and G, the following steps are followed separately:
1) The relative weight vector is calculated as follows where, W_M and W_G are the weight of the matrix vector M and G.

$$W_M = [w_{iM}] \rightarrow w_{iM} = \frac{1}{n}\sum_{i=1}^{n} \frac{a_{ijM}}{\sum_{i=1}^{n} a_{ijM}} \quad (6)$$

$$W_G = [w_{iG}] \rightarrow w_{iG} = \frac{1}{n}\sum_{i=1}^{n} \frac{\sqrt{a_{ijl}a_{iju}}}{\sum_{i=1}^{n}(\sqrt{a_{ijl}a_{iju}})} \quad (7)$$

2) the inconsistency vector (λ) is calculated as follows:

$$\lambda_{maxM} = average(\lambda_{iM}) = \frac{\sum_{i=1}^{n}\lambda_{iM}}{n} = \frac{1}{n}\sum_{i=1}^{n}\sum_{i=1}^{n} a_{ijM}(\frac{w_{jM}}{w_{iM}}) \quad (8)$$

$$\lambda_{maxG} = average(\lambda_{iG}) = \frac{\sum_{i=1}^{n}\lambda_{iG}}{n} = \frac{1}{n}\sum_{i=1}^{n}\sum_{i=1}^{n} \sqrt{a_{ijl}a_{iju}}(\frac{w_{jG}}{w_{iG}}) \quad (9)$$

Where *n* is the number of matrix rows.
3) Computing the consistency index (CI) for both matrices of M and G:

$$CI = \frac{\lambda_{max}-n}{n-1} \quad (10)$$

When λ_{max} = n, the inconsistency index is 0 and the inconsistency rate is also zero.
4) Computing the consistency rate (CR) by dividing the inconsistency index on random inconsistency according to Formula (11).

$$CR = \frac{CI}{RI} \quad (11)$$

Random index (RI) is obtained from the chart of Gogous and Boucher and the random inconsistency for both matrices M and G must be less than 10%.

After ensuring that the inconsistency of pairwise comparison matrices is in suitable ranges, the weights should be calculated. In this paper, the "Chang Development Analysis" approach is used as follows to calculate the network analysis process because this method is simpler and more practical than other fuzzy approaches.

For the given fuzzy pairwise comparison ($\tilde{A}$) as formula (2) and each fuzzy element $\tilde{a}_{ij}$ we have:

$$\tilde{a}_{ij} = (l_{ij}.m_{ij}.u_{ij}) \Rightarrow \tilde{a}_{ij}^{-1} = \left(\frac{1}{u_{ij}}.\frac{1}{m_{ij}}.\frac{1}{l_{ij}}\right) \quad i,j = 1,2,...,n \quad i \neq j \quad (12)$$

According to the mentioned approach the normal values of the sum of the fuzzy elements for each row should be as formula (13) (Vahidnia et al, 2008).

$$\tilde{S}_i = \sum_{j=1}^{n} \tilde{a}_{ij} \otimes \left[\sum_{k=1}^{n}\sum_{j=1}^{n} \tilde{a}_{kj}\right]^{-1} \quad (13)$$

Chang used the concept of degree of feasibility to develop the analytical hierarchy technique in the fuzzy space. The degree of feasibility is meant to determine how likely it is to have a fuzzy number larger than another fuzzy number (Habibi et al, 2014) and (Degdeviren et al, 2008).

If $\tilde{S}_i = (l_i, m_i, u_i)$ and $\tilde{S}_j = (l_j, m_j, u_j)$ are two triangular fuzzy numbers, the probability of $\tilde{S}_j$ being larger than $\tilde{S}_i$ is equal to the height of the subscriber area between $\tilde{S}_i$ and $\tilde{S}_j$ as shown in figure 2.

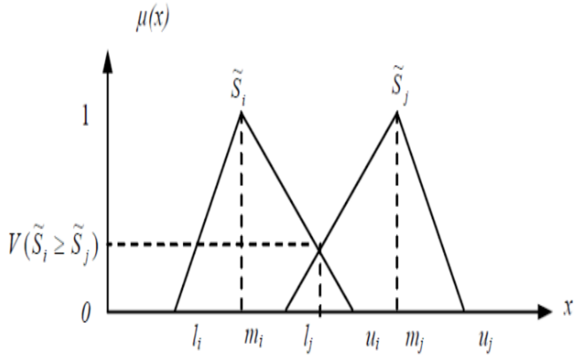

Fig 2. Probability of being larger of two fuzzy number to each other

Above mentioned comparison is mathematically represented as formula (14);

$$V = (\widetilde{S}_i \geq \widetilde{S}_j) = \begin{cases} 1 & if\ m_i \geq m_j \\ 0 & if\ u_i \geq l_j \\ \frac{u_i - l_j}{(u_i - m_i) - (m_j - l_j)} & else \end{cases} \tag{14}$$

The function of *V* leads to a matrix X corresponding to formula (15).

$$X = \left(V(\widetilde{S}_i \geq \widetilde{S}_j) \middle| i.j = 1.2 \ldots\ldots n \quad i \neq j\right) \tag{15}$$

The minimum amount of each row is calculated and a new matrix Y is formed as formula (16).

$$Y = \min(v_{ij}) \quad i.j = 1.2 \ldots\ldots n \quad i \neq j \tag{16}$$

The elements of the matrix Y with size of $n \times 1$ should be normalized and finally the normal weights will be calculated with respect to formula (17).

$$W = \frac{y_{i1}}{\sum_{i=1}^{n} y_{i1}} \qquad i = 1.2 \ldots\ldots n \tag{17}$$

Where the matrix w is a $n \times 1$ matrix as the ultimate matrix of weights and y_{i1} are the elements of matrix y as a $n \times 1$ matrix (Vahidnia et al, 2008).

Above-mentioned procedure should be done for each block of super matrix and finally the super matrix is completed by these computed weights. The initial formed super matrix is called the unweighted matrix, because the sum of the elements of sum columns may be greater than 1 and then the matrix should be normalized to form a weighted one.

The weighted super matrix will turn into limited super matrix with formula (18) and then it should be normalized.

$$W_{ANP} = \lim_{k \to \infty} W^{2\,k+1} \quad k = 1.2 \ldots\ldots \infty \tag{18}$$

After doing these steps, an ultimate matrix will be obtained which contains only the ultimate weights of lowest level of the network.

3- Real case study

The proposed PMS is employed here to measure the performance of e-learning centers of Universities. Several criteria can be used to measure the University's performance and this paper via a huge survey on different metrics tries to find the effective measures. Table 3 summarize the best non-financial criteria and sub criteria which is obtained by a huge survey and in the form of different questionnaires.

Table 3. Selected criteria for measuring performance

criteria	sub-criteria	references
C1 - student	SC1 - Comprehensive Computer Skills SC2 - Interest in learning SC3 - The need for student learning SC4 - Past work experience SC5 - A Surrounding Future Perspective	(Jam Barazmi & Hossein zadeh, 2011) (Heydari, Ghorbani Doolat Abadi, & Hashemi, 2016) (Hosein pour, 2016) (Balabonienca & Vecerskienah, 2014) (Ahmad & Mohamed Zabri, 2016)
C2 - professor	SC6 - Master's attitude towards the course SC7 - Attract Master's Contribution	
C3 - Educational content	SC8 - Up-to-date content SC9 - understandable content	
C4 - relations	SC10 - Possibility of group work in education SC11 - Contact facilities with the teacher	
C5 - research	SC12 - Creativity and Innovation Development SC13 - Development of International Knowledge SC14 - Number of Theses: Number of Thesis Students	
C6 - timing	SC15 - Class Scheduling SC16 - The time allocated to the course SC17 - Availability time of support expert	
C7 - Continuous improvement	SC18 - Presence of Q & A sessions with authorities SC19 - Analyze and improve the education system SC20 - Training Staff	
C8 - substructure	SC21 - Software used in training SC22 - Ease of use of the software SC23 - Backup Expert SC24 - Training Software Platform SC25 - Generating Incentives	

Now with the proper criteria and sub-criteria, it is time to draw the network of methodology. The network is designed according specification of each criterion and sub criteria and the general connection of the criteria with the main purpose of the research. Figure 3 shows the interactive network for identified set of criteria and sub-criteria of E-learning center of IUST.

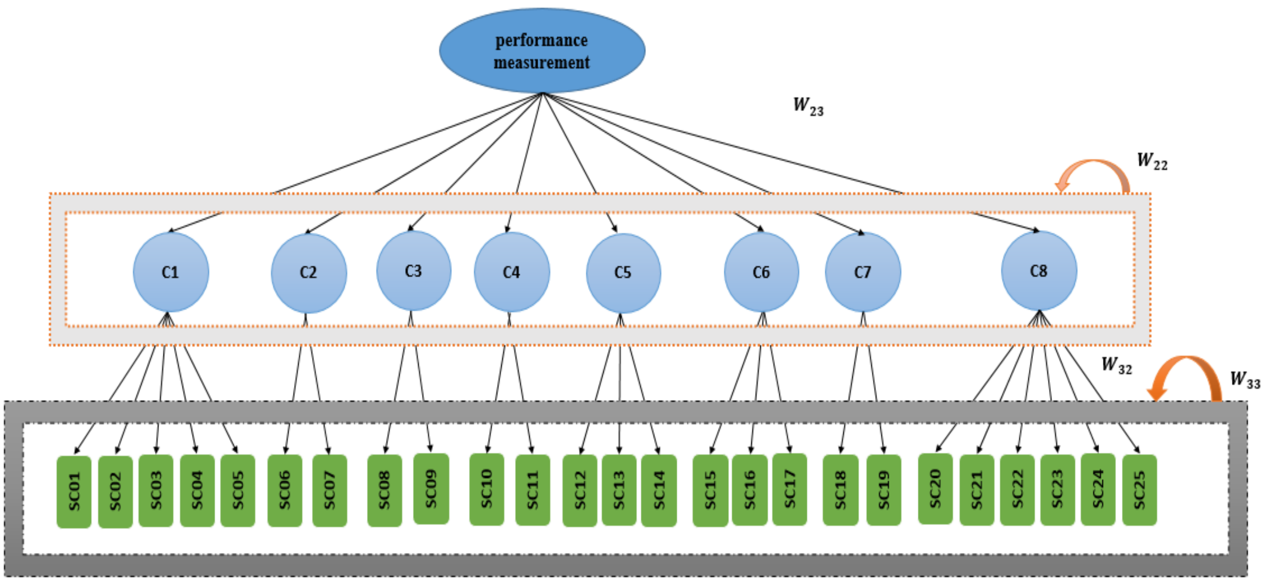

Fig 3. Network of analytical network process

The primary super matrix of this network is also shown as formula (19).

$$W_{ANP}=\begin{bmatrix} 0 & 0 & 0 \\ W_{21} & W_{22} & 0 \\ 0 & W_{32} & W_{33} \end{bmatrix} \quad (19)$$

Where, W_{ANP} means the matrix of the network analytical process, W_{21} represents the relationship of the target with criteria, W_{22} represents the interconnection of the criteria with each other, and W_{32} indicates the relationship of sub criteria with the criteria, as evidenced in figure 3.

The pairwise matrices are drawn from the network and interconnections and completed by a group of experts (as table 4) in form of different questionnaires.

Table 4. Features of experts

Expert	Number	Special feature
Academic staffs	three	They are working at the different divisions of University
Faculty members	three	They are involve in e-learning system
Students of University	six	e-learning students who are familiar with the ANP method

Each matrix is converted into two matrices M and G, and the inconsistency of each one should be computed and analyzed. Table of random inconsistency index of Gogous and Boucher method contains only the matrices which their size (n) is less than 15. In order to calculate the fuzzy inconsistency of matrices with more size, a regression approach is used to calculate the inconsistency for $\widetilde{W}_{33}$where there is no numerical value for the RI index for both the matrices M and G. Figure 4 summarizes the results.

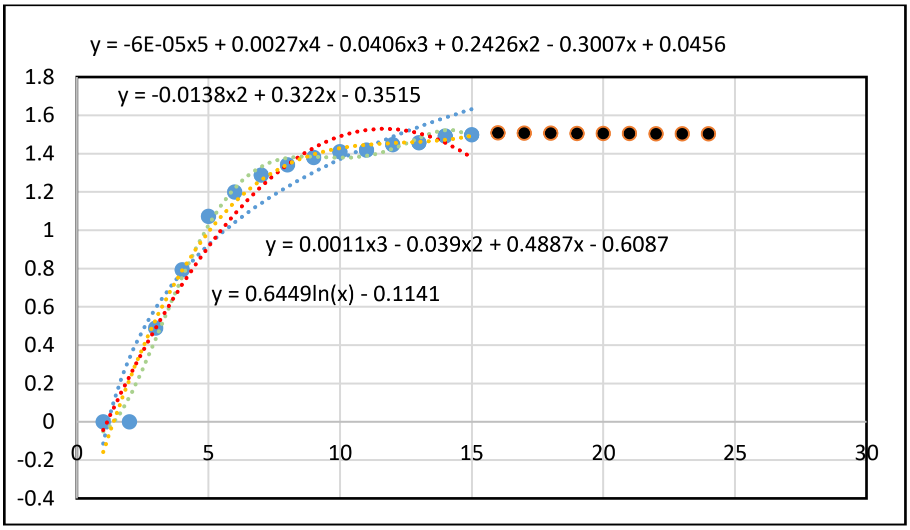

Fig 4. Logarithmic and polynomials equations of degrees 2, 3 and 5

Then, the difference between two consecutive numbers in the chart of Boucher table is obtained and another regression diagram called Power Chart which was depicted in figure 5 and the equivalent line equation was obtained.

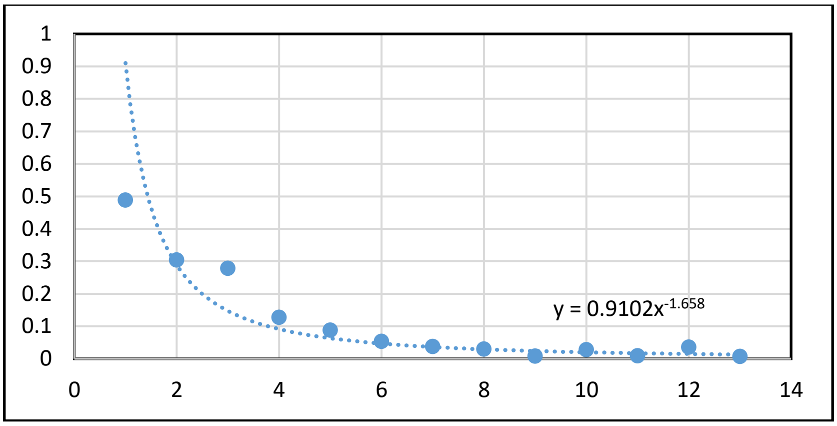

Fig 5. Power chart and its corresponding equation for Rim

Random index for m fuzzy matrices with size of n≥16 according to obtained equations is calculated and shown in table 5.

Table 5. Random index for m matrices with size of n≥16

x or n	y_1	y_2	y_3	y_4	y_5
16	1.673942467	1.2677	1.7321	5.07504	1.507625209
17	1.713039286	1.1343	1.8325	5.89258	1.506757191
18	1.749900747	0.9733	1.9671	6.51732	1.506015405
19	1.784768698	0.7847	2.1425	6.73626	1.505375922
20	1.817847743	0.5685	2.3653	6.2716	1.504820301
21	1.84931252	0.3247	2.6421	4.77354	1.504334131
22	1.879313278	0.0533	2.9795	1.81308	1.503906014
23	1.90798022	-0.2457	3.3841	-3.1258	1.503526828
24	1.935426915	-0.5723	3.8625	-10.6502	1.503189201

A similar method is used for G matrices and is obtained by regression of the following numbers, as shown in figures 6 and 7.

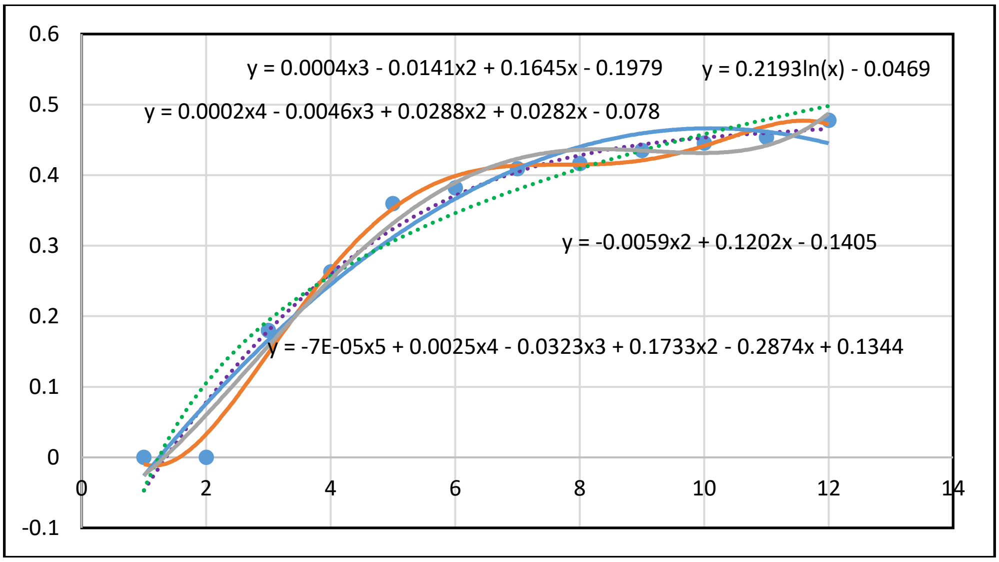

Fig 6. Logarithmic and polynomials equations of degrees 2, 3 and 5 for Rig

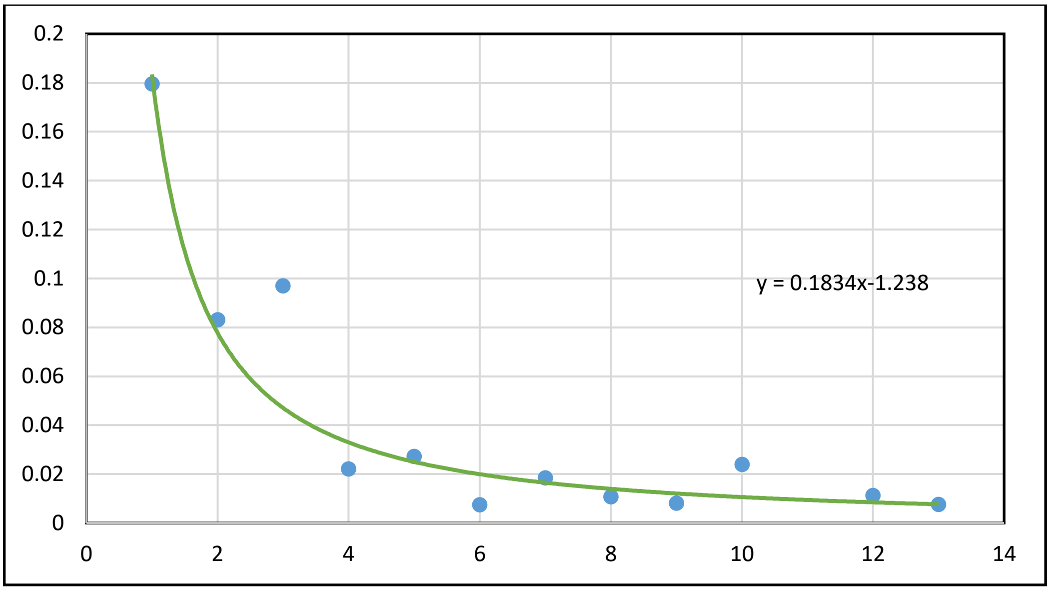

Fig 7. Power chart and its corresponding equation for Rig

Moreover, the random index for g fuzzy matrices with size of n≥16 according to obtained equations is calculated and shown in table 6.

Table 6. Random index for g matrices with size of n≥16

x or n	y_1	y_2	y_3	y_4	y_5	y_6
16	0.5611	0.2723	-1.9603	2.0116	0.4629	0.4939
17	0.5744	0.1978	-3.9650	2.829	0.4889	0.4934
18	0.5869	0.1115	-7.09293	3.9288	0.5275	0.4931
19	0.5988	0.0134	-11.835	5.3674	0.5811	0.4927
20	0.6100	-0.0965	-18.693	7.206	0.6521	0.4924
21	0.6207	-0.2182	-28.39	9.5106	0.7429	0.4922
22	0.6309	-0.3517	-41.355	12.352	0.8559	0.4919
23	0.6407	-0.417	-58.33	15.8058	0.9935	0.4917
24	0.6500	-0.6541	-81.40	19.9524	1.1581	0.4915

The minimum value is 0.4915, which is placed in the equation and the inconsistency with it is calculated. Therefore, according to the above two tables, the inconsistency index for fuzzy matrices with the size equal to larger than 16 can be considered equivalent to the numbers in Table 7.

Table 7. Random index values for fuzzy matrices with size of $n \geq 16$

n	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
RI_m	1.5076	1.5067	1.5060	1.5053	1.5048	1.5043	1.5039	1.5035	1.5032
RI_g	0.4939	0.4934	0.4931	0.4927	0.4924	0.4922	0.4919	0.4917	0.4915

The W_{21} super matrix is given in table 8.

Table 8. Fuzzy matrix of W_{21}

	c1			c2			c3			c4			c5			c6			c7			c8		
c1	1	1	1	0.44	0.52	0.60	0.93	1.47	2.18	1.51	2.29	3.26	1.37	1.67	1.99	1.18	1.76	2.45	0.90	1.17	1.59	0.89	1.19	1.62
c2	2.27	1.94	1.66	1	1	1	1.65	2.75	3.80	1.41	2.22	3.20	2.57	3.69	4.75	2.71	3.89	5.00	2.04	2.87	3.60	2.00	3.05	4.08
c3	1.07	0.68	0.46	0.61	0.36	0.26	1	1	1	1.45	2.33	3.37	1.51	2.57	3.60	1.94	3.10	4.19	1.10	1.57	2.18	0.70	1.00	1.31
c4	0.66	0.44	0.31	0.71	0.45	0.31	0.69	0.43	0.30	1	1	1	0.41	0.52	0.71	1.00	1.33	1.73	0.64	0.79	1.09	0.26	0.32	0.42
c5	0.73	0.60	0.50	0.39	0.27	0.21	0.66	0.39	0.28	2.45	1.92	1.41	1	1	1	1.41	1.99	2.70	1.10	1.68	2.57	0.57	0.72	1.00
c6	0.85	0.57	0.41	0.37	0.26	0.20	0.51	0.32	0.24	1.00	0.75	0.58	0.71	0.50	0.37	1	1	1	0.52	0.63	0.78	0.20	0.26	0.39
c7	1.11	0.85	0.63	0.49	0.35	0.28	0.91	0.64	0.46	1.57	1.26	0.92	0.91	0.60	0.39	1.92	1.59	1.29	1	1	1	0.58	0.66	0.77
c8	1.12	0.84	0.62	0.50	0.33	0.25	1.42	1.00	0.76	3.87	3.17	2.38	1.74	1.39	1.00	4.93	3.81	2.59	1.73	1.52	1.29	1	1	1

According to the designed PMS, the matrix of W_{21} should be devived into two matrices M and G, as shown in tables 9 and 10.

Table 9. M matrix of $\widetilde{W}_{21}$

	c1	c2	c3	c4	c5	c6	c7	c8
c1	1.00	0.52	1.47	2.29	1.67	1.76	1.17	1.19
c2	1.94	1.00	2.75	2.22	3.69	3.89	2.87	3.05
c3	0.68	0.36	1.00	2.33	2.57	3.10	1.57	1.00
c4	0.44	0.45	0.43	1.00	0.52	1.33	0.79	0.32
c5	0.60	0.27	0.39	1.92	1.00	1.99	1.68	0.72
c6	0.57	0.26	0.32	0.75	0.50	1.00	0.63	0.26
c7	0.85	0.35	0.64	1.26	0.60	1.59	1.00	0.66
c8	0.84	0.33	1.00	3.17	1.39	3.81	1.52	1.00

Table 10. G matrix of $\widetilde{W}_{21}$

	c1	c2	c3	c4	c5	c6	c7	c8
c1	1.00	0.52	1.43	2.22	1.65	1.70	1.20	1.20
c2	1.94	1.00	2.50	2.13	3.49	3.68	2.71	2.86
c3	0.70	0.40	1.00	2.21	2.33	2.85	1.55	0.96
c4	0.45	0.47	0.45	1.00	0.54	1.32	0.83	0.33
c5	0.60	0.29	0.43	1.86	1.00	1.95	1.68	0.76
c6	0.59	0.27	0.35	0.76	0.51	1.00	0.64	0.28
c7	0.84	0.37	0.65	1.20	0.59	1.57	1.00	0.67
c8	0.83	0.35	1.04	3.04	1.32	3.57	1.50	1.00

Matlab software is used to calculate the weight of fuzzy matrices. The weighted super matrix is shown in Table 11 by multiplying the unweighted super matrix in the cluster matrix.

Table 11. Harmonic super matrix

	goal	C1	C2	C3	C4	C5	C6	C7	C8	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9	SC10	SC11	SC12	SC13	SC14	SC15	SC16	SC17	SC18	SC19	SC20	SC21	SC22	SC23	SC24	SC25
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C1	0.11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	0.69	0	0.44	0.2	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	0.21	0.56	0	0.63	0.31	0.43	0.83	0.83	0.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	0	0.27	0.39	0	0	0	0	0	0.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	0	0	0	0	0.52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SC1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0	0	0.65	0	0	0
SC2	0	0	0	0	0	0	0	0	0	0.7	0	0.27	0.32	0.31	0	0	0	0	0.5	0	1	0.5	0.45	0	0	0	0	0.09	0	0	0	0	0	0.05
SC3	0	0	0	0	0	0	0	0	0	0	0.34	0	0.25	0.31	0.08	0	0	0	0	0	0	0.5	0.29	0	0	0	0	0.07	0	0	0	0	0	0.07
SC4	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.06
SC5	0	0	0	0	0	0	0	0	0	0	0.45	0.3	0.27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.06	0	0	0	0	0	0.06
SC6	0	0	0	0	0	0	0	0	0	0	0	0	0	0.06	0	1	1	0	0	0	0	0	0	0	1	0	0	0.13	0	0	0	0	0	0.08
SC7	0	0	0.17	0	0	0	0	0	0	0	0.21	0	0	0.18	0.92	0	0	0	0	0	0	0	0	0	0	0	0	0.12	0	0	0	0	0	0.09
SC8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.14	0	0	0	0	0	0.05
SC9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.16	0	0	0	0	0	0.05
SC10	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0	0	0	0	0.01
SC11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.14	0	0	0	0	0	0.04
SC12	0	0	0	0	0.17	0	0	0	0	0	0	0	0.07	0.14	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0.01	0	0	0	0	0	0.06
SC13	0	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SC14	0	0	0	0	0	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04
SC15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04
SC16	0	0	0	0	0	0	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02
SC17	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03
SC18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05
SC19	0	0	0	0	0	0	0	0.17	0	0.3	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	1	0	0	1	0	0.06
SC20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SC21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02
SC22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.07
SC23	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03
SC24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.35	0	0	0.02
SC25	0	0	0	0	0	0	0	0	0	0	0	0.42	0.09	0	0	0	0	1	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

In this matrix, the sum of all columns is equal to 1 so the matrix is normal. Subsequently, by using the Matlab software, the weighted super matrix was brought to high and individual strengths and when all the numbers of each row were equal, these numbers represent the final weights. The final normal weights were obtained in table 12.

Table 12. Ultimate normal weights of sub criteria

Sub criteria	**SC1**	**SC2**	**SC3**	**SC4**	**SC5**	**SC6**	**SC7**	**SC8**	**SC9**
weight	0.0037	0.0462	0.0649	0.0018	0.0435	0.3874	0.3771	0.003	0.0031
Sub criteria	SC10	SC11	SC12	SC13	SC14	SC15	SC16	SC17	SC18
weight	0.0007	0.0028	0.008401	0.0001	0.0011	0.0013	0.0007	0.0009	0.0015
Sub criteria	SC19	SC20	SC21	SC22	SC23	SC24	SC25	--	--
weight	0.010501	0.0001	0.0006	0.005301	0.0009	0.0032	0.031103	--	--

4- Results & discussions

The proposed PMS is employed here to measure the performance of E-learning centers of Universities. The weights of each sub-criterion according the above mentioned procedures are calculated and summarized figure 8. Based on the results, the sub-criterion of "Master's attitude toward the course; SC6" has the most importance in measuring performance. The sub-criterion of "attracting student participation by the professor; SC7" has the next important role. The subcategory of "Learning Need; SC3", "Curiosity Interest in Education; SC2" and "Future Prospects Outlook; SC5" have the following positions.

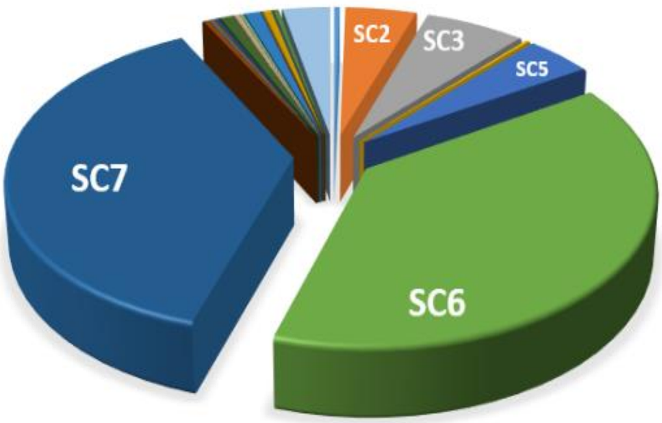

Fig 8. Pie chart of every sub criteria

The proposed performance measurement system (PMS) is implemented with huge surveys for three e-learning centers of reputable Universities in Iran (due to their confidentiality, their names are not mentioned here). Figure 9 shows the performance of each electronic center, which can be used to compare the performance of the centers and gain strengths and weaknesses.

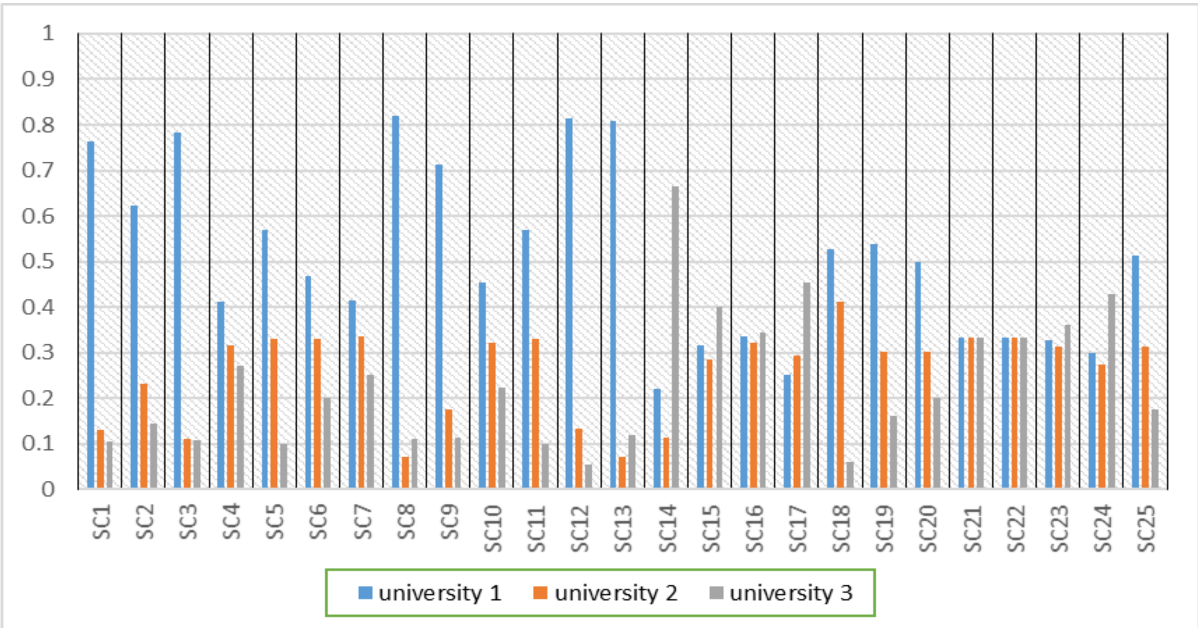

Fig 9. Comparison chart of performance of three e-learning centers

The graph shows that the performance of University 1 is higher from some perspectives, such as educational content so that in cases where there is a better performance, it should maintain the current optimal state and in cases where the performance of each University is lower in terms of some sub-criteria there should be good measures to improve the performance.

The Pareto analysis is also done for these Universities in order to select the number of criteria that produce significant overall effect on performance measurement. As an example, the strengths and weaknesses of University 1 are summarized in figure 10 and it can help the managers to make the preventive and corrective decisions in order to improve the overall performance.

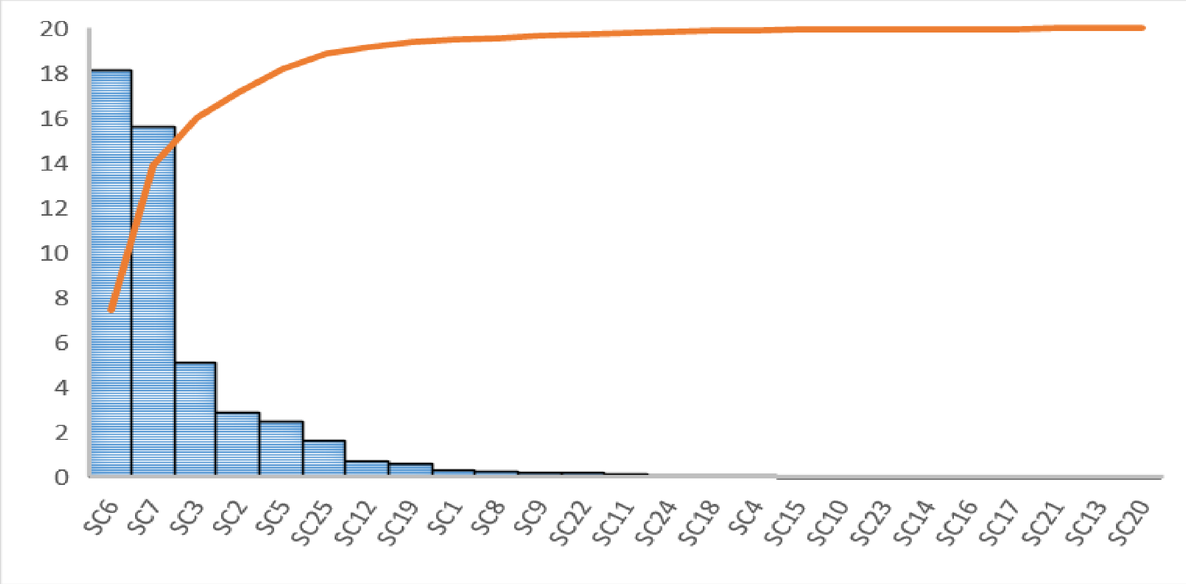

Fig 10. Pareto chart of performance of the University 1

In order to better analysis on criteria and their impact on overall performance, another chart named Tree Map Chart is drawn as figure 11 that in which the factors with smallest area on chart are reducing the total score in performance management.

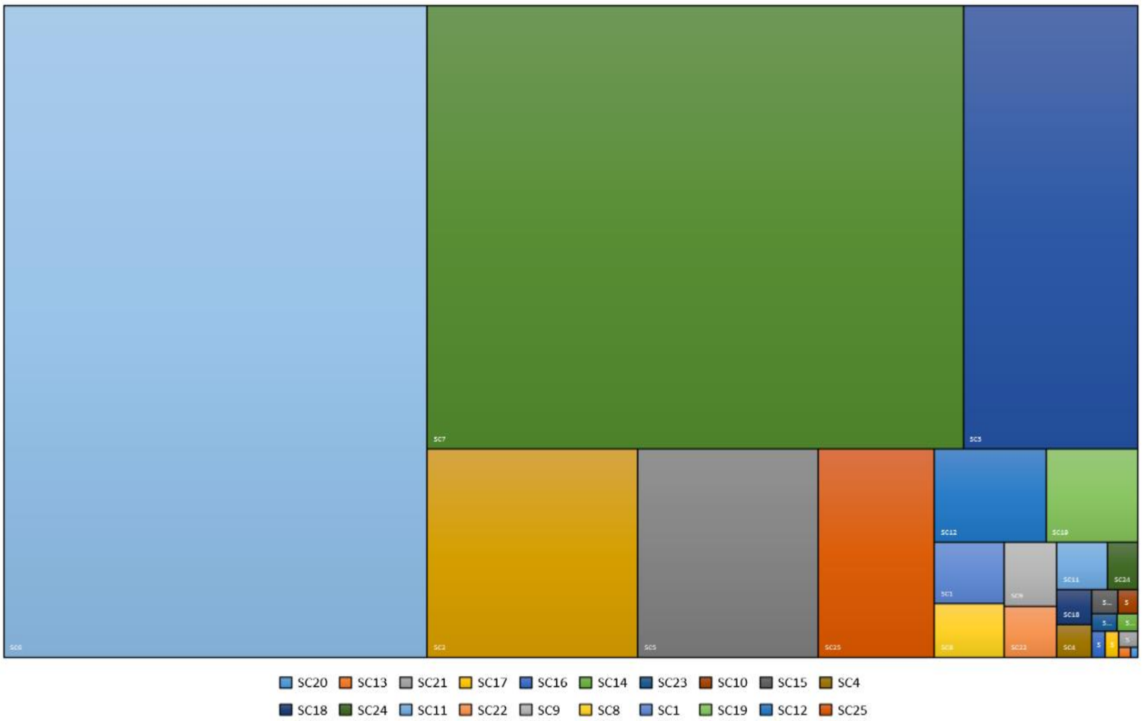

Fig 11. Tree map chart of performance for the University 1

Therefore, the University 1 needs to think on some improvement actions for 20% of factors which have the significant overall effect on performance measurement and promote the current condition for factors with good performance score. Base on the results of this study, this University should consider the following points:

- Recognize the educational needs of electronic center staff;
- elaborate the educational standards for employees;
- Create the opportunities and incentives for students to develop international knowledge;

- Integrate the software and remove the disparities between software used in the electronic center and
- Coordinate the presence of supporting expert with class times.

5- Conclusions

Performance measurement is a key element for continuous improvement and could provide information about the effectiveness of educational and scientific activities. This forces Universities to understand changes not only in processes but also in understanding how their environment varies. In such situations, individual systems are not suitable for measuring performance at a University. Because these systems are mainly designed to evaluate a part of the function and therefore cannot provide accurate information that is not appropriate for the proper management of a modern University. Therefore, several performance models need to be integrated to allow assessment of the performance of Universities from all perspectives. Universities are also classified as general systems in terms of providing services to the general public and a combination of more than one evaluation method is appropriate for measuring their performance. Therefore, this paper tried to design a new system for performance measurement by exploring a complete set of key attributes and designing an evaluation process using fuzzy ANP. Measuring the performance of the organization is recognized as one of the important management functions and is also a key tool that determines whether output are in line with what was planned or should have been achieved. The proposed approach tries to make a relationship between plans and reality results and it could be considered as a process of information collecting, analyzing and reporting. This approach tried to consider all aspects of a University and examined 25 sub-criteria in its own assessments using fuzzy logic and multi attribute decision making (MADM). Fuzzy logic can be used for multiple management systems, including decision making, policy making, planning, and modeling. In the real world, many performance indicators are associated with uncertainty and the decision maker faces uncertainties. In order to integrate the ideas of a decision maker, it is better to convert the decision maker's estimates to fuzzy numbers, that is, to convert input data to fuzzy numbers. Therefore, measuring performance by converting decisions made to fuzzy numbers increases the accuracy of the results. To design of this approach has been attempted to support the cause and effect relationship between the measurements. the analytical network process (ANP) due to their great benefits for analysing the complex systems with multiplicity of qualitative criteria, the relations between criteria and the difficulties of measurement, is recognized better for combining with fuzzy logic. Finally a comprehensive performance measure system (PMS) is designed to measure the performance of the University's electronic center.

Based on the results obtained, the criteria for measuring University performance are mainly "student, teacher, educational content, communication, research, scheduling, continuous improvement and infrastructure." From the results of the final weights obtained, the "master's attitude toward the course" is most important in measuring performance. The sub-criterion of "attracting student participation by the master" has the next important place. The subcategory of the need for learning, the interest of interference in education, and the future prospects of the student future are the next. It is also suggested that the method of calculating the analytical process of fuzzy network with other multi-criteria decision making methods is also compared and its efficiency is examined.

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