A Fuzzy Mapping Approach for Evaluating Success Factors of ABET Accreditation

Nazli Goker and Mehtap Dursun

***Abstract*—**The Accreditation Board for Engineering and Technology (ABET) provides the accreditation of the tertiary education programs in the fields of applied and natural science, computing, engineering, and technology. Although ABET accreditation is voluntary, graduates of the ABET-accredited programs are considered as equivalent in knowledge, behaviors, and attitude with global standards. In this study, the factors that affect the success of ABET process are evaluated, and their importance weights are determined. Causal links among the factors, positive as well as negative relations between pair of criteria, and lack of crisp data lead to employ fuzzy cognitive map as an appropriate methodology to assess success factors of ABET process. The application is illustrated through a case study, which is conducted in a university located in Turkey.

***Index Terms*—**Fuzzy cognitive map, Education, Accreditation, ABET process, Success evaluation.

I. Introduction

Engineering education has historically undergone many stages of evolution, regulation, and quality control via accreditation. To assure similarity and quality in the study programs, accreditation of engineering and computing education through some global benchmarks has become crucial. In addition to their individual national accreditation bodies, the universities in the Gulf Cooperative Council (GCC) region are gradually acquiring Accreditation Board for Engineering and Technology (ABET) accreditation for their engineering and computing programs. A member of the International Engineering Alliance, ABET is one of the initial signatory organizations from the United States for the Washington Accord. At the associate, bachelor's, and master's degree levels, ABET accredits college and university programs in the fields of applied and natural science, computing, engineering, and engineering technology [1]. The ABET Accreditation procedure has been extremely systematic and regulated. It has aided in comparing various engineering and computing programs to international standards and addressing any deficiencies.

This work introduces a fuzzy cognitive map (FCM) technique to determine the importance degrees of success factors of ABET process. Interrelations between pair of criteria, and lack of crisp data lead to employ fuzzy cognitive map as an appropriate methodology for assessing success factors of ABET.

The remaining part of the study is organized as follows. FCM is explained in Section 2. Section 3 illustrates the case study. Conclusions are provided in the last Section.

II. Fuzzy cognitive maps

Fuzzy cognitive map (FCM) is a causal information-based tool that combines fuzzy logic and neural networks. The extension of the tool is provided by including fuzzy numbers or linguistic variables for expressing the causal links among concepts in the map. These concepts represent an entity, a state, a variable or a characteristic of a system, a behavior of the information-based system is denoted by concepts in FCM [2]. Concept nodes and weighted arcs are the elements of FCM which can be graphically showed with feedback. Signed arcs indicate the sign of causality: whether the causal relationship is positive, negative or null; and connected nodes produce causal relationships among concepts [3]. $C = \{C_1, C_2, \ldots, C_n\}$ is the set of concepts, arcs (C_j, C_i) demonstrate how concept C_j causes concept C_i, and are used for causal relationships between concepts. The weights of causality links range can be represented with linguistic variables such as “negatively medium”, “zero”, “positively medium”, etc. The value of each concept is computed, taking into account the effect of the other concepts on the under-evaluation concept, by applying the following iterative formulation.

$$A_i^{(k+1)} = f\left(A_i^{(k)} + \sum_{\substack{j\neq i \\ j=1}}^{N} A_j^{(k)} w_{ji}\right) \quad (1)$$

where $A_i^{(k)}$ is the value of concept C_i at k^{th} iteration, w_{ji} is the weight of the connection from C_j to C_i and f is a threshold function.

III. Case Study

This work presents a FCM approach for evaluating success factors of ABET process. The case study is conducted in a university located in Turkey through three professors’ opinions. Initially, success factors that are determined by interviewing the decision makers of the case institution, are delineated in Table I [4].

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TABLE I: SUCCESS FACTORS OF ABET [4]

Label	Factor	Explication
C_1	Students	Student management deals with devising rules and regulations of admission, progression and graduation and their efficient implementation.
C_2	Program Educational Objectives	The program must have published program educational objectives that are consistent with the mission of the institution, the needs of the program's various constituencies, and these criteria.
C_3	Continuous quality improvement	The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained.
C_4	Quality steering team and leader	Every program must have a quality steering team responsible for ensuring the sustainable quality adoption as witnessed in the literature.
C_5	Document orientation and knowledge sharing culture	The motivation and objectives for documentation should be to facilitate sufficient common understanding among different stakeholders and agencies.
C_6	Academic and research excellence	Academic excellence is the most fundamental aspect of the program. It requires efficient synergies between program design and delivery in order to meet outcome-based learning.
C_7	Top management support	Adoption of innovation, quality and sustainability initiatives requires huge amount of efforts and resources. Endorsements and full-hearted support from top management becomes essential to accommodate required organizational changes and commitment of resources.
C_8	Institutional quality compliance	Institutional quality compliance through setting up of a permanent executive division for quality will help in dealing with various agencies. The responsibility of this division is to provide a quality related centralized assistance to all the programs offered by different colleges and departments.

The decision-makers indicate the direction of causal relationships in three categories: positive, negative, null. Afterwards, experts decide the degree of causal links by using linguistic variables; subsequently linguistic variables are transformed into fuzzy numbers. In this study, nine linguistic terms are used as negatively very strong (nvs), negatively strong (ns), negatively medium (nm), negatively weak (nw), zero (z), positively weak (pw), positively medium (pm), positively strong (ps), positively very strong (pvs). The corresponding triangular fuzzy numbers for these linguistic variables are reported in Table II.

TABLE II: SCALE OF FUZZY NUMBERS [3]

Linguistic term	Triangular fuzzy number
nvs	(-1,-1,-0.75)
ns	(-1,-0.75,-0.5)
nm	(-0.75,-0.5,-0.25)
nw	(-0.5,-0.25,0)
z	(-0.25,0,0.25)
pw	(0,0.25,0.5)
pm	(0.25,0.5,0.75)
ps	(0.5,0.75,1)
pvs	(0.75,1,1)

The matrix of power of causalities according to the experts are given in Tables III, IV and V.

TABLE III: POWER OF CAUSALITIES ACCORDING TO EXPERT 1

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	0	0	pvs	0	0	0	0	pw
C_2	pvs	0	ps	0	0	0	0	0
C_3	0	pm	0	pm	0	0	0	0
C_4	pw	0	0	0	pw	0	pm	pm
C_5	0	pw	0	0	0	0	0	0
C_6	0	0	0	0	0	0	pm	pm
C_7	0	0	0	pvs	0	0	0	0
C_8	0	0	0	pw	0	0	pw	0

TABLE IV: POWER OF CAUSALITIES ACCORDING TO EXPERT 2

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	0	0	ps	0	0	0	0	pm
C_2	ps	0	pm	0	0	0	0	0
C_3	0	ps	0	ps	0	0	0	0
C_4	pm	0	0	0	pm	0	pm	ps
C_5	0	pw	0	0	0	0	0	0
C_6	0	0	0	0	0	0	ps	ps
C_7	0	0	0	ps	0	0	0	0
C_8	0	0	0	pw	0	0	pm	0

TABLE V: POWER OF CAUSALITIES ACCORDING TO EXPERT 2

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	0	0	ps	0	0	0	0	pm
C_2	ps	0	ps	0	0	0	0	0
C_3	0	pm	0	pm	0	0	0	0
C_4	pw	0	0	0	pm	0	pm	pm
C_5	0	pw	0	0	0	0	0	0
C_6	0	0	0	0	0	0	pm	pm
C_7	0	0	0	ps	0	0	0	0
C_8	0	0	0	pw	0	0	pm	0

The linguistic data collected by the experts are converted into triangular fuzzy numbers according to the fuzzy scale given in Table II. The matrices of power of causalities that are transformed into triangular fuzzy numbers with regard to three experts. Afterwards, these triangular fuzzy numbers are aggregated via MAX aggregation, and then defuzzified by using center of gravity (COG) method, and the weight matrix is obtained as in Table VI. MATLAB fuzzy toolbox is used for these operations.

TABLE VI: WEIGHT MATRIX

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	0	0	0.798	0	0	0	0	0.375
C_2	0.798	0	0.625	0	0	0	0	0
C_3	0	0.625	0	0.625	0	0	0	0
C_4	0.375	0	0	0	0.375	0	0.5	0.625
C_5	0	0.25	0	0	0	0	0	0
C_6	0	0	0	0	0	0	0.625	0.625
C_7	0	0	0	0.798	0	0	0	0
C_8	0	0	0	0.25	0	0	0.375	0

The iterative formulation of FCM is run via FCMapper software for obtaining the importance degrees of success factors on achieving ABET. The resulting importance values are listed in Table VII.

TABLE VII: SUCCESS FACTORS OF ABET

Label	Importance degree
C_1	0.866639
C_2	0.828089
C_3	0.890907
C_4	0.917639
C_5	0.748960
C_6	0.659046
C_7	0.890861
C_8	0.901297

IV. CONCLUSIONS

To obtain the importance weights of success factors of ABET, evaluation criteria that influence the success of achieving the accreditation are determined through expert opinions and then algorithm of the work is reported by considering FCM technique. Importance weights of factors are assigned by applying FCM methodology, "quality steering team and leader" and "institutional quality compliance" are the most effective factors however "document orientation and knowledge sharing culture" and "academic and research excellence" are the least influential criteria. Future research will focus on proposing a multi-criteria decision making based selection process, in which a determination whether a university may achieve ABET or not, will be provided.

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