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Research Article

A Model Proposal for Course Selection with the Fuzzy MOORA Approach

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Abstract

Modern engineering study programme made to fit the needs of industrial enterprises. The programme is based on training and education in the field of industrial engineering and on experience gained during implementation of individual projects in industrial enterprises. Many universities offer courses, in areas such as logistics, supply chain management and analytics. In this study, the importance of courses in industrial engineering undergraduate programs has been researched. Compulsory and optional courses given in industrial engineering have been investigated under the determined criteria. Research, academics working in the industrial engineering department in Turkey, the proper course of materiality is an implementation of the fuzzy logic survey work on assessing the work. The sample order with 32 samples prepared by the academicians responding to the questionnaire was determined with «Fuzzy MOORA» technique as compulsory and optional courses. Studies on course selection were examined, to the best of our knowledge this is the first study using «Fuzzy MOORA» technique to select/rank courses. It is evaluated that MOORA method, which is a new criterion decision method for course choice, will contribute to international literature as «Fuzzy MOORA» approach with fuzzy logic.

Keywords: Course selection, multi-criteria decision making, fuzzy MOORA technique

1. Introduction

Education is one of the most important factors for the development of a country as it provides the basis for the production, development and development work of an individual. Therefore, it is very important to educate individuals to make them think, understand, investigate, question and solve problems [1].

There are social, political, cultural and economic factors that affect the education of students within a macro perspective. Nowadays, scientific and technological innovations and changes are occurring at much faster rate as compared to the past. The examination of international education systems (studies) has revealed that knowledge based classical education seems quite inadequate in rapidly changing conditions of societies. Currently, planning in education, obtaining research and learning skills, acquiring the skills of continuous learning, adapting quickly to changing conditions and getting a viewpoint questioning knowledge have gained much importance in the field of education.

Therefore, educational innovations are need of the hour as development tool for any country to deal with the rapidly changing scenario of science and technology. The universities implement various regulations while formulating their academic curricula. In general, there is a balance between theoretical and practical based courses. The curriculum is also supported by social lessons.

There are many thoughts and opinions about the discipline of Engineering. Different perspectives and definitions have been made by different institutions and individuals to define engineering. A few definitions for engineering are given below.

The fields of engineering and education have important place in the management and direction of economic and social areas. For engineers, industry, and technology, new ideas can be created, or ideas can be directed, and outputs can affect the lives of humanity [2].

Engineering is an analytical thinking skill which aims to develop humanity by synthesizing the experiences gained by science and reaching concrete rationales and optimization of resource utilization.

In the field of engineering education, the students are trained to solve the technical problems that they may encounter in future. The basic purpose of engineering education is to develop the technical skills, hardware and technology for production and

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management and service sectors to maximize the benefit for the development of a country.

Therefore, master's degree is also given to the students after completion of the advanced level training for two years besides the undergraduate engineering education in the world and Turkey. In the four years of training program, engineers are aimed to acquire both research and teaching techniques and are awarded doctorate (Ph.D.) degrees.

In Turkey, a study conducted for the industrial engineering profession, the survey participated, and the results depend on the assessment of working with industry engineers in Turkey, in Figure 1 that follows, between 2006- graduated between the years 2012 industrial engineers, statistics of continuing postgraduate education are indicated.

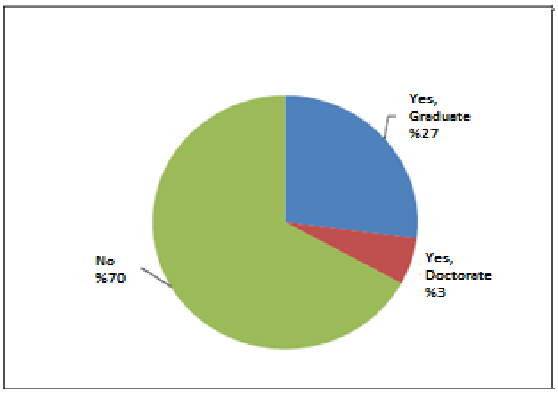

Figure 1. Demonstration of Last Graduates Continuing to Graduate Program (between 2006-2012) [3]

In Figure 1, it is seen that 27% of the continuing engineers, 3% of those continuing in doctoral education and 70% of those who are not continuing undergraduate education.

Based on engineering education, industrial engineering is one of the few professions that can recognize and solve complex problems in the fast-changing and developing world. For this reason, industrial engineering is composed of complex processes which require knowledge of the broad fields related to basic sciences as well as engineering sciences, information science, behavioural sciences, economics, production systems, and the design of future systems [4].

Industrial engineering related work can be found in every company. Because Industrial engineers work in every sector. Industrial engineering is more focused on processes and finding ways to improve processes, in areas such as logistic, supply chain management, process control, finance or marketing.

In Turkey, a study conducted for the industrial engineering profession, industrial engineering courses in the curriculum of undergraduate education, business life usage requirements are indicated in Figure 2 given below.

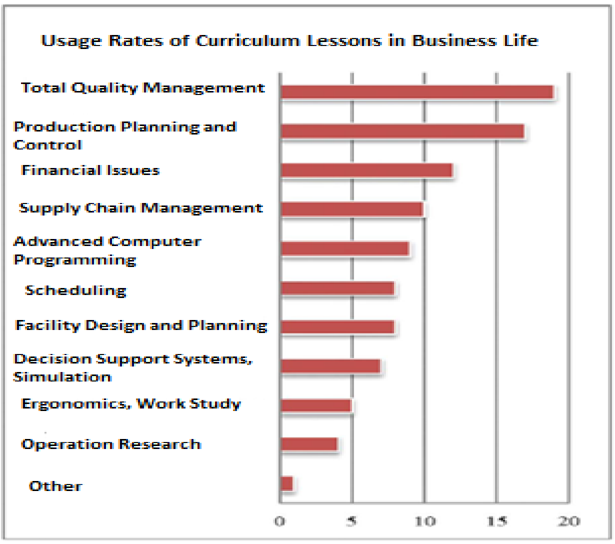

Figure 2. Demonstration of the Need to Use Lessons in the Curriculum in Business [3]

In Figure 2, a distribution chart of the courses in industrial engineering undergraduate courses that may be needed in business life is given. From this point of view, it can be said that courses like total quality management, production planning and control, financial issues, and supply chain management are useful in business life.

It can be said that the information received from business life is internationally accepted as a significant influence in the regulation of industrial engineering curricula (undergraduate, graduate, doctorate).

The significance of the lessons in this study has been researched. The prominence of course, under specified criteria, academics working in industrial engineering in Turkey was determined by appropriate evaluation based on fuzzy logic. The proposed method has been defined as the Fuzzy Multi-Objective Optimization based on Ratio Analysis (MOORA) approach by collecting the MOORA technique, fuzzy logic, appropriate data from multi-criteria decision-making methods. Studies on course selection were examined, to the best of our knowledge this is the first study using «Fuzzy MOORA» technique to select/rank courses. As a result of the study, it is considered that the selection of alternative courses for the undergraduate programs of industrial engineering may be beneficial for curriculum editing and will contribute to the international literature.

1.1. Literature review

The remaining part of the study are in the order of; literature review of studies on course selection and fuzzy MOORA technique.

In the study conducted by Ustun and others in 2011, they used the Analytical Hierarchy Process method to select and evaluate the courses in order to adapt the systems of the universities aiming at being in the European Higher Education Area to the Bologna process. The proposed multi-criteria decision-making method (MCDM) has been applied to the undergraduate program of an Industrial Engineering Department. As a result of the analysis; Engineering Analysis, Engineering Project and Engineering Design are the most preferred courses according to the determined qualifications. It is stated that these courses should be integrated with the theory, implementation and management of industrial engineering subjects [5].

In 2011, Sharma et al. conducted an application for selecting courses among alternative courses using the Analytic Hierarchy Process, which is a Multi-Criteria Decision-Making Technique, for the selection of online computing courses. For this purpose, the opinions of academicians, researchers, students, graduates and representatives of industrial fields were gathered. For alternatives, the AIP-Aggregation of Individual Priorities method was used. The e-learning courses designed in this way are more likely to be approved by the community. As a result of the study, among the alternative programming languages, the total priority weight is listed as Java, VB, C ++ and C programming languages [6].

Karande, P., & Chakraborty, S. (2012) used the fuzzy MOORA technique to select the best enterprise resource planning system for their work. In the study, the order of importance of the alternatives was determined under the criteria determined on two different samples. Alternative ERP systems with Risk, Quality, Effectiveness, Efficiency and User satisfaction criteria were evaluated. Alternative ERP systems with a, b, and c criteria were evaluated. In both examples, Fuzzy MOORA technique was applied. As a result of the analysis, the best choice is A4, the worst choice is A3, the best alternative is SAP, and the worst alternative is Axapta [7].

In his study in 2014, Ozturk developed a model using multiple criteria decision-making techniques, ANP method, to investigate and prioritize the criteria affecting open and distance education (ODL) systems and to help learners in selecting an ODL program. As a result of the study, the most preferred program was defined as ODL degree program. The second most preferred program is the doctorate program. With the ANP model created, it was stated that it will help distance education institutions to take into consideration which criteria and / or criteria to conduct each type of program [8].

In the study of Uygurturk, H. (2015), it was aimed to determine the most suitable internet branch in terms of existing or potential customers by evaluating the internet branches of banks according to the criteria determined by the fuzzy MOORA method. As a result of the study, the internet branches of the banks included in the analysis are ranked according to the values reached by the fuzzy MOORA method and the results are discussed. According to the analysis made, it is determined that the internet branch belonging to the B3 coded bank takes the first place in the order of preference according to the internet branches of the other banks included in the scope of the analysis. In the last place, B4 code bank comes internet branch [9].

Akkaya, G., Turanoğlu, B., Oztas, S. In 2015, they conducted a research on the future field of industrial engineers, which is a profession field that offers various study fields around the world. Therefore, in different universities in Turkey, Industrial Engineering it conducted a survey on 60 students working in the department. Fuzzy AHP (Analytic Hierarchy Process) and Fuzzy MOORA methods were applied. The survey includes 7 sectors (manufacturing, logistics, finance / banking, healthcare, technology, software / information and academics) and 10 criteria (payment, job satisfaction, career opportunities, employment unemployment, and job convenience). The significance of the criteria was determined using the Fuzzy AHP method. The most preferred sectors are identified by the Fuzzy MOORA method under certain criteria. As a result of the research, the most preferred sectors are technology, software/informatics, finance/banking [10].

Sisman and Dogan (2016) assessed the financial performance of 10 deposit banks traded in Stock Exchange Istanbul between 2008 and 2014 with the fuzzy MOORA approach, which determined the weight of the criteria by the fuzzy AHP approach. As a result of the analysis, financial performance evaluations of the banks were made. In the order in which the importance order is formed from small to large, "Akbank" was found in the first row and "TEB" was found in the last row. In addition, it has been concluded that the financial performance of a deposit bank with a high profitability ratio is also high [11].

Dey, B., Bairagi, B., Sarkar, B., Sanyal, S.K. in their work in 2016, three new extended Fuzzy Multidisciplinary Decision-Making Methods are proposed. They have dealt with subjective and objective factors for warehouse site evaluation and selection. The concept of fuzzy set theory is combined with the order preference technique according to similarities. Basically, ideal solution (TOPSIS), simple additive weight (SAW) and multipurpose optimization (MOORA) methods were used to evaluate subjective criteria in terms of subjective factor measures. A classical normalization technique has been used in objectively evaluating objective measures. They used the Brown and Gibson model to calculate the warehouse location selection index. Suggested methods are shown with two examples for warehouse location selection. A comparative study of the results and a sensitivity analysis are carried out. The research finds that effective and recommended methodologies of fuzzy multi-criteria decision-making tools for the evaluation and selection of stocks in the supply chain are useful [12].

Sisman, B. evaluates various green supplier development programs foreseen by experts in his work in 2016, nominal group technique in uncertainty environment and fuzzy MOORA method. Firstly, some criteria have been set to evaluate the nominal group technique and green supplier development programs. Then, the fuzzy MOORA method was used to order and evaluate alternative programs in an uncertain environment in which quantitative data were inadequate. Finally, a sensitivity analysis was conducted to examine and test the effectiveness of the criterial weights of the model on alternative programs. As a result of the work, the best "certification" program has emerged among alternative green supplier development programs. The worst was found as a "supplier meetings" program [13].

In 2016, Lokare et al. applied the Analytic Hierarchy Process (AHP) and Ideal Solution (TOPSIS) Techniques for Multi-Criteria Decision-Making Methods in order to select the best career option in the career or academic-oriented course selection phase of students in India. For this purpose, we determined the weights of the criteria with AHP and the order of all courses obtained from both methods was determined in order to obtain the appropriate course selection. The experimental study shows that the course selection rankings of the applied methods are similar. In addition, Management, Chartered Accountancy, MBBS and Engineering courses were selected among the alternative courses [14].

In their study conducted in 2016, Zare et al. examined many studies using multi-criteria decision-making methods to evaluate and investigate academic research on e-learning. Based on the findings, AHP was defined as the most popular individual technique and subsequently merged with fuzzy logic theory. According to the results obtained from the analysis, fuzzy analysis is widely used together with the MCDM. Out of 42 (45.2%) articles in the evaluation of e-learning, 19 applied fuzzy analysis together with MCDM techniques [15].

Altunoz assessed the financial performance of banks in assessing their bank performance in the development of the banking sector and the determination of the banks' own self-talents in the work. For evaluation, fuzzy AHP and fuzzy MOORA methods were used in combination. The fuzzy AHP approach has been compared with the criteria and the importance weights are determined. The banks were then ranked according to the fuzzy MOORA approach, considering the importance ratings. As a result of the analysis, bank ranked first in terms of financial performance. In addition, the profitability ratios, liquidity ratios and capital and balance sheet ratios are high, and the financial performance of the bank can be high [16].

Arabsheybani, A., Paydar, M. M., Safaei, A.S. A Fuzzy Multi-Objective Optimization Model based on ratio analysis (MOORA) was applied to evaluate the supplier's overall performance in order to develop a sustainable supply chain in their work in 2018. Failure Mode Effects Analysis (FMEA) are applied to assess the supplier's risks. In addition, a new multi-purpose mathematical model has been developed to evaluate the supplier's sustainability and order allocation at the same time. The results show that employing the proposed model has the potential to reduce not only the total profit but also the amount of risks imposed on sustainability [17].

1.2. Method

In this study, 32 academicians working in the Department of Industrial Engineering were asked to list the importance of compulsory and elective courses and the data were collected by the questionnaire. Fuzzy Moora method and model selection model are presented. The MOORA technique, which is a MCDM Method, will be extended with the fuzzy logic as the Fuzzy MOORA approach and the alternative courses will be compared under the determined criteria.

1.2.1. Multi-Criteria Decision Making

MCDM can be defined as decision-making using rational methods to optimize decision-makers with multiple criteria. The MCDM ensures that more than one discipline coexist, and the decision maker evaluates in more than one dimension. However, it also provides the opportunity for optimum decision-making.

1.2.2. Fuzzy Logic

It can be said that many terms used in everyday life are in a blurry structure. Numerical or verbal expressions used in many situations, such as defining something, announcing an event, giving a command, are fuzzy. Examples are verbal terms such as hot, cold, warm, fast, slow, long, short, little, very little, much, much more. These are examples of the way in which the human brain is assessed and behaved in uncertain and uncertain situations [18]. The linguistic variables used in this study are listed below. The fuzzy values of the data obtained from the questionnaire were calculated according to the scales in Table 1.

Table 1. Linguistic variables and fuzzy number correspondences for criterion

Linguistic Variable	**Fuzzy Scale**
Very low	(1, 1, 3)
Low	(1, 3, 5)
Medium	(3, 5, 7)
High	(5, 7, 9)
Very high	(7, 9, 9)

Resource (Awasthi ve Govindan, 2016) [19]

1.2.3. MOORA Method

MOORA (Multi Objective Optimization Based on Ratio Analysis), one of the most categorical decision-making techniques, was introduced by Willem Karel M. Brauers and Edmundas Kazimieras Zavadskas in their work on public privatization in 2006 [20]. The MOORA method, a multi-objective optimization technique, is a newly developed multi-criteria decision-making technique, but it has been used in many studies in the literature.

1.2.4. Fuzzy MOORA Method

In this study, multi-objective optimization based on ratio analysis was applied as the Fuzzy MOORA method together with the collected data in accordance with the fuzzy logic theory.

The criteria for the selection of courses in the industrial engineering undergraduate program are important. The criteria were determined by detailed research and Industrial Engineering courses were given according to their importance. The outcomes of the Industrial Engineering Undergraduate Program are; knowledge, skills and competence. For this purpose, a lecturer in industrial engineering academic staff in Turkey, the company received information from experts working in the field of industry and technology were evaluated through a survey. Industrial Engineering bachelor’s degree program exits be complementary in terms of current and future scope which are weighted equally among themselves and set as benefit criteria. Criteria are given below:

- Use in solving the problems encountered in the industry
- Availability in thesis / academic studies
- Effect on occupational specialization
- Availability in futuristic (Industrial revolutions, nanotechnology etc.) areas

Before using the method, it is necessary to convert the fuzzy values of the criteria and alternative programs to non-fuzzy (Crisp) numbers. The following formula is used to convert fuzzy numbers to non-fuzzy numbers [13].

$$a = \frac{a_1 + 4a_2 + a_3}{6}$$

2. Experimental Study

In this study, an evaluation has been conducted on which compulsory and optional courses given in industrial engineering have been investigated under the determined criteria. A web-based questionnaire has been developed for the data use the application and 32 academicians. The academicians have been asked which ones our of 4 given criteria (Use in solving the problems encountered in the industry, availability in thesis/academic studies, effect on occupational specialization and availability in futuristic). It was determined with «Fuzzy MOORA» technique as compulsory and optional courses.

In Table 2, the weights of the criteria were determined according to the determined form. Courses are randomly selected and sorted.

Table 2. Finding the weights of the criteria

Courses	Criterion-1 weight	Criterion-2 weight	Criterion-3 weight	Criterion-4 weight
Course 1	6.20	6.67	6.55	6.25
Course 2	5.93	5.63	5.90	5.19
Course 3	6.43	6.67	6.28	6.52
Course4	6.78	6.07	6.32	5.85

The method has six steps.

Step 1: Creation of decision matrix with triangular fuzzy numbers.

$$\underset{\sim}{X} = \begin{bmatrix} [x_{11}^l, x_{11}^m, x_{11}^u] & [x_{12}^l, x_{12}^m, x_{12}^u] & \dots [x_{1n}^l, x_{1n}^m, x_{1n}^u] \\ \dots & \dots & \dots \quad \dots \\ \dots & \dots & \dots \quad \dots \\ [x_{z1}^l, x_{z1}^m, x_{z1}^u] & [x_{z2}^l, x_{z2}^m, x_{z2}^u] & \dots [x_{zn}^l, x_{zn}^m, x_{zn}^u] \end{bmatrix}$$

The total number of fuzzy obtained from the evaluation of the courses under the specified criteria is shown Table 3.

Table 3. Representation of total fuzzy numbers

Courses	Criterion-1 (max)	Criterion-2 (max)	Criterion-3 (max)	Criterion-4 (max)
Course 1	1, 6.8, 9	3, 7, 9	3, 6.83, 9	1, 6.88, 9
Course 2	1, 6.40, 9	1, 5.95, 9	1, 6.35, 9	1, 5.28 ,9
Course 3	1, 7.14, 9	3, 7, 9	1, 6.92, 9	3, 6.78, 9
Course4	3, 7.17, 9	1, 6.6, 9	1, 6.98, 9	1, 6.28, 9

Step 2: Normalization of the generated decision matrix.

$$r_{ij}^l = \frac{x_{ij}^l}{\sqrt{\sum_{i=1}^n \left[\left(x_{ij}^l\right)^2 + \left(x_{ij}^m\right)^2 + \left(x_{ij}^u\right)^2 \right]}}$$

$$r_{ij}^m = \frac{x_{ij}^m}{\sqrt{\sum_{i=1}^n \left[\left(x_{ij}^l\right)^2 + \left(x_{ij}^m\right)^2 + \left(x_{ij}^u\right)^2 \right]}}$$

$$r_{ij}^u = \frac{x_{ij}^u}{\sqrt{\sum_{i=1}^n \left[\left(x_{ij}^l\right)^2 + \left(x_{ij}^m\right)^2 + \left(x_{ij}^u\right)^2 \right]}}$$

Table 4 shows the normalized fuzzy decision matrix.

Table 4. Normalized fuzzy decision matrix

Courses/ Criterion	Normalize criterion- 1			Normalize criterion- 2		
Course 1	0,013	0,095	0,121	0,042	0,097	0,125
Course 2	0,013	0,086	0,121	0,014	0,083	0,125
Course 3	0,013	0,096	0,121	0,042	0,097	0,125
Course 4	0,040	0,096	0,121	0,014	0,092	0,125
Courses/ Criterion	**Normalize criterion- 3**			**Normalize criterion- 4**		
Course 1	0,042	0,095	0,125	0,014	0,097	0,127
Course 2	0,014	0,088	0,125	0,014	0,075	0,127
Course 3	0,014	0,096	0,125	0,042	0,096	0,127
Course 4	0,014	0,097	0,125	0,014	0,089	0,127

Step 3: Generation of a weighted normalized fuzzy decision matrix.

$$v_{ij}^l = W_j r_{ij}^l$$

$$v_{ij}^m = W_j r_{ij}^m$$

$$v_{ij}^u = W_j r_{ij}^u$$

In Table 5, the weighted normalized fuzzy decision matrix obtained by multiplying the fuzzy decision matrix normalized by the criterial weights is given.

Table 5. Generation of weighted normalized fuzzy decision matrix

Courses/ Criterion	Weight -Normalize Criterion - 1			Weight-Normalize Criterion - 2		
Course 1	0,083	0,567	0,751	0,278	0,649	0,835
Course 2	0,079	0,511	0,718	0,078	0,466	0,705
Course 3	0,086	0,617	0,778	0,278	0,649	0,835
Course 4	0,274	0,654	0,821	0,084	0,557	0,759
Courses/ Criterion	**Weight - Normalize Criterion - 3**			**Weight -Normalize Criterion - 4**		
Course 1	0,274	0,623	0,821	0,088	0,608	0,795
Course 2	0,082	0,522	0,739	0,073	0,389	0,659
Course 3	0,087	0,605	0,786	0,276	0,624	0,829
Course 4	0,088	0,614	0,791	0,083	0,519	0,744

Step 4: Find the normalized performance values (S) in terms of benefit (benefit) and cost (loss) criteria. The triangular fuzzy numbers for benefit criteria are calculated separately.

$$S_i^{+l} = \sum_{j=1}^n v_{ij}^l \mathrm{I}\, j \in J^{man}$$

$$S_i^{+m} = \sum_{j=1}^n v_{ij}^m \mathrm{I}\, j \in J^{max}$$

$$S_i^{+u} = \sum_{j=1}^n v_{ij}^u \mathrm{I}\, j \in J^{max}$$

For cost criteria, triangular fuzzy numbers are calculated separately.

$$S_i^{-l} = \sum_{j=1}^n v_{ij}^{-l} \mathrm{I}\, j \in J^{min}$$

$$S_i^{-m} = \sum_{j=1}^{n} v_{ij}^{-m} \mathrm{I}\; j \in J^{min}$$

$$S_i^{-u} = \sum_{j=1}^{n} v_{ij}^{-u} \mathrm{I}\; j \in J^{min}$$

Table 6 shows normalized performance values. Criteria are the criteria of benefit and the greatest value of the values are required. There is no cost criterion and its value set to 0.

Table 6. Finding Normalize performance values

Course/Ranking	S+(a)	S+(b)	S+(c)
Course 1	0,7236	2,4470	3,2011
Course 2	0,3136	1,8854	2,8220
Course 3	0,7284	2,4957	3,2282
Course 4	0,5287	2,3441	3,1162
Course/Ranking	S-(a)	S-(b)	S-(c)
Course 1	0	0	0
Course 2	0	0	0
Course 3	0	0	0
Course 4	0	0	0

Step 5: Normalized performance values are still composed of fuzzy numbers. The performance values are converted to non-fuzzy performance values by the vertex method.

$$S_i = \sqrt{\frac{1}{3}[(S_i^{+l} - S_i^{-l})^2 + (S_i^{+m} - S_i^{-m})^2 + (S_i^{+u} - S_i^{-u})^2]}$$

In Table 7, it is stated that performance values are converted to non-fuzzy numbers.

Table 7. Conversion of performance values to non-fuzzy numbers

Course/ Ranking	**$(S)^2$**	**S**
Course 1	5,5862	2,3635
Course 2	3,8723	1,9678
Course 3	5,7269	2,3931
Course 4	5,1616	2,2719

Step 6: Alternatives are listed according to their performance values. The highest performance alternative is preferred.

Table 8. Conversion of performance values to non-fuzzy numbers

Course/ Ranking	**Ranking**
Course 1	2
Course 2	4
Course 3	1
Course 4	3

Since the non-fuzzy numbers obtained in Table 8 are desired to maximize the criterion, a large to small order is shown. The order of importance of the courses is determined and accordingly, it can be said that the course 3 will provide a higher benefit than the other alternatives.

3. Results and Discussion

The compulsory courses are listed below in Table 9, starting with the highest level of importance when solving with the Fuzzy MOORA approach.

Table 9. Ranking of compulsory courses in undergraduate education in Industrial Engineering

Compulsory Courses	**Ranking**
Data Mining	1
Information Technologies	2
Modern Production Systems	3
Production Engineering	4
Logistics Systems	5
Production Planning and Control	6

Supply Chain Management	7
Decision Support Systems	8
Database Management Systems	9
System Simulation (Simulation)	10
Project Scheduling and Management	11
Service Systems Design and Planning	12
Business Processes	13
Quality Engineering	14
Warehouse (Stock) Management	15
Enterprise Resource Planning	16
Introduction to Optimization Methods	17
Manufacturing Materials and Processes	18
Operations Research	19
Probability and Statistics	20
Compulsory Courses (Continue)	**Ranking**
Dynamic Programming	21
Scheduling	22
Occupational Health and Safety	23
Statistics for Engineers	24
Linear Programming	25
Statistical Quality Control	26
Introduction to Java Programming	27
Introduction to C Programming Language	28
Network Streams and Integer Programming	29
Quality Assurance and Reliability	30
Stochastic Models	31
Facility Planning	32
Institutional Engineering and Institutional Modelling	33
Management and Organization	34
Work study	35
Engineering Economics	36
Systems and Control	37
Manufacturing Procedures	38
Ergonomics	39
Computer Aided Drawing	40
Business for Engineers	41
Financial Accounting and Cost Accounting	42

In Table 9, Data Mining, Information Technology, Modern Production Systems, Production Engineering and Logistics Systems courses are ranked at the top in the list of compulsory courses in Industrial Engineering undergraduate program.

It can be said that taking the data mining course in the top-ranked shows that the students have a high level of awareness and knowledge of data development and analysis. Nowadays, the value and value of the data is growing much faster than expected, and it becomes increasingly important to generate meaningful patterns from these large numbers of data. Data mining uses many areas. Many areas, such as marketing, health, and trade, can improve their field and make it more important by learning from the analysis of large data in their fields. Large data analysis, together with the Industrial Revolution 4.0, helps customers to better identify their customer needs and needs and increase their competitiveness by creating better strategies. The use of industry data mining is expected to increase.

The second-ranked information technology in the rankings has a significant contribution to the basic knowledge of the students regarding the future design and management of information technologies and systems in production with the industry 4.0 revolution. In the changing and developing industry sector, knowledge is important.

According to Table 9, modern production systems and production engineering courses at the top of the ranking are about new production technologies and production engineering. These courses discuss the processes of production systems, possible future changes and the issues that will transform production to the fastest, lowest and the highest quality. According to the results of the analysis these courses will be important for future industrial engineering in the industry.

The courses in the upper ranks such as logistics systems, modern production systems, production engineering, production planning and control, supply chain management and enterprise resource planning, optimization of future production systems and future processes in order to determine today's production and inventory policies, it is aimed that the understanding of production of the future, knowledge of the students aimed at decision making with modern techniques. Considering that industrial engineers are currently working in the production sector intensively, it can be said that the future development of the future manufacturing industry and the understanding of changing conditions are high. Moving from this, it can be stated that these courses are important in the areas of the industrial engineering curriculum.

Database management systems course is about software that enables the creation and management of databases in general. Database software is the means of creating, updating and managing data. It can be said that it is important for industrial engineers, given that the right data will lead the system to the right direction.

The optional courses are listed below in Table 10, starting with the highest level of importance when solving with the Fuzzy MOORA approach.

Table 10. Ranking of optional courses for undergraduate education in Industrial Engineering

Optional Courses	**Ranking**
Productivity Management	1
Quality Management	2
Computer Aided Statistics- SPSS, R	3
Data Processing for Industrial Engineering	4
Statistical Estimation and Time Series	5
Advanced Manufacturing Systems	6
Group Technology	7
Customer Relations Management	8

Algorithm and Data Structure	9
Machine Scheduling Theory	10
Numerical Analysis	11
Brand Management	12
Industrial Psychology	13
Business law	14

In Table 10, it is observed that "Productivity Management" and "Quality Management" courses from the optional courses take place at the top in the order prepared from the alternative courses according to the determined criteria.

It can be said that the best alternative lessons obtained in the sequence of optional courses, productivity management and quality management support the studies that industrial engineers will take part in quality management and quality assurance studies in the next 10 years.

Computer-aided courses in statistics and data processing for industrial engineering, industrial engineers in Turkey, said it may help to use a computer for which the areas they need to develop themselves heard.

Statistical estimation and time series are in the upper order of the course. This course provides basic information for the preparation of students for situations where it is necessary to make decisions about production and inventory at risk with various futures, such as production planning and control, which is one of the units where industrial engineers work mostly.

It can be stated that advanced manufacturing systems and group technology courses will provide benefits mainly for the understanding of modern production techniques and management. In the factories of this developing and differentiating future, modern production has a high level of precaution. These lessons can be said to help industrial engineers understand the future changes in the manufacturing sector.

3.1. Sensitivity Analysis

In this part of the study, four different situations were examined in order to test the effectiveness of the criterion's weighted weights on the results obtained by the Fuzzy MOORA method. Table 11 gives the results of sensitivity analysis.

Table 11. Sensitivity analysis results

Situa-tions	**Initial Situation**	**Situation 1**	**Situation 2**	**Situation 3**	**Situation 4**
Priority	***All Criterion 1,2,3,4= 1***	**Criterion *1=1* Criterion *2,3,4= 0***	**Criterion *2=1* Criterion *1,3,4= 0***	**Criterion *3=1* Criterion *1,2,4= 0***	**Criterion *4=1* Criterion *1,2,3= 0***
1	Data Mining	Business Processes	Data Mining	Project Scheduling and Management	Data Mining
2	Information Technologies	Logistics Systems	System Simulation (Simulation)	Modern Production Systems	Database Management Systems
3	Modern Production Systems	Information Technologies	Supply Chain Management	Production Planning and Control	Information Technologies
4	Production Engineering	Database Management Systems	Decision Support Systems	System Simulation (Simulation)	Supply Chain Management
5	Logistics Systems	Modern Production Systems	Production Planning and Control	Data Mining	Decision Support Systems
6	Production Planning and Control	Quality Engineering	Information Technologies	Production Engineering	Production Engineering
7	Supply Chain Management	Manufacturing Materials and Processes	Logistics Systems	Information Technologies	Modern Production Systems
8	Decision Support Systems	Project Scheduling and Management	Production Engineering	Quality Engineering	Service Systems Design and Planning
9	Database Management Systems	Enterprise Resource Planning	Service Systems Design and Planning	Warehouse (Stock) Management	Logistics Systems
10	System Simulation (Simulation)	Production Engineering	Modern Production Systems	Supply Chain Management	System Simulation (Simulation)
…	…	…	…	…	…
36	Engineering Economics	Facility Planning	Business Processes	Financial Accounting and Cost Accounting	Quality Assurance and Reliability
37	Systems and Control	Systems and Control	Ergonomics	Stochastic Models	Facility Planning
38	Manufacturing Procedures	Institutional Engineering and Institutional Modelling	Financial Accounting and Cost Accounting	Systems and Control	Engineering Economics
39	Ergonomics	Computer Aided Drawing	Computer Aided Drawing	Business for Engineers	Computer Aided Drawing
40	Computer Aided Drawing	Manufacturing Procedures	Manufacturing Procedures	Ergonomics	Business Processes
41	Business for Engineers	Ergonomics	Systems and Control	Manufacturing Procedures	Business for Engineers
42	Financial Accounting and Cost Accounting	Business for Engineers	Business for Engineers	Computer Aided Drawing	Financial Accounting and Cost Accounting

When the results of the sensitivity analysis are examined in Table 11, it is seen that the ranking (first case) considering all criterion ratios and the ranking (case 2, case 3, case 4) taking the ratios of criterion 2, criterion 3, criterion 4 into consideration are similar to first case. While this is an evaluation of course choice, it shows that the ratio of "Use in solving the problems encountered in the industry" has a low priority for others.

When examining the first case with other cases, there is lower similarity in Case 1. For this reason, it can be said that while the evaluation for the course selection is made, the situation is more determinant for the other cases.

Specifically, for the worst alternatives in the Table 11, it is seen that the ranking (first case) considering all criterion ratios and the ranking (case 1, case 2, case 3) taking the ratios of criterion 1, criterion 2, criterion 3 into consideration are similar to first case. Moving from this, it can be said that the ratio of "Availability in futuristic (Industrial revolutions, nanotechnology etc.) areas" has a low priority for others.

4. Conclusions and recommendations

The courses given in undergraduate education are influencing students' future choices, outlooks and achievements. An accurate training plan will increase the quality of the training. It is very important for the development of the country that the graduates who will be adapting to the future and adapting to the changes while the curriculums are being created.

Industrial engineering courses are commonly defined as the modern production systems, systems and control, financial accounting and cost accounting, decision support systems, system simulation, facility planning, logistics systems, project scheduling and management, data mining, integration of machines, staff management, operations research, and scientific methods. Also, today's industrial engineers work in many more settings than just factories.

In this study, it is aimed to determine which courses should be given under the degree of industrial engineering. Among the alternative courses, it was determined under which of the four criteria which courses are more important. It is envisaged that the courses taught will increase the knowledge and skill levels of industrial engineers today and in the future and will provide a higher added value to the country.

Courses are determined by examining the courses that are generally given in industrial engineering undergraduate programs in our country and abroad. Materiality under the criteria defined by the course, academics working in the industrial engineering department in Turkey, was evaluated by a survey organized according to fuzzy logic. The MOORA technique was developed as a "Fuzzy MOORA" approach, which is a multi-criteria decision-making technique as 32 compulsory and optional courses with 32 samples prepared by academicians responding to the questionnaire.

When the application results for the compulsory courses are examined, courses are listed in the first place in data mining, information technology, modern production systems, production engineering, logistics systems, production planning and control, supply chain management, decision support systems, database management systems, system simulation (simulation) courses. Considering that these courses are evaluated under the determined criteria, it can be said that they are more important than the other alternative compulsory courses.

When the application results for the compulsory courses are examined, courses are listed in the first place in information technology, business processes, logistics systems, modern production systems, data mining, database management systems, production engineering, production planning and control, quality engineering, project scheduling and management courses. Considering that these courses are evaluated under the determined criteria, it can be said that they are more important than the other alternative compulsory courses.

Studies of course selection, when examining the international literature, it seems that the «Fuzzy MOORA» technique is not used. It is evaluated that the MOORA method, which is a new criterion decision-making method for the course selection, contributes to the international literature as "Fuzzy MOORA" approach together with fuzzy logic. It is expected that the employee will benefit from the stages of preparing industrial engineering degree program curricula.

In future studies, it is predicted that better results will be obtained by conducting a new research by taking the evaluations of the academicians who are working in the departments of industrial engineering abroad.

References

[1] Gunes, F. (2012). Bologna Süreci ile Yükseköğretimde Öngörülen Beceri ve Yetkinlikler. *Journal of Higher Education & Science/Yüksekögretim ve Bilim Dergisi*, *2*(1).

[2] Dincer, H. (1994). Türkiye' de Mühendislik Eğitimi. 2000'li Yıllara Girerken Bilgi Çağında Nasıl Bir Mühendislik Eğitimi Konulu 1. *Kongre, EMO İstanbul*.

[3] Erginel, N., Tekçe, M., Küçük, G., & Alper, A. (2016). Türkiye'de Endüstri Mühendisliği Mesleğine Bilimsel Açıdan Bir Bakış. *Journal of Industrial Engineering (Turkish Chamber of Mechanical Engineers)*, *27*(1).

[4] Ercan, S., Metin, B. C., & Düzdar, İ. (2005). Endüstri Mühendisliğine Güncel bir Bakış.

[5] Ustun, Ö., Kırış, Ş., & Deliktaş, D. (2011). 1. Multi-Criteria Decision Making Methodology for Course Evaluation and Selection in Bologna Process. *Dumlupınar Üniversitesi Sosyal Bilimler Dergisi*, (45).

[6] Sharma, R., Banati, H., & Bedi, P. (2011, August). Incorporating Social Opinion in Content Selection for an E-Learning Course. In *Computer Science & Education (ICCSE), 2011 6th International Conference on* (pp. 1027-1032). IEEE.

[7] Karande, P., & Chakraborty, S. (2012). A Fuzzy-MOORA Approach for ERP System Selection. *Decision Science Letters*, *1*(1), 11-21.

[8] Ozturk, Z. K. (2014). Using a Multi Criteria Decision Making Approach for Open and Distance Learning System Selection. *Anadolu University Journal of Science and Technology–A Applied Sciences and Engineering*, *15*(1), 1-14.

[9] Uygurturk, H. (2015). Bankalarin Internet Şubelerinin Bulanık Moora Yöntemi ile Değerlendirilmesi. *Uluslararası Yönetim İktisat ve İşletme Dergisi*, *11*(25), 115-128.

[10] Akkaya, G., Turanoğlu, B., & Öztaş, S. (2015). An Integrated Fuzzy AHP and Fuzzy MOORA Approachtothe Problem of Industrial Engineering Sector Choosing. *Expert Systems with Applications*, *42*(24), 9565-9573.

[11] Sisman, B., Dogan, M. (2016). The Evaluations of Financial Performance in Turkish Banks By Using Fuzzy AHP and Fuzzy Moora. *Yönetim ve Ekonomi: Celal Bayar Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *23*(2), 353-371.

[12] Dey, B., Bairagi, B., Sarkar, B., &Sanyal, S. K. (2016). Warehouse Location Selection by Fuzzy Multi-Criteria Decision Making Methodologies Based on Subjective and Objective Criteria. *International Journal of Management Science and Engineering Management*, *11*(4), 262-278.

[13] Sisman, B. (2016). Bulanık Moora Yöntemi Kullanılarak Yeşil Tedarikçi Geliştirme Programlarının Seçimi ve Değerlendirilmesi. *Journal of Yaşar University*, *11*(44), 302-315.

[14] Lokare, V. T., & Jadhav, P. M. (2016, January). Using the AHP and TOPSIS Methods for Decision Making in Best Course Selection After HSC. In *Computer Communication and Informatics (ICCCI), 2016 International Conference on* (pp. 1-6). IEEE.

[15] Zare, M., Pahl, C., Rahnama, H., Nilashi, M., Mardani, A., Ibrahim, O., & Ahmadi, H. (2016). Multi-Criteria Decision Making Approach in E-Learning: A Systematic Review and Classification. *Applied Soft Computing*, *45*, 108-128.

[16] Altunoz, U. (2017). The Analysing of the Financial Performance of Banks by Using Fuzzy AHP and Fuzzy Moora

Approaches: Case of Turkish Banks. *Route Educational and Social Science Journal. Volume 4(4), 116-132.*

[17] Arabsheybani, A., Paydar, M. M., & Safaei, A. S. (2018). An integrated fuzzy MOORA Method and FMEA Technique for Sustainable Supplier Selection Considering Quantity Discounts and Supplier's Risk. *Journal of Cleaner Production*, *190*, 577-591.

[18] Altas, İ. H. (1999). Bulanık Mantık: Bulanıklılık Kavramı. *Enerji, Elektrik, Elektromekanik-3e*, *62*, 80-85.

[19] Awasthi, A., & Kannan, G. (2016). Green supplier development program selection using NGT and VIKOR under fuzzy environment. *Computers & Industrial Engineering*, *91*, 100-108.

[20] Brauers, W. K., & Zavadskas, E. K. (2006). The MOORA method and its application to privatization in a transition economy. *Control and Cybernetics*, *35*, 445-469.