MULTI-CRITERIA DECISION MAKING METHODOLOGY FOR COURSE EVALUATION AND SELECTION IN BOLOGNA PROCESS

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ABSTRACT: The Bologna process is the creation of the European Higher Education Area by making academic degree standards and quality assurance standards more comparable and compatible throughout Europe. The universities aimed to be in the European Higher Education Area have to adapt their systems to the Bologna process. One of the main problems in the adaptation process is to evaluate and select the courses by considering the stakeholders' opinions and Bologna process' restrictions. In this study, a multi-criteria decision making methodology is proposed to solve the course evaluation and selection problem. The proposed multi-criteria decision making methodology is applied to a graduate program of an Industrial Engineering Department.

Key words: Multi-criteria decision making, Analytical Hierarchy Process, course evaluation, group decision making,
Bologna process.

JEL Format: C44, I23

BOLOGNA SÜRECİNDE DERS DEĞERLENDİRME VE SEÇİMİ İÇİN ÇOK ÖLÇÜTLÜ KARAR VERME YÖNTEMİ

ÖZET: Bologna süreci, akademik değerlendirme ve kalite güvence standartlarını Avrupa'da daha uyumlu ve daha karşılaştırılabilir yaparak Avrupa Yükseköğretim Alanı'nı oluşturma olarak tanımlanır. Avrupa Yükseköğretim Alanı'nda olmayı amaçlayan üniversiteler, sistemlerini Bologna sürecine adapte emek zorunda kalmışlardır. Adaptasyon sürecindeki ana problemlerden biri, Bologna sürecinin kısıtlarını ve paydaşların düşüncelerini dikkate alarak derslerin değerlendirilmesi ve seçilmesidir. Bu çalışmada çok ölçütlü karar verme yöntemi, dersleri değerlendirme ve seçme problemini çözmek için önerilmiştir. Önerilen çok ölçütlü karar verme yöntemi, bir Endüstri Mühendisliği Bölümü'nün lisans programına uygulanmıştır.

Anahtar Kelimeler: Çok ölçütlü karar verme, Analitik Hiyerarşi Süreci, ders değerlendirme, grup karar verme,
Bologna süreci.

JEL Kodu: C44, I23

1. Introduction

Increasing competition in global markets urges universities to put more emphasis on student training process. Nowadays, the students should be trained not only for local but also global markets to cope with the competition. The stakeholders of the universities are the government, the industry, the management of the university, the society and the students. Naturally, all of the stakeholders have some requests and these requests cause varied expectations in the training system such as contribution to the economy, qualified education, expertise, communication skills, creativity, multicultural personality and leadership. These properties can be met by the universities with the qualified education.

Universities are divided into different departments based on special education fields. These departments have individual plans and programs to reach their aims depend on the strategic plan of the university. There should be harmony within the same departments among the universities for collaborations and accreditations. One of the strategic decisions to provide the harmony is the adaptation of the Bologna Process.

According to Cano (2010), the aim of the Bologna Process is to create a European Higher Education Area (EHEA) based on quality assurance, student-centered, life-long learning-oriented and compatible with each other. This European Higher Education Area is envisaged as an open space that allows students, graduates, and higher education staff to benefit from unhampered mobility and equitable access to high quality higher education. The main ideas of such an open space are mutual recognition of degrees and other higher education qualifications, and European cooperation in quality assurance.

The Bologna Process derived its name from the Bologna Declaration, which was signed on 19 June 1999 by ministers in charge of higher education from 29 European countries. The Bologna Process was taken forward through a work program that received orientations from biannual ministerial conferences Prague 2001, Berlin 2003, Bergen 2005, London 2007, Leuven 2009, and Budapest and Vienna 2010. Today, the Process combines with 47 countries, all party to the European Cultural Convention, that cooperate in a flexible way, involving also international organizations and European associations representing higher education institutions, students, staff and employers.

The main lines of action in the Bologna Process are the Qualifications Frameworks (QF), Quality Assurance (QA), Recognition and the European Credit Transfer and Accumulation System (ECTS) and Diploma Supplement (DS) implementations, Mobility, Lifelong Learning Program (LLLP), Joint Degrees and the Social Dimension.

Turkey was involved in Bologna process with Prague Declaration in 2001. Turkey is undertaking steps to enact various instruments of those lines of action. To facilitate integration with the Process, ECTS was defined and accepted by many higher education institutions. Among five applicant higher education institutions in the European Higher Education Area, Karadeniz Teknik University and Sakarya University were awarded ECTS Label in 2010. The Short Cycle in Turkey requires an accumulation of 120 ECTS credits (2 years), the First Cycle requires an accumulation of 240 ECTS credits (4 years), with 90-120 ECTS credits required for the Master's and 180-240 ECTS credits for the Doctorate. Further work is being carried out on defining the learning outcomes of field based qualifications and program based qualifications. Fields in Turkish Higher Education Qualifications Framework are defined by taking The International Standard Classification of Education (ISCED) as a reference point. Working groups are established for each of the main fields. After completing this work, program based qualifications will be defined. According to the timetable prepared, The Framework for Higher Education Qualifications in Turkey will start to be implemented in all of the higher education institutions in 2012 (YÖK).

In the literature, there are few studies related to the adaptation of the Bologna process in Turkey. Kabakçı et al. (2010) determined the program outcomes of Computer Education and Instructional Technology (CEIT) department at Anadolu University in Turkey and evaluated the program outcomes by view of the educational partners of CEIT to meet the needs mentioned. Grossman et al. (2010) studied on teacher education accreditation in Turkey. Erişen et al. (2009) determined the professional development needs of the academic staff working at the process of educating teachers to vocational education in Turkey. Gül et al. (2010) reviewed the main trends and policies in higher education, and explored the dimensions of internationalization and the future of higher education. In addition, Soota et al. (2009) selected the curricular topics using the QFD and AHP approaches. For this purpose, the change in the landscape of higher education and the roles and autonomy of higher education institutions were analyzed.

In this study, the adaptation of the Bologna process in the industrial engineering department for the graduate program at Dumlupınar University is analyzed. The study is especially focused on the course selection problem according to the expectations of the related stakeholders. Lots of criteria can be appeared by considering the stakeholders’ opinions. The course selection problem is a multi-criteria decision making (MCDM) problem. The qualifications defined in the Bologna process are considered as criteria in the course selection process.

In the next section the materials and methods are described with a case study and then, the obtained results are given in Section 2. Finally Section 3 concludes with some remarks.

2. Material and Methods

In this section, the proposed approach is applied for evaluation and selection of courses in Industrial Engineering Department according to the Bologna process. The AHP and the SAW approaches are proposed to solve this problem.

2.1 The Bologna Process in the Industrial Engineering Department

Dumlupınar University started their studies related to the Bologna process on 15th May 2009. The Engineering Faculty and the Industrial Engineering Department also began the adaptation studies simultaneously. Firstly, the information meetings are performed by the different levels of managements. Then the following stages are determined for the adaptation of the Bologna process in the department.

Stage 1. The strategic plan is updated based on the decision of the Bologna process adaptation.
Stage 2. The qualifications of the graduate program are defined by brainstorming techniques with the stakeholders as given in Table 1.
Stage 3. The candidate courses are determined by analyzing the other same departments in Turkey and the abroad.
Stage 4. The course information forms are designed to evaluate the candidate courses by including the qualifications, course outlines, references, evaluation percentages, workloads and ECTS.
Stage 5. The course information forms are filled by the lecturers and the course evaluation results are obtained via Likert scale.
Stage 6. The qualifications are evaluated by the stakeholders.
Stage 7. The scores of the courses are calculated.
Stage 8. The compulsory and elective courses are determined based on the scores.

2.2 The Multi-Criteria Decision Making Methodology

Different alternatives and the criteria are defined based on various points of view from stakeholders. Then, a finite set of alternatives can be evaluated in terms of multi-criteria. Choosing a suitable method to measure the criteria can help the decision makers to process the cases to be evaluated and determine the priorities of the alternatives. Like most cases of evaluation, a number of criteria have to be considered. Consequently, the course selection can be regarded as an MCDM problem. There are multiple criteria, various courses and multiple decision makers in the problem. All of the candidate courses can be included into the course plan of the department. But the total ECTS load is restricted with 240 in the Bologna process.

In this case, the most critical step of the adaptation process for the department is the determination of the candidate courses' priorities to prepare the course plans. On the other hand, the courses titled as Turkish Language I-II and History of Revolution and Principle of Atatürk I-II are defined as compulsory by the Council of Higher Education (YÖK). Therefore, the evaluation of these courses is not required in the study.

In the study, the Analytic Hierarchy Process (AHP) and the Simple Additive Weighting (SAW) approaches are combined to construct the course plans. The priorities of the criteria are determined by the AHP and the candidate courses are evaluated by the SAW.

2.1.1 Analytic Hierarchy Process (AHP)

AHP is a structured technique to solve the complex decisions. It was developed by T.L. Saaty (1980) as a decision-making approach that involves multiple choice criteria into a hierarchy. AHP evaluates the relative importance of these criteria, compares alternatives for each criterion and determines an overall ranking of the alternatives. Saaty (1980, 1991) developed the following steps for applying the AHP:

Step 1. Define the problem and the goal.
Determining the priorities of the qualifications is the goal of this study.

Step 2. Structure the hierarchy of the problem.

The AHP hierarchy is given in Figure 1. The qualifications are divided into two criteria as Vocational education and technical sciences (VE&TS) and Social sciences (SS).

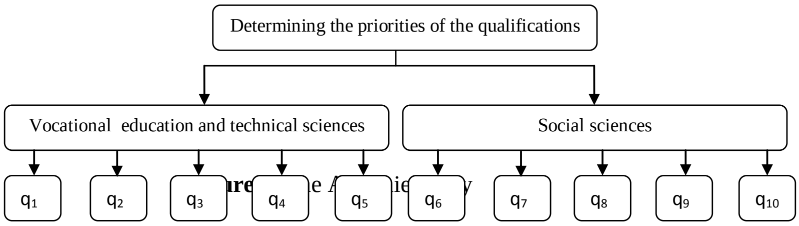

Table 1. The qualifications defined for the Industrial Engineering Department

ID	The qualifications
q_1	Engineering graduates with sufficient theoretical and practical background for a successful profession and with application skills of fundamental scientific knowledge in the engineering practice
q_2	Engineering graduates with skills and professional background in describing, formulating, modeling and analyzing the engineering problem, with a consideration for appropriate analytical solutions in all necessary situations
q_3	Engineering graduates with the necessary technical, academic and practical knowledge and application confidence in the design and assessment of machines or mechanical systems or industrial processes with considerations of productivity, feasibility and environmental and social aspects.
q_4	Engineering graduates with the practice of selecting and using appropriate technical and engineering tools in engineering problems, and ability of effective usage of information science Technologies, Ability of designing and conducting experiments, conduction data acquisition and analysis and making conclusions
q_5	Engineering graduates who are aware of the importance of safety and healthiness in the project management, workshop environment as well as related legal issues
q_6	Ability of identifying the potential resources for information or knowledge regarding a given engineering issue The abilities and performance to participate multi-disciplinary groups together with the effective oral and official communication skills and personal confidence
q_7	Ability for effective oral and official communication skills in Turkish Language and, at minimum, one foreign language
q_8	Engineering graduates with motivation to life-long learning and having known significance of continuous education beyond undergraduate studies for science and technology
q_9	Engineering graduates with well-structured responsibilities in profession and ethics
q_{10}	Consciousness for the results and effects of engineering solutions on the society and universe, awareness for the developmental considerations with contemporary problems of humanity

Step 3. Determine the sample size (n) of the problem by using Eq(1) used in Aktar et al. (2009) where p and (1-p), α and e stand for the ratio of preferring (p=0.20) and not preferring (1-p) the department graduates, the significance level (α=0.05) and error (e=0.10), respectively.

$$n = \frac{Z_{\alpha/2}^{2}\, p(1-p)}{e^{2}} \quad \ldots \quad (1)$$

The sample size is calculated as 61. In the study, the sample size is taken as 66 stakeholders.

Step 4. Construct a set of pair-wise comparison matrices (size n×n) of each qualification for stakeholders by using Table 2. The pair-wise comparisons are done in terms of which element dominates the other. Combine the pair-wise comparison matrices of each qualification for stakeholders by using geometric mean.

Table 2. Pair-wise comparison scale for AHP preferences used in Saaty (1980, 1991)

Numerical rating	Verbal judgments of preferences
9	Extremely preferred
8	Very strongly to extremely
7	Very strongly preferred
6	Strongly to very strongly
5	Strongly preferred
4	Moderately to strongly
3	Moderately preferred
2	Equally to moderately
1	Equally preferred

The pair-wise matrices are combined by using geometric mean as given in Figure 2. In Figure 2(a), it can be seen that VE&TS is equally-moderately preferred than SS. The other comparisons can be described in the similar way. The red numbers show the reciprocal values.

Step 4. There are n(n-1)/2 judgments required to develop the set of matrices in step 3. Reciprocals are automatically assigned in each pair-wise comparison.

Step 5. Hierarchical synthesis is now used to weight the eigenvectors by the weights of the criteria and the sum is taken over all weighted eigenvector entries corresponding to those in the next lower level of the hierarchy.

	Vocational education&Technical sciences	Social sciences
Vocational education&Technical sciences		1,92
Social sciences	Incon: 0,00	

(a) Pair-wise comparison matrix for criteria

	q1	q2	q3	q4	q5
q1		2,25	1,9	1,96	1,31
q2			1,27	1,14	2,16
q3				1,34	1,73
q4					2,65
q5	Incon: 0,01				

	q6	q7	q8	q9	q10
q6		1,38	1,21	2,18	1,53
q7			1,38	1,52	1,09
q8				2,07	1,32
q9					1,5
q10	Incon: 0,00				

(b) Pair-wise comparison matrix for VE&TS (c)Pair-wise comparison matrix for SS

Figure 2. Aggregate pair-wise comparison matrices

Step 6. The consistency is determined by using the eigenvalue, λ_{max}, to calculate the consistency index, CI as follows: CI= $(\lambda_{max} - n)/(n - 1)$, where n is the matrix size. Judgment consistency can be checked by taking the consistency ratio (CR) of CI with the appropriate RI value in Table 3. The CR is acceptable, if it does not exceed 0.10. If it is more, the judgment matrix is inconsistent. To obtain a consistent matrix, judgments should be reviewed and improved.

Table 3. Average random consistency (RI) used in Saaty (1980)

Size of matrix	1	2	3	4	5	6	7	8	9	10
Random consistency	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

The inconsistency ratios of the aggregate pair-wise comparison matrices are smaller than 0.1 as can be seen in Figure 2.

Step 7. Steps 4-6 are performed for all levels in the hierarchy.

Professional commercial software, Expert Choice, developed by Expert Choice, Inc. can be used for all calculations. Expert Choice software is a tool for decision analysis prepared based on AHP. The weights of the criteria and the qualifications are determined by using Expert Choice and the results are given in Figure 3. The VE&TS is two times more important than the SS. The qualifications of 2 and 4 are more important than the others.

The obtained weights of the qualifications are used to calculate the scores of the candidate courses by using SAW.

2.1.2 Simple Additive Weighting (SAW)

Simple Additive Weighting method is one of the simple approaches used in MCDM problems. The candidate courses are evaluated according to the each qualification by using Likert scale.

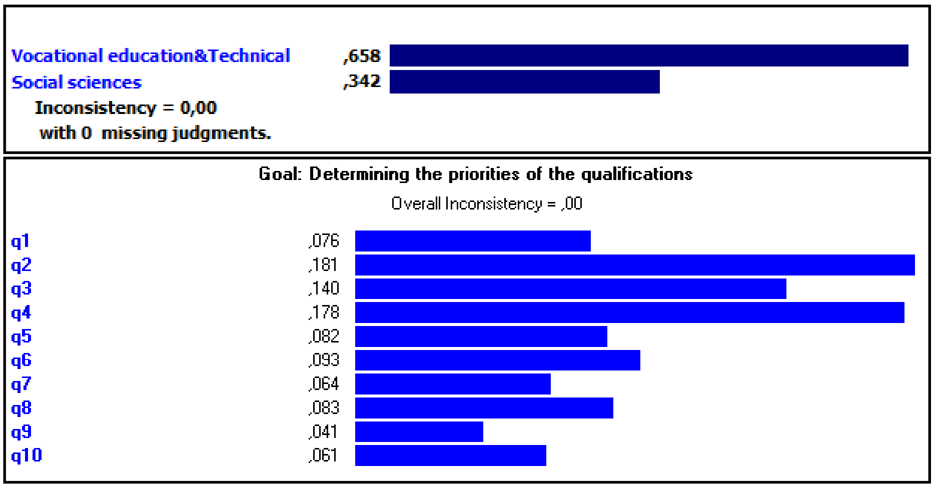

Figure 3. Weights of the criteria and the qualifications

The Likert scale is a useful method that allows the researcher to quantify opinion based items. Questions are typically grouped together and rated based on a five-point scale. This scale typically ranges in order from one extreme to the other, such as (1) very interested; (2) somewhat interested; (3) unsure; (4) not very interested; and (5) not interested at all. An example evaluation form for the course of "Introduction to Industrial Engineering (IEE)" is given in Table 4.

Table 4. Evaluation form for a candidate course

ID	Likert scale				
	1	2	3	4	5
q_1	X				
q_2					X
q_3					X
q_4				X	
q_5				X	
q_6					X
q_7				X	
q_8				X	
q_9					X
q_{10}					X

The scores of the candidate courses are calculated by using Eq. (2).

$$S_i = \sum_{j=1}^{10} w_j v_{ij} \quad i = 1,2,\ldots,71 \quad j = 1,2,,\ldots,10 \qquad \ldots \qquad (2)$$

S_i is the score of the candidate course based on the qualifications. w_j is the weight of the j^{th} qualification obtained by the AHP approach and v_{ij} is the Likert scale value of i^{th} course according to j^{th} qualification.

The score of the IEE can be calculated as the following:

S_{11}=(1x0.076)+(5x0.181)+(5x0.14)+(4x0.178)+(4x0.082)+(5x0.093)+(4x0.064)+(4x0.083)+(5x0.041)+(5x0.061) = 4.284

The other scores can be calculated in the similar way. The scores and the ECTS values of the candidate courses are given in the Appendix.

In the Bologna process, ECTS value of the courses in the graduate program is restricted with 240. The elective courses have to be at least % 25 of the total ECTS in the program. Therefore, the elective courses should be at least 60 ECTS. In addition, the compulsory courses defined by the YÖK have totally 8 ECTS. In this case, the compulsory courses should be at most 172 ECTS. The candidate courses are ranked in descending order based on the scores as given in Appendix. As a result of the MCDM approach, the courses titled Engineering Analysis, Engineering Project and Engineering Design are determined as the most preferred courses based on the defined qualifications. These courses especially are emphasized on the integration of the theory, application and management of the Industrial Engineering subjects. These courses are given by all the lecturers at the same semester in the department, so these courses can be defined as elective courses.

The compulsory courses are selected respectively except Engineering Analysis, Engineering Project and Engineering Design from i=4 to 35. In this way, the sum of the ECTS value of the selected compulsory courses becomes 165.

The courses from i=36 to 67 can be defined as the elective courses. The ideal situation is to include all of the elective courses into the program. But unfortunately, it cannot be possible to open all of the courses because of the lecturers' availability. In the program, it is proposed to give priority to the courses which have higher scores to satisfy the stakeholders. In this case, the courses can be included into the program by considering the scores.

3. Conclusion

In this study, a novel approach is applied to course evaluation and selection problem in Bologna process. This problem is a common issue for higher education systems in Bologna process with 47 countries. An MCDM approach consists of the AHP and the SAW approaches is proposed to solve the problem and a case study is applied to a graduate program of an Industrial Engineering Department.

In evaluating the candidate courses, multi-criteria are defined in Bologna process as the qualifications. Firstly, the AHP approach is used to determine the priorities of the qualifications by considering the stakeholders' opinions. The priorities of the qualifications may vary from program to program and have influence on the selection process of the courses. The candidate courses are evaluated based on the qualifications by the lecturers. Then, the scores of the candidate courses are calculated by using SAW approach.

The proposed approach provides a flexible decision making process by considering multi-criteria and group decision making with stakeholders. The proposed graduate program can be improved by considering the Industrial Engineering programs of both national and international universities. The final decision can be made by the management of the department with minor adjustments based on the system constraints and requirements. Therefore, a satisfactory graduate program can be obtained.

The approach can be easily adapted to the different programs. On the other hand, the course evaluation and selection problem can be solved by the other MCDM approaches as a future work.

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Appendix. The scores and the ECTS values of the candidate courses

i	Course Name	S_i	ECTS	i	Course Name	S_i	ECTS
1	Engineering Analysis	4.871	8	**35**	Chemistry	3.398	5
2	Engineering Project	4.871	5	**36**	Cost Accounting	3.375	5
3	Engineering Design	4.871	6	**37**	Decision Analysis	3.373	5
4	Manufacturing Systems	4.747	4	**38**	Productivity Management	3.331	5
5	Operations Research I	4.615	6	**39**	Effective Communication	3.328	5
6	Production Management	4.571	4	**40**	Service Systems	3.318	5
7	Production Planning and Control	4.571	6	**41**	Technical English I	3.318	5
8	Quality Control	4.354	5	**42**	Technical English II	3.318	5
9	Ergonomics	4.333	5	**43**	Human Resource Management	3.299	5
10	Material Science	4.320	5	**44**	Logistics Management	3.295	5
11	Introduction to Industrial Engineering	4.284	4	**45**	Computer Programming and Its Applications	3.293	5
12	Work Study	3.874	4	**46**	Artificial Neural Networks	3.293	5
13	Systems Analysis and Design	3.810	5	**47**	Computer Aided Design and Manufacturing	3.293	5
14	System Simulation	3.810	5	**48**	Fuzzy Logic	3.293	5
15	Thermodynamics	3.809	5	**49**	Visual Basic and Its Applications	3.293	5
16	Management and Organization	3.714	4	**50**	Decision Support Systems	3.293	5
17	Facility Design and Planning	3.673	6	**51**	Investment Analysis	3.118	5
18	Technical Drawing	3.657	5	**52**	Energy Management	3.111	5
19	Operations Research II	3.580	6	**53**	Genetic Algorithms	3.089	5
20	Physics I	3.562	6	**54**	Scheduling	3.075	5
21	Mathematics I	3.562	6	**55**	Foreign Language I	2.985	4
22	Physics II	3.562	6	**56**	Foreign Language II	2.985	4
23	Mathematics II	3.562	6	**57**	Supply Chain Management	2.98	5
24	Mathematics III	3.562	6	**58**	Design of Experiment	2.945	5
25	Probability	3.562	6	**59**	Network Flows and Project Management	2.914	5
26	Statistics I	3.562	6	**60**	Risk Management	2.866	5
27	Numerical Analysis	3.562	6	**61**	Stochastic Process	2.765	5
28	Statistics II	3.562	6	**62**	Entrepreneurship	2.718	5
29	Engineering Economics	3.562	5	**63**	Nanotechnology and Nanomaterials	2.717	5
30	Int.to Information technologies and Applications	3.520	3	**64**	Data Structure and Algorithms	2.671	5
31	General Economics	3.512	3	**65**	Business Law	2.431	5
32	Engineering Mechanics	3.488	6	**66**	Markets and Firm Behaviors	2.014	5
33	Basic Computing Science	3.455	4	**67**	Marketing Management	2.014	5
34	Manufacturing Processes	3.455	6				