Atatürk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, Aralık 2017 21(4):1597-1614

Implementation of The Fuzzy Dematel Method in Higher Education Course Selection: The Case of Eskişehir Vocational School

Serpil ALTINIRMAK (*)
Mustafa ERGÜN (**)
Çağlar KARAMAŞA (***)

Abstract: *Elective courses play an essential role in the process of improving students' skills and also help with identifying their interests, talents and potentials for a given field or vocation. Therefore the relationships between course selection criteria have been considered crucial in the decision making process. In this study, the aim has been to determine what constitutes the course selection criteria for students in Eskişehir Vocatonal School. Given this aim, a survey was designed and applied to 50 student respondents from different departments (marketing, hospitality management, secretary and office management, foreign trade, culinary arts, real estate and property management) current at Eskişehir Vocational School. Criteria, which are defined within the literature review undertaken, are ranked according to importance level via the fuzzy DEMATEL (The Decision Making Trial and Evaluation Laboratory) method. In addition, a general review of criteria has also been considered but as part of a cause and effect process, by using a causal diagram.*

Keywords: *Course Selection, Vocational School, Fuzzy Logic, DEMATEL*

Yüksek Öğretimde Ders Seçiminde Bulanık Dematel Yönteminin Uygulanması: Eskişehir Meslek Yüksekokulu Örneği

Öz: *Seçmeli dersler öğrecilerin yeteneklerinin geliştirilmesinin yanı sıra alanları dışındaki ilgilerinin, kabiliyetlerinin ve kapasitelerinin belirlenmesine yardımcı olmaktadır. Bu nedenle seçmeli ders belirleme kriterleri arasındaki ilişkiler karar verme sürecinde önem arz etmektedir. Bu çalışmada Anadolu Üniversitesi Eskişehir Meslek Yüksekokulu'nda öğrenim gören öğrencilerin ders seçimlerinde öncelikli kriterlerini belirlemek amaçlanmıştır. Eskişehir Meslek Yüksekokulu'nda farklı bölümlerde (Pazarlama, Konaklama işletmeciliği, Sekreterlik ve Büro Yönetimi, Dış Ticaret, Aşçılık, Emlak Yönetimi) eğitim gören 50 öğrenci çalışmaya katılmıştır. Literatür taraması sonucunda belirlenen kriterler bulanık DEMATEL yöntemiyle önem derecesine göre sıralanmıştır. Buna ek olarak oluşturulan nedensellik diyagramıyla önemli olarak belirlenen kriterler, ders seçim kararını etkileyen ve bu karardan etkilenenler olarak iki kısımda ele alınmıştır.*

Anahtar Kelimeler: *Ders seçimi, Meslek Yüksekokulu, Bulanık Mantık, DEMATEL*

Makale Geliş Tarihi: 05.11.2017
Makale Kabul Tarihi: 08.12.2017

---

*) Doç.Dr., Anadolu Üniversitesi Eskişehir Meslek Yüksekokulu Finansman Bölümü (e-posta: saltinirmak@anadolu.edu.tr)

**) Dr.,Anadolu Üniversitesi Yer ve Uzay Bilimleri Enstitüsü Coğrafi Bilgi Sistemleri ABD (e-posta: mustafaergun@gmail.com)

***) Arş.Gör.,Anadolu Üniversitesi İşletme Fakültesi Muhasebe Finansman Bölümü (e-posta: ckaramasa@anadolu.edu.tr)

I. Introduction

Every country has its preferred training approach or method that they adopt and this is usually created using internationally acquired experience, in accordance with each countries defined criteria and subsequently, its manpower requirement is supplied via this approach. However, it is important to mention that a diversified vocational education systems is applied across the world. On this subject matter, the required research as well as relevant educational standards are currently being developed across Turkey, a country with a very young population. The said purpose for the creation of vocational education systems in Turkey, is to create young entrepreneurs who possess the required levels of professional knowledge as well as thinking and are able to access and facilitate research as well as possess the needed artistic sensitivity and self-confidence (www.kalkinma.gov.tr).

According to Turkish Higher Education Laws, issued in 1981, vocational schools are defined as higher education institutions that aim to train up qualified human resources, for specific professions, that would last for upto two years and it will comprise two or three semesters per year. These regulations have applied to the vocational school system in Turkey since its republican era and also, includes its structural and functional changes made as well (www.yok.gov.tr).

Though the primary aim for vocational schools' is to train a qualified work force for specific professions, however, vocational schools also have the aim of becoming a social and regional leader, in terms of producing and spreading knowledge through scientific research conducted by their instructors. (Yücebaş et el.,, 2013, p.45).

Furthermore and according to Turkish educational data, from 2015 to 2016, there were 846 vocational schools that are affiliated with state universities. But it is important to note that whilst there are 95 vocational schools affiliated to foundation universities, 6 of these vocational schools are affiliated to foundations. However, according to education figures on offer, approximately 35% of university students across Turkey study at a vocational school (https://istatistik.yok.gov.tr)

Vocational schools have an important position and indispensable role to play, within Turkey's society. An important rule for educating versatile students, with respect to achieving required standards, is to build applicable programs under a flexible structure and the flexibility of such programs is important to this subject matter. Each students' interests and their requirement is continually satisfied via the flexibility from such programs and the most important representation of flexibility offered and in practice, is comprised of elective courses. Throughout university education, students are expected to choose courses from their own field and/ or the vocational options they are expected to complete during their program. In today's university education system within which focus has been placed on professional development and on economic efficiency, it becomes essential to also promote an educational system that aims to cultivate a multi-faceted person with robust academic, personal and social skills.

Students are able to improve on their skills in different interest areas and are also offered the opportunity of being informed, within their areas of interest, with the help of chosen elective courses. Given this perspective, elective courses will ultimately allow students identify their interests, talents and potentials from within their field.

The effectiveness of elective course is further accelerated by participating in various other studies that will provide young people, with access to the benefits on offer, from partaking in a higher education system. Hence, it is important to determine what constitutes an acceptable criteria for course selection and also, for achieving the desired personal development in terms of selecting an appropriate elective course. Selection of the appropriate elective courses tends to play an important role in the training up of students, giving them the desired qualities after considering all mentioned criteria. Dündar (2008) conducted a survey that was focused on the 3rd year students of Business Administration Department, at the Faculty of Economics and Administrative Sciences, in Afyon Kocatepe University, Turkey. As a result of his study, he has reached the conclusion that course selection can be made more realistic by applying Analytic Hierarchy Process (AHP). However, there are a few other studies that have been examined, analyzing students' course selection criteria further in the literature. But no other study has been conducted, focusing on students, with the sole purpose of examining the selection of elective courses at vocational schools.

Consequently, the objective for this study is to help prioritize the process of evaluating course selection criteria, by making use of the fuzzy DEMATEL (The Decision Making Trial And Evaluation Laboratory) method. In addition, direct and indirect interactions between selected criteria is obtained and examined by building a cause and effect model, whilst making use of a causal diagram.

II.Literature Review

There is a requirement to ensure the delivery of education according to a students' personal interests, abilities and needs, as part of the higher education system. Assistance on offer whilst undertaking course selection, being offered by lecturers whilst considering each students' need as well as interest, has started to gain importance (Özgüven, 1989, p.121)

This has helped to determine the impact on each students' special interests in a non-technical course and its subsequent selection, at the Faculty of Education (Paykoç et al., 1989, pp.1-21).

Following on with other researches undertaken that focused on assessing first year students at the Department of Biology, it was aimed at examining the process of course selection and its influencing criteria and it was observed that males were found to be more interested in science topics than examined females (Woolnough, 1994, pp.368-374).

Also highlighted was the perceived lecturers' neglect, in terms of supporting the process of course selection and it was identified as a critical criterion and the main source of influence on choices made, according to the views shared by students at the Middle East Technical University (Demir & Ok, 1996, pp. 121-125).

Furthermore, the lecturers' personal characteristic is also identified as positively affecting the course selection process. Consequently, students are found to select courses after considering the lecturers' attitude (Babad, Darley & Kaplowitz, 1999, pp.157-168).

Then students at the Engineering Faculty were also found to select courses that increase their professional competence and were found to be compatible with their special interests (Isabel, 2000, pp.1201-1218).

Essentially, factors found to influence course selection when focusing on first grade students from various departments, was identified as comprising environmental attitude as well as social beliefs (Hodgkinson & Innes, 2001, pp.37-40).

A different set of course selection indicators have been identified as effective, with respect to most 3rd and 4th year students of the Physics, Chemistry and Biology departments, at Gazi University (Tezcan & Gümüş, 2008, pp.1-17).

The results obtained from conducted research was aimed at examining the influencing factors during the course selection process for students undertaking studies, at masters and doctorate level at Afyon Kocatepe University and was assessed using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), which is regarded as consistent with the decision criteria process (Ersöz et al., 2011, pp.227-244).

Both multi criteria decision making methods, namely AHP and TOPSIS, have been adopted to select the most appropriate courses for 3rd and 4th year students at the Kırıkkale University, by taking into account the assigned heirarchy of importance for an adopted criteria (Kutlu et al., 2012, pp.6-21).

Onay et al., (2016) compared the performance of different fuzzy ranking methods aimed at analyzing selection criteria used for choosing between various accounting elective courses, for a business undergraduate and an accounting graduate education.

Given an outline target, to undertake an analysis and follow on weighting for several course selection criteria, for vocational schools, 17 of such examined course selection criteria were found to reflect what appears to be causal relationships and was determined in accordance with the depth of literature review conducted and is shown as Table 1.

Table 1: Course selection criteria and their explanations

Criteria	Explanation	References
C1	Course time is suitable for the students	Onay et al., (2016)
C2	Quota of course	Ömürbek et al., (2013); Dündar (2008); Onay et al., (2016)
C3	Course difficulty level	Demir (1996); Dündar (2008); Kurnaz and Alev (2003); Onay et al., (2016)
C4	Requirement for numerical knowledge and ability	Ömürbek et al., (2013);
C5	Understandability of courses to be selected	Kurnaz and Alev (2003); Onay et al., (2016)
C6	Similarity of content to other previously selected courses	Demir (1996), Dündar (2008); Onay et al., (2016)

C7	Facilitating ease of a working life	Ömürbek et al., (2013); Kurnaz and Alev (2003); Onay et al., (2016)
C8	Students' success rate from previous years	Ömürbek et al., (2013)
C9	Levels of course interest amongst students	Demir (1996); Ömürbek et al., (2013); Kurnaz and Alev (2003); Onay et al., (2016)
C10	A requirement to make presentations during the course	Our criterion
C11	A requirement to deliver a project and submit assignments	Our criterion
C12	Exam type	Our criterion
C13	Sitting through delivered lessons from a lecturer, from previous semesters	Demir (1996); Dündar (2008); Kurnaz and Alev (2003)
C14	Lecturer's attitude	Demir (1996); Dündar (2008); Kurnaz and Alev (2003); Onay et al., (2016)
C15	Lecturer's teaching style	Demir (1996); Dündar (2008); Kurnaz and Alev (2003); Onay et al.,(2016)
C16	Lecturer's domain knowledge and experience	Demir (1996); Dündar (2008); Kurnaz and Alev (2003); Onay et al.,(2016)
C17	Teaching location (classroom, laboratory, kitchen etc.)	Onay et al., (2016)

III.Methodology

In this study, both fuzzy logic and the DEMATEL methods are used, given their recognised capacity to deal with the ambiguity of a human being's perception and also, the offered capacity of modeling interdependent and complex course selection criteria that models everyday life and are able to effectively reflect and represent, vagueness and uncertainty. Accordingly, this fuzzy set theorem adopted measures subjective and ambiguous concepts by avoiding the loss of information, related human judgments. Whilst use of the DEMATEL approach is aimed at examining existing interrelationships within the criteria under examination and has been explained respectively.

A.Fuzzy Logic

Every decision made by experts or alternatively, by decision makers on a qualitative criteria, in relation to a certain or given subject will involve some level of vagueness, imprecision and ambiguity because of the subjective nature of judgments made or offered, in relation to real world applications. These are being expressed in linguistic terms and are based on available expertise. At this stage, the use of fuzzy logic first introduced by Zadeh (1965) helps the decision maker eliminate the deficiencies embedded within the crisp set theory, by examining all anticipated sources of uncertainty or imprecision that are considered both vague and non-statistical in nature (Chang,

Chang & Wu, 2011, p.1852). These linguistic terms are transformed into fuzzy numbers and are then ascribed to various experiences, opinions and judgments that can be affilitated with decision makers. Consequently, a fuzzy set which is an extension of the crisp set allows for partial associations of an element, as a result of its membership function. The membership values for objects within a fuzzy set will range from 0 (non-memberhip) to 1 (complete membership). However, values inbetween these defined boundaries are referred to as possessing an intermediate degree of membership and also, reflects an anticipated degree of association for each element that belongs to a set (Ertuğrul & Karakaşoğlu, 2009, p.704). In comparison with the crisp set theory, the fuzzy set theory is identified as better at representing ambiguous data and also, it makes an allowance for the mathematical operators to be applied, within a given fuzzy domain (Mahmoodzadeh, Shahrabi, Priazar & Zaeri, 2007, p.272).

A fuzzy set ' $\tilde{A}$ ' is a subset of the universe of discourse ' U ', which can be characterized by the membership function ' $\mu_{\tilde{A}}(x)$ ' and is found ranging between 0 and 1 and also, represents the continuous mapping from U to a number of closed intervals '$[0,1]$'. Also, $\mu_{\tilde{A}}(x)$ is the normality of a fuzzy subset, which means that there exists a given number ' x_0 ' that makes $\mu_{\tilde{A}}(x_0) = 1$ (Dubois & Prade, 1978). The fuzzy set $\tilde{A}$ can be shown as follows:

$$\tilde{A} = \{(x, \mu_{\tilde{A}}(x)) | x \in U\} \quad (1)$$

Linguistic terms provide a suitable avenue for decision makers to express and to also, present their judgments as a collection of phrases or sentences, in natural language, which is then converted into fuzzy numbers from within the theory (Wu and Lee, 2007, p.502). It is also important to note that triangular and trapezoidal fuzzy numbers are mostly used for practical applications. Hence, in this study triangular fuzzy numbers are mainly used for representation and computational usefulness. A triangular fuzzy number ' $\tilde{A}$ ' can be represented as a triplet (l, m, u) and membership function $\mu_{\tilde{A}}(x)$, which is defined as follows:

$$\mu_{\tilde{A}}(x) = \begin{cases} (x-l)/(m-l), l \le x \le m, \\ (u-x)/(u-m), m \le x \le u, \\ 0, otherwise \end{cases} \quad (2)$$

An effective fuzzy aggregation method that contains a defuzzification step, should ideally be used in order to deal the with problems arising from an uncertain and imprecise environment. Defuzzification can be defined as the selection of a specific crisp set element, based on an initial output fuzzy set that converts fuzzy numbers into crisp set scores (Opricovic & Tzeng, 2003). The centroid (Center-of-gravity) for the most commonly used defuzzification method is unable to distinguish between two fuzzy numbers that possess the same crisp set of values and also, possess different shapes. So, adopting the Converting Fuzzy data into Crisp Scores (CFCS) defuzzification method, as proposed by Opricovic and Tzeng (2003), which can be applied to a fuzzy aggregation process and is used for a course selection problem, due to its ability to offer a better crisp set value when compared against the centroid method. The CFCS method is based on the capacity to determine the left and right scores, bounded by the fuzzy min and max and its total score is calculated as a weighted average in terms of membership functions. Hence, assuming that $\tilde{a}_{ij}^{k} = (l_{ij}^{k}, m_{ij}^{k}, r_{ij}^{k})$ representing fuzzy assessments for the evaluator, k $(k = 1,2,...,d)$, which is about the fuzzy weight of 'ith'criterion and affecting 'jth' one. Steps of CFCS method can be summarized as follows (Tseng & Lin, 2009, p.524; Wu & Lee, 2007, p.503):

Step 1- Normalization:

$$xl_{ij}^{k} = (l_{ij}^{k} - \min l_{ij}^{k}) / \Delta_{\min}^{\max} \tag{3}$$

$$xm_{ij}^{k} = (m_{ij}^{k} - \min l_{ij}^{k}) / \Delta_{\min}^{\max} \tag{4}$$

$$xr_{ij}^{k} = (r_{ij}^{k} - \min l_{ij}^{k}) / \Delta_{\min}^{\max} \tag{5}$$

where $\Delta_{\min}^{\max} = \max r_{ij}^{k} - \min l_{ij}^{k}$

Step 2- Computing left (ls) and right (rs) normalized values:

$$xls_{ij}^{k} = xm_{ij}^{k} / (1 + xm_{ij}^{k} - xl_{ij}^{k}) \tag{6}$$

$$xrs_{ij}^{k} = xr_{ij}^{k} / (1 + xr_{ij}^{k} - xm_{ij}^{k}) \tag{7}$$

Step 3- Computing total normalized crisp values:

$$x_{ij}^{k} = \left[xls_{ij}^{k}(1 - xls_{ij}^{k}) + xrs_{ij}^{k} xrs_{ij}^{k}\right] / \left[1 - xls_{ij}^{k} + xrs_{ij}^{k}\right] \tag{8}$$

Step 4- Computing crisp values:

$$a_{ij}^{k} = \min l_{ij}^{k} + x_{ij}^{k} \Delta_{\min}^{\max} \tag{9}$$

Step 5- Integrating crisp values:

$$a_{ij} = \frac{1}{d}(a_{ij}^{1} + a_{ij}^{2} + \cdots + a_{ij}^{d})$$

(10)

B.DEMATEL

The DEMATEL method was developed by the Geneva Research Centre, of the Battelle Memorial Institute, between the years 1972 and 1976. It was used to create an association, between complex and intertwined problem groups (Fontela & Gabus, 1974, pp. 67-69). This method is a structural model capable of revealing the causal relationships existing between evaluated factors and is represented,using a diagram known as the directed graph and matrices (Bai and Sarkis, 2013, p. 285). Components within this system of evaluation can be readily visualized, by making use of the directed graph diagram and its associated matrices that helps to portray the strength of both direct and indirect influences (Tseng & Lin, 2009, p.525). The DEMATEL technique does not require large amounts of data. However, use of this method involves establishing an indirect implicit relationship that comprises a cause and effect model. Elements within the system are then divided into causal and effected groups, via a relationship visualization. The relationship between a cause and effect factor can then be converted into an intelligible structural model, via use of this evaluation method (Wu & Lee, 2007, p.501). This methodology helps to confirm the existing interdependence between criteria and also, restricts the relationships from showing similar properties from within the whole system (Gharakhani, 2012, p.3217).

The procedure for the DEMATEL method, can be summarized as follows (Aksakal and Dağdeviren, 2010, pp. 907-908; Tsai and Chou, 2009, pp. 1444-1455; Wu and Lee, 2007, pp. 501-502; Hung et al., 2006, p.227; and, Zhou et al., 2011, p.246):

Step 1: Generating the direct-relation matrix

Supposing that a given system is comprised of the following criteria $D = \{d_1, d_2, ..., d_n\}$. In order to examine the relationships existing between these criteria, a pair-wise comparison scale will need to be designed. Following, Table 2. shows the desired pair-wise comparison scale that is compartmentalised into five levels, by utilizing a scale that ranges from 0 to 4. The result of this comparison will produce a direct-relation matrix.

Table 2: A Comparison scale of the DEMATEL method

Numeral	Definition
0	No influence
1	Very low influence

2	Low influence
3	High influence
4	Very high influence

The initial direct relation matrix 'A', is a nxn matrix obtained by pair-wise comparisons, in terms of the influences and directions existing between criteria where 'a_{ij}' is denoted as the degree to which the criterion 'i' affects the criterion 'j', i.e. $A = \lfloor a_{ij} \rfloor_{nxn}$.

Step 2: Normalizing the direct-relation matrix

On the basis of the direct-relation matrix 'A' and the normalized direct-relation matrix, 'X' can be obtained through Eqn. (11) and (12) in which all principal diagonal elements are equal to zero.

$$X = k.A \tag{11}$$

$$k = \frac{1}{\max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}} \qquad i, j = 1,2,..., n \tag{12}$$

Step 3: Obtaining the total-relation matrix

Once the normalized direct-relation matrix 'X' has been obtained, the total relation matrix 'T' can be derived by using Eqn. (13), where 'I' is denoted as the identity matrix.

$$T = X(1 - X)^{-1} \tag{13}$$

Step 4: Producing causal diagram and analyzing results

In this step, the sum of rows and the sum of columns, are used to derive the vector 'S' (the degree of influential impact) as well as the vector 'R' (the degree of influenced impact) from within the total relation matrix 'T', as shown in Eqn. (14), (15), and (16) respectively. Whilst the sum of rows shows all direct and indirect influences, given by the factor 'i' to all other factors, the sum of the columns represent all direct and indirect impact received, by the factor 'j' to all other factors. Then, the horizontal axis vector $(S + R)$ that is described as the "Prominence", is determined by adding R to S. This indicates a level of importance assigned to the criterion. Similarly, the vertical axis $(S - R)$ that is described as the "Relation", is then formed by subtracting R from S. This helps to divide criteria into a cause and effect group. Where $(S - R)$ is positive, the criterion is identified to belong to the cause group. Otherwise, it is identified to belong to the effect group. Therefore, the causal diagram can be derived by mapping the datasets derived from $(S+R, S-R)$, which then provides valuable insight for making decisions.

$$T = \lfloor t_{ij} \rfloor_{nxn}, \qquad i, j = 1,2,..., n \tag{14}$$

$$S = \left[\sum_{j=1}^{n} t_{ij} \right]_{nx1} \tag{15}$$

$$R = \left[\sum_{i=1}^{n} t_{ij} \right]_{1xn} \tag{16}$$

where vector S and vector R, respectively, denote the sum of rows as well as the sum of columns, from the total-relation matrix $T = \lfloor t_{ij} \rfloor_{nxn}$.

Step 5: Obtaining the importance of criteria

The importance of criteria (i=1,2,…,n) is calculated by taking the values of (S+R) and (S-R) into account, respectively (Baykasoğlu et al., 2013, p.902; and, Dalalah et al., 2011, pp.8386-8387).

$$\omega_i = \left\{ (D_i + R_i)^2 + (D_i - R_i)^2 \right\}^{\frac{1}{2}} \tag{17}$$

Then, the importance of any criterion can be normalized shown as below:

$$w_i = \frac{\omega_i}{\sum_{i=1}^{n} \omega_i} \qquad i = 1,2,..., n \tag{18}$$

where ‘ w_i ’ is the final criteria weight that can be used in the decision making process.

IV.Analysis

In a bid to apply the DEMATEL method within a fuzzy environment, a survey was designed to identify the importance levels adopted for the evaluation of criteria via the fuzzy linguistic scale, by converting the DEMATEL comparison scale into triangular fuzzy numbers. Fuzzy linguistic scale, defined by Wang and Chang (1995), was adopted for this study as Table 3. The respondents were selected from amongst students of different departments (marketing; hospitality management; secretarial and office management; foreign trade; culinary arts; and also, real estate and property management) at the Eskişehir vocational school. At the end of the survey, 50 respondents completed the survey questionnaires and their offered responses were collected and used for analyzing the interrelationships, from amongst 17 of the adopted course selection criteria.

Table 3: Fuzzy linguistic scale

Linguistic terms	Influence score	Triangular fuzzy numbers
No influence	0	(0,0.1,0.3)
Very low influence	1	(0.1,0.3,0.5)
Low influence	2	(0.3,0.5,0.7)
High influence	3	(0.5,0.7,0.9)
Very high influence	4	(0.7,0.9,1.0)

An initial direct relation matrix, obtained after applying the CFCS method and has been referenced within the provided Eqn. (1) through to (8) and its output is shown in Table 4.

Table 4: Initial direct relation matrix

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17
C1	0.000	0.688	0.688	0.527	0.513	0.496	0.472	0.448	0.616	0.515	0.545	0.462	0.458	0.458	0.461	0.424	0.500
C2	0.450	0.000	0.469	0.496	0.545	0.503	0.439	0.533	0.473	0.488	0.492	0.435	0.420	0.450	0.447	0.431	0.458
C3	0.605	0.635	0.000	0.559	0.571	0.526	0.529	0.485	0.500	0.511	0.549	0.454	0.500	0.446	0.488	0.465	0.477
C4	0.564	0.609	0.642	0.000	0.537	0.477	0.521	0.560	0.541	0.526	0.496	0.424	0.462	0.447	0.469	0.476	0.522
C5	0.624	0.647	0.643	0.650	0.000	0.579	0.454	0.560	0.504	0.522	0.538	0.491	0.481	0.428	0.470	0.443	0.500
C6	0.556	0.613	0.643	0.644	0.617	0.000	0.552	0.557	0.523	0.564	0.504	0.465	0.476	0.450	0.500	0.468	0.510
C7	0.643	0.714	0.688	0.639	0.665	0.639	0.000	0.586	0.530	0.552	0.598	0.488	0.469	0.447	0.526	0.496	0.473
C8	0.527	0.557	0.519	0.537	0.538	0.557	0.545	0.000	0.459	0.496	0.466	0.473	0.716	0.458	0.492	0.446	0.496
C9	0.519	0.500	0.485	0.556	0.538	0.527	0.509	0.500	0.000	0.496	0.527	0.485	0.443	0.439	0.483	0.473	0.473
C10	0.519	0.560	0.526	0.583	0.549	0.605	0.597	0.546	0.583	0.000	0.459	0.410	0.451	0.465	0.462	0.426	0.413
C11	0.549	0.519	0.556	0.602	0.519	0.609	0.549	0.564	0.542	0.560	0.000	0.462	0.477	0.442	0.473	0.450	0.432
C12	0.631	0.542	0.620	0.624	0.651	0.529	0.610	0.579	0.528	0.561	0.594	0.000	0.500	0.447	0.485	0.439	0.439
C13	0.632	0.609	0.696	0.647	0.643	0.633	0.639	0.654	0.587	0.613	0.632	0.462	0.000	0.445	0.485	0.526	0.473
C14	0.536	0.529	0.455	0.632	0.569	0.539	0.548	0.448	0.526	0.465	0.448	0.422	0.425	0.000	0.475	0.473	0.451
C15	0.627	0.533	0.534	0.620	0.535	0.548	0.549	0.482	0.537	0.485	0.407	0.449	0.450	0.483	0.000	0.483	0.415
C16	0.535	0.645	0.627	0.555	0.567	0.454	0.578	0.528	0.577	0.476	0.447	0.415	0.475	0.450	0.415	0.000	0.492
C17	0.518	0.625	0.648	0.623	0.576	0.579	0.480	0.479	0.528	0.590	0.417	0.446	0.479	0.438	0.506	0.443	0.000

Following on from this, this normalized direct relation matrix was obtained by also applying the formulas (8) and (9). After this, the total relation matrix was acquired using the formula in Eqn. (10) and the output is shown as Table 5. After that, the degree of influential (S) and degree of influenced impact (R) values were calculated, by calculating the sum of rows and columns within the total relation matrix. Following on from this, a causal diagram is generated by obtaining the prominence (horizontal) and relation (vertical) axes, denoted by and respectively. This is represented as Table 6.

Table 5: Total relation matrix

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17
C1	0.584	0.687	0.680	0.665	0.643	0.621	0.603	0.600	0.618	0.600	0.586	0.523	0.549	0.493	0.547	0.526	0.545
C2	0.583	0.566	0.609	0.612	0.597	0.575	0.554	0.562	0.558	0.553	0.537	0.481	0.505	0.456	0.504	0.486	0.500
C3	0.649	0.686	0.614	0.672	0.652	0.627	0.611	0.606	0.610	0.603	0.590	0.525	0.556	0.495	0.552	0.532	0.545
C4	0.643	0.681	0.677	0.612	0.646	0.620	0.608	0.612	0.611	0.602	0.582	0.520	0.551	0.493	0.549	0.531	0.548
C5	0.666	0.703	0.695	0.697	0.608	0.647	0.619	0.628	0.624	0.618	0.602	0.541	0.568	0.504	0.563	0.543	0.561
C6	0.668	0.708	0.703	0.704	0.679	0.595	0.635	0.635	0.633	0.630	0.606	0.545	0.574	0.512	0.573	0.551	0.568
C7	0.710	0.753	0.743	0.739	0.718	0.694	0.610	0.670	0.666	0.660	0.646	0.575	0.602	0.538	0.604	0.582	0.593
C8	0.643	0.678	0.668	0.671	0.649	0.631	0.614	0.557	0.606	0.602	0.582	0.527	0.578	0.495	0.553	0.531	0.548
C9	0.618	0.648	0.640	0.648	0.626	0.605	0.588	0.586	0.536	0.580	0.567	0.510	0.531	0.477	0.532	0.514	0.526
C10	0.632	0.668	0.658	0.665	0.640	0.626	0.609	0.604	0.609	0.541	0.572	0.513	0.544	0.489	0.542	0.521	0.531
C11	0.645	0.675	0.672	0.677	0.648	0.636	0.614	0.615	0.614	0.609	0.534	0.527	0.555	0.495	0.552	0.532	0.542
C12	0.685	0.711	0.712	0.713	0.693	0.660	0.651	0.647	0.644	0.639	0.624	0.505	0.585	0.520	0.580	0.557	0.570
C13	0.696	0.730	0.731	0.726	0.703	0.681	0.664	0.665	0.660	0.655	0.638	0.562	0.543	0.484	0.590	0.574	0.582
C14	0.619	0.650	0.636	0.654	0.627	0.605	0.590	0.580	0.589	0.576	0.558	0.502	0.528	0.430	0.530	0.513	0.523
C15	0.641	0.664	0.658	0.667	0.637	0.619	0.603	0.596	0.603	0.590	0.566	0.516	0.542	0.490	0.492	0.525	0.530
C16	0.638	0.682	0.673	0.667	0.647	0.616	0.612	0.606	0.613	0.595	0.576	0.517	0.550	0.491	0.541	0.480	0.543
C17	0.646	0.689	0.685	0.683	0.657	0.637	0.611	0.610	0.616	0.615	0.581	0.528	0.558	0.497	0.558	0.534	0.500

Table 6: Prominence and relation axis for the causal diagram

Criteria	S (Sum)	R (Sum)	S+R	S-R
C1	10.9666	10.0711	21.0377	0.8955
C2	11.5792	9.2376	20.8168	2.3416
C3	11.4562	10.1259	21.5822	1.3302
C4	11.4710	10.0877	21.5588	1.3832
C5	11.0695	10.3878	21.4573	0.6816
C6	10.6960	10.5195	21.2156	0.1764
C7	10.3977	11.1038	21.5015	-0.7061
C8	10.3796	10.1338	20.5135	0.2457
C9	10.4097	9.7338	20.1436	0.6758
C10	10.2695	9.9640	20.2336	0.3055
C11	9.9466	10.1423	20.0889	-0.1957
C12	8.9159	10.6958	19.6117	-1.7798
C13	9.4205	10.8845	20.3050	-1.4639
C14	8.3603	9.7099	18.0703	-1.3495
C15	9.3631	9.9411	19.3043	-0.5779
C16	9.0336	10.0472	19.0809	-1.0135
C17	9.2553	10.2044	19.4597	-0.9490

The causal diagram for this elective course selection process, is shown as Figure 1. According to the diagram, the given criteria is divided into cause (C1, C2, C3, C4, C5, C6, C8, C9 and C10) and effect (C7, C11,C12,C13,C14,C15,C16 and C17) criteria groups. This is according to the relationship value (S-R), which is both positive and negative. Hence, criteria affecting elective course selection can be stated to consist C1, C2, C3, C4, C5, C6, C8, C9 and C10. On the contrary, criteria that has also been affected from among the elective course selection are defined as C7, C11,C12,C13,C14,C15,C16 and C17.

Criteria included within cause criteria group, should ideally be paid more attention due to its anticipated impact on the whole system and also, the overall goal. Subsequently, a high level of performance, focused on the effect criteria, can be obtained by controlling and focusing on cause group criteria. Amongst all the criteria in the defined cause group, the quota of course (C2) is identified with the highest S-R score with '2.3416' meaning that C2 has a greater level of impact on the whole system than it does when receiving from other criteria. The degree of importance (S+R) score for criteria C2 is 20.8168, which ranks in sixth place from among all examined causal criteria. Additionally, the degree of influential impact (S) of C2 is output as 11.5792 and is ranked as being in the top place from among all examined causal criteria. The degree of influenced impact (R) of C2 is 9.2376, meaning the smaller impact it receives from others values examined, ultimately leads to a small value for the degree of importance (S+R). Therefore, C2 has been identified to have a notable impact on other criteria and an ancitipated improvement of C2 will lead to the recovery of the whole system, despite the registered smaller value for S+R.

Criteria with the second highest S-R score is identified as C4, namely the requirement for possessing numerical knowledge and ability, with a score of 1.3832. The degree of influential impact (S) for C4 is 11.4710 and is ranked second place, from among all the causal criteria examined. Furthermore, the impact C4 receives from other values (R) is relatively high and this leads to it receiving a second place rank with the degree of importance (S+R) value, with a score of 21.5588. These deductions imply the impact and consideration assigned to C4, in curriculum design process, is one of great importance to the whole system.

In terms of anticipated course difficulty level (C3), the impact dispatched from C3 to other criteria (11.4562) is found to be greater than the impact it is identified as receiving from other associated criteria (10.1259). Also, given its higher S and R values derived, this consequently leads to the highest degree of importance (S+R) value of 21.5822, for C3. So, C3 is identified as essential to the course selection process and the related adjustments to be made, by taking C3 into account.

With regards a course's time suitability for students (C1), which was identified as having the fourth highest S-R value, the impact dispatched from C1 to other criteria (10.9666) is identified as having a greater impact than it receives (10.0711). Given it has higher S and R values, this leads to a relatively higher degree of importance (S+R) value of 21.0377, for C1. As a result of all the given evidence, it presents the critical nature of C1 to decision making.

Another causal criteria, the ability to understand courses to be selected (C5), is identified as having the fifth highest S-R value. The impact dispatched from C5 to other criteria (11.0695) is found to be greater than the impact it receives (10.3878). So, given there is a higher S and R value that leads to a degree of importance (S+R) value of 21.4573, it effectively places this criteria third in rank. Thus, C5 can be considered a critical factor for course selection.

Other causal criteria examined, namely those that have similar content output and include: the previously selected courses (C6), students' success rate from prior years (C8), shown display of course interest from students (C9) and also, the requirement for making a presentation on the course (C10), all have a lower relation (S-R) value from among causal criteria examined. Also, a lower degree of influence and the degree of influenced impact values lead to a lower degree of importance (S+R) values. Therefore, these criteria cannot be considered as critical, to the whole system.

The features for each affected criterion needs to be examined closely, to identify which factor would prove critical in the course selection process, despite being easily impacted by other criteria. From among all criteria within affected group, exam type (C12), which has the lowest S-R score with -1.7798 and can be identified as the most affected by other criteria. But with a lower degree of influence and the degree of influenced impact values, this leads to a lower degree of importance (S+R) value of 19.6117. However, this criterion can be improved upon by adjusting other examined criteria, so it is not recognized as an important factor for the course selection process.

Other criterion, namely the requirement for project and assignment submission (C11), has the relation (S-R) value of -0.1957 that is slightly less than zero and this suggests that it is slightly affected by other criteria. Also, the degree of importance (S+R) value is positioned third in rank from among the effect criteria examined. When carefully considered, the criteria C11 is recognized to be essential for course selection, from among the effect criteria.

With respect to the criteria, facilitating a productive working life (C7), it has the relation (S-R) value of -0.7061, which means that it is easily affected by other criteria. But its degree of influence and degree of influenced impact values are relatively high, from among criteria examined that leads to a degree of importance (S+R) value of 21.5015. Thus, placing it third in rank from among all criteria. Though C7 is considered an effect factor, it however has considerable impact on other criteria as well as the whole system. So, C7 is recognized as essential for course selection by considering ascibed importance of its position, from within the whole system.

Other effect criteria is identified to include: attending lessons delivered by an instructor from a previous semester (C13), the instructor's attitude (C14), instructor's teaching style (C15), instructor's domain knowledge and experience (C16) and teaching place (C17), all have negative (S-R) values meaning that they are strongly affected by other criteria and will output low importance values from among all criteria examined. So, these effect criteria now being examined cannot be considered as critical during the course selection process but could be developed, by adjusting other criteria.

To sum it all up, there are seven critical criteria identified from within the course selection process and includes five cause and two effect factors. Whilst the cause criteria is composed of: the course's time suitability for students (C1); quota of course (C2); course difficulty level (C3); requirement of numerical knowledge and ability (C4); and, the ability to understand courses that will be selected (C5). The effect criteria can be identified to include: facilitating a productive working life (C7); and, the requirement for project and assignment submission (C11).

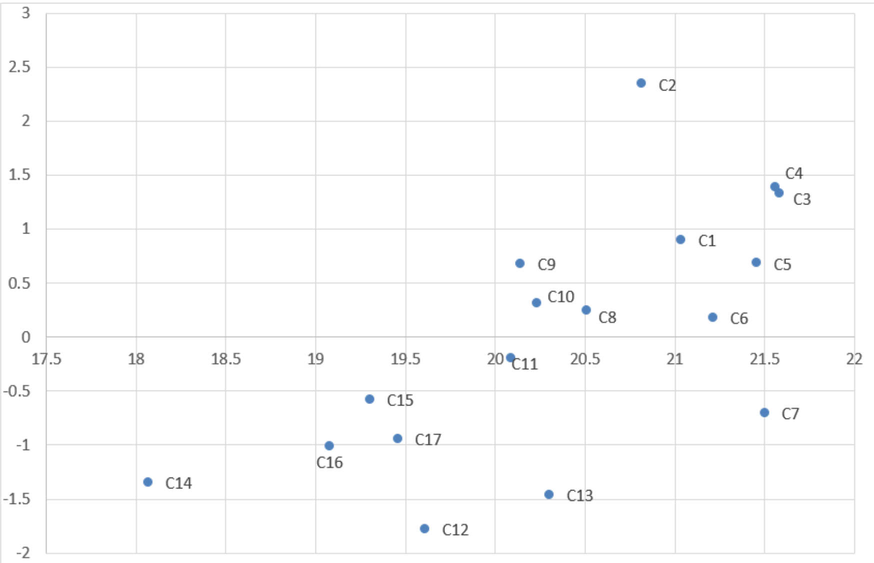

Figure 1: Cause and effect diagram for elective course selection

In addition, the importance of course selection criteria is calculated by using Eqn. (17) and (18) and are shown in Table 7.

Table 7: Course selection criteria weights

Criteria	w_i
C1	0.0607
C2	0.0604
C3	0.0624
C4	0.0623
C5	0.0619
C6	0.0612
C7	0.0620
C8	0.0592
C9	0.0581
C10	0.0584
C11	0.0579
C12	0.0568
C13	0.0587
C14	0.0522
C15	0.0557
C16	0.0551
C17	0.0562

Now, according to information contained within Table 7, whilst course difficulty level (C3) is identified to have the highest importance value of 0.0624, the instructor's attitude (C14) can be identified as having the lowest importance value of 0.0522. The importance weight for the course selection criteria examined can be ranked as: C3>C4>C7>C5>C6>C1>C2>C8>C13>C10>C9>C11>C12>C17>C15>C16>C14. The result obtained from the importance of course selection criteria, shows parallelism with the cause and effect model. Within this context, only two effect criteria namely C7 and C13 are placed within the top ten importance ranking (third and ninth). The results obtained from criteria weights support the review of the critical nature and impact of cause and effect groups for the whole system.

V.Conclusion

The decisions being made and related to course selection, have been made in a complex and intertwined environment. In a bid to overcome this identified shortcoming, the fuzzy logic based DEMATEL method is used in analyzing interrelationships, between criteria and extract criteria or being a strong impact or being impacted by other factors.

Hence, the examined cause and effect criteria groups related to course selection, were found and analyzed within this study. Seven critical criteria were identified as part of the course selection process, including five cause and two effect factors. Whilst the identified cause criteria was composed of: the course's time suitability for students (C1), the assigned quota of course (C2), the level of difficulty of the course (C3), a requirement for numerical knowledge and ability (C4) and a good understanding, of courses to be selected (C5). The effect criteria that was examined includes: facilitating an effective working life (C7) and also, the requirement to deliver a project and an assignment (C11).

Also, criteria examined has been ranked according to an assigned importance level. In this context, whilst identified course difficulty level (C3) has the highest importance value of 0.0624, the instructor's attitude (C14) can be identified as having the lowest importance value of 0.0522. The results obtained for the importance level of criteria examined, are consistent with the adopted cause and effect model.

Each students' anticipated success and motivation can be improved upon, by considering the results of conducted scientific studies, with respect to taking on and participating on elective courses that have been selected and are deliverd at vocational schools. It is was considered an important part of the study, the application of an outline scientific approach to achieving the anticipated results for a course determination process, for an examined vocational school directory. The comparison of course selection criteria, between faculty and vocational school, can be made more effective whilst being aimed determining what constitutes the similarities and/ or differences, between choices made, for future studies. Also, the relationship between the course selection criteria to examined and lecturer expected to deliver the course content, can euqally be examined. In future studies, the fuzzy DEMATEL method which is considered as offering a comprehensive review, can equally be applied to the group decision making requirement, within a fuzzy environment and can better be used in modelling uncertain causal relationships between criteria.

This study has had its limitations, one of which is the sample size used during the assessment of the requirement. Therefore, the number of respondents to be considered for a more robust study will need to be increased. Thus, ensuring an improvement of study output and validity, for anticipated or future research.

References

Aksakal, E. & Dağdeviren M. (2010). ANP ve DEMATEL Yöntemleri ile Personel Seçimi Problemine Bütünleşik Bir Yaklaşım, *Gazi Üniversitesi Mühendislik, Mimarlık Fakültesi Dergisi*, 25(4), 905-913.

Babad, E., Darley J., M. & Kaplowitz H. (1999). Development Aspects in Course Selection, *Journal of Educational Psychology*, 91(1), 157-168.

Bai, C. & Sarkis, J. (2013). A Grey-Based DEMATEL Model for Evaluating Business Process Management Critical Success Factors, *International Journal of Production Economics*, 146(1), 281-292.

Baykasoğlu, A., Kaplanoğlu, V., Durmuşoğlu, Z.D.U. & Şahin, C. (2013). Integrating Fuzzy DEMATEL and Fuzzy Hierarchical TOPSIS Methods for Truck Selection, *Expert Systems with Applications*, 40(3), 899-907.

Chang, B., Chang, C.H. & Wu, C.H. (2011). Fuzzy DEMATEL Method for Developing Supplier Selection Criteria. *Expert Systems with Applications*, 38, 1850-1858.

Dalalah, D., Hayajneh, M. & Batieha, F. (2011). A Fuzzy Multi-Criteria Decision Making Model for Supplier Selection, *Expert Systems with Applications*, 38(7), 8384-8391.

Demir, A. (1996). Üniversitedeki Seçmeli Ders Uygulamasının Öğrenciler ve Öğretim Üyelerince Değerlendirilmesi, *Türk Psikolojik Danışma ve Rehberlik Dergisi,* 2(7), 24-31.

Demir, A. & Ok, A. (1996). Orta Doğu Teknik Üniversitesindeki Öğretim Üye ve Öğrencilerinin Seçmeli Dersler Hakkındaki Görüşleri, *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 12, 121-125.

Dubois, D. & Prade, H. (1978). Operations on Fuzzy Number, *International Journal of Systems Science*, 9, 613-626.

Dündar, S. (2008). Ders Seçiminde Analitik Hiyerarşi Proses Uygulaması. *Süleyman Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 13(2), 217-226.

Ersöz, F., Kabak M. & Yılmaz Z., (2011). Lisansüstü Öğrenimde Ders Seçimine Yönelik Bir Model Önerisi, *Afyon Kocatepe Üniversitesi İİBF Dergisi*, 13(2), 227-244.

Ertuğrul, İ. & Karakaşoğlu, N. (2009). Performance Evaluation of Turkish Cement Firms with Fuzzy Analytic Hierarchy Process and TOPSIS Methods, *Expert Systems with Applications*, 36, 702-715.

Fontela, E. & Gabus, A. (1974). DEMATEL, Innovative Methods. Report No.2 Structural Analysis of the World Problematique, *Battelle Geneva Research Institute*, 67-69.

Gharakhani, D. (2012). The Evaluation of Supplier Selection Criteria by Fuzzy DEMATEL Method, *Journal of Basic and Applied Scientific Research*, 2(4), 3215-3224.

Hung, Y., Chou, S.T. & Tzeng, G. (2006). Using a Fuzzy Group Decision Approach-Knowledge Management Adoption, *APRU Distance Learning and the Internet 2006 Conference*, 225-228.

Isabel, F.R. (2000). Influences on Choice of Course Made by University, Year I Bioscience Students a Case Study. *International Journal of Science Education*, 22(1), 1201-1218.

Kurnaz, M.A. & Alev, N. (2003). İlköğretim ve Ortaöğretim Lisansüstü Öğrencilerinin Ders Seçimi Yaklaşımları ve İlgili Sorunları, *Türk Fen Eğitimi Dergisi*, 6(3), 38-52.

Kutlu, B.S., Abalı,Y.A. & Eren T. (2012). Çok Ölçütlü Karar Verme Yöntemleri İle Seçmeli Ders Seçimi, *Kırıkkale Üniversitesi Sosyal Bilimler Dergisi*, 2 (2), 6-21.

Mahmoodzadeh, S., Shahrabi, J., Priazar, M. & Zaeri, M.S. (2007). Project Selection by Using Fuzzy AHP and TOPSIS Technique, *International Scholarly and Scientific Research & Innovation*, 1(6), 270-275.

Malaviya, A. & Peters, L. (1997). Fuzzy Feature Description of Handwriting Patterns, *Pattern Recognition,* 30(10), 1591-1604.

Onay, A., Karamaşa, Ç. & Saraç, B. (2016). Application of Fuzzy AHP in Selection of Accounting Elective Courses in Undergraduate and Graduate Level, *Journal of Accounting, Finance and Auditing Studies*, 2(4), 20-42.

Opricovic, S. & Tzeng, G.H. (2003). Defuzzification within a Multicriteria Decision Model, International Journal of Uncertainty. *Fuzziness and Knowledge-Based Systems,* 11(5), 635-652.

Ömürbek, N., Demirci, N. & Akalın, P. (2013). Analitik Ağ Süreci ve TOPSIS Yöntemleri ile Bilimdalı Seçimi, *Akademik Araştırmalar ve Çalışmalar Dergisi,* 5(9), 118-140.

Özgüven, İ. E. (1989). *Yükseköğretimde Öğrenci Kişilik Hizmetleri, Yükseköğretimde Rehberlik ve Psikolojik Danışma Toplantısı.* Ankara: A.Ü Eğitim Bilimleri Fakültesi Yayınları, No.161.

Paykoç, F., İçöz, N. & Zorba, E. (1989). *ODTÜ Lisans Programlarında Verilen Teknik Nitelikte Olmayan Seçmeli Derslerle İlgili Bir Çalışma,* Yayınlanmamış ODTÜ Eğitim Kurulu Komisyon Raporu.

Tezcan, H. & Gümüş Y. (2008). Üniversite Öğrencilerinin Seçmeli Ders Tercihlerine Etki Eden Faktörlerin Karşılaştırılması, *Gazi Üniversitesi Eğitim Fakültesi Dergisi*, 28(1), 1-17.

Tseng, M. & Lin, Y. (2009). Application of Fuzzy DEMATEL to Develop a Cause and Effect Model of Municipal Solid Waste Management in Metro Manila, *Environmental Monitoring and Assessment,* 158, 519-533.

Von Altrock, C. (1996) *Fuzzy Logic and Neurofuzzy Applications in Business and Finance,* New Jersey: Prentice-Hall.

Wang, M.J.J. & Chang, T.C. (1995). Tool Steel Materials Selection Under Fuzzy Environment, *Fuzzy Sets and Systems,* 72, 263-270.

Woolnough, B. E. (1994). Why Students Choose Physics or Reject it. *Physics Education*, 29(6), 368-374.

Wu, W. & Lee, Y. (2007). Developing Global Managers' Competencies Using the Fuzzy DEMATEL Method, *Expert Systems with Applications,* 32, 499-507.

Yücebaş E., Alkan, G., Atasağun, H. G. & Egeli, H.A.(2013). Ege Bölgesi'nde Bulunan Meslek Yüksekokullarının Durum Analizi; Sorunlar ve Çözüm Önerileri. *Electronic Journal of Colleges.* Aralık 2013 UMYOS Özel Sayı.

Zadeh, L.A. (1965). Fuzzy Sets. *Information and Control*, 8, 338-353.

Zhou, Q., Huang, W. & Zhang, Y. (2011). Identifying Critical Success Factors in Emergency Management Using a Fuzzy DEMATEL Method, *Safety Science*, 49, 243-252.

https://istatistik.yok.gov.tr (Accessing time: 20.01.2017)

www.kalkinma.gov.tr (Accessing time: 15.04.2017)

www.yok.gov.tr (Accessing time: 20.01.2017)