STUDENT SATISFACTION IN ENGINEERING EDUCATION USING WLC AND GIS

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ABSTRACT
Computer and communication technologies have been developing very quickly from past to present. This provides access to information and makes sharing of information easier than ever. Universities are one of the places where information is produced and used extensively. The main activities of universities consist of producing knowledge, transferring knowledge to new generation, making them gain profession, and educating people who research and think. Knowledge transfer to students is possible through lectures given by instructors. Feedback mechanisms on lectures' effectiveness and education quality are used by most educational institutions in our country and around the world.
It is not possible to certainly limit the number of factors affecting education quality. However, a weighted average value can be generated from the combination of selected criteria and evaluator's answers. This value, called the suitability, is calculated for all alternatives, and then the alternative with the highest suitability is determined as the best choice.
The education quality survey questionnaire consists of 41 questions (criteria) regarding the subjects including instructors (teaching staff), teaching and learning services infrastructure, physical conditions, university services and activities, management and student affairs, preparation of the students for professional career life and their satisfaction with career opportunities. Criteria weights are determined by the Analytical Hierarchy Process (AHP) method, which is a multi-criteria decision-making technique. The questionnaire has been applied on 400 students who were studying at Erciyes University Faculty of Engineering, and the answers given to 41 questions were transformed into a single suitability using the Weighted Linear Combination (WLC) method. Finally, a Student Satisfaction Map was created in Geographic Information Systems (GIS) based engineering from the obtained results by using the Inverse Distance Weighting (IDW) interpolation method.
Keywords: *Student Satisfaction, Weighted Linear Combination, Geostatistical Analyst,*

1. INTRODUCTION

Today, there is an intense competition in the global market. It has become increasingly important to train students who can meet the expectations of the business world. If it is desired to have a workforce with certain knowledge and skills, the concept of quality should be addressed and discussed in educational institutions as well. Therefore good quality products and services are only possible with good education (Yıldız and Ardıç, 1999). While competition dominates all markets, the same effect is felt in all service branches. Universities are also one of the areas with intense competition. Service quality in universities is the reason for preference. Higher education institutions can also be considered as a service business. As a service business, they have a responsibility to improve the quality of services for individuals. In addition to this situation, unlike other establishments, higher education institutions have an advantage in terms of quality, because they have a mission of raising human resources that have a significant impact on social life and play a fundamental role in the development of countries. Higher education institutions should not limit their applications, which aim at realizing high quality services, only to the instant satisfaction of an individual who is being served, however, the applications should be addressed with a broader understanding that will ensure continuity and improvement of the satisfaction (Aygün, 2014).

Academic institutions have started to care about customer satisfaction in the new economic environment where science has begun to commercialize and entrepreneurial spirit has begun to dominate (Kelsey and Bond 2001). Different opinions are put forward regarding the place of academic institutions in this age and their adaptation to information and communication technologies. Placing the debate on one side, it is not possible for the society in general and the universities in particular to ignore the needs and satisfaction of the students (Ensari and Onur, 2003)

Improvement in education and training programs is important in terms of bringing a qualified, conscious and confident workforce in society, and thus developing and moving forward the society. In addition to increase in quantity of educational institutions, the quality also needs to increase. Achieving a desired level of education is possible by focusing on the issues such as quality, satisfaction and performance. However, the unilateral design of the offered education and training services and the delivery of these services irrespective of the students' evaluations can lead to problems in achieving the desired degree of goodness. In planning the actions to prevent such problems, students' satisfaction with existing services can be regarded as an important precedent. Student satisfaction is considered to be a short-term attitude as a result of evaluating a student's educational experience. Student satisfaction occurs when his/her needs are meet (Elliot and Healy, 2008). Satisfaction does not just mean meeting the needs. At the same time, expectations must also be met (Zemke, 2000). However, service needs and expectations of students in higher education have a highly complex structure (Oldfield and Baron, 2000; Erdoğan and Bulut, 2015).

Many studies on student satisfaction have been found in the literature in terms of ensuring competitive developments in the education sector. Athiyaman (1997) found a high degree relation of student satisfaction and perceived quality with enrollment in university in his study conducted on student satisfaction and service quality perception in university education. By using Herzberg's two factor theory and comparing the satisfaction of business students, DeShields Jr *et al.* (2005) concluded that students with positive experiences in their colleges had higher satisfaction levels than those with negative experiences. Douglas *et al.* (2006) conducted a study in business and law faculty in the United Kingdom, and found that student satisfaction was related to learning and teaching quality rather than physical possibilities. Clemes *et al.* (2008) measured the overall student satisfaction in higher education according to the hierarchical model used to measure the service quality, and found that the high service quality perceptions of the students increased their satisfaction levels, and positively affected their future behavioral intentions. Elliot and Healy (2008) also examined the factors affecting student satisfaction, and found that factors such as student-centered approach, campus climate, and teaching effectiveness were the most powerful factors affecting the student's overall educational experience (Erdoğan and Bulut, 2015).

There are a variety of studies on this subject in our country. Some of these studies are as follows: a) Students' expectations on quality: The example of education faculties (Hoşcan and Ensari, 2003); Determination of nursing students' satisfaction levels in their education (Ulusoy *et.al.,* 2010); b) Evaluation of teacher candidates' satisfaction levels in higher education and their subjective well-being status: The example of Kafkas University (Osmanoğlu and Kaya, 2013); Determination of expectations and satisfaction levels of the Hacettepe University students in some academic services (Ekinci and Burgaz, 2007); Evaluation of student satisfaction for quality improvement in a department of high education associatıon (Kaya and Engin, 2004).

When the literature on decision making is examined; it is observed that the decision making is defined as the determination of the option or options that can give the most appropriate/optimal outcome as a result of the evaluation of all aspects of the problems that must be solved in any event or situation which is encountered at all levels of management (Toksarı and Toksarı, 2003). In cases where there are more than one variable (criterion) in decision making problems, various scientific methods have been introduced to find solutions to these problems. These solution methods are called multi-criteria decision making methods, and different approaches are used according to the situation that is encountered (Göksu and Güngör, 2008). The number of multi-criteria decision making techniques has been increasing day by day as a result of scientific researches and development of new techniques. Some of these techniques are as follows; AHP, ANP, ELECTRE, TOPSIS, PROMETHEE, SAW, VIKOR, DEMATEL, Gray Relational Analysis and so on (Şengül *et al.,* 2012).

Spatial decision support systems that combine the GIS and spatial decision making methods are also frequently used in the literature. Spatial decision support systems (SDSS) are computer-based systems that facilitate decision making on spatial problems, combining the data storage, synthesis and analysis features of the GIS in the solution of decision models, decision making methods, and optimization algorithms. These systems provide decision makers with the ability to determine the most appropriate option using multiple spatial criteria in the solution space where spatial and attribute information are combined. SDSS, which can be used to select the most suitable sites according to criteria including site selection, housing evaluation, facility location, land use and planning, and route selection, is often preferred in spatial scientific researches (Bostancı, 2016).

The study aims to measure student satisfaction in engineering education through questionnaires, calculate a general satisfaction value for each student by using the WLC method with AHP weights, and obtain a general GIS-based satisfaction map over the province/district where the student lives. The AHP method, WLC method and Geostatistical Analysis will be explained in the method section of the study.

2. METHODS

2.1. AHP Method

The AHP was initiated by Saaty (1980) and is a well-known multi-attribute weighting method for decision support (Brent *et al.* 2007). This process is a flexible multicriteria decision-making methodology that transforms a complex problem into a hierarchy with respect to one or more criteria (Mohajeri and Amin 2010; Bostancı *et al.,* 2015). The AHP is a framework of logic and problem-solving that covers consciousness by organizing perceptions, feelings, judgments and memories into a hierarchy of forces that influence decision results. The AHP is based on the innate human ability to use information and experience to estimate relative magnitudes through paired comparisons. These comparisons are used to construct ratio scales in a variety of dimensions. Arranging these dimensions in a hierarchical or network structure allows a systematic procedure to organize our basic reasoning and intuition by dividing a problem into its smaller constituent parts. The AHP, therefore, leads from simple pair-wise comparison judgments to the priorities in the hierarchy (Saaty, 2006).

A suitable measurement scale for the pair-wise comparisons arises when verbal judgments are expressed by the degree of preference: equally preferred = 1, moderately preferred = 3, strongly preferred = 5, very strongly preferred = 7 and extremely preferred = 9. The numbers 2, 4, 6 and 8 are used for similar alternatives (Brent *et al.,* 2007). AHP methodology is given below stage by stage.

Stage 1: An A pair-wise comparison matrix is created by comparing $C_1, C_2, C_3, \cdots, C_n$ criteria based on their levels of significance in the AHP method.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

For example, if C_1 and C_1 criteria is compared, a_{11}= 1; if C_1 and C_2 criteria is compared a_{12} is calculated and always a_{21} is equal to $\frac{1}{a_{12}}$.

Stage 2: Each component of comparison matrix is subdivided to total of its column and standardized comparison matrix (*B*) is calculated.

Based on the formula of $b_{11} = \frac{a_{11}}{a_{11} + a_{21} + \cdots + a_{n1}}$,

$$B = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ b_{n1} & b_{n2} & \cdots & b_{nn} \end{bmatrix} \text{ matrix is calculated.} \tag{1}$$

Stage 3: Mean of each line in standardized comparison matrix is calculated. These mean values represent relative importance of criteria.

$$w_i = \frac{\sum_{j=1}^{n} b_{ij}}{n} \quad \text{(i= 1,2,…,n)} \tag{2}$$

$$W = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix}$$

Stage 4: Validity of results of the AHP methodology is dependent on consistency of A matrix. Saaty (2006) uses Consistency Rate (CR) to evaluate the consistency. Calculation of the CR is below.

D (column vector) = A.W

$$D = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} . \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} \rightarrow D = \begin{bmatrix} d_1 \\ d_2 \\ \vdots \\ dn \end{bmatrix} \quad (3)$$

Calculation of eigenvector (E) and eigenvalue (λ) are as follows:

$$E = \begin{bmatrix} \frac{d_1}{w_1} \\ \frac{d_2}{w_2} \\ \vdots \\ \frac{d_n}{w_n} \end{bmatrix} \text{ and } \lambda = \frac{\sum_{i=1}^{n} E_i}{n} \quad (4)$$

$$CI\ (Consistency\ Index) = \frac{\lambda - n}{n-1} \quad (5)$$

CR is calculated by dividing CI with Random Index (RI) values given below (Saaty, 2006). For example, RI value used in a comparison having 4 criteria is 0.90.

Random Index values:

n	1	2	3	4	5	6	7	8	9	10	11	12	13
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56

$$CR\ (Consistency\ Rate) = \frac{CI}{RI} \quad (6)$$

If $CR \leq 0.1$, pair-wise comparison matrix is consistent; otherwise, a new matrix is solicited until $CR \leq 0.1$ (Saaty, 2006).

2.2 Weighted Linear Combination

The weighted linear combination, or simple additive weighting, is based on the weighted average concept where the criteria are standardized in a common numerical range. The decision maker directly assigns the relatively important weights to a proper feature map layer. The total score of each alternative is derived from the sum of the significance weight value determined for the criteria and the score value products calculated within the scale for all the criteria. Suitability values are calculated for all alternatives and the alternative with the highest suitability is determined as the best choice. The method can be carried out using any GIS program with spatial analysis capabilities. These programs allow the layers created for each criterion to be combined to determine the composite map by assigning weights. The method can be applied to both raster and vector GIS environments (Drobne and Lisec, 2009). Some GIS systems such as Idrisi (Eastman, 2006) have built-in routines for the WLC method. In order to apply spatial multi-criteria decision making analysis in ArcGIS (ArcGIS, 2008; Boroushaki and Malczewski, 2008), a weight is applied to each criterion, of which the weighted linear combination score value was already determined, and then the sum of the criteria results is combined into a single layer to obtain a suitability map.

$$S = \sum Wi.Xi \quad (7)$$

Where,
S = suitability
Wi = criterion weight

Xi = score value

All of the GIS programs provide basic solution tools for the evaluation of such models (Drobne and Lisec, 2009).

2.3. Geostatistical Analysis

Spatial analysis has become one of the most important branches of statistics that has been increasingly growing in importance in recent years. Tobler (1970) noted that "all spaces are related, but the closest ones are more related to each other." This rule is particularly important when social and physical elements are examined. In the classical statistics, it is assumed that the selected representative points are independent of each other and the sampling average represents the population average in the best way. However, in the analysis of spatial data, the assumptions of classical statistics cannot be obtained when neighboring data are considered to be related to each other (Mardia and Marshal, 1984). In other words, it is natural that the points sampled close to each other are related and similar to each other (Başbozkurt *et al.,* 2013).

Geostatistical Analyst an additional module used in spatial data analysis and statistical interpolation surfaces creation on ArcGIS software. Geostatistical analysis is a cost-effective and logical solution for the analysis of various data sets, which requires large amount of cost and plenty of time to perform. It is a method to predict the variables, which do not have observations, by making an intermediate value determination according to the spatial positioning between the local variables that do not have observations with a certain structure in an observation area and the variables that have observations. The first and most important step of the geostatistical analysis is the semi-variogram analysis which reveals the spatial dependence structure within the observation area (Keskiner, 2008). It is the step that uses mostly computer resources and takes a long time. The intermediate value is used to calculate the values at other points with reference to the raw data received from specific points. There are many different methods of determining intermediate values: inverse distance weighting method, Kriging method, radial-based functions, global and local polynomials (Tural, 2011).

The Inverse Distance Weighting (IDW) method, which aims at calculating intermediate values by using the points with known locations, is an intermediate value detection technique used to determine cell values of the points that cannot be sampled with the help of known sample point values. The cell value is calculated by taking into consideration the various distances from the cell concerned (taking into account) and the increase in distance. The estimated values are a function of distance and magnitude of neighboring points, and the significance and influence of the estimated values on the cell to be estimated decreases with the increase in the distance. It is a deterministic method (Law and Collins, 2013).

Although several types of IDW method are known, one of the well-known is “Shaperd’s Method”. Number of scattered points on the surface is n, function and weight that defines the sample points and “Shaperd’s equation” is as follows in Eq. (8) [Tural, 2011]:

$$f(x, y) = \sum_{i=1}^{n} w_i \cdot f_i \qquad (8)$$

Weights are as follows in Eq. (9):

$$w_i = \frac{h_i^{-p}}{\sum_{j=1}^{n} h_j^{-p}} \qquad (9)$$

p is “power parameter” and generally expresses a positive squared real number, hi describes the three dimensional spatial distance of (10) equation between the sample points and the point to be interpolated (Tural, 2011; Arslanoğlu and Özçelik, 2005):

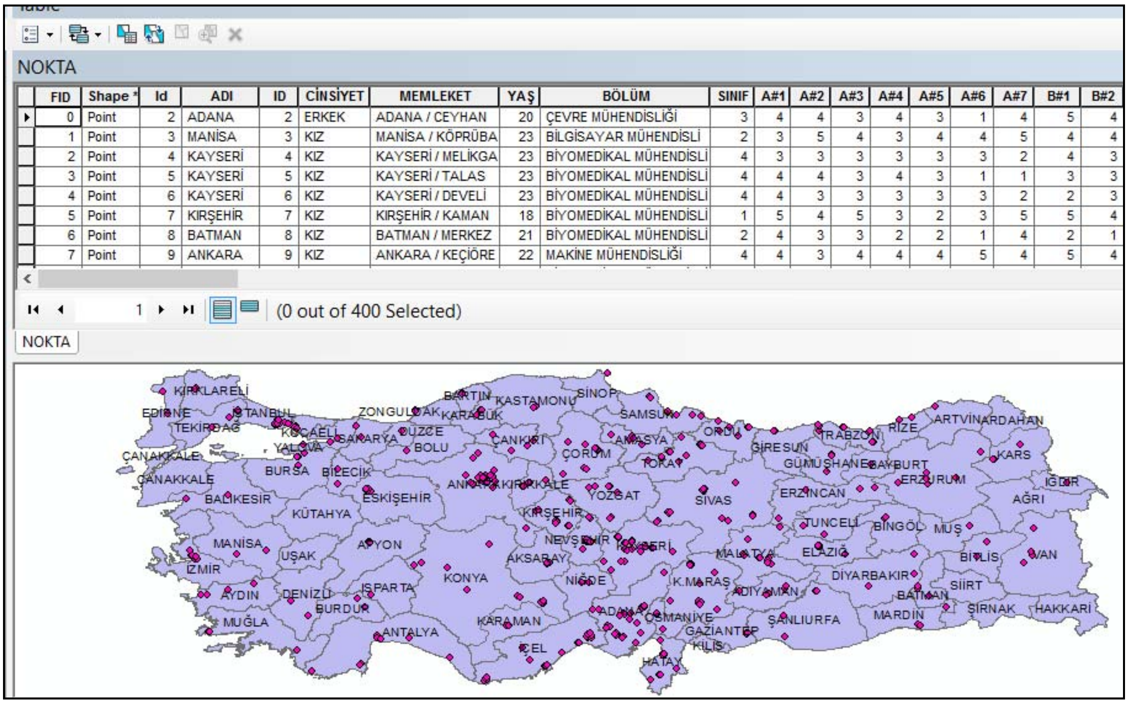
$$h_i = \sqrt{(x - x_i)^2 + (y - y_i)^2 + (z - z_i)^2} \qquad (10)$$

Good results are obtained from the IDW when the sampling is sufficiently dense compared to the local variation that we tried. If sampling of entry points is sparse or irregular, the results may not adequately represent the desired surface (Watson and Philip, 1985).

3. APPLICATION AND FINDINGS

The Student Satisfaction Survey questionnaire has been developed to include 7 main criteria and 41 sub-criteria from literature research and author evaluations from previous studies. The questionnaire has been implemented

on approximately 600 randomly selected students from 12.000 students studying at Erciyes University Faculty of Engineering and 400 of those students whose residence complies with the study were used as samples. The number of samples is 372, according to 95% confidence level, and 5% sample error. The student satisfaction survey questionnaire consists of 41 questions (criteria) regarding student satisfaction in the following fields:
A- Satisfaction with the instructors in the faculty (7 questions),
B- The infrastructure of education and training services in the faculty (6 questions),
C- Physical conditions of the faculty (8 questions),
D- Social-cultural services and activities within the university (7 questions),
E- School management (4 questions),
F- Students related to student affairs (5 questions)
G- Preparation of students for their careers and business life (4 questions)
The answers to the questionnaires were scored with 1 to 5 points on the Likert scale, and a location-based database was created on the ArcGIS software according to the student's residential location (Figure 1).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FID	Shape *	Id	ADI	ID	CİNSİYET	MEMLEKET	YAŞ	BÖLÜM	SINIF	A#1	A#2	A#3	A#4	A#5	A#6	A#7	B#1	B#2
0	Point	2	ADANA	2	ERKEK	ADANA / CEYHAN	20	ÇEVRE MÜHENDİSLİĞİ	3	4	4	3	4	3	1	4	5	4
1	Point	3	MANİSA	3	KIZ	MANİSA / KÖPRÜBA	23	BİLGİSAYAR MÜHENDİSLİ	2	3	5	4	3	4	4	5	4	4
2	Point	4	KAYSERİ	4	KIZ	KAYSERİ / MELİKGA	23	BİYOMEDİKAL MÜHENDİSLİ	4	3	3	3	3	3	3	2	4	3
3	Point	5	KAYSERİ	5	KIZ	KAYSERİ / TALAS	23	BİYOMEDİKAL MÜHENDİSLİ	4	4	4	3	4	3	1	1	3	3
4	Point	6	KAYSERİ	6	KIZ	KAYSERİ / DEVELİ	23	BİYOMEDİKAL MÜHENDİSLİ	4	4	3	3	3	3	3	2	2	3
5	Point	7	KIRŞEHİR	7	KIZ	KIRŞEHİR / KAMAN	18	BİYOMEDİKAL MÜHENDİSLİ	1	5	4	5	3	2	3	5	5	4
6	Point	8	BATMAN	8	KIZ	BATMAN / MERKEZ	21	BİYOMEDİKAL MÜHENDİSLİ	2	4	3	3	2	2	1	4	2	1
7	Point	9	ANKARA	9	KIZ	ANKARA / KEÇİÖRE	22	MAKİNE MÜHENDİSLİĞİ	4	4	3	4	4	4	5	4	5	4

Figure 1. Input of the questions of the questionnaire to the database based on the province/district in which the student lives

The main criterion weights were obtained from the average of the dual comparison importance ratios that the 10 experts working at the Erciyes University has created using the AHP importance scale (Table 1).

Table1. The average main criteria coefficient matrix according to Saaty's AHP importance scale

Criterion	A	B	C	D	E	F	G
A	1.00	4.00	4.00	4.00	5.00	4.00	5.00
B	0.25	1.00	2.00	2.00	3.00	2.00	3.00
C	0.25	0.50	1.00	2.00	4.00	2.00	2.00
D	0.25	0.50	0.50	1.00	3.00	3.00	2.00
E	0.20	0.33	0.25	0.33	1.00	2.00	1.00
F	0.25	0.50	0.50	0.33	0.50	1.00	2.00
G	0.20	0.33	0.50	0.50	1.00	0.50	1.00
Total	2.40	7.17	8.75	10.17	17.50	14.50	16.00

Using Equation 1, the coefficients matrix was normalized and is represented by the C matrix.

C=

0.41667	0.55814	0.45714	0.39344	0.28571	0.27586	0.31250
0.10417	0.13953	0.22857	0.19672	0.17143	0.13793	0.18750
0.10417	0.06977	0.11429	0.19672	0.22857	0.13793	0.12500
0.10417	0.06977	0.05714	0.09836	0.17143	0.20690	0.12500
0.08333	0.04651	0.02857	0.03279	0.05714	0.13793	0.06250
0.10417	0.06977	0.05714	0.03279	0.02857	0.06897	0.12500
0.08333	0.04651	0.05714	0.04918	0.05714	0.03448	0.06250

Using Equation 2, the AHP weights were obtained (Table 2).

Table 2. Weights of the main criteria (W_i)

Main criteria	Wi	Order of importance
A	0.38564	1
B	0.16655	2
C	0.13949	3
D	0.11897	4
E	0.06411	6
F	0.06949	5
G	0.05576	7
Total	1.00000	

CR = 0.06 was calculated with the help of Equation (3-6) and is smaller than the 0.10 value. The matrix created for main criteria binary comparisons is consistent. The sub-criterion weights were obtained by dividing the main criteria weights by the number of sub-criteria.

In order to be able to calculate the suitability as a numerical value, it is necessary to convert the linguistic variables into numerical values. The WLC score values were generated by normalization process according to the Likert Scale values. Table 3 gives a normalization scale for the WLC criterion score values.

Table 3. WLC score values for criteria

Linguistic Variable	Likert scale value	WLC score value
I am very satisfied	5	1.00
I am satisfied	4	0.80
Middle	3	0.60
I am not satisfied	2	0.40
I am not satisfied at all	1	0.20

As shown in Equation 7, the overall satisfaction suitability of each student was found by multiplying each criterion weight with the score value of the criterion. This value will be in the range of 0-1. In the frame of this information, the Si suitability of the student with ID number 2 is calculated as follows:

$S_1= 0.60. (W_A/7) + 0.80. (W_A/7) + 0.60. (W_A/7) +\ldots+ 0.80. (W_B/6) + 0.60. (W_B/6) + 0.20. (W_B/6) +\ldots+ 0.40. (W_C/4)+ 0.20. (W_C/4) + 0.60. (W_C/4) +\ldots+ 0.60. (W_D/7) + 0.40. (W_D/7) + 0.60. (W_D/7) +\ldots+ 0.80. (W_E/8) + 0.80. (W_E/8) + 0.20. (W_E/8) +\ldots+ 0.20. (W_F/5) + 0.80. (W_F/5) + 0.60. (W_F/5) +\ldots+ 0.60. (W_G/4) + 0.60. (W_G/4) + 0.40. (W_G/4) + 0.40. (W_G/4) =0.5892$

The general satisfaction suitability of the other students were obtained in the same way. Figure 2 gives the overall satisfaction suitability of the first 40 students by ID number.

ID	A.1	A.2	A.3	A.4	A.5	A.6	A.7	B.1	B.2	B.3	B.4	B.5	B.6	C.1	C.2	C.3	C.4	D.1	D.2	D.3	D.4	D.5	D.6	D.7	E.1	E.2	E.3	E.4	E.5	E.6	E.7	E.8	F.1	F.2	F.3	F.4	F.5	G.1	G.2	G.3	G.4	Si
2	0.6	0.8	0.6	0.6	0.6	0.8	0.8	0.8	0.6	0.2	0.8	0.4	0.6	0.4	0.2	0.6	0.2	0.6	0.4	0.6	0.2	0.8	0.8	0.8	0.8	0.8	0.2	0.4	0.8	0.8	0.6	0.4	0.2	0.8	0.6	0.4	0.6	0.6	0.6	0.4	0.6	0.5892
3	0.8	0.8	0.6	0.8	0.6	0.2	0.8	1	0.8	0.6	0.6	0.8	0.8	1	0.8	1	0.6	1	0.8	0.8	0.6	0.6	1	1	1	1	0.8	1	1	0.8	1	1	1	1	0.8	1	1	0.6	0.6	0.6	0.2	0.7438
4	0.6	1	0.8	0.6	0.8	0.8	1	0.8	0.8	0.8	0.8	0.8	0.8	1	0.8	0.8	0.8	0.2	0.6	0.6	0.2	0.6	0.2	0.6	0.8	0.8	0.8	0.6	0.8	0.8	0.6	0.6	0.4	0.4	0.4	0.4	0.2	0.6	0.6	0.8	0.6	0.6957
5	0.6	0.6	0.6	0.6	0.6	0.6	0.4	0.8	0.6	0.4	0.4	0.2	0.2	0.4	0.4	0.4	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.8	0.6	0.4	0.6	0.4	0.8	0.6	0.6	0.4	0.8	0.6	0.6	0.6	0.6	0.2	0.2	0.2	0.2	0.5011
6	0.8	0.8	0.6	0.8	0.6	0.2	0.2	0.6	0.6	0.2	0.2	0.6	0.4	0.6	0.6	0.6	0.8	0.2	0.2	0.4	0.4	0.6	0.4	0.8	0.8	0.2	0.2	0.2	0.8	0.6	0.2	0.2	0.8	0.6	0.6	0.6	0.2	0.2	0.2	0.2	0.2	0.4771
7	0.8	0.6	0.6	0.6	0.6	0.6	0.4	0.4	0.6	0.2	0.2	0.6	0.4	0.8	0.6	0.4	0.4	0.6	0.4	0.4	0.6	0.6	0.4	0.8	0.8	0.2	0.4	0.4	0.8	0.6	0.4	0.2	0.6	0.6	0.6	0.6	0.4	0.2	0.2	0.2	0.4	0.5030
8	1	0.8	1	0.6	0.4	0.6	1	1	0.8	0.8	0.4	0.2	0.6	0.6	1	0.8	1	0.6	0.6	0.6	0.6	0.6	0.2	0.6	0.8	0.2	0.4	0.4	0.8	0.8	0.6	0.4	1	1	0.8	0.4	0.8	0.6	0.6	0.6	0.8	0.6767
9	0.8	0.6	0.6	0.4	0.4	0.2	0.8	0.4	0.2	0.2	0.2	0.4	0.2	0.6	0.8	0.6	0.6	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.6	0.4	0.2	0.8	0.8	0.2	0.2	0.2	0.2	0.6	0.2	0.8	0.2	0.2	0.2	0.8	0.4	0.4487
10	0.8	0.6	0.8	0.8	0.8	1	0.8	1	0.8	0.8	0.8	0.8	0.6	0.8	0.6	0.6	0.6	0.2	0.8	0.2	0.2	0.8	0.8	0.6	0.8	0.6	0.8	0.8	0.6	0.8	0.6	0.2	0.8	0.8	0.6	0.8	0.6	0.8	0.4	0.8	0.6	0.7076
11	0.8	0.8	0.8	0.6	0.6	0.4	0.6	0.6	0.8	0.4	0.6	0.6	0.6	0.6	0.8	0.6	0.6	0.4	0.4	0.6	0.4	0.6	0.8	0.8	0.8	0.8	0.4	0.2	0.8	0.8	0.6	0.6	0.8	0.8	0.8	0.8	0.8	0.4	0.6	0.6	0.6	0.6225
12	0.6	0.4	0.6	0.6	0.6	0.6	0.4	0.2	0.2	0.2	0.6	0.8	0.6	0.2	0.2	0.2	0.6	0.2	0.2	0.6	0.2	0.8	0.2	0.6	0.6	0.6	0.6	0.6	0.2	0.2	0.2	0.2	0.4	0.6	0.6	0.6	0.4	0.6	0.6	0.8	0.6	0.4660
13	0.8	0.8	0.8	0.8	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.6	0.8	0.6	0.8	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.8	0.6	0.8	0.8	0.6	0.8	0.8	0.8	0.8	0.7526
14	0.4	0.2	0.4	0.2	0.2	0.6	0.4	0.8	0.4	0.4	0.8	0.2	0.2	0.2	0.4	0.6	0.8	0.2	0.2	0.2	0.2	0.2	0.8	0.8	0.6	0.8	0.8	0.8	0.4	0.6	0.2	0.2	0.4	0.4	0.4	0.6	0.4	0.8	0.8	0.8	0.8	0.4276
15	0.8	0.8	0.6	0.6	0.8	0.4	0.2	0.6	0.8	0.8	0.6	0.8	0.6	0.6	0.8	0.8	1	0.4	0.4	0.4	0.2	0.6	0.6	0.2	0.8	0.6	0.4	0.4	0.8	0.8	0.2	0.4	0.6	0.8	0.8	0.8	0.8	0.6	0.4	0.4	0.4	0.5875
16	0.6	0.8	0.8	0.4	0.8	0.2	0.6	0.8	0.8	0.2	0.2	0.8	0.4	0.8	0.8	0.8	0.6	0.4	0.4	0.8	0.4	0.6	0.8	0.8	0.8	0.4	0.4	0.4	0.8	0.8	0.2	0.2	0.8	0.8	0.8	0.8	0.6	0.4	0.6	0.4	0.4	0.5734
17	0.8	0.8	0.6	0.8	0.8	0.6	0.8	0.8	0.8	0.4	0.4	0.8	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.2	0.8	0.8	0.4	0.2	0.4	0.4	0.2	0.8	0.2	0.2	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.8	0.6	0.6647
18	0.8	0.8	0.8	0.6	0.6	0.6	0.6	0.8	0.6	0.2	0.2	0.6	0.6	0.8	0.6	0.8	0.6	0.4	0.6	0.6	0.4	0.6	0.8	0.8	0.8	0.8	0.6	0.6	0.6	0.6	0.4	0.4	0.8	0.8	0.8	0.8	0.6	0.4	0.4	0.6	0.4	0.6116
19	0.8	0.8	0.8	0.4	0.6	0.4	0.8	0.8	0.8	0.2	0.2	0.8	0.6	0.8	0.8	0.8	0.6	0.4	0.8	0.6	0.6	0.8	0.8	1	0.8	0.8	0.4	0.2	0.4	0.6	0.6	0.4	0.8	0.8	0.8	0.8	0.6	0.6	0.8	0.8	0.6	0.6320
20	1	0.8	0.8	0.8	0.6	0.6	0.8	0.8	0.8	0.6	0.8	1	0.6	0.8	1	0.8	0.8	0.6	0.6	0.6	0.6	0.6	1	1	0.8	0.4	0.6	0.8	0.8	0.8	0.6	0.4	0.8	0.8	0.8	0.8	0.6	0.6	0.8	0.4	0.6	0.7276
21	0.8	0.8	0.8	0.6	0.8	0.4	0.6	0.8	0.8	0.6	0.8	0.8	0.4	0.6	0.6	0.8	0.6	0.4	0.4	0.4	0.4	0.6	0.8	0.8	0.6	0.4	0.4	0.4	0.4	0.8	0.4	0.4	0.8	0.8	0.6	0.8	0.8	0.6	0.6	0.8	0.6	0.6321
22	0.8	0.8	0.8	0.8	0.8	0.4	0.6	0.4	0.8	0.6	0.4	0.2	0.8	0.6	0.8	0.6	0.6	0.4	0.8	0.8	0.6	0.6	0.8	0.8	0.4	0.8	0.4	0.8	0.8	0.8	0.6	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.6	0.6457
23	0.4	0.6	0.4	0.6	0.4	0.6	0.6	0.8	0.8	0.4	0.4	0.4	0.4	0.6	0.6	0.4	0.4	0.2	0.6	0.4	0.6	0.8	0.8	0.8	0.8	0.8	0.6	0.8	0.6	0.8	0.4	0.2	0.8	0.8	0.6	0.8	0.6	0.4	0.4	0.4	0.4	0.5362
24	0.8	0.8	0.8	0.6	0.8	0.4	0.8	0.8	0.6	0.6	0.4	0.8	0.4	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1	0.6	0.4	0.4	0.6	0.8	0.8	0.8	0.4	0.6	0.6	0.6	0.6	0.4	0.8	0.6	0.6	0.6	0.6736
25	0.8	0.6	0.4	0.6	0.4	0.4	0.8	1	0.6	0.2	0.4	1	0.8	0.6	0.2	0.4	0.8	0.4	0.2	0.4	0.2	0.6	0.8	0.8	1	0.8	0.4	0.6	0.6	0.6	0.8	0.4	0.8	0.8	0.6	0.8	0.6	0.2	0.6	0.4	0.4	0.5668
26	0.8	0.6	0.4	0.8	0.6	0.4	0.4	0.4	0.6	0.2	0.8	1	1	0.6	0.8	0.4	0.8	0.4	0.8	1	0.2	0.8	0.2	0.2	0.8	1	0.6	0.6	0.8	0.8	0.6	0.6	0.8	0.8	0.6	0.8	0.8	0.2	0.6	0.2	0.6	0.5965
27	0.8	0.4	0.6	0.2	0.4	0.8	0.6	0.8	0.8	0.6	0.4	0.8	0.2	0.2	0.2	0.4	0.8	0.6	0.6	0.4	0.6	0.8	1	0.8	0.8	0.8	0.6	0.8	0.6	0.8	0.6	0.2	0.8	0.8	0.6	0.6	0.6	0.4	0.6	0.6	0.6	0.5711
28	0.8	0.8	0.8	0.6	0.8	0.4	0.4	0.6	0.8	0.4	0.6	0.8	0.4	0.8	0.6	0.6	0.6	0.2	0.4	0.6	0.2	0.4	0.8	0.8	0.8	0.4	0.4	0.2	0.8	0.8	0.4	0.2	0.6	0.8	0.6	0.6	0.6	0.2	0.2	0.6	0.2	0.5698
29	0.8	0.4	0.6	0.4	0.6	0.4	0.4	0.8	0.8	0.4	0.4	0.4	0.4	0.4	0.8	0.6	0.6	0.6	0.4	0.4	0.4	0.6	0.4	0.2	0.8	0.4	0.8	0.2	0.4	0.8	0.2	0.2	0.8	0.8	0.4	0.6	0.6	0.6	0.2	0.4	0.4	0.4957
30	0.8	1	0.8	0.6	0.8	0.8	1	0.8	0.8	0.4	0.4	0.8	0.8	0.8	0.8	1	1	0.6	0.6	0.8	0.8	0.8	0.8	0.4	0.8	0.8	0.6	0.4	0.4	0.8	0.4	0.2	0.4	0.4	0.6	0.6	0.2	0.8	1	1	0.4	0.7078
31	0.8	0.8	0.8	0.6	0.6	0.6	0.8	0.8	0.6	0.4	0.6	0.6	0.6	0.8	0.6	0.8	0.8	0.6	0.6	0.6	0.6	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1	0.8	0.6	0.8	0.8	0.8	0.8	0.8	0.6	0.6	0.4	0.4	0.6828
32	0.8	0.6	0.8	0.8	0.8	0.6	0.6	0.8	0.8	0.6	0.4	0.8	0.6	0.8	0.8	0.8	0.6	0.4	0.8	0.4	0.6	0.6	0.8	0.8	0.8	0.8	0.6	0.6	0.8	0.8	0.6	0.4	0.2	0.2	0.2	0.2	0.2	0.6	0.6	0.6	0.6	0.6369
33	0.6	0.6	0.8	0.6	0.4	0.4	0.6	0.8	0.6	0.8	0.6	0.6	0.4	0.6	0.8	0.6	0.4	0.2	0.6	0.4	0.4	0.6	0.8	0.6	0.8	0.6	0.6	0.8	0.8	0.8	0.6	0.6	0.2	0.2	0.2	0.2	0.2	0.6	0.6	0.6	0.6	0.5565
34	0.8	0.8	0.8	1	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.8	0.8	0.6	0.8	0.8	0.6	0.8	0.8	0.8	0.8	0.2	0.8	0.8	0.6	0.8	0.4	0.4	0.6	0.8	0.8	0.8	0.6	0.8	0.8	0.8	0.6	0.7508
35	0.8	0.8	0.8	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.8	0.8	0.6	0.8	0.8	0.6	0.8	0.8	0.8	0.8	0.2	0.8	0.8	0.6	0.8	0.4	0.4	0.6	0.8	0.8	0.8	0.6	0.8	0.8	0.8	0.6	0.8	0.7387
36	0.8	0.8	1	1	1	1	0.8	1	1	0.6	1	0.8	0.8	0.8	0.8	0.8	0.6	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.4	0.6	0.6	0.6	0.4	0.4	0.4	0.4	0.6	0.2	0.8	0.8	0.8	0.8	0.7789
37	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.8	0.8	0.8	0.8	1	0.6	0.8	0.8	0.6	0.6	0.6	0.8	1	1	0.8	0.8	0.6	0.6	0.8	0.2	0.6	0.4	0.2	1	0.8	0.6	0.8	0.8	0.8	0.6	0.6	0.6	0.7304
38	0.4	0.4	0.8	1	0.8	0.8	0.8	1	0.8	0.8	0.4	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.8	0.2	0.8	0.8	0.8	0.8	1	0.8	0.8	0.8	0.8	0.8	0.6	0.6	0.8	0.8	0.8	0.8	0.2	0.8	0.6	0.6	0.8	0.7130
39	1	0.8	0.8	0.8	0.8	0.8	0.8	1	0.8	0.2	0.2	0.4	0.6	0.4	0.8	0.6	0.8	0.6	0.6	0.8	0.6	0.8	0.8	0.2	0.8	0.8	0.8	0.4	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.2	0.6	0.6	0.6	0.6989
40	0.8	0.6	1	0.6	0.6	0.4	0.8	0.8	0.6	0.4	0.4	0.8	0.4	0.8	0.6	0.8	0.8	0.4	0.8	0.6	0.4	0.4	0.4	0.6	0.2	0.2	0.4	0.6	0.8	0.8	0.2	0.8	0.4	1	0.8	0.8	0.8	0.4	0.2	0.2	0.2	0.6011
41	0.8	0.6	0.6	0.4	0.8	0.4	0.6	0.4	0.4	0.2	0.4	0.8	0.8	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.8	0.8	0.8	0.4	0.4	0.8	0.8	0.8	0.8	0.4	0.2	0.8	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.2	0.5603

Figure 2. The Si suitability scores of the first 40 students

The general satisfaction suitability are processed in ArcGIS database, and a suitability map is obtained for the students in Erciyes University Faculty of Engineering in Turkey by using IDW interpolation method of which mathematical background in Geostatistical Analysis module was given in Equation 8-10. The suitability close to 1 and 0 were considered as high and low satisfaction, respectively. The suitability were divided into 5 intervals in the map. According to this situation, it is assumed that the brown and red regions are satisfied, the light blue and blue color regions are dissatisfied and the yellow color regions are undecided (Figure 3).

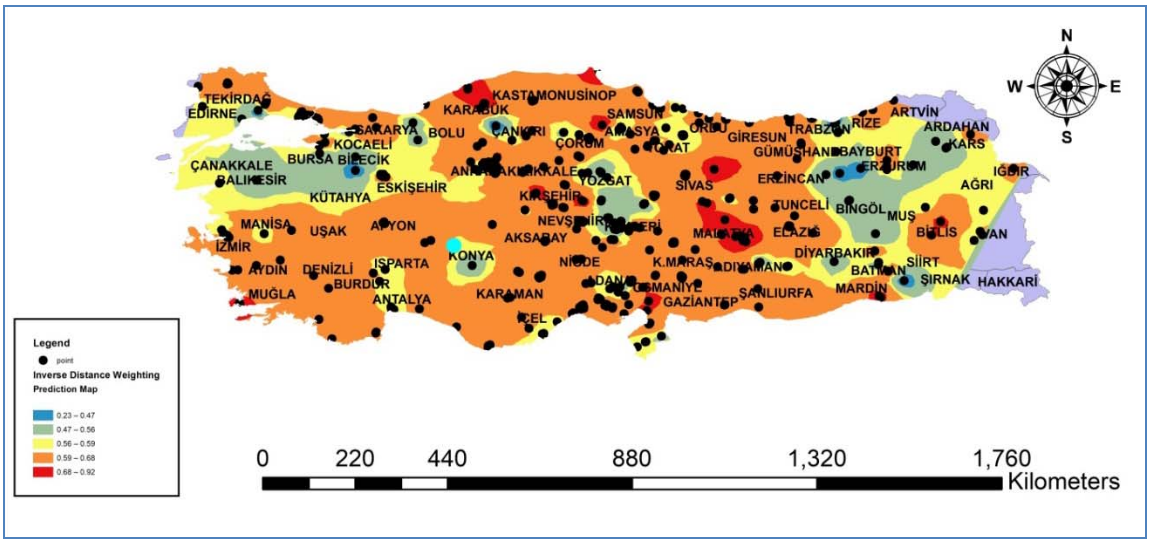

Figure 3. Student satisfaction map

4. CONCLUSIONS

The AHP and Weighted Linear Combination have been successfully applied in the GIS-based research on the Student Satisfaction in Engineering Education. The answers to 41 questions in the questionnaire was converted into a general satisfaction suitability using the AHP weighted WLC method. A general satisfaction map has been created with the suitability according to the province and district centers where the students live. It was observed that sampling could not be selected from every province center on the map. This situation was solved by calculating the general satisfaction suitability using the values in neighboring provinces. The reliability of the results in terms of the provincial center without sampling is still a matter of debate.

According to the map obtained by IDW Geostatistical Analysis method:
The engineering students in Marmara Region and Eastern Anatolia Region are generally not satisfied with the engineering education they have received. No administrative region is very satisfied with the engineering education. Also, the participants are classified as follows;

10% undecided group (neither satisfied nor dissatisfied)
15% unsatisfied group,
70% satisfied group
5% very satisfied group.

There are not too many regional differences in the student satisfaction map. Those students study in the regions where the provinces of Çanakkale, Bursa, Bilecik, Yozgat, Konya, Kayseri, Muş, Bingöl, Erzincan and Erzurum are located have general dissatisfaction in their engineering education.

Student satisfaction can be also determined with the WLC method using the criterion weights to be calculated from different decision making methods (Entropy, Dematel, and Analytic Network Process). GIS-based raster maps can be created using the suitability to be obtained from the WLC and intermediate value determination methods. In visual studies, it is necessary to increase the number of samples for more accurate and healthy mapping of the results.

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