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Research Article

An integrated approach to identify engineering student requirements

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ABSTRACT

Rapid increase in the number of universities in Turkey resulted in competition among higher education institutes to recruit the best students. Student requirements are important information for universities because if universities have a better understanding of students' requirements, they would be in a better position to recruit them and manage the educational service quality. The purpose of this study is to determine the most important requirements of engineering students in a Turkish university. The proposed methodology integrates Service Quality (SERVQUAL), Analytic Hierarchy Process (AHP) and Quality Function Deployment (QFD) methods. Results show that (1) engineering students value contemporary education system more than traditional education system (2) they are demanding partnership from their instructors based on trust, respect and guidance (3) curriculum should be designed with courses that are industry oriented, interactive and case study based with practical information provided to participate in real-life engineering projects. In addition, institutions should recognize the importance of investing in academic faculty when they are trying to improve the quality of their programs and recruit the best students.

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INTRODUCTION

Higher education in Turkey has been expanding at a rapid pace in the last two decades. According to the Higher Education Council of Turkey (Yüksek Öğrenim Kurumu, or YÖK in short), in 2005 there were 53 state and 24 private universities in Turkey; currently there are 130 state and 73 private universities. Th s rapid expansion provided students with wider selection of universities, which resulted in increased competition among the universities to recruit the best students.

In order to receive successful candidates, universities must understand student expectations, because if they have a better understanding of students' expectations, they would manage them better and provide higher quality service. Although this paper is concerned with one particular

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stakeholder in higher education, students, every stakeholder in higher education (e.g., students, professors, teaching and research assistants, and potential employers) have particular expectations depending on their specific needs. Identifying the stakeholders' expectations in higher education is therefore important.

However, even with this increased importance of understanding student expectations and providing education accordingly, there has been limited amount of research conducted to extend service management concepts to educational settings. In this research, an integrated methodology utilizing Service Quality Assessment (SERVQUAL), Analytic Hierarchy Process (AHP) and Quality Function Deployment (QFD) methods is used to quantitatively prioritize student requirements from Industrial and Systems Engineering department at a Turkish University, and to determine the relationship weightings between these student requirements and technical service elements. Thus, the research questions that are investigated in this study are as follows:

1. What are the most important requirements of Industrial and Systems Engineering students at a Turkish University?
2. What technical service elements (educational items) are needed to satisfy these requirements?

LITERATURE REVIEW

Application of SERVQUAL in higher education

There are several studies that applied the SERVQUAL method in university settings. It is examined that the suitability of the SERVQUAL scales to measure student perceptions of university-level service quality [1].Cuthbert's (1996) study has been replicated by other researchers [2]. They used SERVQUAL to measure student perceptions through exploratory factor analysis. Another research investigated the applicability of SERVQUAL to measure student perceptions of service quality in a university in India [3]. A longitudinal study was performed and used SERVQUAL to investigate the influence of time on student's perceptions of service quality [4]. SERVQUAL also utilized to investigate the gap between students' and staff's opinions on perceived and expected quality [5]. All of these researchers suggest SERVQUAL to be a suitable instrument to be used in educational settings. To modify SERVQUAL dimension, the researchers did an extensive review of literature on SERVQUAL dimensions and used their review results to prepare a survey using SERVQUAL dimensions adjusted to educational context to capture engineering student requirements [6]. Their results were verifi d to be suitable for educational settings in Turkey. Thus, in this research we will use their results as student requirements. Although previous study revealed results on investigation of perceptions of service quality among engineering students, it did not separate the responses based on importance. Th s research is going to establish that separation. In recent years, a group of researchers applied a questionnaire to measure the educational service quality, and they used SERVQUAL dimensions for these analyses [7].

Application of AHP in higher education

There are numerous studies that need to be noted for their application of AHP in higher education settings. A multi objective nonlinear programming model was formulated for course assignment [8]. They used AHP to capture the importance weightings of the objectives and the preferences of instructors and administrators. The purpose of another study was to understand and classify the learning contents of higher education, and discuss the key success factors in the curriculum design [9]. Their results show that the key factors in the curriculum design are (1) Course objective, (2) Learner characteristics, (3) Material production (4) Word choice, and (5) Learning results. AHP was used to study the resource allocation problem in a university to determine the relative importance of the proposed projects with respect to teaching, quality, and consultancy [10]. Based on the results they allocated resources to these projects accordingly. In another study, AHP used to redesign the undergraduate curriculum of a higher education institute by using [11]. They used the method to rank the claims of the stakeholders. In this study, the student requirements captured by the SERVQUAL survey are ranked using AHP method to determine the most important ones.

Application of QFD in higher education

The quality of the study program depends on how well it meets the requirements of internal and external stakeholders [12]. The study indicated that a university study program has to have high value, flex bility and quality in order to fulfill the education service market requirements [12]. Thus, in this paper they proposed a well-established design process, which is based on the use of QFD method to curricular design in higher education to increase the success rate of the study program and its effici cy. Another study assessed and evaluated how higher education institutions using Quality Function Deployment draw out the relevancy and how the model shaped the concept of 'Quality' in their program [13]. Th s paper shows the need for research on closing the gap between hypothesized, planned, and offered Quality to expected Quality. An analytical model for enhancing the service quality of e-learning using a hybrid approach from the perspective of customers intended to develop [14]. They used QFD to analyze the interrelationships between the voice of customer and the voice of the engineer and to create an order of priority for the technical requirements for service quality. To design the curriculum in management information systems, again, the QFD method was proposed [15]. In this research, they linked student abilities to knowledge requirements and to course activities to fi alize the proposed curriculum. The QFD framework was developed as an assessment tool to evaluate the degree of achievement for course learning objectives [16]. On the other hand, application of integrated QFD with AHP and/or QFD with SERVQUAL in the literature is relatively few: an integrated AHP-QFD approach was used to plan an industrial design curriculum that meets practical workplace needs [9]. They identifi d the competencies required for an industrial design. The Fuzzy-AHP and the linear programming method were embedded into QFD in order to capture and prioritize students' requirements regarding courses' learning outcomes for an academic course design [17]. Sahney (2011) integrated SERVQUAL and QFD methodologies to identify student requirements, develop educational services by incorporating these requirements, and fi ally measure performance and evaluate service quality through these requirements. Milojević and Radosavljević (2019) proposed to combine AHP and SERVQUAL methods to measure assessment of higher education service quality. Their study focused on the students that are classifi d as major stakeholder in higher education, and they found a gap between the expected service quality and perceived.

To measure customer satisfaction in an educational institution, the researcher proposed to integrate

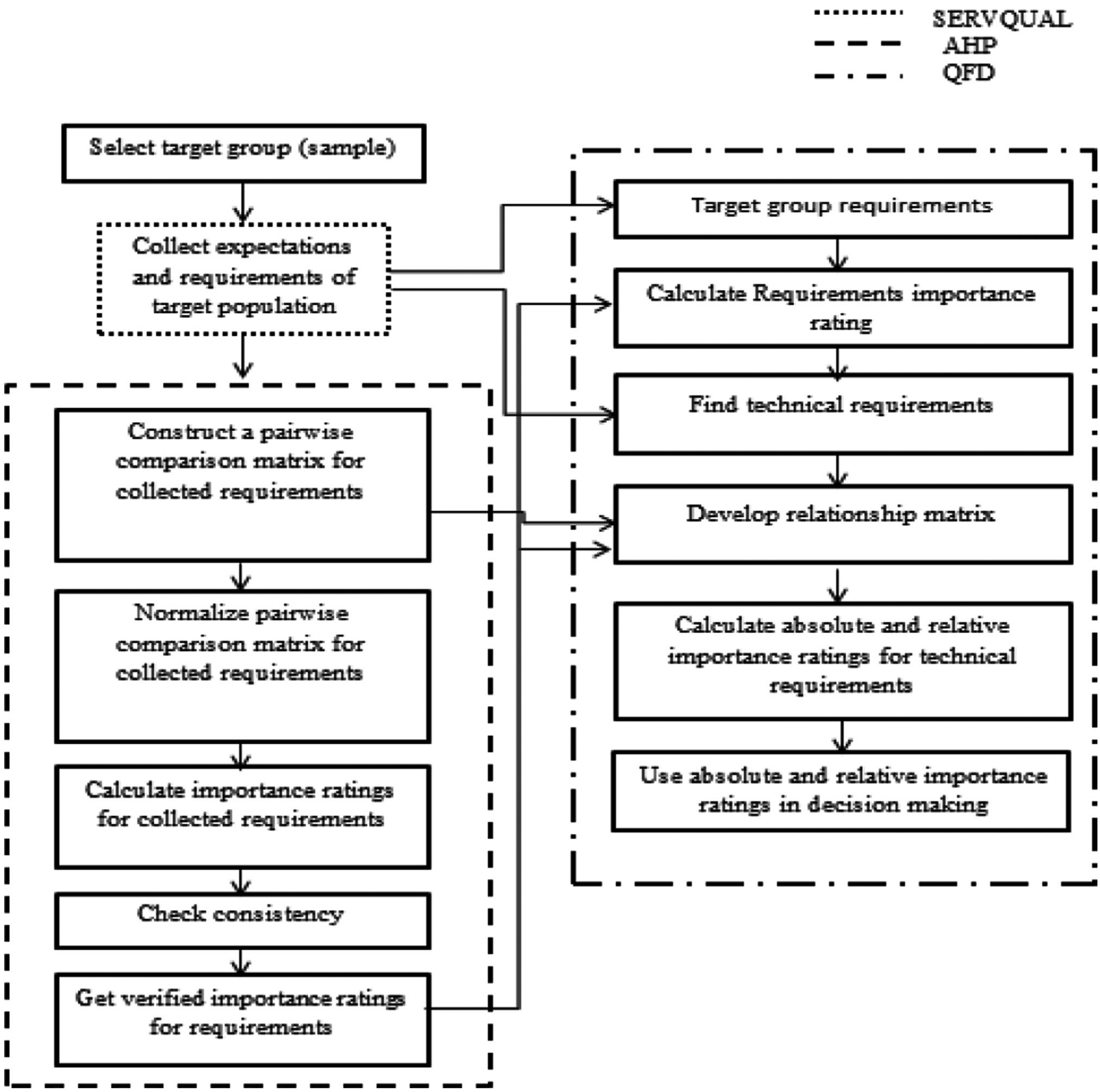

Figure 1. Proposed Framework to combine QFD-AHP-SERVQUAL.

SERVQUAL, KANO, and QFD methods [20]. Both Kano and QFD methods were utilized to the requirements and SERVQUAL used for quality measurements. The results of literature review show that although there is some research conducted on application of AHP-QFD and/or QFD-SERVQUAL, integrating SERVQUAL-AHP-QFD is relatively new. An article suggested that integrating these three methods to measure the quality of services in higher education [21]. However, their model was applied to evaluate Direction and Coordination, Secretariat and Library services of a university, not the educational service quality. Thus, this research is going to have an important contribution to the higher education literature in terms of combining these three methods, SERVQUAL, AHP and QFD to determine and quantitatively prioritize student requirements and to identify educational service elements that need to be focused on in order to satisfy these student requirements.

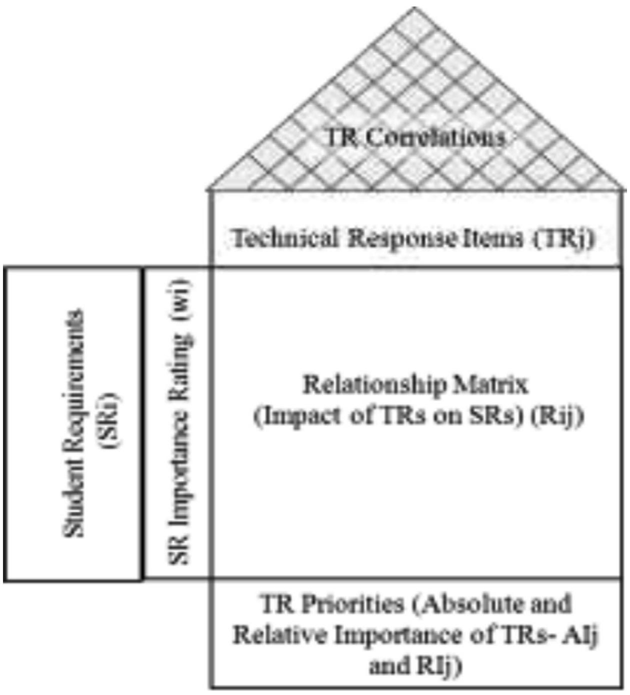

Figure 2. House of Quality (HOQ) Framework.

PROPOSED METHODOLOGY

The proposed methodology, integrating SERVQUAL, AHP and QFD, to determine the most important student requirements and the relationship weightings between these student requirements and technical service elements contains the steps shown in Figure 1:

Application of Proposed Methodology

Step 1. Identify students to be used in the analysis. Students of the Industrial and Systems engineering department were used in this research.

Step 2. Conduct QFD analysis by constructing HOQ - Figure 2. (step 3 - Step 9)

Step 3. Identify student requirements (SR_i): The expectations and requirements of students are based on the SERVQUAL statements that emerged from the research conducted by [6]. A total of 20 statements were taken as student requirements from their research.

Step 4: Quantitatively prioritize student requirements and calculate student requirement importance rating using AHP method (w_i).

Step 4.1: Construct a pairwise comparison matrix for each student requirements in HOQ, using the 9-point rating scale [23], shown in Table 1.

Step 4.2: Generate a normalized pairwise comparison matrix,

Step 4.3: Compute column vector C that represents student requirement (SR) importance rating (w_i)

As previously stated that the student requirements are directly taken from the study which is conducted by [6]. Table 2 shows and summarizes these requirements and their importance ratings.

SR 1, 5-7 correspond to the questions related to SERVQUAL dimension Assurance, which is the knowledge and courtesy of faculty and university and their ability to inspire trust and confide ce.

SR 2-4, 11, 17-20 correspond to the questions related to SERVQUAL dimension Tangibles, which is the condition of

Table 1. The Saaty Rating Scale

Degree of importance	Definition	Explanation
1	Equal importance (imp.)	Two factors contribute equally to the objective.
3	Somewhat more imp.	Experience and judgment slightly favor one over the other.
5	Much more important	Experience and judgment strongly favor one over the other
7	Very much more imp.	Experience and judgment very strongly favor one over the other.
9	Absolutely more imp.	The evidence favoring one over the other is of the highest possible validity.
2,4,6,8	Intermediate values	When compromise is needed. For inverse comparison

physical facilities, equipment, courses content and appearance of personnel.

SR 8-10, 12, 15 correspond to the questions related to SERVQUAL dimension Responsiveness, which is willingness to help students and provide prompt service.

SR 14 and 16 correspond to the questions related to SERVQUAL dimension Empathy, which is caring, and individualized attention the university provides its students.

SR 13 corresponds to the questions related to SERVQUAL dimension Reliability, which is the ability to perform the promised service dependably and accurately.

Step 4.4: Perform Consistency Verifi ation: Compute consistency ratio (CR). If CR is greater than 0.10, then step 4.1, otherwise, step 5 will be performed. For computation of CR, consistency index (CI) and random consistency index (RI) are utilized [24];

$$CI = (\lambda_{max} - n)/(n-1), n \text{ is the matrix size} \tag{1}$$

$$CR = CI/RI \tag{2}$$

CR = 0.02, CR <0.1 Thus, consistency verifi d.

Step 5: Include the student requirements - SR (step 3) and their importance ratings-w_i (step 4) into HOQ (Table 2).

Step 6. Identify technical responses: After identifying the student requirements, the study focused on technical responses. The technical responses – TR (educational service elements) used in this study are based on the research conducted by [22]. They were determined by conducting focus group interviews with engineering students. The main purpose of educational service elements is to translate the requirements from the students' language into the technical language.

The technical responses (educational service elements) used in this study are:

1. Seminars, conferences, training
2. Recruitment criteria
3. Competency in teaching
4. Preparation for lectures
5. Consultation procedure

Table 2. Student Requirements and their Importance Ratings

Sl. No.	Student Requirements	Importance Rating	Rank
1.	National and international academic reputation of the university/department. (Reliability)	0.045	10
2.	Structure and content of courses should respond to industry demand. (Reliability)	0.091	4
3.	Content of the courses should provide more than one discipline issue. (Reliability)	0.039	11
4.	Content of the courses should acquire the ability to solve and defi e actual engineering problems. (Reliability)	0.025	14
5.	Faculty members should evaluate the performance of students carefully and equally. (Assurance)	0.083	5
6.	Faculty members should maintain high level of communication and interest throughout the course. (Assurance)	0.062	7
7.	Faculty members should teach the subject based on both theoretical and practical aspects. (Assurance)	0.100	3
8.	Course and exam dates should be scheduled according to the needs of students. (Assurance)	0.013	18
9.	Curriculum should include project-intensive courses. (Tangibles)	0.026	13
10.	Curriculum should be built around selection of various technical elective courses. (Tangibles)	0.006	20
11.	11.Appropriate connection among the courses in the curriculum. (Reliability)	0.014	17
12.	Easy and effective communication should be available between students and faculty members. (Responsiveness)	0.107	2
13.	Students should feel attached to the department. (Empathy)	0.011	19
14.	Relationship between student and faculty member should be based on respect and trust. (Assurance)	0.119	1
15.	University should provide an effective psychological guidance service. (Tangibles)	0.029	12
16.	Faculty members should answer student questions according to their knowledge and perception level with patience.(Responsiveness)	0.060	8
17.	Courses should be interactive and student participation to the courses should be encouraged.	0.075	6
18.	Courses should acquire the ability to make presentations.	0.019	16
19.	Course content should encourage flex ble and free thinking.	0.051	9
20.	Course content should support life-long learning.	0.023	15

6. Student organizations
7. Up-to-date materials
8. Theoretical course content
9. Industry oriented course content
10. Class discussions
11. Problem solving sessions
12. Group projects
13. Case studies
14. Guest lecturer from industries
15. Technical fi ld trips
16. Industrial projects
17. Computer labs
18. Electronics equipment
19. Elective courses with no prerequisites
20. Meetings between dean and student representatives

Step 7. Determine relationship weightings between technical responses j and corresponding student requirements i, R_{ij}, using AHP method (steps 4.1 and 4.4).

Step 8. Include technical response items and their importance ratings R_{ij} – (step 7) into HOQ as Relationship Matrix.

Step 9. Calculate absolute and relative importance ratings: The fi al part of the study is to fi d the technical responses that need to be improved which have the highest contribution to the student requirements. Absolute importance rating of TRs;

$$AI_j = \sum_{i=1}^{m} w_i R_{ij} \tag{3}$$

where

AI_j absolute (technical) importance rating of TR_j,

w_i relative degree of importance of the SR to the student SR_i,

R_{ij} relationship rating representing the strength of the relationship between SR_i and TR_j.

$$RI_j = \frac{AI_j}{\sum_{j=1}^{n} AI_j} \tag{4}$$

Step 10. Include absolute and relative importance ratings (AI_j and R_{ij}) as TR priorities into HOQ (Table 3).

ANALYSIS AND DISCUSSION

Sample statistics

All Industrial and Systems engineering students (215) were asked to conduct the study for pairwise comparison of student requirements. 185 were responded (response rate 86%). The demographic features of the participants are displayed in Table 4. The demographics show that there is a good representation of students for each class, gender and status type.

Table 3. Weights of Educational Service Elements

Educational Service Elements	Absolute Importance	Relative Importance
Seminars, conferences, training	0.025	2.54%
Recruitment criteria	0.080	8.24%
Competency in teaching	0.084	8.68%
Preparation for lectures	0.036	3.73%
Consultation procedure	0.020	2.09%
Student organizations	0.005	0.56%
Up-to-date materials	0.013	1.32%
Theoretical course content	0.046	4.76%
Industry oriented course content	0.096	9.98%
Class discussions	0.138	14.26%
Problem solving sessions	0.035	3.67%
Group projects	0.034	3.50%
Case studies	0.095	9.85%
Guest lecturer from industries	0.066	6.81%
Technical fi ld trips	0.018	1.89%
Industrial projects	0.082	8.53%
Computer labs	0.030	3.11%
Electronics equipment	0.028	2.93%
Elective courses with no prerequisites	0.012	1.20%
Meetings between dean and student representatives	0.023	2.34%

Table 4: Demographic Features of Participants

		Sample Number	Frequency (%)
Gender	Male	96	52%
	Female	89	48%
Class	1. Year	33	18%
	2. Year	41	22%
	3. Year	54	29%
	4. Year	57	31%
Status of the student	Scholarship	74	40%
	No Scholarship	111	60%

Discussion of results

The aim of this study was to identify and prioritize the student requirements and to identify the most important technical responses that need to be focused on in order to satisfy these student requirements. The results of the analysis show that most important student requirements are: having relationship with the faculty member based on respect and trust, easy and effective communication with the faculty member, careful and equal student performance evaluations, course content with both the theoretical and practical aspects of the subjects, interactive course content to support industry demand. If the ultimate goal of the university is to increase the quality of education at Industrial and Systems Engineering department, emphasis must be placed on improving the following technical responses to satisfy these student requirements: industrial projects and case studies embedded into the course content, class discussions as part of the lectures, industry oriented course content and having an established recruitment criteria for instructor selection. Thus, for each one of these technical responses a committee was built consisting of two faculty members, two students, one department alumni and a member from industry to discuss the implication of these items in detail:

Industrial Projects: Partnership with industry to assign students to various industrial fi ms to work on their graduation and/or class projects. Students will apply the knowledge they learned in the courses to industrial projects. Since most of the projects are done as a group work, industrial projects not only prepare students to the next chapter of their life, but also teach them to work as a group, developing their social skills that may affect their future decisions. They also increase experience on real-life problems, which may create job opportunities. To this extent, it was recommended that all senior year engineering design projects are restructured to include partnership with industry. Each group should be assigned to an organization where they come up with a real engineering problem, and through the guidance of their advisor and a member from the organization they should provide design based solutions to the problem.

Class Discussions: Class discussions allow students to not only express their ideas, but discover those of others. It gives students a chance to see things from different perspectives, and a chance to practice listening and respectfully countering or agreeing with topics. Thus, class discussions enhance and enrich students' learning experience. To this extent, to promote class discussion, in several classes class participation in class discussions should be graded.

Case Studies: Case studies performed in the lectures ensure that the students know how to implement their technical knowledge into real life problems. Case studies put the theoretical knowledge in use. Cases help to assess the application of various concepts to real world situations, and help to build analytic skills to differentiate high priority from low priority elements. Working in groups on cases also helps students develop interpersonal skills and the ability to work as a team member. Being placed in real situations, students are asked to make critical decisions, and asked to use their knowledge of facts. Case studies were always part of the lectures. So they should continue to be so.

Industry Oriented Course Content: Industry oriented education is an approach to learning from an industry perspective. Industry oriented course content helps students be easily adapted to business life. It will equip students with an updated knowledge of the current industry standards and the processes involved in executing the business functions. Students educated with such concepts will have better opportunities to fi d jobs due to the fact that employers don't have to worry about acquainting students with the actual job process as they will already be knowledgeable about them. To this extent, it was recommended that senior year classes should include seminars given by experts from the industry.

Recruitment Criteria and Competency in Teaching: There are many factors that contribute to the education of students, among these factors is the most important educational determinant is having an effective teacher. A good grasp of the subject(s) being taught is necessary, and ability to manage a classroom is also important. Teacher's ability to recognize and respond according to the needs of the particular kinds of students is essential. In addition to these attributes, degrees of intelligence, personal charisma and dedication to help, make a teacher more effective. Being the key players of the education, instructors need to understand how students' think, respond and how much information they can absorb. Many times students can only absorb what their instructors give them. Thus, good recruitment strategies must be followed when selecting instructors. It is recommended that institutions should invest in faculty when they are trying to improve the quality of their programs.

CONCLUSION

A proposed methodology that integrates AHP, QFD, and SERVQUAL techniques is applied to engineering students at a Turkish university. In order to fi d the most important student requirements, pairwise comparison surveys are conducted using AHP method. Survey results indicated that Industrial and System Engineering curriculum should be designed with courses that are industry oriented, interactive and case study based with practical information provided; and courses that require participation in real-life engineering projects. Results also indicate that students demand partnership with faculty members, which is built on trust, respect and guidance. Thus, proposed methodology can be successfully used to determine and rank the students requirements regarding the quality of education, and identify the corresponding technical items to satisfy these requirements. It is recommended to use the proposed methodology with every new batch of students in order to identify their unique expectations.

Th s study was conducted at a Turkish University to contribute to the engineering education in Turkey. However, it also contributes to engineering education world-wide in terms of providing a methodology to capture most important stakeholder requirements and introducing these requirements into the education system. One of the advantages of this proposed methodology is that the evaluating criteria are determined based on the interest to the stakeholders (students), which ensures student requirement satisfaction.

The proposed methodology can also support universities in assessing their current education system and/or in selecting the best system that generates teaching and learning benefits to its students.

Th s research can be further extended including other stakeholders such as professors, university board, employer, and alumni when conducting surveys for SERVQUAL dimensions and when preparing the QFD. Th s study was conducted for an engineering department of a private university, it can be extended to public universities and other departments including social, art, science departments. These extensions might generate new requirements and thus the technical responses might have to be altered accordingly.

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