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Factors Affecting Selection of Elective Courses: The Use of Multi-Criteria Decision Making Model

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ABSTRACT

Elective course selection has always been a serious and important decision making process for students in institutions. The aim of this study is to determine weights of factors affecting elective course selection from students' perspective. So as to solve the problem, Analytic Hierarchy Process (AHP) based model was used. Factors which affect the elective course selection from students' point of view include five main criteria and 13 sub-criteria which were indicated by students. An online questionnaire containing demographic questions, enabled each student to compare the relative priority of criteria with all of the other criteria. The responses were evaluated via Super Decisions software, and priorities were determined using the Analytic Hierarchy Process (AHP). According to the analysis of 40 experts (i.e., graduate students studying in engineering programs), course schedule and teaching staff related factors are the two most important factors affecting the elective course selection. A real-life situation which will help students who are indecisive and hesitates while selecting an elective course was observed. AHP contributes to develop an analytic and comprehensive framework decision making. The method should be considered by faculty member involved in decisions about curriculum update and offering new courses.

1. Introduction

Decision making is the process of selecting one or more options based on at least one target direction and accordingly at least one criterion among the available options. The decision-making process mainly involves decision makers, decision-making alternatives, criteria, environmental factors, and decision results in the direction of the decision-maker's priorities. The process ends with the decision maker sorting the alternatives and

choosing one among them. In order to make the right decision in this decision process, very specific decision making methods come to the forefront^[1].

Multi-criteria decision-making is the whole set of practices that help people make the right decision under multiple criteria that conflict with one another in the direction of their preferences. It can be said that multi-criteria decision making is a process in which a complex problem can be analyzed in detail and then broken down into smaller, comprehensible parts^[2].

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In almost all universities, students have to choose courses from among many elective courses in the teaching process. Decision making within this course selection process is not easy since it is not possible to select the most appropriate choice among the many different courses in the decision making process. The aim of the study was to select the most appropriate courses by means of multi-criteria decision making methods in accordance with the criteria determined by the graduate students.

Selection of an elective course is a multi-criteria decision making (MCDM) problem, constitutes an advanced field of operations research, since it involves many conflicting multiple criteria, goals or objectives. A variety of decision making approaches and tools are available to support education decision making. The intent of MCDM methods is to improve the quality of decisions about elective course selection involving multiple criteria by making choices more explicit, efficient and rational. MCDM Methods have six basic functions:

- structuring the decision process,
- displaying trade-off among criteria,
- helping decision makers reflect upon, articulate, and applying value judgments concerning acceptable trade-offs, resulting in recommendations concerning alternatives,
- helping people make more consistent and rational evaluation of risk and uncertainty,
- facilitating negotiation,
- documenting how decisions are made.

The Analytic Hierarchy Process is one of the most widely used MCDM tools in the last 30 years; it has been used in almost all the applications related with decision making [3-8]. This approach enables the decision maker to construct problems in the system of a hierarchy: the objective, the criteria, and the alternatives. The main benefit of the AHP is its use of pairwise comparisons to measure the impact of items on one level of the hierarchy on the next higher level. Its flexibility, ease of use and wide applicability attract decision-makers and researchers in different fields including health care, education, management, manufacturing, political, and finance. There have been numerous research published based on AHP which include applications of AHP in various areas such as selection, evaluation, resource allocation, decision making, etc. A bibliographic review of the MCDM tools is provided [9].

In this study, a multi-criteria decision making methodology is proposed to determine weights of factors affecting elective course selection from students' perspective. In the proposed methodology, graduate students' opinions on the relative importance of the selection criteria are determined by the AHP procedure. Although there have been

several applications of AHP method in education, to the best of knowledge, this is the first study where a multi-criteria decision making tool, is used to examine the determinants affecting the selection of elective course selection from the perspective of students.

2. Methodology

2.1 Identifying Main Criteria and Sub-criteria

The problem to be implemented is the selection of elective courses belonging to the engineering department. The research focuses on the criteria that students have taken into consideration in the assessment process during the pre-course selection phase. Evaluation criteria for elective course selection were identified and grouped into five main categories: course schedule, teaching staff, course content, course requirements, friend-environment factor. In this paper the main and sub-criteria in Table 1 are obtained by taking into account the students' experience and opinions.

Table 3. Main criteria and sub-criteria taken into account to select the best elective course

Main criteria	Sub-criteria
C1: Course Schedule	C11: Course hours C12: Schedule in curriculum
C2: Teaching Staff	C21: Relationship with course instructor C22: Lecture teaching style
C3: Course Content	C31: Practicality of the course in real life C32: Interest in course content
C4: Course Requirements	C41: Obligation to attend the course C42: Project-homework assignment C43: Midterm exam-Final exam-Homework points % distribution
C5: Friend-Environment Factor	C51: Comments of the students previously taken the course C52: Passing grade in past semester C53: Number of people to choose course C54: Friend factor

2.2 Multi-criteria Decision Making

Decision-making is the process of choosing among the available alternatives. This phenomenon, which emerges from the moment when man is born, continues throughout all life in a wide variety of forms and environments [1].

The decision-making process is the implementation of the methods used to achieve the decision and the way it is applied. A successful decision-making process should meet the following six criteria:

- Focus on what is important,
- Logical and consistent,
- Using objective and subjective factors and bringing together analytical and intuitive thinking,
- Need information and analysis as needed for solution,
- Encourage and guide relevant information and thinking,
- Accurate, reliable, easy to use and flexible ^[10].

Decision makers live in every environment where chained decision making occurs. The factors that make up the ring that makes up this decision-making chain are:

- Experts
- Resolution environment (constraints)
- Objectives (criteria, targets)
- Alternatives
- Resources ^[1].

In the decision-making process, strategies are developed to find a number of solutions with existing problems. Different types of decision criteria can be applied while selecting the most appropriate strategy. These criteria are:

- Decision making under certainty,
- Decision making under risk,
- Decision making under uncertainty ^[11].

The Multi-Criteria Decision Making defines the decision-making process that will lead to a probing solution when multiple and often inconsistent criteria exist. In daily life, a very wide area is encountered with the problems of MCDM. Under the many criteria, the MCDM is able to reach the optimal solution from various alternatives. It is able to make the right decision even in any complex problem. For this reason, many areas include methods that provide application possibilities ^[12].

2.3 Analytic Hierarchy Process

The Analytic Hierarchy Process is a multi-criteria decision-making technique as described by Thomas L. Saaty ^[3]. The AHP is considered for decisions that necessitate incorporation of quantitative data with less tangible, qualitative considerations such as values and preferences. The AHP method is an effective and easy-to-understand that allows individuals and groups to process all the quantitative and qualitative factors together in the decision-making process. The AHP identifies the set of criteria that can be influenced by multi-criteria decisions in real life, and the significance of these criteria to be given to the experts. The AHP approach has a wide range of applications. The difference between AHP and other decision-making methods is that the decision-maker's own ideas can be evaluated directly in the process ^[13]. The technique, is an Eigen value approach to the pair-wise comparisons, has been

applied to many areas including education and medical decision making. An AHP method involves the following key and basic steps:

- state the problem,
- identify goal of the problem,
- identify the criteria, sub-criteria and alternatives under consideration,
- construct the problem in a hierarchy of different levels-goal, criteria, sub-criteria and alternatives,
- conduct a series of comparisons among each element in the corresponding level and calibrate them on the numerical scale,
- calculate the maximum Eigen value, consistency ratio (CR), and normalized values for each criteria/alternative
- determine the relative ranking or the best alternative.

The selection hierarchy for the best elective course selection is illustrated in Figure 1.

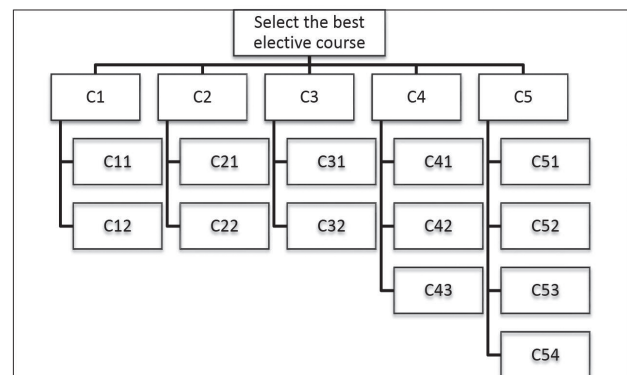


Figure 1. A hierarchy for selection of the most appropriate elective course

3. Data Collection

This study is a descriptive cross-sectional study for the purpose of assessing and identifying the importance of aforementioned criteria affecting elective course selection from students' perspective. A questionnaire, containing demographic questions, enables each student to compare the relative priority of criteria with all of the other criteria within the same category. Before conducting the survey, a pilot test was conducted with few students in the university. Based on the input received, the questionnaire was modified. The resulting questionnaire was e-mailed to the respondents. Hence, the questionnaires were applied to all 40 students individually. Students with the following demographic characteristics of experts are provided in Table 2. The average age of the students is 24.8 of which 52.7 % are male, 47.3 % are female.

Table 2. Demographic characteristics of the students

Gender (%)		
Female: 47.3	Male: 52.7	
Age (year)		
Max: 26	Min: 22	Avg: 24.8

In order to detect the relevant criteria, Saaty's pairwise comparison was applied. For each pair of criteria, the students were asked the following question: "in the selection of an elective course, considering merely "course schedule", how important is each element on the left compared with each element on the right?" The respondents were asked to rate each factor using the nine-point scale shown in Table 3.

Table 3. Saaty's nine-point scale

Intensity of importance	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2,4,6,8	For compromises between above

The personal judgments of each decision maker were converted to joint group decision by means of geometric mean and their weights were calculated in Super Decision software, and the consistency ratios of the paired comparisons were analyzed. An example of survey questionnaire is provided in Figure 2.

In the selection of an elective course, considering merely "course schedule", how important is each element on the left compared with each element on the right?

1 = Equal 3 = Moderate 5 = Strong 7 = Very Strong 9 = Extreme

Course hours	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Schedule in curriculum
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Figure 2. An example of survey questionnaire

4. Results

In order to determine the relative importance of various criteria affecting elective course selection from students' perspective in the analytic hierarchy, the data gained from the sample was analyzed using AHP method. The responses concerning the ranking of the criteria were computed using the software, and the consistency ratios of the paired comparisons were analyzed. The primary step was to assess the relative priorities of the main criteria at level 1; the priority weights of the main criteria influencing the selection of elective course are provided in Table 4. The re-

sults indicate a good consistency with a CR of 0.1, which represents more than 90% confidence level.

Table 4. Priority of criteria at level 1 of AHP

Criteria	Priority weight
Course Schedule	0.28
Teaching Staff	0.20
Course Content	0.20
Course Requirements	0.14
Friend-Environment Factor	0.18

Consistency ratio (CR): 0.02 (values at 0.1 or below represent 90% or higher confidence level)

Among five main criteria, "course schedule" is the most important criteria with the highest weight and "course requirement" is the least important with the lowest weight value. All responders achieved the threshold for coherence ($CR \leq 0.1$). According to the students, "teaching staff" and "course content" are indifferent.

Next, the relative priorities of the sub-criteria at level 2 were assessed, and the results are available in Table 5. The CRs for different comparisons range from 0.01 and 0.02, implying well over 90% confidence levels. Good consistency ratios imply that the responses expressed by students are not arbitrary, and well thought responses. CR is "not applicable" if only two criteria are being compared as transitivity would not be an issue ^[14].

According to Table 5, "course schedule" includes two sub-criteria where "course hours" is the most influential sub-criteria with the priority weight of 0.68, and "schedule in curriculum" is the least important one with the weight of 0.32. "Teaching staff" includes two sub-criteria; "relationship with course instructor" and "lecture teaching style" have the same importance with the priority weight of 0.5. "Course content" has two sub-criteria, "Practicality of the course in real life" has the higher priority with the weight of 0.65 than "interest in course content" with the weight 0.35. "Course requirements" includes three sub-criteria, "obligation to attend the course" has more priority than "project-homework assignment" and "mid-term exam-final exam-homework points % distribution". Finally, "friend-environment factor" includes four sub-criteria that "comments of the students previously taken the course" is the most influential with the priority weight of 0.34.

The global priority of each sub-criterion, which enables comparison of relative importance of different sub-criteria across criteria, was also calculated by multiplying the priority weight of the sub-criterion with its higher level criterion in the hierarchical path. The global priorities for

the sub-criteria at level 2 are provided in Table 6 after rescaling the fractional weights by multiplying with 100^[15].

Table 5. Priority of sub-criteria at level 2 AHP

Criteria	Priority weight	Global priority	CR
Sub-criteria for Course Schedule			
Course hours	0.68	0.19	Not applicable
Schedule in curriculum	0.32	0.09	
Sub-criteria for Teaching Staff			
Relationship with course instructor	0.5	0.10	Not applicable
Lecture teaching style	0.5	0.10	
Sub-criteria for Course Content			
Practicality of the course in real life	0.65	0.13	Not applicable
Interest in course content	0.35	0.07	
Sub-criteria for Course Requirements			
Obligation to attend the course	0.42	0.06	0.01
Project-homework assignment	0.29	0.04	
Midterm exam-Final exam-Homework points % distribution	0.29	0.04	
Sub-criteria for Friend-Environment Factor			
Comments of the students previously taken the course	0.34	0.06	0.02
Passing grade in past semester	0.22	0.04	
Number of people to choose course Friend factor	0.22	0.04	
	0.22	0.04	

CR values at 0.1 or below represent 90% or higher confidence level)

Table 6. Global priority weights for level 2 Sub-criteria (Scaled to 100)

No	Criteria	Global priority level 2
1	Course hours [course schedule]	18.69
2	Practicality of the course in real life [course content]	13.21
3	Relationship with course instructor [teaching staff]	10.21
4	Lecture teaching style [teaching staff]	10.21
5	Schedule in curriculum [course schedule]	9.34
6	Interest in course content [course content]	6.60
7	Obligation to attend the course [course requirements]	6.42
8	Comments of the students previously taken the course [friend-environment factor]	6.16
9	Midterm exam-Final exam-Homework points % distribution [course requirements]	4.45
10	Friend factor [friend-environment factor]	4.38
11	Passing grade in past semester [friend-environment factor]	3.62
12	Number of people to choose course [friend-environment factor]	3.62
13	Project-homework assignment [course requirements]	3.09

The higher-level criteria are specified in square brackets for easy reference

5. Discussion

This study aims to prove a mathematical method for a real-life situation which can help people make their decisions accurately. The situation of selecting an elective course is a problem for the students as they want to select the best option for them. There is a need to develop feasible decision-support tools that can provide feedback to facilitate this decision-making process. This study can be a baseline for a decision-support system for students assisting in making multi-criteria decisions. It will help students who are indecisive and hesitates while selecting an elective course.

With this study, the students can compare their options in a fairly simple way and find an optimum result. Other than the criteria aspect, it is shown that AHP method is an appropriate method for this kind of problems. The results propose the importance of issues in elective course selection from the perspective of graduate students. The priority weights stated in this paper may be useful in the elective course selection process for classifying various potential course by taking a weighted average of the calculated scores on different criteria.

Students give the highest priority to course schedule in selecting an elective course with a weight of 0.28 as provided in Table 4. Faculty members pay attention to the quality of the courses which are important for qualified curriculum and students' satisfaction. Therefore, they prefer to offer the best elective course available subject to their availability. Our results show that the students search for the appropriateness through course schedule. In order to be successful in a graduate program, students have to take several courses during the semester. Since their weekly programs become quite busy, finding out a course that is in the curriculum and fits their schedule is very crucial. The next criterion in importance is teaching staff with a weight of 0.20. In addition to course schedule, it is revealing that the students pay attention to the relationship with course instructor and lecture teaching style through teaching staff. Students tend to take the courses offered by the instructors whom they have known from other courses, or have an easier connection with compared to the other instructors. Moreover, instructors not boring during teaching and utilizing proactive teaching tools are preferred by the students. Similar to the teaching staff, students give priority to course content with a weight of 0.20. Students always tend to ask for the applicability of a course in practice. Therefore, they prefer to take the courses that they are interested in and they observe the practicality in real life. Friend-environment factor is the fourth important criteria with weight of 0.18. In every course registration period, if the course was previously offered,

students get the opinion of their friends on this specific course who have taken the course earlier. If the number of students who are taking a course is high, the course is considered as "popular" or "easy", which motivates them to add it to their program. In addition to that, students tend to take the courses whose average passing grade are higher. Finally, course requirements received the lowest priority from the graduate students with a weight of 0.14. Since in majority of the courses the course requirements are similar, for instance, expectations from the course, attendance requirements and grade distributions for mid-term, final, homework, project, course requirements are considered to be the least important factor while selecting an elective course. Discussion of the AHP results with the students verifies that their views are the same: first course schedule, followed by teaching staff and course content, friend-environment factor and course requirements.

6. Conclusion

Selection of an elective course plays an important role in course registration, is a multifaceted problem due to number of stakeholders, criteria and alternatives. This study identifies a set of criteria for elective course selection based on input from graduate students, and provides useful insights into students' preferences. A set of criteria are identified based on the inputs from students, and organized into a rational hierarchical framework consisting of the five main criteria and thirteen sub-criteria. In order to classify the relative importance of various criteria in the hierarchy, surveys were conducted in order to get responses from experts for the AHP method. Results show that students give the highest priority to the course schedule related factors such as course hours and schedule in curriculum. Teaching staff and course content related factors such as practicality of the course in real life, relationship with course instructor, Lecture teaching style are considered important discriminators by students in elective course selection, next to the course schedule. On the other hand, students are less concerned with course requirement related factors. Moreover, good CRs indicate that the responses are not random, and they are well thought. Given the multiple, competing criteria for the selection of an elective course, the results of this study can be useful for decision-makers in ranking and selection of elective course.

This study has limitations. Our sample was limited to graduate students in Turkey. Future research in a more culturally diverse geographical region could be completed and compared with the results of this paper since preferences may differ by country. Furthermore, for further research, the other multi-criteria decision making approaches such as TOPSIS, PROMETHEE II and VIKOR can be

used and compared with the results of this paper.

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