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FUZZY MCDM APPROACH FOR ORAL EXAMINATION IN ERASMUS STUDENT SELECTION PROCESS

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ABSTRACT

In recent years, the mobility has become one of the most important goals of the European Union (EU). Erasmus (European Region Action Scheme for the Mobility of University Students) Program is the EU program which encourages Higher Education Institutions to cooperate with each other. This program conducts short-term exchange of students and staff. The student selection process has a critical role to achieve effectively corporations among universities which are at least one in EU. The purpose of this article is to score and rank the students at the oral examination for the Erasmus Student Mobility. The evaluation of the students by an oral examination is not easier than a written exam. The evaluation process according to an oral exam is a Multiple-Criteria Decision Making (MCDM) process including group decision-making with tangible and intangible criteria. In this study, the students were evaluated by fuzzy Analytic Hierarchy Process (AHP) method and the results obtained from fuzzy AHP were compared with the results achieved from Rubric.

Keywords: *Fuzzy AHP, Fuzzy MCDM, Fuzzy number, Rubric, Student selection.*

ERASMUS ÖĞRENCİ SEÇİM SÜRECİNDE SÖZLÜ MÜLAKAT İÇİN BULANIK ÇOK ÖLÇÜTLÜ KARAR VERME YAKLAŞIMI

ÖZET

Son yıllarda, öğrenim ve staj hareketliliği, Avrupa Birliği (AB)'nin en önemli hedeflerinden biri olmuştur. Erasmus (Üniversite Öğrencilerinin Hareketliliği için Avrupa Bölgesi Eylem Planı) Programı, Yükseköğretim Kurumları'nın karşılıklı işbirliğini teşvik eden AB programıdır. Bu program, öğrencilerin ve personelin kısa süreli değişimini yürütür. Öğrenci seçme süreci, en az biri AB'de olan üniversiteler arasındaki işbirliğini etkili bir şekilde yürütmede kritik bir role sahiptir. Makalenin amacı, Erasmus Öğrenci Hareketliliği sözlü mülakatında öğrencileri puanlamak ve sıralamaktır. Sözlü mülakatla öğrencileri değerlendirme yazılı sınavla değerlendirme kadar zordur. Bir sözlü mülakata göre değerlendirme süreci, soyut ve somut ölçütlerle grup karar vermeyi içeren Çok Ölçütlü Karar Verme (ÇÖKV) sürecidir. Bu çalışmada, öğrenciler, bulanık Analitik Hiyerarşi Süreci (AHS) yöntemi ile değerlendirildi ve bulanık AHS ile elde edilen sonuçlar, Rubrik'den elde edilen sonuçlarla karşılaştırıldı.

Anahtar Kelimeler: *Bulanık AHS, Bulanık ÇÖKV, Bulanık sayı, Rubrik, Öğrenci seçimi.*

1. INTRODUCTION

The study abroad experience is widely believed to be an effective way to acquire foreign language competence and enhance cultural awareness among young adult learners [1]. As more and more European students take advantage of Erasmus to broaden their educational, cultural and professional horizons, their special needs have begun to surface [2, 3]. In recent years, the mobility has become one of the most important goals of the EU. Different projects and programs support the mobility of students, staff and other people employed. Erasmus Program is an EU program which encourages Higher Education Institutions to cooperate with each other. This program is financed in order that Higher Education Institutions produce and implement joint projects and conduct short-term exchange of students and staff with each other. Higher Education Institutions need a selection process to rank students and staff because the grant provided by EU for each university is limited. The selection process is very important for increasing the grant of the related university. The student selection has a key role for that this program should continue in success.

Exams make up general evaluation process for the student selection. If Higher Education Institution would like to organize its own exam in order to determine students' level of foreign language, this exam should be carried out by professional organizations. After written exam results are evaluated, an oral exam can be applied to determine the level of speaking skill.The evaluation of the students by an oral examination is not an easier task than a written exam. The evaluation process according to an oral exam is an MCDM process including group decision-making with tangible and intangible criteria. Preference relations are among the most common ways to represent information for decision making problems. In MCDM, the decision-makers (DMs) generally need to compare a set of *n* decision alternatives with respect to each criterion and construct a preference relation, then certain techniques are applied to derive aggregated weights based on individual preference relations [4]. One of MCDM techniques is AHP method introduced by Saaty [5]. AHP is particularly useful for evaluating complex multi-attribute alternatives involving tangible and intangible criteria [6]. Since it is difficult to map qualitative preferences to point estimates, a degree of uncertainty will be associated with some or all pair-wise comparison values in an AHP problem. The problem of generating such a priority vector in the uncertain pair-to-pair comparison environment is called the fuzzy AHP problem [7]. Chang [8] proposed the extent analysis method which is used as the most common method in the solution of fuzzy AHP applications. In the method, fuzzy number is used to quantify the "extent". For the extent analysis of each object, a fuzzy synthetic degree value can be obtained based on the fuzzy values. Fuzzy AHP method is used in many application areas such as machine selection [9, 10, 11, 12, 13], portfolio selection [14, 15], supplier selection [16, 17, 18, 19, 20, 21, 22], location selection [23, 24], vendor selection [25], landfill site selection [26], technology selection [27], personnel selection [28, 29, 30, 31, 32, 33, 34, 35], etc.

In the student selection literature including the MCDM approaches, Yeh [36] and Yeh and Chang [37] formulate the student selection process as an MCDM problem, and present suitable compensatory methods for solving the problem. They developed a new empirical validity procedure to deal with the inconsistent ranking problem caused by different MCDM methods.

The student selection approaches are not limited by MCDM .There are also other approaches applied such as goal-programming [4], factor analysis [38, 39], cognitive tests [40], AHP [41], linear programming [42] and etc.

In this study, a fuzzy MCDM approach is applied to select students in Erasmus oral examination. The students are evaluated using fuzzy MCDM method and the results obtained from fuzzy MCDM are compared with the results achieved from Rubric.The rank obtained by the fuzzy MCDM approach is more satisfactory for DMs. The fuzzy MCDM approach is more flexible than Rubric because the criteria weights can change from DM to another as explained in the case study. Also, more criteria can be considered for evaluating the student qualifications. The fuzzy MCDM approach allows sensitivity analysis by changing the criterion weights and DM weights.

The global steps of the proposed method are as follows: (1) describe the materials and methods; (2) use fuzzy MCDM to find the fuzzy weights of the criteria by subjective opinion and to compare the results with Rubric; (3) discuss the results and suggest new approaches. The Fuzzy MCDM methodology is also discussed for tenders selection problem in Hsieh et al. [43]'s study.

2. MATERIALS AND METHODS

2.1. Studying Abroad Within Erasmus Program

The Erasmus Program, established in 1987, represents a part of the initiatives of the European Commission in higher education. The goal of this program is to encourage and support academic mobility of students and teachers in higher education within the EU or countries of the European Economic Area. Each year the universities (home institutions) that signed the Erasmus partnership collaboration agreement with other universities offer the possibility for some of their selected students or teachers to make a 3–6 months exchange visit to a partner university (host institution) [44]. This program is financed in order that Higher Education Institutions produce and implement joint projects and conduct short-term exchange of students and staff with each other. Erasmus Student Mobility Program consists of SMS and Student Mobility for Placement.

Exchange students within this program do not have to pay tuition fees at the host university. Instead, they receive an Erasmus grant from the Commission, which financially supports this program with budget that has been increasing. The Erasmus Student Mobility annual grant per student varies among countries but in general, it is only a fraction of the total annual living costs [45].

The determination of SMS is an announcement, application and students selection process. In the selection of the students, Higher Education Institutions select their students according to the selection criteria determined by Center for EU Education and Youth Programs (Headquarters). Students who meet the minimum requirements are selected by ranking their scores from highest to lowest and taking into account their weighted scores and the evaluation criteria announced by the Headquarters. In the calculation of the final scores,% 50 of GPA (Grade Point Average) and % 50 of total foreign language score is considered. Higher Education Institutions should establish criteria for oral examination to be applied equally to all the students in the selection process. If Higher Education Institution would like to organize its own examination in order to determine the level of foreign language, this examination should be carried out by professional organizations. After the exam results are evaluated, an oral exam can be applied to determine the level of speaking skill. Oral exam results cannot be more than % 25 of the total scores of foreign language exam. In other words, if foreign exam score is considered as maximum 100 points, oral exam score has to be determined as maximum 25 points.

2.2. Current Application

Erasmus selection process in Dumlupinar University consists of English Proficiency Exam organized by the School of Foreign Languages and an oral examination applied by the Erasmus Committee. Written exam called English Proficiency Exam is applied to students. This exam is a multiple-choice exam and a student can get maximum 80 points out of 100. To be successful in this exam, the student must get a minimum score of 30 (This minimum score for students of Foreign Languages School is 50). Then the students who pass the English Proficiency Exam take the oral examination for which the maximum score is 20. In the evaluation step of the oral examination, there are some challenges which need to be addressed. One of the challenges is the evaluation of the students in accordance with subjective criteria. The considered criteria are capability of listening, fluency, vocabulary, pronunciation, grammar and self-expression. These criteria are formed by Erasmus Coordinators and Erasmus Committee with brainstorming method as given in Figure 1.

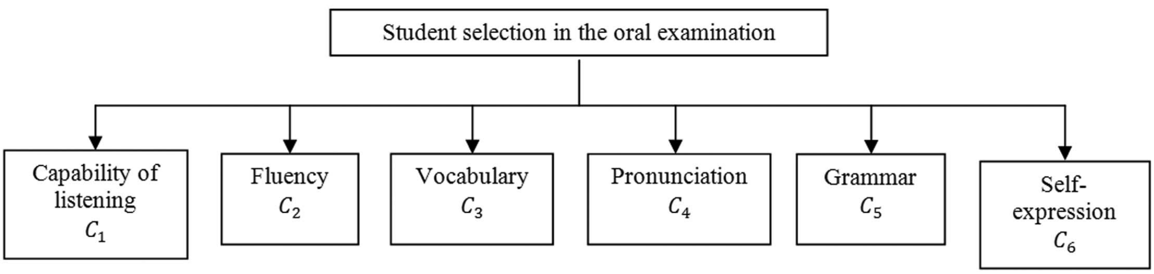

Figure 1. The hierarchical structure of evaluation

The current practice for selecting student is Rubric method. The fuzzy MCDM approach is proposed for the student selection instead of Rubric method. These methods are described as below.

2.2.1. Rubric

A rubric is a scoring tool that lists the criteria for a piece of work, or "what counts" (for example, purpose, organization, details, voice, and mechanics are often what count in a piece of writing); it also articulates gradations of quality for each criterion, from excellent to poor [46]. Rubrics may be used as part of student portfolios to help students, teachers, and family members reflect on student work, identify process and product skills mastered and not mastered, and make suggestions to guide instruction [47]. There are two primary types of rubrics used to assess public speaking performance: rating scales and descriptive rubrics (also known as analytic rubrics) [48].

In the development of rubrics to be prepared, specific criteria and steps are used. In this study, the rubric preparation method of Airasian [49] is used. Rubric preparation steps are discussed below.

(1) A process or product is selected.
(2) Performance metrics for process or product are determined.
(3) Which performance metrics are to be used is decided (Scoring criteria can be used from 3 to 5 points).
(4) The best student performance and other student performances are defined.

Step 1. Selecting of the performance containing product or process. "In the Erasmus interview, students are expected to make the best of their capability in listening, fluency, vocabulary, pronunciation, grammar and self-expression." Thus, here the aim is to observe students' performance levels. An analytic rubric is decided to be employed so that the performances of the students can be assessed with a process-based approach.

Step 2. Determination of performance criteria for the selected process or product. It should be determined which performance dimensions should be considered to observe performance levels carried out by the students in this process. The performance dimensions are decided as the capability of listening, fluency, vocabulary, pronunciation, grammar and self-expression. But first it should be decided which performance metrics will be used to assess each of the performance dimensions.

Step 3. Determination of performance levels to be used in rubric assessment. Performance levels are determined by using either numbers or descriptive phrases on rubrics. Performance tasks are defined by the teachers as excellent, good, fair, poor, or always, sometimes, rarely, and never. All of these criteria indicate different performance areas [50]. In addition, numbers can be utilized for the identification of performances. The scoring criteria are used to categorize performances that the students realize in the process. 4 points, 3 points, 2 points, 1 point and 0 point are used for the scoring.

Step 4. Identification of the performances of the best student and other students. Rubrics can take many forms and levels of complexity; however, they involve criteria that are used to measure performance, behavior or quality, and these criteria contain a range of indicators showing the different levels of achievement that need to be reached [51]. The students are observed to show different performances due to their different abilities and levels. Therefore, the best performance levels of the students and other performance levels must be considered and definitions of performance for each criterion should be made clearly as presented in the Table 1.

Table 1. Analytic rubric for the student performance

	1 Point	2 Points	3 Points	4 Points	5 Points
Capability of listening	Does not understand anything.	Understands simple expressions barely.	Understands simple expressions correctly.	Understands simple expressions and some more complex questions.	Understands complex sentences and gives consistent answers to complicated questions.
Fluency	Does not attempt to complete.	Speech halting and uneven with long pauses and/or incomplete thoughts.	Speech choppy and/or slow with frequent pauses; few or no incomplete thoughts.	Some hesitation but manages to continue and complete thoughts.	Speech continuous with few pauses or stumbling.
Vocabulary	Does not attempt to complete.	Inadequate and/or inaccurate use of vocabulary.	Somewhat inadequate and/or use of vocabulary.	Adequate and accurate use of vocabulary.	Rich use of vocabulary.
Pronunciation	Does not attempt to complete.	Frequently interferes with communication.	Occasionally interferes with communication.	Doesn't interfere with communication.	Enhances communication.
Grammar	Does not attempt to complete.	Inadequate and/or inaccurate use of basic language structures.	Emerging use of basic language structures.	Emerging control of basic language structures.	Control of basic language structures.
Self-expression	Does not attempt to complete.	Responses barely comprehensible.	Responses mostly comprehensible, requiring interpretation on the part of the listener.	Responses comprehensible, requiring minimal interpretation on the part of the listener.	Responses readily comprehensible, requiring interpretation on the part of the listener.

2.3. Proposed Approach: The Fuzzy MCDM Approach

A fuzzy MCDM approach is proposed to select students in Erasmus Oral Examination. Details of the proposed approach are as below.

2.3.1. Fuzzy AHP

This study uses the fuzzy AHP approach to determine the criteria weights from subjective judgments of each decision maker. Since the AHP developed by Saaty [5] is a very useful decision analysis tool in dealing with

MCDM. Buckley [52] extended Saaty's AHP to the case where the evaluators are allowed to use fuzzy ratios in place of exact ratios. Therefore, in this study, we employ Buckley's method, fuzzy AHP, to fuzzify hierarchical analysis. Concepts for fuzzy hierarchical evaluation are briefly given as follows:

2.3.2. Fuzzy number

Fuzzy numbers are a fuzzy subset of real numbers, representing the expansion of the idea of the confidence interval. According to the definition of Laarhoven and Pedrycz [53], a triangular fuzzy number (TFN) should possess the following basic features.

A fuzzy number $\tilde{A}$ on R to be a TFN if its membership function $\mu_{\tilde{A}}(x): R \rightarrow [0,1]$is equal to

$$\mu_{\tilde{A}}(x) = \begin{cases} (x-L)/(M-L), & L \leq x \leq M, L \neq M \\ (U-x)/(U-M), & M \leq x \leq U, M \neq U \\ 0, & otherwise. \end{cases} \quad (1)$$

where$L$ and U stand for the lower and upper bounds of the fuzzy number $\tilde{A}$, respectively, and M is for the modal value. The TFN can be denoted by$\tilde{A} = (L, M, U)$and the following is the operational laws of two TFNs$\tilde{A}_1(L_1, M_1, U_1)$ and $\tilde{A}_2(L_2, M_2, U_2)$, as shown [54]:

Addition of a fuzzy number $\oplus$: $\tilde{A}_1 \oplus \tilde{A}_2 = (L_1, M_1, U_1) \oplus (L_2, M_2, U_2) = (L_1 + L_2, M_1 + M_2, U_1 + U_2)$ (2)

Subtraction of a fuzzy number $\ominus$: $\tilde{A}_1 \ominus \tilde{A}_2 = (L_1, M_1, U_1) \ominus (L_2, M_2, U_2) = (L_1 - U_2, M_1 - M_2, U_1 - L_2)$ (3)

Multiplication of a fuzzy number $\otimes$: $\tilde{A}_1 \otimes \tilde{A}_2 = (L_1, M_1, U_1) \otimes (L_2, M_2, U_2)$
$= (L_1 L_2, M_1 M_2, U_1 U_2) L_i > 0, M_i > 0, U_i > 0.$ (4)

Division of a fuzzy number $\oslash$: $\tilde{A}_1 \oslash \tilde{A}_2 = (L_1, M_1, U_1) \oslash (L_2, M_2, U_2)$
$= (L_1/U_2, M_1/M_2, U_1/L_2)\ L_i > 0, M_i > 0, U_i > 0$ (5)

Reciprocal of a fuzzy number $\otimes$: $\tilde{A}_1^{-1} = (L_1, M_1, U_1)^{-1} = \left(1/_{U_1}, 1/_{M_1}, 1/_{L_1}\right) L_i > 0, M_i > 0, U_i > 0.$ (6)

2.3.3. Linguistic variables

In this paper, the computational technique is based on the following fuzzy numbers as shown Table 2.

Table 2. Membership function of linguistic scale

Fuzzy number	Linguistic scales	Scale of fuzzy number
$\tilde{1}$	Equally importance	(1,1,1)
$\tilde{2}$	Intermediate values between $\tilde{1}$ and $\tilde{3}$	(1,2,3)
$\tilde{3}$	Moderate importance	(2,3,4)
$\tilde{4}$	Intermediate values between $\tilde{3}$ and $\tilde{5}$	(3,4,5)
$\tilde{5}$	Essential importance	(4,5,6)
$\tilde{6}$	Intermediate values between $\tilde{5}$ and $\tilde{7}$	(5,6,7)
$\tilde{7}$	Very vital importance	(6,7,8)
$\tilde{8}$	Intermediate values between $\tilde{7}$ and $\tilde{9}$	(7,8,9)
$\tilde{9}$	Extreme vital importance	(9,9,9)

Linguistic variables are primarily used to assess the linguistic ratings given by evaluators for pair-wise comparisons of the importance of criteria in fuzzy AHP. Performance of alternatives for each criterion are also used as a way to measure by using linguistic terms as "very good", "good", "fair", "poor" and "very poor". The procedure for determining the evaluation criteria weights by fuzzy AHP can be summarized as follows:

Step 1. Construct pair-wise comparison matrices among all the elements/criteria in the dimensions of the hierarchy system. Assign linguistic terms to the pair-wise comparisons by asking which is the more important of each two element/criteria.

Step 2. To use geometric mean technique to define the fuzzy geometric mean and fuzzy weights of each criterion by Buckley (1985) are as follows:

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \ldots \otimes \tilde{a}_{in})^{1/n},$$

$$\widetilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \ldots \oplus \tilde{r}_n)^{-1} \quad (7)$$

where $\tilde{a}_{in}$, is fuzzy comparison value of criterion i to criterion n, thus, $\tilde{r}_i$ is geometric mean of fuzzy comparison value of criterion i to each criterion, $\widetilde{w}_i$, is the fuzzy weight of the ith criterion, can be indicated by a TFN, $\widetilde{w}_i = (L\widetilde{w}_i, M\widetilde{w}_i, U\widetilde{w}_i)$, where $L\widetilde{w}_i, M\widetilde{w}_i$ and $M\widetilde{w}_i$, are the lower, middle and upper values of the fuzzy weight of the ith criterion.

2.4. Fuzzy Simple Additive Weighting (SAW)

The fuzzy SAW can be given as follows:

(1) Alternatives measurement: Using the measurement of linguistic variables to demonstrate the criteria performance by expressions such as "very good", "good", "fair", "poor", " very poor" the evaluators are asked for conduct their subjective judgments, and each linguistic variable can be indicated by a TFN within the scale range 0-100. Take $\tilde{E}_{ij}^{k}$ to indicate the fuzzy performance value of evaluator k towards alternative i

under criterion *j*, and all of the evaluation criteria will be indicated by $\tilde{E}_{ij}^{k} = (L\tilde{E}_{ij}^{k}, M\tilde{E}_{ij}^{k}, U\tilde{E}_{ij}^{k})$. This study uses the notion of average value to integrate the fuzzy judgment values of *m* evaluators, that is,

$$\tilde{E}_{ij} = (1/m)\otimes\left(\tilde{E}_{ij}^{1} \oplus \tilde{E}_{ij}^{2} \oplus \ldots \oplus \tilde{E}_{ij}^{m}\right) \quad (8)$$

The end-point values $L\tilde{E}_{ij}$,$M\tilde{E}_{ij}$ and $U\tilde{E}_{ij}$of the average fuzzy number $\tilde{E}_{ij}$can be solved by the method by Buckley (1985), that is,

$$L\tilde{E}_{ij} = \left(\sum_{k=1}^{m} L\tilde{E}_{ij}^{k}\right)/m; M\tilde{E}_{ij} = \left(\sum_{k=1}^{m} M\tilde{E}_{ij}^{k}\right)/m; U\tilde{E}_{ij} = \left(\sum_{k=1}^{m} U\tilde{E}_{ij}^{k}\right)/m. \quad (9)$$

(2) Fuzzy synthetic decision: According to the each criterion weight $\tilde{w}_j$ derived by FAHP, the criteria weight vector $\tilde{w} = \left(\tilde{w}_1, \ldots, \tilde{w}_j, \ldots, \tilde{w}_n\right)^t$can be obtained, whereas the fuzzy performance matrix $\tilde{E}$of each of the alternatives can also be obtained from the fuzzy performance value of each alternative under *n* criteria, that is, $\tilde{E} = (\tilde{E}_{ij})$.

The approximate fuzzy number $\tilde{R}_i$, of the fuzzy synthetic decision of each alternative can be shown as $\tilde{R}_i = (LR_i, MR_i, UR_i)$, where LR_i, MR_i and UR_i are the lower, middle and upper synthetic performance values of the alternative *i*, that is,

$$LR_i = \sum_{j=1}^{n} LE_{ij} \times Lw_j\, ; MR_i = \sum_{j=1}^{n} ME_{ij} \times Mw_j; UR_i = \sum_{j=1}^{n} UE_{ij} \times Uw_j \quad (10)$$

(3) Ranking the fuzzy number: In this study, the procedure of defuzzification is to locate the Best Nonfuzzy Performance Value (BNP) which is simple and practical method and there is no need to bring in the preferences of any evaluators. The BNP value of the fuzzy number $\tilde{R}_i$ can be found by the following equation:

$$BNP_i = [(UR_i - LR_i) + (MR_i - LR_i)]/3 + LR_i,\ \forall i \quad (11)$$

According to the value of the calculated BNP for each of the alternatives, the ranking of the stocks for constructing the portfolio can then proceed.

3. CASE STUDY

This study is performed by International Relations Office of Dumlupinar University in Turkey. 68 students, four of whom are from the School of Foreign Languages Department, are evaluated by the oral examination. Erasmus committee that involves two decision-makers, who are lecturers, has been formed to conduct the interview and to select students to study abroad. To be successful in this oral examination the student must get a minimum of 10 points (minimum of 15 points for students in the School of Foreign Languages). In the evaluation, the fuzzy MCDM approach and Rubric Method are employed.

In the fuzzy MCDM approach, after the construction of the hierarchy in Figure 1, the different priority weights of each criterion and student are calculated. The comparison of the importance or preference of one criterion or student over another is made with the help of the questionnaire. The method of calculating priority weights of the students is discussed below.

Step 1. Firstly criteria (C_1, C_2, C_3, C_4, C_5 and C_6) given in Figure 1 are evaluated by two decision makers with linguistic scales and they are turned into fuzzy numbers. Two decision makers are indicated by DM_1 and DM_2, respectively. The pair-wise comparisons are given in Table 3.

Table 3. The pair-wise comparisons matrices of decision makers for criteria

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	1	$\tilde{5}$	$\tilde{7}$	$\tilde{3}$	$\tilde{5}$	$\tilde{3}$
C_2	$\tilde{5}^{-1}$	1	$\tilde{3}$	$\tilde{3}^{-1}$	$\tilde{1}$	$\tilde{3}^{-1}$
C_3	$\tilde{7}^{-1}$	$\tilde{3}^{-1}$	1	$\tilde{3}^{-1}$	$\tilde{1}$	$\tilde{5}^{-1}$
C_4	$\tilde{3}^{-1}$	$\tilde{3}$	$\tilde{3}$	1	$\tilde{5}$	$\tilde{5}^{-1}$
C_5	$\tilde{5}^{-1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{5}^{-1}$	1	$\tilde{7}^{-1}$
C_6	$\tilde{3}^{-1}$	$\tilde{3}$	$\tilde{5}$	$\tilde{5}$	$\tilde{7}$	1

a)DM_1

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	1	$\tilde{7}$	$\tilde{5}$	$\tilde{5}$	$\tilde{3}$	$\tilde{1}$
C_2	$\tilde{7}^{-1}$	1	$\tilde{5}$	$\tilde{3}$	$\tilde{3}$	$\tilde{5}^{-1}$
C_3	$\tilde{5}^{-1}$	$\tilde{5}^{-1}$	1	$\tilde{3}$	$\tilde{3}$	$\tilde{5}^{-1}$
C_4	$\tilde{5}^{-1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	1	$\tilde{5}^{-1}$	$\tilde{7}^{-1}$
C_5	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{5}$	1	$\tilde{7}^{-1}$
C_6	$\tilde{1}$	$\tilde{5}$	$\tilde{5}$	$\tilde{7}$	$\tilde{7}$	1

b)DM_2

Step 2. Geometric mean method suggested by Buckley (1985) is used to obtain the synthetic pair-wise comparison matrix and the comparison is given in Table 4.

Table 4. Synthetic pair-wise comparison matrix for criteria

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	**1.000**	(4.899;5.916;6.928)	(4.899;5.916;6.928)	(2.829;3.873;4.899)	(2.829;3.873;4.899)	(1.414;1.732;2.000)
C_2	(0.149;0.173;0.206)	**1.000**	(2.829;3.873;4.899)	(0.707;1.010;1.410)	(1.414;1.732;2.000)	(0.206;0.261;0.354)
C_3	(0.149;0.173;0.206)	(0.206;0.261;0.354)	**1.000**	(0.707;1.010;1.410)	(1.414;1.732;2.000)	(0.170;0.200;0.250)
C_4	(0.206;0.261;0.354)	(0.707;1.002;1.414)	(0.707;1.002;1.414)	**1.000**	(0.825;1.000;1.225)	(0.149;0.173;0.206)
C_5	(0.206;0.261;0.354)	(0.500;0.583;0.707)	(0.500;0.583;0.707)	(0.825;1.000;1.210)	**1.000**	(0.149;0.173;0.206)
C_6	(0.500;0.583;0.707)	(2.829;3.841;4.854)	(4.000;5.000;6.000)	(4.854;5.775;6.730)	(4.854;5.775;6.735)	**1.000**

Step 3. The calculations of fuzzy geometric means ($\tilde{r}_i$) can be given as follows:

$$\tilde{r}_1 = (\tilde{a}_{11} \otimes \tilde{a}_{12} \otimes \tilde{a}_{13} \otimes \tilde{a}_{14} \otimes \tilde{a}_{15} \otimes \tilde{a}_{16})^{1/6}$$
$$= ((1 \times 4.899 \times \ldots \times 1.414)^{1/6}, (1 \times 5.916 \times \ldots \times 0.732)^{1/6}, (1 \times 6.928 \times \ldots \times 2.000)^{1/6} = (2.540, \quad 3.113, \quad 3.630)$$

Likewise, $\tilde{r}_2 = (0.670, \quad 0.821, \quad 1.000)$, $\tilde{r}_3 = (0.420, \quad 0.501, \quad 0.610)$, $\tilde{r}_4 = (0.480, \quad 0.597, \quad 0.750)$, $\tilde{r}_5 = (0.430, \quad 0.499, \quad 0.590)$ and $\tilde{r}_6 = (2.260, \quad 2.684, \quad 3.120)$.

For the weight ($\widetilde{w}_i$) of each dimension, they can be done as follows:

$$\begin{aligned}\widetilde{w}_1 = \tilde{r}_1 \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3 \oplus \tilde{r}_4 \oplus \tilde{r}_5 \oplus \tilde{r}_6)^{-1} &= (2.540, \quad 3.113, \quad 3.630) \\ &\otimes \big(1/(3.63 + \cdots + 3.12), 1/(3.313 + \cdots + 2.684), 1/(2.54 + \cdots + 2.26)\big) \\ &= (0.26, \quad 0.321, \quad 0.38).\end{aligned}$$

Likewise, $\widetilde{w}_2 = (0.07, \quad 0.085, \quad 0.1), \widetilde{w}_3 = (0.04, \quad 0.052, \quad 0.06), \widetilde{w}_4 = (0.05, \quad 0.062, \quad 0.08)$, $\widetilde{w}_5 = (0.05, \quad 0.052, \quad 0.06)$ and $\widetilde{w}_6 = (0.23, \quad 0.277, \quad 0.32)$.

Step 4. Use the Eq. (11) to compute the BNP value of the fuzzy weights of each criterion. To take the BNP value of the weight of C_1 (capability of listening) as an example, the calculation process is as follows:

$$BNP_{w1} = \frac{[(U_{w1} - L_{w1}) + (M_{w1} - L_{w1})]}{3} + L_{w1} = \left[\frac{[(0.38 - 0.26) + (0.321 - 0.26)]}{3}\right] + 0.26 = 0.32.$$

Then, the weights for the remaining criteria can be found as shown in Table 5. According to the fuzzy AHP results, it is clear that the first two important criteria for student selection are capability of listening (0.320) and self-expression (0.278). Moreover, the less important criterion is vocabulary and grammar (0.053).

Table 5. Weights of dimensions and criteria

Criteria	Overall weights	BNP
Capability of listening	(0.260; 0.321; 0.380)	0.320
Fluency	(0.070; 0.085; 0.100)	0,086
Vocabulary	(0.040; 0.052; 0.060)	0,053
Pronunciation	(0.050; 0.062; 0.080)	0,064
Grammar	(0.050; 0.052; 0.060)	0,053
Self-expression	(0.230; 0.277; 0.320)	0.278

Step 6. Each decision makers evaluated the students under the defined criteria based on the expressions given in Table 6 and decision makers' expressions are given in Table 7 as DM_1 and DM_2, respectively.

Table 6. Range for the linguistic variables of decision makers

Decision makers	very poor	poor	fair	good	very good
1	(0;0;15)	(15;25;40)	(30;45;65)	(55;70;80)	(80;90;100)
2	(0;5;10)	(10;30;45)	(35;55;60)	(65;75;80)	(90;95;100)

For one of the students (A_1) as an example, the average fuzzy performance value of criterion C_1 (capability of listening) from decision makers' judgment is obtained as follows:

$$\begin{matrix} E^1 & E^2 \\ [\text{ very good} & \text{very good }] \end{matrix} = \begin{matrix} E^1 & E^2 \\ [\ (80;90;100) & (90;95;100)\ ] \end{matrix}$$

$$\tilde{E}_{11} = \left(\left(\sum_{k=1}^{2} LE_{11}^{k}\right)/2,\ \left(\sum_{k=1}^{2} ME_{11}^{k}\right)/2,\ \left(\sum_{k=1}^{2} UE_{11}^{k}\right)/2\right) = (85;\quad 93;\quad 100)$$

The remainder elements of fuzzy performance values of each criterion of decision makers for each student can be obtained by the similar way.

After calculations of synthetic performance values, fuzzy numbers have to be turned into non-fuzzy forms. BNP values are also used in this phase and the results are given in Table 7. BNP values and the results for the students of the School of Foreign Languages Department are given in Table 10. Ranking of the students is determined based on BNP values and ratios are calculated. These values for the students except the School of Foreign Languages Department are also given in Table 7.

Table 7. BNP values, rank and ratios of students

*S	DM_1		DM_2		Compromised		*S	DM_1		DM_2		Compromised	
	BNP_i	Ranking	BNP_i	Ranking	BNP_i	Ranking		BNP_i	Ranking	BNP_i	Ranking	BNP_i	Ranking
A_1	70.559	2	78.715	4	75.175	2	A_{33}	26.96	43	19.630	56	24.354	49
A_2	55.089	14	54.559	16	55.165	14	A_{34}	45.74	25	50.849	20	48.321	24
A_3	39.58	32	57.749	9	48.640	23	A_{35}	33.987	37	20.217	53	27.915	44
A_4	20.067	52	31.085	36	25.912	47	A_{36}	47.442	23	52.134	18	49.978	21
A_5	61.339	8	47.199	25	55.547	13	A_{37}	15.195	60	11.859	63	13.12	63
A_6	42.269	29	46.534	26	44.246	28	A_{38}	43.775	26	26.130	41	35.333	34
A_7	18.589	55	24.459	45	22.024	54	A_{39}	47.085	24	40.919	29	44.049	29
A_8	41.217	31	56.464	10	47.605	25	A_{40}	57.089	11	60.430	8	58.716	9
A_9	37.614	36	18.747	57	29.161	41	A_{41}	26.445	45	34.839	33	30.752	38
A_{10}	12.505	63	28.540	39	21.315	55	A_{42}	25.564	47	29.770	37	27.889	45
A_{11}	66.279	5	80.025	3	73.609	4	A_{43}	20.04	54	16.889	58	19.563	58
A_{12}	21.279	51	14.814	60	17.695	60	A_{44}	53.75	15	39.522	31	47.529	26
A_{13}	43.247	28	22.112	50	32.881	36	A_{45}	65.859	6	81.082	2	73.721	3
A_{14}	**11.109**	**64**	15.825	59	13.850	62	A_{46}	52.84	19	50.737	22	52.690	19
A_{15}	65.587	7	56.339	11	61.475	7	A_{47}	25.509	49	21.775	52	24.238	50
A_{16}	28.199	41	38.235	32	33.653	35	A_{48}	52.84	20	50.072	23	51.570	20
A_{17}	68.055	4	67.570	6	68.746	5	A_{49}	53.75	16	52.754	17	53.241	17
A_{18}	13.497	61	14.700	62	14.975	61	A_{50}	53.675	18	50.849	21	53.238	18
A_{19}	12.917	62	**4.784**	**64**	**8.678**	**64**	A_{51}	27.015	42	25.124	44	26.936	46
A_{20}	28.484	40	32.230	35	31.154	37	A_{52}	26.079	46	29.665	38	29.066	42
A_{21}	37.897	33	22.900	46	30.420	39	A_{53}	25.564	48	26.130	42	28.694	43
A_{22}	37.897	34	22.900	47	30.277	40	A_{54}	52.84	21	33.422	34	43.599	30
A_{23}	37.897	35	22.900	48	40.262	31	A_{55}	17.707	58	22.112	51	19.987	57
A_{24}	20.04	53	14.814	61	17.947	59	A_{56}	52.84	22	52.134	19	53.244	16
A_{25}	53.675	17	43.060	28	48.984	22	A_{57}	**76.267**	**1**	**82.784**	**1**	**79.563**	**1**
A_{26}	31.512	38	44.457	27	38.736	32	A_{58}	43.775	27	72.639	5	58.465	10
A_{27}	55.112	13	65.790	7	61.106	8	A_{59}	18.589	56	26.130	43	22.680	53
A_{28}	57.089	10	54.997	12	56.166	12	A_{60}	26.96	44	20.217	54	24.545	48
A_{29}	57.615	9	54.997	13	56.515	11	A_{61}	30.572	39	40.807	30	35.705	33
A_{30}	41.332	30	49.452	24	45.222	27	A_{62}	17.707	59	26.795	40	22.755	52
A_{31}	70.559	3	54.997	14	63.451	6	A_{63}	18.589	57	20.217	55	20.295	56
A_{32}	55.344	12	54.997	15	55.054	15	A_{64}	24.627	50	22.900	49	24.074	51

***S: Students**

It can be seen from Table 7 that the student $\boldsymbol{A_{57}}$ is the best performing student when the two decision makers' weights are considered both together and separately. However, it is clear that the ranks of the other students are different for DM_1 and DM_2.

3.1. Comparison Of The Results Produced By The Proposed Approach And Rubric

The rubrics are employed in the student selection problem for the case study. Each criterion is scored separately on analytic rubrics and a total score is obtained by adding the each criterion score. Below is an example showing how the total score of a student is obtained from decision makers' judgments.

Table 8. An analytic rubric for the oral examination assessment

Criteria / Points	1 Point	2 Point	3 Points	4 Points	5 Points
Capability of listening					X
Fluency				X	
Vocabulary				X	
Pronunciation				X	
Grammar				X	
Self-expression					X

a)DM_1

Criteria / Points	1 Point	2 Point	3 Points	4 Points	5 Points
Capability of listening					X
Fluency				X	
Vocabulary				X	
Pronunciation					X
Grammar				X	
Self-expression					X

b)DM_2

Total scores for DM_1 and DM_2given in Table 8 are 26 points and 27 points respectively. Here arithmetic mean method is used to obtain the compromised score, but this arithmetic mean value, which is 26.5 in this case, is converted to the score 17.667 out of 20.

BNP values for the students except the School of Foreign Languages Department given in Table 9 (called as Fuzzy AHP-I) show the subjective criterion values of DM_1 and DM_2. Also, new BNP values (called as Fuzzy AHP-II) are obtained by using different criterion weights. As can be seen in Table 9, when the criterion weights change, the ranking of students also change. However the ranking of the best performing student and the last student are the same. The new BNP values and Rubric values for the students of the School of Foreign Languages Department are presented in Table 10.

Table 9. Comparison Rubric values and the new BNP values

*S	*Fuzzy AHP – I*		*Fuzzy AHP – II*		*Rubric*		*S	*Fuzzy AHP – I*		*Fuzzy AHP-II*		*Rubric*	
	BNP_i	Ranking	BNP_i	Ranking	*Arit.Mean*	Ranking		BNP_i	Ranking	BNP_i	Ranking	*Arit.Mean*	Ranking
A_1	75.175	2	79.928	2	17.667	2	A_{33}	24.354	49	26.683	41	6.667	53
A_2	55.165	14	58.808	13	13.333	15	A_{34}	48.321	24	51.300	22	11.667	26
A_3	48.640	23	47.596	26	11.667	25	A_{35}	27.915	44	24.449	44	7.000	45
A_4	25.912	47	20.695	54	7.667	39	A_{36}	49.978	21	58.545	14	12.667	19
A_5	55.547	13	54.001	19	12.667	18	A_{37}	13.12	63	13.049	62	5.000	63
A_6	44.246	28	46.478	28	10.667	31	A_{38}	35.333	34	35.655	34	9.334	34
A_7	22.024	54	21.002	53	6.667	52	A_{39}	44.049	29	47.596	27	11.334	28
A_8	47.605	25	50.261	23	12.667	20	A_{40}	58.716	9	63.355	10	14.333	11
A_9	29.161	41	29.729	38	7.667	40	A_{41}	30.752	38	26.064	42	7.333	44
A_{10}	21.315	55	19.892	55	6.334	55	A_{42}	27.889	45	24.190	45	7.000	46
A_{11}	73.609	4	74.953	5	16.667	4	A_{43}	19.563	58	21.057	52	6.667	50
A_{12}	17.695	60	19.465	56	6.334	56	A_{44}	47.529	26	48.659	24	12.000	24
A_{13}	32.881	36	31.007	37	8.334	36	A_{45}	73.721	3	76.455	3	17.000	3
A_{14}	13.850	62	12.26	63	5.667	61	A_{46}	52.690	19	53.019	20	12.667	22
A_{15}	61.475	7	70.546	6	15.334	6	A_{47}	24.238	50	23.053	48	6.667	51
A_{16}	33.653	35	31.438	36	8.000	38	A_{48}	51.570	20	48.044	25	12.333	23
A_{17}	68.746	5	75.387	4	16.334	5	A_{49}	53.241	17	55.385	18	13.334	14
A_{18}	14.975	61	16.458	60	6.334	57	A_{50}	53.238	18	57.775	16	13.000	16
A_{19}	**8.678**	**64**	**7.137**	**64**	**4.667**	**64**	A_{51}	26.936	46	23.945	46	7.667	41
A_{20}	31.154	37	32.151	35	8.667	35	A_{52}	29.066	42	22.590	49	7.334	42
A_{21}	30.420	39	26.752	40	8.334	37	A_{53}	28.694	43	23.925	47	7.334	43
A_{22}	30.277	40	27.919	39	6.667	49	A_{54}	43.599	30	43.744	31	11.333	29
A_{23}	40.262	31	40.248	32	10.667	32	A_{55}	19.987	57	14.126	61	5.667	62

Table 9.(Continue) Comparison Rubric values and the new BNP values

A_{24}	17.947	59	19.214	57	6.334	58	A_{56}	53.244	16	56.390	17	13.000	17
A_{25}	48.984	22	52.691	21	12.667	21	A_{57}	**79.563**	**1**	**91.934**	**1**	**20.000**	**1**
A_{26}	38.736	32	45.465	30	11.334	27	A_{58}	58.465	10	61.638	11	13.667	12
A_{27}	61.106	8	64.221	8	15.000	8	A_{59}	22.680	53	24.965	43	7.000	47
A_{28}	56.166	12	63.494	9	14.333	9	A_{60}	24.545	48	21.519	51	6.667	54
A_{29}	56.515	11	60.785	12	14.333	10	A_{61}	35.705	33	36.232	33	9.667	33
A_{30}	45.222	27	45.998	29	11.000	30	A_{62}	22.755	52	22.310	50	7.000	48
A_{31}	63.451	6	67.690	7	15.333	7	A_{63}	20.295	56	17.963	59	6.000	60
A_{32}	55.054	15	58.138	15	13.667	13	A_{64}	24.074	51	18.050	58	6.334	59

***S: Students**

It is shown as separate tables because Erasmus Committee determines minimum 15 points for the students of the School of Foreign Languages Department and minimum 10 points for the students of the other departments when using Rubric. It is determined how many points correspond to these points in fuzzy AHP. For this calculation, it is considered that DMs evaluate a student by using linguistic terms as “fair” for each of the criteria. Threshold point in fuzzy AHP is achieved as 42.683 points. Thus, after the students are listed from 1 to 64, since minimum threshold point is 10 the first 33 students must be selected, if the students are assessed according to Rubric. However, if the fuzzy AHP is used, the first 30 students must be selected because minimum threshold point is 42.683. For the students of the School of Foreign Languages

Department, the student A_{68} in Table 10 must be selected according to Rubric; all of the students in Table 10 must be selected according to fuzzy AHP.

Table 10. BNP values, rank and ratios of students and comparison Rubric values and the new BNP values for thestudents of the School of Foreign Languages Department

Students	DM_1		DM_2		Compromised ($Fuzzy\ AHP - I$)		$Fuzzy\ AHP$-II		$Rubric$	
	BNP_i	Ranking	BNP_i	Ranking	BNP_i	Ranking	BNP_i	Ranking	$Arit.Mean$	Ranking
A_{65}	44.592	4	61.715	3	53.760	3	58.811	3	13.000	3
A_{66}	47.135	3	64.342	2	55.968	2	63.708	2	14.000	2
A_{67}	51.974	2	52.629	4	52.844	4	56.775	4	12.667	4
A_{68}	63.842	1	70.989	1	67.410	1	70.315	1	15.667	1

4. CONCLUSIONS

In this study, instead of Rubric, the fuzzy MCDM approach is proposed for the student selection problem in Erasmus oral examination. The student selection problem is defined in detail. The fuzzy MCDM approach and Rubric are given step by step. The case study demonstrates how the proposed framework can be applied in practice. 68 students are evaluated and ranked by using these methods. The obtained rankings are different for each approach. The ranking obtained by the fuzzy MCDM approach is more satisfactory for DMs. The fuzzy MCDM approach is more flexible than Rubric because the criteria weights can change from DM to another as explained in the case study. Also, more criteria can be considered for evaluating the student qualifications. The proposed method is more sensitive than Rubric in terms of the differences of the foreign language skills. The fuzzy MCDM approach allows sensitivity analysis by changing the criterion weights and DM weights.

Different MCDM methods can be applied in the selection process and results can be compared. A mathematical model can be proposed to assign students by considering the requirements of the system.

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