Assessment of education types for university education via multi-criteria decision-making methods

Üniversite eğitiminde kullanılan eğitim türlerinin çok kriterli karar verme yöntemleriyle değerlendirilmesi

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Abstract

Traditional face-to-face education has been applied as the primary method for centuries in universities, but synchronous distance education and blended education have become increasingly popular in recent decades. Students, academicians, and university administrators are the main stakeholders in university education. This study is the first to use multi-criteria decision-making (MCDM) to determine the best education type, considering these three stakeholder groups. Criteria were identified through a literature review, and stakeholders completed three questionnaires to finalize criteria, compare them pairwise, and rate alternatives. The Analytical Hierarchy Process (AHP) and Criteria Importance Through Inter-criteria Correlation (CRITIC) methods were applied to prioritize criteria, and Visual PROMETHEE was used to rank alternatives. As a result of the calculations traditional face-to-face education was found as the most appropriate in 5 out of 6 cases across the three stakeholder groups. Therefore, face-to-face education should remain integral to university education. If synchronous distance education is offered as a separate program alongside traditional face-to-face education, they should not be considered equivalent, and distinct diplomas should be awarded.

Keywords: Evaluation of education types, AHP, CRITIC, Multi-Criteria decision-making.

Öz

Üniversitelerde yüzyıllardır geleneksel yüz yüze eğitim birincil yöntem olarak uygulanıyor ancak son yıllarda senkronize uzaktan eğitim ve karma eğitim giderek daha popüler hale geliyor. Üniversite eğitiminin temel paydaşları öğrenciler, akademisyenler ve üniversite yöneticileridir. Bu çalışma, bu üç paydaş grubunu dikkate alarak en iyi eğitim türünü belirlemek için çok kriterli karar verme (ÇKKV) yöntemini kullanan ilk çalışmadır. Kriterler literatür taraması yoluyla belirlendi ve paydaşlar kriterleri son haline getirmek, bunları ikili olarak karşılaştırmak ve alternatifleri derecelendirmek için üç anket doldurdu. Kriterlerin önceliklendirilmesi için Analitik Hiyerarşi Süreci (AHP) ve Kriterler Arası Korelasyon Yoluyla Kriterlerin Önemi (CRITIC) yöntemleri uygulandı ve alternatiflerin sıralanması için Visual PROMETHEE kullanıldı. Hesaplamalar sonucunda üç paydaş grubundaki 6 vakanın 5'inde geleneksel yüz yüze eğitimin en uygun olduğu görüldü. Bu nedenle yüz yüze eğitim üniversite eğitiminin ayrılmaz bir parçası olarak kalmalıdır. Senkron uzaktan eğitim, geleneksel yüz yüze eğitimin yanında ayrı bir program olarak sunuluyorsa eşdeğer sayılmamalı, farklı diplomalar verilmelidir.

Anahtar kelimeler: Eğitim türlerinin değerlendirilmesi, AHP, CRITIC, Çok kriterli karar verme.

1 Introduction

After the establishment of University of Bologna which is accepted as the first university in the world, in 1088, university education has continued to be institutionalized. Despite this ongoing development and institutionalization for almost a thousand years, university education has not been accessible for the large masses due to obstacles such as geographical, cost, capacity, physical, etc. barriers. Additionally, extraordinary conditions restrained to access education have occurred such as wars and pandemics like COVID-19.

Traditional education is described as a process in which an academician is the supervisor of the learning process and has control over students in the same classroom environment [1]. Nevertheless, if students and academicians, cannot attend the classes because of limitations such as war, pandemic, etc. sustaining the class may not be possible. Different education types were proposed to exceed the problems in traditional education, such as synchronous distance and blended. Synchronous distance education is an education type that can

be conducted on TV, the internet, radio, etc., simultaneously. Blended education was expressed as a blended form of traditional face-to-face education realized in the classroom and synchronous distance education [2]. This study compares synchronous distance education and blended education, the most widely used education types during the pandemic times, with traditional face-to-face education. These three education types were involved in the study because all these stakeholders have experienced these education types during the pandemic.

There are differences for students, academicians, and university administrators in several education types. For instance, synchronous distance education provides lower accommodation cost and easy access for students. On the other hand, technological cost is higher for all stakeholders and academicians can have difficulty in controlling students due to the high number of students and virtual environment. Both measuring the knowledge level of students and realization of fair grade distribution are much more possible in traditional education; however, students can get grades as high as undeserved because of the ease of cheating in online and take-

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home exams. From the university administrators' perspective, although the operational cost is lower based on massive campus usage in synchronous distance education, the technological cost is lower due to the nature of this education type. Another important difference is the environmental impact. Students and academicians work from home synchronously, thus, the CO_2 emission rate based on transportation gets lower.

The decision maker has a difficult process to select the most appropriate one because each education type has typical negative and positive sides. It is aimed to decide the most appropriate type for student, academician, and university administrator stakeholders of university departments no required lab-works among traditional face-to-face education, synchronous distance education, and blended education. As the selection of the most appropriate education type necessitates the evaluation of education types concerning several main criteria, Multi-Criteria Decision-Making (MCDM) methods were utilized in the selection process.

To reveal the evaluation of the main criteria, firstly, a literature review was carried out in the second chapter. In the third chapter, the aim of the study was given, and the methods used in this article were discussed. In chapter 4, the application and the findings obtained, including the determination of the criteria, the determination of the importance of the criteria with the AHP and CRITIC methods, and the evaluation of alternative education types with the PROMETHEE method was explained. Conclusions and further suggestions were discussed in chapter 5.

2 Literature review

Each education type has distinctive positive and negative impacts on students. Distance education is better in terms of commute cost, the opportunity to attend classes from anywhere existed the internet connection, preparation time, and employee students; however, this education type is worse in terms of technological cost, less interaction between students and academicians, perceived diploma quality, and possible distractibility due to being in a non-classroom environment [3].

The communication between students and academicians is crucial because it affects learning satisfaction [4]. Additionally, Keramati and Gillies [5] said that implication of cooperative learning can enhance students' academic achievement. Dendir and Stockton Maxwell [6] indicated that cheating in online courses is a serious problem, especially in the absence of a proctor during the exam. Prinsloo and Uleanya [7] stated that distance education gives a chance to disabled and disadvantaged people to access education who cannot access traditional face-to-face university education. According to Kotera et al. [8], the number of students with disabilities studying in an online learning program is three times higher than the average in the United Kingdom. Topuz et al. [9] conducted a study on midwifery students. They presented handicaps of distance education as the lack of practice, forgetting the learned topics, power outages, distraction because of being home, losing concentration due to insufficient software/hardware, difficulty in communication with others, and difficulty in following the classes. Although fun activities, interactive study environments and augmented reality technologies might be practical to decrease the negative impacts of learning difficulty, interaction, and student-student communication problems, these cannot eliminate problems entirely [10]-[12]. Also, recorded classes provide to study by

stopping and taking notes. Additionally, decreased transportation time and not being disturbed by other students ensure staying in the comfort zone. Both synchronous distance education and traditional face-to-face education have different favourable impacts, thus blended education is used to take advantage of these together.

In several articles, synchronous distance education and traditional face-to-face education types were reviewed from the academician perspective. Laaser [13] listed the difficulties in distance education as gaining the trust of students, discomforts due to teaching under record, and the usage of required software and hardware. Ivaniuk and Ovcharuk [14] made research with Ukrainian educators at the beginning of the COVID-19 pandemic and indicated problems such as the lack of experience, the lack of knowledge about technology tools, and internet issues which decrease motivation. Lack of experience and knowledge about technology tools was an enormous problem for education because moving the class contents to a digital environment is not enough during the transition from face-to-face to online, students and lecturers should be educated to build digital skills. On the other hand, academicians could have self-improvement opportunities by watching other academicians who record their lessons. Different education types have impacts also on university administrators. Since distance education has increasing hardware and software costs and increasing cheat risk, it has disadvantages for university administrators. However, it easily ensures the schedule arrangement and decreases capacity problems, paper, photocopy, and transportation costs. Thus, it has a positive impact on nature. Access of disabled physically/geographically, special needer, and employee students to university education is also related to university administrator stakeholder.

Tepe [15] found the evaluation of students, exam problems, motivation, and teaching performance of academician as the most important criteria as a result of the study, which was conducted on 4009 high school students with the AHP method to determine the best one among distance education, face-to-face education, and hybrid education. Also, the best type was determined as face-to-face education using TOPSIS and VIKOR.

Topuz et al. [9] recommended blended education to utilize the advantages of different education types. Alqahtani and Rajkhan [16] found blended education as better than other alternatives.

Griffith et al. [17] found no differences in terms of students' performance among online, video synchronous education, and traditional education. Alamer and Alharbi [10] compared traditional and distance education types on 145 radiology students and found both types equally effective. Ananga and Biney [1] found no important differences between online education and face-to-face education. Mohammed et al. [18] conducted a study on 95 participants consisting of students, university administrators, and academicians and found flipped classrooms as good as e-learning. Environmental impact is different in each education type because each type has a different CO_2 emission rate. Distance education is better than others in terms of impact on the environment [19]. As it has advantages in terms of cost of paper, photocopy, technology, accommodation, and usage of campus/class.

Articles published in the literature in the last 10 years were carefully reviewed. The criteria included in multi-criteria decision-making studies published in the education field were examined. The obtained criteria list is presented in Table 1.

Table 1. Criteria list obtained from the literature.

References	Access to More Students	Accommodation Cost	Assessment of students	Building construction cost	Comfort Zone	Commute Cost	Ease of Understanding	Environmental impact	Internet Accessibility	Learning environment	Motivation	Operational Cost	Socialization	Student-Academician Communication	Student-Student Communication	Technological Cost	The time spent for preparation	The Use of Required Technology
[3]									X	X				X		X	X	
[4]														X				
[6]			X															
[7]	X																	
[9]									X	X	X			X				
[13]	X			X						X			X	X				X
[14]									X		X		X					X
[15]			X								X							
[16]					X				X	X	X							X
[18]																		
[19]	X			X		X	X					X						X
[21]		X				X			X		X							X
[24]	X									X								X
[25]							X		X									X
[26]																		X
[27]	X			X					X		X				X			
[28]			X												X			
[29]			X	X					X							X		
[30]	X	X				X										X		
This Article	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

This study distinguishes itself from the existing literature in two key aspects. First, it is the pioneering research to employ multi-criteria decision-making (MCDM) for determining the most suitable type of education, considering the perspectives of three stakeholder groups. Moreover, no study in the literature has utilized all the criteria listed in Table 1. In addition to the criteria list, experts from various stakeholder groups were asked whether any additional criteria should be considered for inclusion.

In the literature, several studies used different MCDM methods in the education area. Artsın and Günal [20] utilized the AHP to determine the importance of criteria in the distance education platform selection process. Alqahtani and Rajkhan [16] applied integration of AHP and TOPSIS methods to determine the critical success main criteria of e-learning during the COVID-19 pandemic. Bhattacherjee et al. [21] used fuzzy AHP and TOPSIS methods to determine the important criteria in employability by considering the review of experts from sector, academy, and students. Mohammed et al. [18] combined AHP and TOPSIS to select the most suitable e-learning type. Tepe [15] used these methods to analyse students' performance in different education types. Çelikbilek and Tüylü [22] applied Fuzzy AHP and Fuzzy DEMATEL methods to prioritize the components of e-learning systems. Yilmaz et al. [23] integrated AHP and Copeland to reveal the critical success factors in distance education in line with the review of information technology specialists, managerial staff, academic staff, and student perspectives.

Even though there are studies on MCDM methods used in the literature, most researchers considered from one stakeholder's perspective [1],[9],[10],[13],[15]-[17]. Authors who evaluated from different perspectives did not compare education types. Although Yilmaz et al. [23] discuss distance education in university in terms of different stakeholders, it was limited to only one education type. This article aims to select the best alternative for institutions in line with the opinions of different stakeholders. The multi-criteria decision-making research is the first study to include not only different stakeholders, such as students, academicians, and university management, but

also various types of education, including traditional face-to-face, synchronous distance, and blended learning.

3 Methodology

In this chapter, the application steps and the methods used in the application are explained. The flowchart of the application is given in Figure 1.
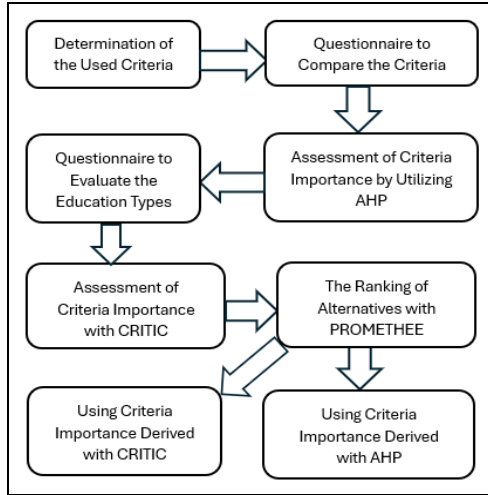

Figure 1. The process of the application of the research.

3.1 Analytical hierarchy process

The Analytical Hierarchy Process, presented by Saaty in 1977 [31], is an MCDM method robust and easy to understand that provides to combine qualitative and quantitative variables in complex problem organization. This method was used in the literature with different methods for different decision such as material selection and green production [32]-[34]. AHP, which is used in areas such as plastic pipe and welding machine selection, has also been used in research such as customer evaluation and manager assignment [35],[36]. Furthermore, it has been used in areas such as the defence industry [37].

Comparison questions are asked to experts for both criteria pairwise and alternative pairwise. In cases where the number of criteria is high as in this paper, a hierarchical structure can be created by gathering these criteria under main criteria and the solution can be reached more quickly, easily, and reliably. Thus, this method was preferred in the study.

The method has 6 steps as below:

1. A hierarchical structure consisting of criteria and sub-criteria is created,

2. Criteria taken part at the same level are compared using a pairwise comparison matrix. After experts choose the more important criterion, it is determined that the chosen criterion is how much important than the other one. Verbal expressions of importance level are indicated in Table 2.

Table 2. Verbal expression of the numeric values.

Numbers	Definition
1	Equal Importance
3	Weak Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2, 4, 6, 8	Intermediate Values

3. Geometric mean of n decision makers answers to comparison question of criterion i and j $X(a_i, a_j)$ is calculated and entered to the matrix.

4. Eigenvector of matrix is calculated.

$$W(i) = \frac{\sum_{j=1}^{J} \frac{X(a_i, a_j)}{\sum_{i=1}^{J} X(a_i, a_j)}}{J} \quad (1)$$

5. The matrix product of the A matrix and the W weight matrix, in which the criteria are compared with each other, is divided by the W matrix to obtain the λ_{max} value. Then, consistency indices (CI) is calculated.

$$\lambda_{max} = \frac{AxW}{W} \quad (2)$$

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (3)$$

6. CI value is divided into consistency ratio which is found from the random consistency index. If this value is under 0.10, values are accepted as consistent.

$$CR = \frac{CI}{RI} \quad (4)$$

3.2 Criteria importance through the inter-criteria correlation

Criteria Importance Through the Inter-criteria Correlation (CRITIC) is an MCDM method proposed by Diakoulaki et al. [38] aimed to determine the criteria importance objectively. This method utilizes alternative scores gotten from criteria.

CRITIC method consists of five steps as follows:

1 Decision matrix consisted of alternatives' scores gotten from criteria is created,

2 The decision matrix is normalized using the formulas below.

$$x_{ij} = \frac{X_{ij} - X_j^{min}}{X_j^{mak} - X_j^{min}} \text{ , for benefit criteria} \quad (5)$$

$$x_{ij} = \frac{X_{ij} - X_j^{mak}}{X_j^{min} - X_j^{mak}} \text{ , for cost criteria} \quad (6)$$

3 Standard deviation of alternatives' scores belonging to each criterion is calculated.

$$s_j = \sqrt{\frac{\sum x_{ij} - \overline{x_{iJ}}}{n - 1}} \quad (7)$$

4 Correlation values belonging to each pairwise criteria are calculated.

$$r_{jk} = \frac{\sum (x_{ij} - \overline{x_{iJ}})(x_{ik} - \overline{x_{ik}})}{\sqrt{\sum (x_{ij} - \overline{x_{iJ}})^2 (x_{ik} - \overline{x_{ik}})^2}} \quad (8)$$

5 c_j values and criteria importance values (W_j) are calculated.

$$C_j = s_j * \sum_{k=1}^{n}(1 - r_{jk}) \quad (j = 1,2,3, \dots, n) \tag{9}$$

$$W_j = \frac{C_j}{\sum_{j=1}^{n} C_j} \tag{10}$$

In this study, the method is utilized to ensure robustness between reviews for criteria and alternatives. This allows to compare the different answers from various experts.

3.3 Preference ranking organization method for enrichment evaluation

Brans and Vincke [39] proposed the Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) as an MCDM method based on priority between alternatives.

The PROMETHEE method was used in this study because it can ensure that there is no superiority between alternatives within the indifference level and that there is absolute superiority between alternatives exceeding the determined threshold in pairwise comparisons.

It has 5 steps as follows:

1. Decision matrix that alternatives and criteria are taken part is constituted. The scores of the alternatives from the criteria are entered into the matrix. Linear function preference function is selected among 6 different functions given Table 3. Since small differences between alternatives are neglectable and continuous values are preferred to compare alternatives in this research.

Table 3. Preference function types

Function Type	Function
Usual	$P(x) = \begin{cases} 0 & x \leq 0 \\ 1 & x > 0 \end{cases}$
U Type	$P(x) = \begin{cases} 0 & x \leq q_j \\ 1 & x > q_j \end{cases}$
V type	$P(x) = \begin{cases} 0 & x \leq 0 \\ d/p_j & 0 < x \leq p_j \\ 1 & p_j \leq d \end{cases}$
Level	$P(x) = \begin{cases} 0 & x \leq q_j \\ 0.5 & q_j < x \leq p_j \\ 1 & p_j \leq x \end{cases}$
Linear	$P(x) = \begin{cases} 0 & x \leq q_j \\ \dfrac{d - q_j}{p_j - q_j} & q_j < x \leq p_j \\ 1 & p_j \leq x \end{cases}$
Gaussian	$P(x) = \begin{cases} 0 & x \leq 0 \\ 1 - exp\left(-x^2/2\sigma_j^2\right) & 0 < x \end{cases}$

q: Indifference Level   p: Absolute Preference Threshold

2. Alternatives' scores gotten from the compared criteria, f_i and f_k, are calculated.

$$P(a_i, a_k) = \begin{cases} 0, & f(a_i) < f(a_k) \\ P(f(a_i) - f(a_k)), & f(a_i) \geq f(a_k) \end{cases} \tag{11}$$

3. Preference index is calculated.

$$\pi(a_i, a_j) = \sum_{i=1}^{k} w_i * P_i(a_i, a_j) \tag{12}$$

4. Positive and negative advantage values of alternatives are calculated.

$$\varphi^+(a_i) = \frac{1}{n-1} \sum_{a_j \in A, i \neq j} \pi(a_i, a_j) \tag{13}$$

$$\varphi^-(a_i) = \frac{1}{n-1} \sum_{a_j \in A, i \neq j} \pi(a_j, a_i) \tag{14}$$

5. The alternatives are ranked from the highest to the smallest according to φ⁺ points and from the smallest to the highest according to φ⁻ points. Complete order can be acquired according to φ from the highest to the smallest. φ value is calculated as indicated below:

$$\varphi(a_i) = \varphi^+(a_i) - \varphi^-(a_i) \tag{15}$$

4 Application and findings

The conducted research consists of determination of the evaluation criteria, assessment of criteria importance applying AHP, evaluation of alternative education types, assessment of criteria importance applying CRITIC, and rank of the alternatives. These phases are stated in the chapter.

4.1 Determination of the criteria

Firstly, the literature was reviewed to determine the possible criteria used in the evaluation of education types. Accordingly, 14 possible criteria for students, 11 for academicians, and 7 for university administrators were determined. Possible criteria with definitions for students, academicians, and university administrators were given in Appendix 1, Appendix 2, and Appendix 3.

Then, students, academicians, and university administrators were asked whether the criteria are necessary or not. Besides, experts' comments were taken about whether any other criteria can be added or not with an open-ended question. The procedure executed in addition to the extensive literature review made the research more comprehensive and representative. All experts were selected from among the individuals affiliated with the departments that do not require laboratory work in state universities in Istanbul. Departments required laboratory studies may be not appropriate for distance education. Also, one location, Istanbul, was chosen because several criteria such as commute, and accommodation cost may be different in different locations. This study was conducted on state universities to compare universities gotten similar conditions.

21 students, 16 academicians, and 5 university administrators from Istanbul Technical University and Yıldız Technical University answered questions in December 2021. These experts were shown the criteria obtained through literature review and expert opinions. The criteria that at least 70% of the experts deemed necessary were included in the model. All possible criteria for academicians were accepted. For

university administrators, the building construction cost criterion was eliminated due to the necessary rate constraint. Based on the responses to open-ended questions, the commute cost criterion for university administrators was removed, and the perceived diploma quality criterion for students and academician-academician communication for academicians were added.

The definitions of the added criteria were formed according to the expert opinions. The definition of diploma quality perception is the students' perception of how much employers consider diplomas valid obtained in different education types. Academician-academician communication was described as direct and face-to-face communication of academicians established with other academicians.

Main criteria were created, and criteria were classified according to relevant main criteria. 4 main criteria for students and 5 main criteria for academicians were created. No main criteria were created for university administrators because of the low number of criteria.

4.2 Assessment of criteria importance by utilizing AHP method

In this phase, 106 students, 59 academicians, and 23 university administrators from Istanbul Technical University, Yıldız Technical University, and Istanbul University answered questions consisting of pairwise comparison questions. These experts answered the questions in January 2022 on Google Forms. Geometric means of answers were calculated and placed in the pairwise comparison matrix. The inconsistency ratios are also checked, and all were found to be less than 10%.

These priorities for the student, academician, and university administrator stakeholders are seen in Table 4, 5, and 6.

Table 4. Criteria priorities of student stakeholder.

Main Criterion	Priority	Criterion	Priority
Education	31.88%	Motivation	8.49%
		Perception of being assessed fairly	7.80%
		Ease of understanding	6.73%
		Diploma quality perception	5.50%
		Comfort zone	3.36%
Cost	30.55%	Accommodation cost	19.13%
		Technological cost	11.42%
Communication	19.48%	Student-academician communication	11.98%
		Student-student communication	7.50%
Technology	18.10%	The internet accessibility	11.27%
		The use of required technology	6.83%

The most important criterion is accommodation cost for students. The reason can be increased house rents and dorm prices in Istanbul. The most important main criteria were found as education, and cost and two other criteria have similar importance levels.

Table 5. Criteria priorities of academician stakeholder

Main Criterion	Priority	Criterion	Priority
Education	32.56%	Fair evaluation of students	11.66%
		Motivation	9.19%
		The total time spent for class	5.95%
		Learning environment	3.73%
		Comfort zone	2.03%
Communication	25.84%	Academician-students communication	17.90%
		The use of required technology	10.52%
Technology	17.72%	Academician-academician communication	7.94%
		The internet accessibility	7.20%
Environmental	12.87%	Environmental impact	12.87%
Cost	11.02%	Technological cost	8.57%
		Commute cost	2.45%

It is seen that academicians considered academician-academician communication as the most important criterion because academicians got used to teaching in a classroom environment have difficulties in the online environment due to communication problems. The most important main criteria for academicians were calculated as education and communication.

Table 6. Criteria priorities of university administrator stakeholder

Criterion	Priority
Fair evaluation of students	39.03%
Access to more students	24.61%
Environmental impact	13.41%
Technological cost	12.73%
Operational cost	10.23%

The fair evaluation of students has 39.03% importance level and access to more students has 24.61% while others have between 10% and 15% importance levels.

According to these importance levels, inconsistency ratios for students, academicians, and university administrators are 0.77%, 0.7%, and 0.23%, relatively.

4.3 Evaluation of alternative education types

In this phase, the judgment of education-type alternatives was assessed with appropriate verbal expression in a questionnaire prepared for each stakeholder group to evaluate the education alternative types concerning criteria. The answers to questions were organized as the worst verbal expression takes 1 and the

best one takes 5. Each questionnaire has a different number of questions, 33 for students, 36 for academicians, and 15 for university administrators.

59 students, 61 academicians, and 27 university administrators participated in the questionnaire in April-May 2022. The arithmetic means of the ratings were calculated to reveal the group judgments.

The ratings of the alternatives for the student, academician, and university administrator are shown in Table 7, 8, and 9, respectively.

Table 7. Rating of alternatives according to student criteria

	Traditional Face-to-face	Synchronous Distance	Blended
Diploma quality perception	4.29	2.83	3.46
Student-student communication	4.25	2.31	3.07
Student-academician communication	4	2.83	3.24
Motivation	3.8	2.32	3.02
Perception of being assessed fairly	3.75	2.14	2.83
The internet accessibility	3.66	1.37	1.95
The use of required technology	3.59	1.93	2.44
Ease of understanding	3.44	2.86	3.08
Technological cost	3.2	2	2.36
Comfort zone	3.08	4	3.54
Accommodation cost	1.66	4.15	2.27

Traditional face-to-face education is the most preferred alternative with respect to all criteria except ease of understanding, comfort zone, and accommodation cost.

Table 8. Rating of alternatives according to academician criteria.

	Traditional Face-to-face	Synchronous Distance	Blended
Academician-students communication	4.52	2.54	3.31
Motivation	4.16	3.05	3.41
Academician-academician communication	4.11	2.43	3
Fair evaluation of students	4.05	2.18	3
The internet accessibility	4	2.54	2.91
Learning environment	3.9	2.9	3.31
Technological cost	3.44	2.33	2.49
Comfort zone	3.38	3.9	3.44
The use of required technology	3.23	1.93	2.16
The total time spent for class	2.25	2.48	2.26
Commute cost	2.07	4.66	3.08
Environmental impact	2	3.85	2.97

Synchronous distance education is the preferred alternative in terms of comfort zone and total time spent for class criteria, while traditional education is favoured for other criteria.

Table 9. Rating of alternatives according to university administrator criteria

	Traditional Face-to-face	Synchronous Distance	Blended
Fair evaluation of students	4.11	2.36	3.18
Technological cost	2.89	2.36	2.46
Access to more students	2.54	3.86	3.04
Environmental impact	2.46	3.75	3.07
Operational cost	2.14	3.46	2.96

Synchronous distance education is the preferred alternative according to criteria except the fair evaluation of students and technological cost.

4.4 Assessment of criteria importance by utilizing CRITIC method

In this phase, the CRITIC method was utilized in line with the ratings of alternatives by the experts.

The priorities of criteria for student according to CRITIC method illustrated in Table 10.

Table 10. Student stakeholder's criteria importance level in CRITIC method

Main Criterion	Priority	Criterion	Priority
Communication	11.06%	Student-academician communication	5.53%
		Student-student communication	5.53%
Technology	11.22%	The internet accessibility	5.66%
		The use of required technology	5.56%
Cost	30.51%	Accommodation cost	24.93%
		Technological cost	5.58%
Education	47.22%	Motivation	5.63%
		Perception of being assessed fairly	5.56%
		Ease of understanding	5.52%
		Diploma quality perception	5.56%
		Comfort zone	24.95%

According to the CRITIC technique, the most important criteria for students was found to be comfort zone (24.95%) and accommodation cost criterion (24.93%). Other criteria have similar importance levels.

The priorities of criteria for academician derived using CRITIC method is as shown in Table 11. Also, priorities for university administrator stakeholder calculated via CRITIC can be seen in Table 12.

Table 11. Academician stakeholder's criteria importance level in CRITIC method

Main Criterion	Priority	Criterion	Priority
Communication	12.46%	Academician-students communication	6.25%
		Academician-academician communication	6.22%
Technology	12.73%	The use of required technology	6.37%
		The internet accessibility	6.36%
Cost	18.70%	Commute cost	12.30%
		Technological cost	6.40%
Education	43.56%	Fair evaluation of students	6.32%
		Motivation	6.22%
		The total time spent for class	12.30%
		Learning environment	6.31%
		Comfort zone	12.42%
Environmental	12.54%	Environmental impact	12.54%

The most important criteria were revealed as environmental impact (12.54%), comfort zone (12.42%), commute cost (12.30%), and the total time spent for class (12.29%). Other criteria have importance level between 6.22% and 6.37%.

Table 12. University administrator stakeholder's criteria importance level in CRITIC method

Criterion	Priority
Technological cost	25.58%
Fair evaluation of students	24.90%
Operational cost	16.82%
Access to more students	16.36%
Environmental impact	16.34%

The most important criteria for university administrators were found as technological cost (25.58%) and the fair evaluation of students (24.90%). Operational cost, access to more students, and environmental impact criteria have importance levels 16.82%, 16.36%, and 16.34%, respectively.

4.5 The ranking of alternatives

After prioritizing the criteria using AHP and CRITIC methods, the global scores of the alternatives were computed separately for these using PROMETHEE. The cases AHP-used can be seen in Table 13.

The results used the importance level derived from CRITIC method is shown in Table 14.

All stakeholders preferred traditional face-to-face education to the other types of education types in AHP used case. On the other hand, synchronous distance education was preferred by university administrators, traditional face-to-face education was by others in CRITIC used cases.

Table 13. The ranking result of AHP method

Education Types	Student	Academician	University Administrator
Traditional Face-to-Face	0.4430	0.5755	0.0785
Synchronous Distance	-0.2207	-0.3361	0.0193
Blended	-0.2224	-0.2393	-0.0978

Table 14. The ranking result of CRITIC method

Education Types	Student	Academician	University Administrator
Traditional Face-to-Face	0.1169	0.2128	-0.0769
Synchronous Distance	0.0777	-0.0568	0.1148
Blended	-0.1946	-0.156	-0.0379

4.6 Sensitivity analysis

Sensitivity analysis was conducted for the two most important criteria in each case.

4.6.1 AHP-used case for student

In the case where AHP was used for the students, sensitivity analysis was conducted for accommodation cost and student-academician communication criteria. The results were shown in Figure 2 and Figure 3.
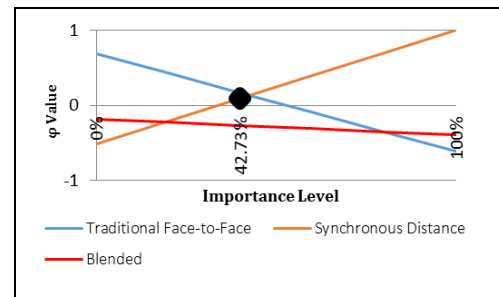

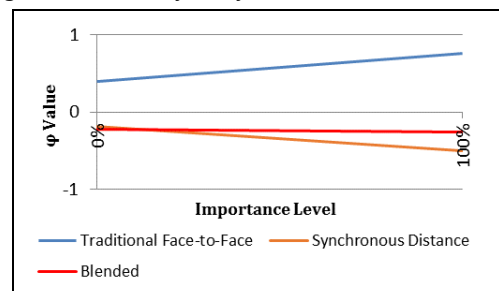Figure 2. Sensitivity analysis for accommodation cost.

Figure 3. Sensitivity analysis for student-academician communication.

As depicted in Figure 2, synchronous distance education becomes the preferred alternative if the importance value of accommodation cost exceeds 0.4273. The ranking remains unchanged until there is a 0.236 increase in importance level of the criterion.

For all importance values of the other criterion, the best alternative is traditional face-to-face education.

4.6.2 CRITIC-used case for student

In this case, accommodation cost and comfort zone criteria were used. The results of the analysis were indicated in Figure 4 and Figure 5.
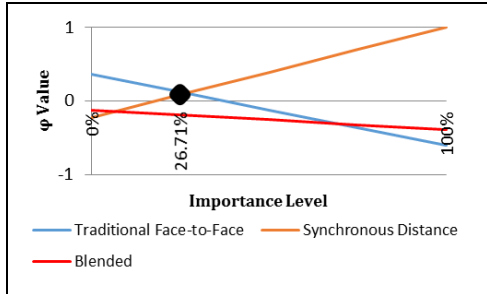

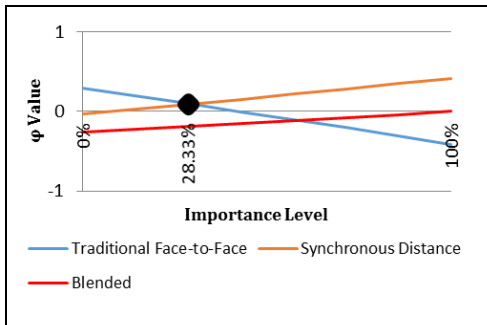Figure 4. Sensitivity analysis for accommodation cost.

Figure 5. Sensitivity analysis for comfort zone.

If the accommodation cost criterion has an importance level below 0.2671, the best alternative is traditional education, otherwise synchronous distance education is the preferred choice. When the importance level of the comfort zone criterion is less than 0.2833, traditional face-to-face education is the best alternative, while for larger values, synchronous distance education is the best alternative.

An increase of 0.0178 in the accommodation cost and 0.0338 in the comfort zone causes a change in the preferred alternative.

4.6.3 AHP-used case for academician

The results of the sensitivity analysis applied to the criteria of student-student communication and environmental impact were presented in Figures 6 and 7. For all importance levels of the academician-student communication criterion, traditional face-to-face education is the preferred choice. While traditional face-to-face education is preferred until the importance of the environmental impact criterion reaches 0.4160, after this value the best alternative is synchronous distance education. If there is a 0.2873 increase in the importance of this criterion, which has an importance of 0.1287, the ranking changes.
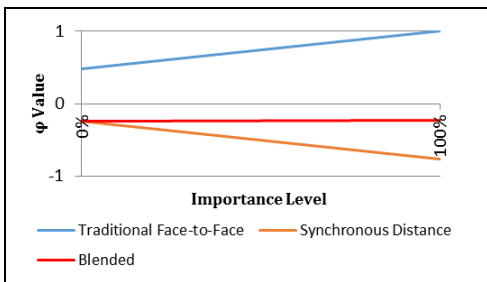

Figure 6. Sensitivity analysis for academician-student communication.
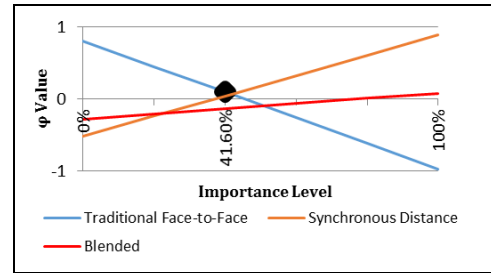

Figure 7. Sensitivity analysis for environmental impact.

4.6.4 CRITIC-used case for academician

Sensitivity analysis was conducted for internet accessibility and comfort zone, and the results are presented in Figure 8, and 9.
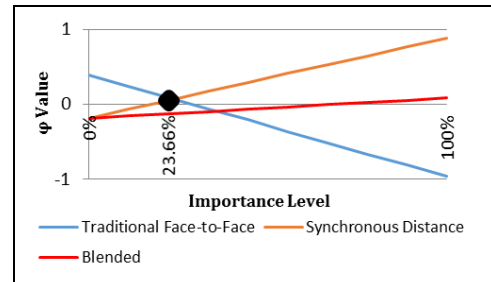

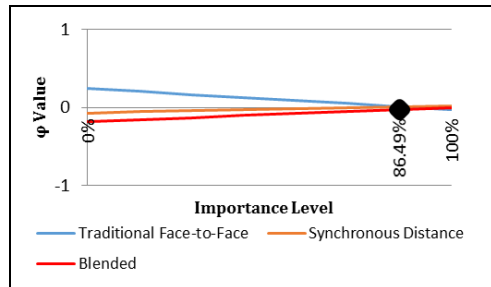Figure 8. Sensitivity analysis for environmental impact.

Figure 9. Sensitivity analysis for comfort zone.

If the importance level of the environmental impact criterion falls below 0.2366, the best alternative is face-to-face education; otherwise, distance education is the best. In the comfort zone criterion, traditional education is the best alternative for lower importance levels than 0.8649, and synchronous distance education is the best alternative for higher values.

While increases up to 0.1112 in the importance of the environmental impact criterion do not change the ranking, the ranking changes for larger increases. In the comfort zone criterion, increases greater than 0.7407 affect the ranking.

4.6.5 AHP-used case for university management

In this case, sensitivity analysis was performed for the most important two criteria of university management. The analysis was given in Figure 10 and Figure 11.

If the importance level of the fair evaluation of students criterion falls below 0.3689, distance education is the preferred choice; otherwise, face-to-face education is the best type. Unless the importance level of the access to more students criterion falls below 0.0429, synchronous distance education is preferred; otherwise, traditional face-to-face education is preferred. Since the importance level of fair evaluation of students is 0.3903, a decrease of 0.0214 causes a change in the

ranking. On the other hand, a decrease of 0.2032 in the other criterion makes traditional face-to-face education the best.
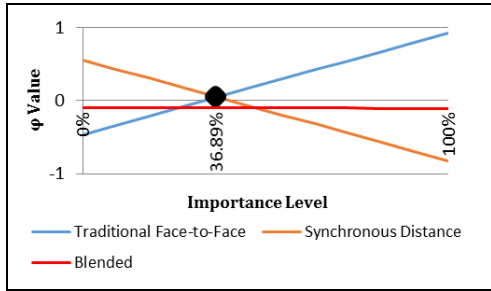

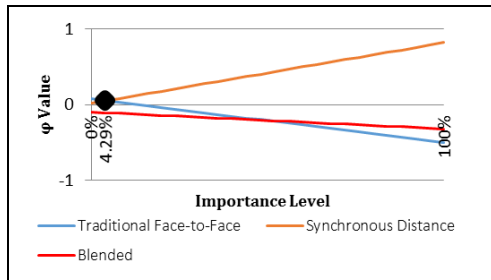Figure 10. Sensitivity analysis for fair evaluation of students.

Figure 11. Sensitivity analysis for access to more students.

4.6.6 CRITIC-used case for university management

In the CRITIC-used case for university management, sensitivity analysis was made for the fair evaluation of students and technological cost criteria, as illustrated in Figure 12 and Figure 13.
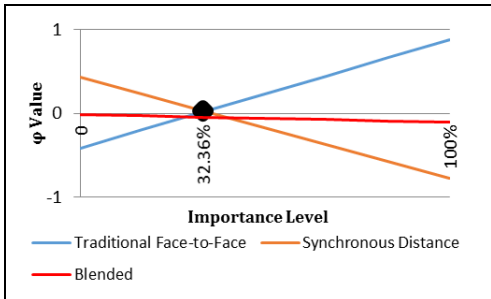

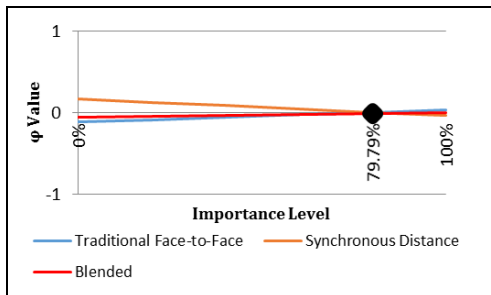Figure 12. Sensitivity analysis for fair evaluation of students.

Figure 13. Sensitivity analysis for technological cost.

If the importance level of fair evaluation of students criterion is lower than 0.3236, synchronous distance education is the best alternative. If not, traditional face-to-face education is the best type. If the importance of the technological cost criterion is lower than 0.7979, synchronous distance education is the optimal choice; otherwise, traditional face-to-face education is the optimal type. The reason for these changes is that face-to-face education receives higher scores in both criteria.

While a 0.0741 increase in the fair evaluation of students criterion changes the ranking, there is a change in the ranking if the importance of the other criterion deviates upwards by 0.5410.

5 Conclusions and further suggestions

Globalization brings different dimensions to many fields with the effect of increasing internet usage. Inevitably education is one of these affected areas such that university education has been conducted for 50 years in different styles. Universities benefit from these developments to not only conduct classes but also open new university departments in online and synchronous distance education types. Even though the existence of these departments most universities had to change traditional education with other education types provide to make classes online such as synchronous distance education during the COVID-19 pandemic. The universities provided to access education together with the transformation started to transition from distance education to blended education towards to end of the pandemic. In this period, students, academicians, and university administrator stakeholders got the opportunity to experience different education types together with compulsory changes. Although different research evaluated different education types exist in the literature, any research was not found that evaluation of university education from these stakeholders' perspectives. In this paper, the integration of AHP and CRITIC with the PROMETHEE method were used to determine the best education type for students, academicians, and university administrator stakeholders from state university departments required no lab-works. Accordingly, 6 different cases 2 in for each stakeholder group were considered applying these integrations.

Within this scope, criteria were determined with a literature review and experts' opinions, and these were asked of stakeholder groups. These answers were used in the importance level determination process in AHP and CRITIC methods. In the CRITIC method, the importance levels of the alternatives are determined according to the alternatives' scores received from the criteria, while in the AHP method, experts are asked. For this reason, the importance levels of the criteria differ from each other. Also, there are different criteria for different stakeholders. Thus, same criteria can have different importance level for different stakeholders. In the AHP method, accommodation costs for students, academician and student communication for academicians, and fair evaluation of students for university administrators were found as the most important criterion. In the CRITIC method, no criterion had an absolute advantage over other criteria, so no criterion could be considered as the most important one solely. Comfort zone, internet accessibility, and accommodation cost criteria for students, internet accessibility, the time spent for classes, commute cost, and environmental impact criteria for academicians, fair evaluation of students and technological cost criteria for university administrators were found as the most important criteria.

Traditional face-to-face education became prominent in all situations except CRITIC-used case for university administrators. When the CRITIC method was used for university administrators, synchronous distance education was found as the best. However, this education type was discovered as better than others in the case AHP-used for university administrators. Traditional face-to-face education type was identified as the most appropriate option in all cases AHP or

CRITIC used in assess the importance of criteria for student and academician stakeholders. Eventually, in 5 of 6 cases traditional face-to-face education was prominent and synchronous distance education was determined as the best in the other one. Traditional face-to-face education is preferred even in Istanbul, where accommodation and commute costs are higher than other cities. This education type can be found more prominent in other cities because of the high importance level of these costs.

So, traditional face-to-face education should be kept, stakeholders do not prefer transformation into distance education. Despite the result, if any distance-based department is opened to enhance continuing education opportunity, the department should give a different diploma from face-to-face education. Since the new department can decrease the perceived quality of diploma of face-to-face education.

In the next studies, the importance level of stakeholders can be calculated. These importance levels can be adjusted according to the prioritization level given by universities or responses of stakeholder groups. Also, other stakeholder groups such as administrative staff can be added. Thereby, more comprehensive results can be achieved. Additionally, different education types can be added to compare with the education types used in the study. However, the new education types should be experienced by stakeholder groups to get more robust and reliable results. Moreover, future studies could include different universities, as stakeholders' technological and financial conditions may vary between institutions, such as state and private universities.

6 Author contribution statements

In this study conducted by Mehmet Soydan under the supervision of Yusuf İlker Topcu, Mehmet Soydan is responsible for conducting the literature search, obtaining and processing data for analysis, and examining the results. Yusuf İlker TOPCU is responsible for the formation of the basic idea and checking the article in terms of content and method.

7 Ethics committee approval and conflict of interest statement

"There is no need to obtain ethics committee permission for the article prepared".

"There is no conflict of interest with any person/institution in the article prepared".

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Appendices A

Table A.1. Possible criteria list for students.

Criteria	Definitions
Perception of being assessed fairly	Student's perception that all students in the class receive the grade they deserve
The internet accessibility	The internet accessibility level required in the education type
Motivation	The motivation of students toward the classes and learning
The use of required technology	Students' usage capability of required hardware and software to follow classes
Student-academician communication	Face-to-face and direct communication between students and academicians
Student-student communication	Face-to-face communication of students with other students
Comfort zone	Attendance of students to classes from wherever he/she feels comfortable, without the obligation to be in a certain place at a certain time
Ease of understanding	Convenience of understanding major issues and details of classes
Accommodation cost	Extra accommodation costs paid by students who leave home to study university in another city
Technological cost	Cost to access required technology hardware and software
Commute cost	Commute cost and time of students
Learning environment	The changing learning environment caused by the environment (classroom, university, home, etc.) and distractions in the environment (such as other students in the classroom, other technology devices at home) during and after the classes
Time spent for preparation	Time spent by students for preparation for the classes
Environmental impact	Carbon footprint due to transportation and intensive campus use of students

Table A.2. Possible criteria list for academicians.

Criteria	Definitions
Fair evaluation of students	Assessment of students by academicians as fairly
Internet accessibility	The internet accessibility level required in the education type
The use of required technology	Hardware and software usage capability of academicians
Technological cost	The cost to reach necessary technology hardware and software for academicians
Commute cost	Cost related to leaving and backing home
Academician-student communication	Face-to-face and direct communication between student and academicians
Comfort zone	Attendance of academicians to the classes from where they feel more comfortable without necessarily being in class
Environmental impact	Carbon footprint due to transportation and intensive campus use of academicians
Learning environment	The changing course process for academicians due to the environment in which the lesson was conducted (such as classroom, home) and the difficulty in the use of necessary auxiliary material (multimedia components such as cameras, sound recorders)
The total time spent for class	spent non-class time by academician preparation for class, assessment of homework, project, exam, etc.
Motivation	Motivation of academicians toward given classes and other academic responsibilities

Table A.3. Possible criteria list for university administrator.

Criteria	Definitions
Access to more students	Opportunity to access to more students (who cannot access education due to geographical, economic, or physical disability) with lower cost
Fair evaluation of students	Execution of student assessment process fairly and properly
Technological cost	The cost of required technology hardware and software covered by university
Operational cost	Variable cost of water, electricity, paper, plastic, etc., materials on campus
Environmental impact	Carbon footprint due to transportation and intensive campus use of university stakeholders
Commute cost	Cost and spent time for university stakeholders to travel to and from the university
Building construction cost	Required additional construction cost to enhance student capacity