International Journal of Assessment Tools in Education
2023, Vol. 10, No. 1, 12–28
https://doi.org/10.21449/ijate.1104005
Published at https://ijate.net/ https://dergipark.org.tr/en/pub/ijate *Review Article*

A systematic literature review on multi-criteria decision making in higher education

Fatma Seyma Yuksel[1,*], **Ayse Nilgun Kayadelen**[2], **Zahide Figen Antmen**[3]

[1]Cukurova University, Faculty of Engineering, Department of Industrial Engineering, Adana, Türkiye
[2]Kutahya Dumlupinar University, Tavsanli Faculty of Applied Sciences, Department of Management Information Systems, Tavsanli, Kutahya, Türkiye
[3]Cukurova University, Faculty of Engineering, Department of Industrial Engineering, Adana, Türkiye

ARTICLE HISTORY

Received: Apr. 15, 2022

Accepted: Jan. 25, 2023

Keywords:

Multi-Criteria Decision-Making Techniques,

Higher education,

Literature review.

Abstract: The three components that form the basis of the educational process are the teacher, the learner, and the environment. These three components are affected by the developing and changing technology as a result of globalization considerably. Teaching and learning techniques should be updated and connected with these developments; new tools are therefore needed to make the necessary updates. Determination and application of the new tools include many decisions. Decision-makers can make more effective decisions using Multi-Criteria Decision-Making Techniques (MCDM), a complex decision-making tool that includes both quantitative and qualitative factors at present time. This study aimed to determine which MCDM methods are used in studies conducted in higher education, which is one of the most important development level indicators of countries, and to present a systematic literature review of MCDM method applications. The study was conducted in three stages: first, known electronics were searched until the end of 2021 using keywords; then, all studies were listed in a systematic taxonomy, and in the last stage, Thematic Network Analysis was used to evaluate the development of MCDM studies in the higher education area. It is determined that the Analytical Hierarchy Process (AHP) method is the most widely used method in higher education in MCDM applications. It was observed that the most common use of MCDM applications in higher education is e-learning as well. This study aims to be a guide for all researchers and practitioners who will study in both higher education and the MCDM areas.

1. INTRODUCTION

Higher education, also referred as post-secondary education or the third level, occurs after completing secondary education, is optional, and forms the final stage of formal education. Higher education includes many institutions and employees and a pretty high number of people benefit from such institutions as vocational schools, colleges, faculties, and institutions. The decision-making process in an institution becomes significant as the work in the institution gets intensive, the number of employees increases, and the institution's structure gets more complicated. The administration process, which begins with planning, emphasizes the necessity and importance of decision-making through research conducted eventually. The decision-

***Corresponding Author:** Fatma Seyma Yuksel ✉ seymadnmz@gmail.com Cukurova University, Faculty of Engineering, Department of Industrial Engineering, Adana, Türkiye

e-ISSN: 2148-7456 /© **IJATE** 2023

making process, vital to institutions, significantly affects administrators, employees, and people who demand a product and service from such institutions. Decision-makers may have to take more responsibilities as they make decisions on behalf of their institutions (Celikten et al., 2019). Therefore, decision-making is an essential process for higher education institutions.

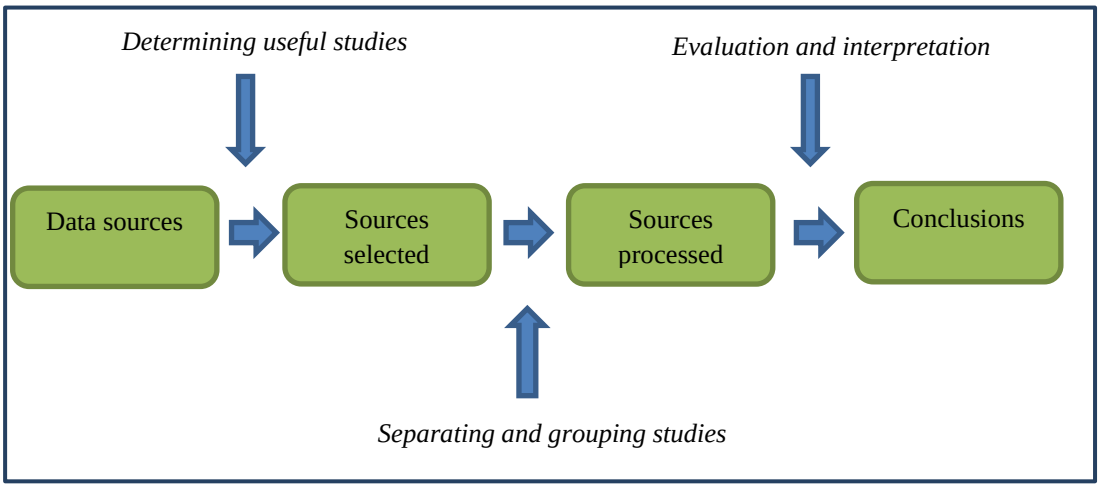
Academic and administrative staff selection, source selection, selection of learning systems, performance evaluation, etc. can be stated as examples of decision-making processes in higher education. Decisions to be made can be complex or straightforward, and their risk levels can be higher than expected. As the complexity and importance of a decision increase, the pressure on decision-makers and their importance increase as well. Here, decision-makers can select one or more alternatives among the others using various methods. Multi-Criteria Decision-Making (MCDM) techniques are the tools that provide decision-makers to make accurate, reliable, and quick decisions. For this reason, MCDM is among the most effective methods which decision-makers frequently apply and as a tool it ensures the best selection among alternatives adhering to multiple criteria used simultaneously (Mendoza & Prabhu, 2000). Since the 1960s, MCDM has been on the research agenda and many theories, many theoretical and applied articles, and books have been published in this field (Naveed et al., (2020); Rakesh et al., 2019; Roy, 2005). These techniques have an extensive application area, particularly in education, health, supply chain, transportation, computer science applications, energy, airway, banking, and production. MCDM techniques come to the forefront in case of a criterion and a goal that involves multiple qualities and quantities, particularly for educational institutions. Higher education institutions are rapidly and extensively affected by external factors such as social, economic, technological, or cultural (Timor, 2011).

This study aimed to review the literature that mainly focused on decision-making regarding the problems in higher education. The study is also thought to guide future studies to be conducted on MCDM problems in higher education.

Decision-making problems in higher education that were investigated by this study are commonly used for academic and administrative staff selection, graduate student selection, and e-learning systems selection. Studies on the Analytic Hierarchy Process (AHP) show that this technique is frequently used in the field of education (Chen et al., 2015; Sanchez et al., 2020; Yiğit et al., 2014). The studies examined also reveal AHP as the most frequently applied MCDM technique. In addition to AHP, the following techniques are used: Analytic Network Process (ANP), Fuzzy AHP (FAHP), VIse KriterijumsaOptimiz Ecija I Kompromisno Resenje (VİKOR), Technique for Order of Preference by Similarity to Ideal Solution (TOPSİS), Fuzzy TOPSİS (FTOPSIS), Complex Proportional Assessment (COPRAS), ELimination Et Choice Translating Reality (ELECTRE III), and also some hybrid techniques in which these techniques are used together (Anggrainingsih et al., (2018); Chen & Chen, 2010; Choi & Jeong, 2019; Giannoulis, 2010; Mazumdar, 2009; Naveed et al., 2020; Subbaiah et al., 2014).

In the in-depth analysis of the related literature, no study addressing MCDM techniques in higher education was encountered. To fill this gap in the literature, the present study, focusing on the MCDM and the latest related trends, reviewed publications on MCDM practices in higher education by the beginning of 2021. Figure 1 depicts the implementation stages of the present study.

Figure 1. *Study diagram.*



2. METHOD

In studies taken as reference, those using MCDM were primarily scanned considering the field of higher education. For this purpose, known databases (Web of Science, IEEE Xplore, Scopus, Science Direct, & Google Scholar) were searched using appropriate keywords by the beginning of 2021. "MCDM Techniques and Their Practices", "Higher Education", and "University" were examples of the keywords used. The search was done using different combinations of these keywords. Articles on MCDM practices in higher education were published by journals mainly in EBSCO, Google Scholar, ProQuest, SCImago, SCOPUS, Social Science Citation Index, Science Citation Index Expanded, Scopus, Emerging Sources Citation Index, Web of Science, and IEEE. Criteria for the articles to be included in this study were published either in English or in Turkish and in a journal or in a significant conference paper or in an article generated from a thesis.

Studies including MCDM practices outside of higher education, articles published in a language different from English (e.g., Arabic, French, etc.), and reviews that are not research articles were not included in the study. In line with these criteria, the present study was summarized in a table consisting of 72 scientific articles and conference papers (Table 1).

Table 1. *General literature table.*

Author Name	Year	MCDM Technique Used	Publication Type
Saaty & Ramanujam	1983	AHP	Journal
Liberatore &Nydick	1997	AHP	Journal
Kwak & Lee	1998	AHP	Journal
Drake	1998	AHP	Journal
Murakoshi et al.	2001	AHP	Conference
Aytaç & Bayram	2001	AHP	Journal
Özdemir & Gasimov	2004	AHP	Journal
Badri & Adulla	2004	AHP	Journal
Fenga et al.	2004	AHP	Journal
Grandzol	2005	AHP	Journal
Bali & Gencer	2005	AHP-FAHP	Journal
Kousalya et al.	2006	AHP	Journal
Begicevic & Divjak	2006	AHP & ANP	Journal
Colace et al.	2006	AHP	Conference
Ho et al.	2006	AHP	Journal
Tzeng et al.	2007	AHP & DEMATEL	Journal
Begicevic et al.	2007	AHP	Journal
Ray	2007	AHP	Journal

Table 1. *Continues*

Ho et al.	**2007**	**AHP**	**Journal**
Ozkul et al.	2007	AHP	Conference
Mustaffa et al.	2007	AHP	Journal
Tekindal & Erumit	2007	Classic Technique-AHP-FAHP	Journal
Begicevic et al.	2007	AHP	Journal
Melon et al.	2008	AHP & Direct Evaluation	Journal
Shee & Wang	2008	AHP	Journal
Chen & Chen	2008	VIKOR	Conference
Dundar	2008	AHP	Journal
Chi et al.	2008	FAHP	Journal
Nikoomaram et al.	2009	FAHP & FTOPSİS	Journal
Chao & Chen	2009	AHP (within CFPR)	Journal
Bo et al.	2009	FAHP	Conference
Ho et al.	2009	AHP	Journal
Lesmes et al.	2009	ANP	Conference
Sagir & Ozturk	2010	ANP	Journal
Altunok et al.	2010	Hybrid Model	Journal
Chen & Chen	2010	Hybrid Model	Journal
Gupta et al.	2010	AHP	Journal
Giannoulis & Ishizaka	2010	ELECTRE III	Journal
Lee	2010	AHP	Journal
Kara & Karaca	2010	AHP	Journal
Jie	2010	FAHP	Conference
Chen & Yang	2010	AHP	Conference
Lin	2010	FAHP	Journal
Mehregan et al.	2011a	FAHP	Journal
Mehregan et al.	2011b	FAHP	Conference
Nilashi & Janahmadi	2012	AHP	Journal
Li et al.	2012	AHP	Conference
Soba	2012	AHP	Journal
Wu et al.	2012	Hybrid Model	Journal
Syamsuddin	2012	FAHP	Journal
Kiarazm & Koohkan	2013	AHP	Journal
Kurilovasa & Zilinskiene	2013	Hybrid Model	Journal
Ozturk	2014	ANP	Journal
Yigit et al.	2014	AHP	Journal
Subbaiah et al.	2014	TOPSİS	Journal
Omurbek et al.	2014	TOPSİS+VİKOR based on AHP	Journal
Aly et al.	2014	AHP-TOPSİS	Journal
Mondal & Pramanik	2014	Hybrid Model	Journal
Nagpal et al.	2015	FAHP	Journal
Chen et al.	2015	AHP	Journal
Jain et al.	2016	AHP-TOPSİS	Journal
Garg	2017	FAHP, WEDBA, COPRAS	Journal
Garg & Jain	2017	FAHP, COPRAS, VIKOR, WDBA	Journal
Naveed et al.	2017	FAHP	Conference
Kabak et al.	2017	Hybrid Model	Journal
Ghosh & Pal	2017	Hybrid Model	Journal
Cebi & Karal	2017	FAHP	Journal
Anggrainingsih et al.	2018	FAHP	Conference
Mohammed et al.	2018	FAHP-TOPSİS	Journal
Choi & Jeong	2019	ANP	Journal
Garg et al.	2019	COPRAS-F	Conference
Naveed et al.	2020	AHP & FAHP	Journal

3. RESULT

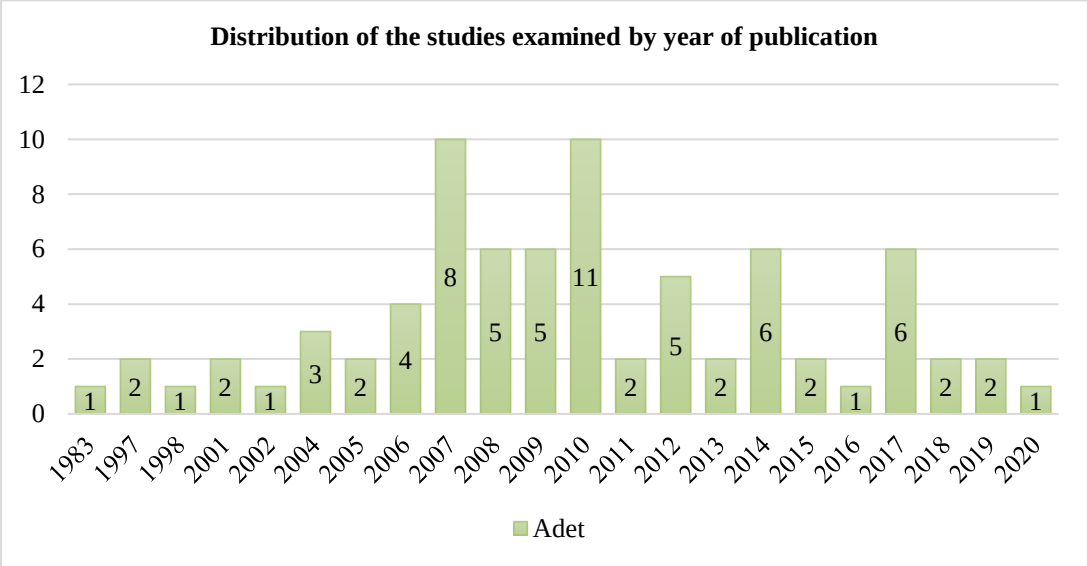
3.1. Classification of MCDM Techniques in Higher Education

In this section, the reference articles were grouped according to these characteristics: (1) Publication year, (2) MCDM technique applied, (3) Application Field, (4) Publication Type, and (5) Index Scanned.

3.1.1. *Publication year*

Among the reference articles according to their publication year, the first study on MCDM practice in higher education was carried out in 1983. The most up-to-date study in the application field was carried out in 2020. Besides, an increase in the number of articles published was observed between 2007–2010 and 2014–2017 (Figure 2).

Figure 2. Distribution of the reference studies by year of publication.



3.1.2. *MCDM technique applied*

Studies on MCDM practices in higher education used various MCDM techniques. In the reference studies, AHP, FAHP, ANP, TOPSIS, FTOPSIS, VIKOR, etc. techniques and the hybrid techniques combining these techniques were used. As shown in the graph of the distribution of the methods used in Figure 3, AHP is the most frequently used one among all the techniques (Table 1). The AHP technique, developed by Thomas Saaty in 1980, is an effective MCDM tool to help decision-makers determine the best choice while making complicated decisions. An essential characteristic of the AHP technique is comparing alternatives based on various criteria and using pairwise comparisons to predict criterion weights. AHP is based on the priority theory. At the core of AHP, a systematic approach is followed for an alternative selection and justification problem using the fuzzy set theory and hierarchical structure analysis. Since it has a fuzzy basis, this technique can be used in situations where user preference is identified (Aruldoss et al., 2013). In the first MCDM practice in Higher Education (Saaty & Ramanujam, 1983), an evaluation was made regarding staff selection in universities using AHP. With this study, 35 reference studies used AHP for MCDM practices in higher education. In this field, Chen et al. (2010) carried out the most up-to-date study in 2015 on determining the educational quality level of administrators (Table 2).

Figure 3. *Distribution of the reference studies by the technique applied.*

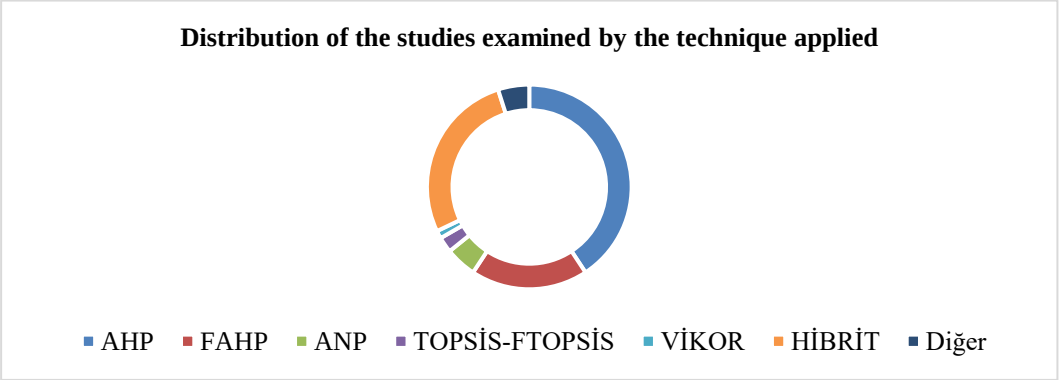


Table 2. *Studies applying AHP*.

Author Name	Year	Application Field	Publication Type
Saaty & Ramanujam	1983	Staff Selection	Journal
Liberatore & Nydick	1997	Academic Research Articles	Journal
Kwak & Lee	1998	Source Distribution	Journal
Drake	1998	Engineering Major Selection	Journal
Murakoshi et al.	2001	e-Learning Comparison in formal education	Conference
Aytac & Bayram	2001	Undergraduate Student	Journal
Ozdemir & Gasimov	2004	Faculty Course Assignment System	Journal
Badri & Adulla	2004	Higher Education Performance	Journal
Fenga et al.	2004	Performance Evaluation in Universities	Journal
Grandzol	2005	Staff Selection	Journal
Kousalya et al.	2006	Student Absence	Journal
Colace et al.	2006	e-Learning Platforms	Conference
Begicevic et al.	2007	e-Learning	Journal
Ray S.	2007	Thesis Advisor Selection	Journal
Ho et al.	2007	Source Distribution	Journal
Ozkul et al.	2007	Distance Education	Conference
Mustaffa et al.	2007	Academic Staff	Journal
Begicevic et al.	2007	e-Learning	Journal
Melón et al.	2008	Face-to-Face and Online Education	Journal
Shee & Wang	2008	Student Satisfaction	Journal
Dundar	2008	Course Selection	Journal
Chao & Chen	2009	e-Learning	Journal
Ho et al.	2009	e-Learning	Journal
Lee	2010	Performance Evaluation in Universities	Journal
Kara & Karaca	2010	Determining criteria that are effective in department selection	Journal
Chen & Yang	2010	e-Learning	Conference
Gupta et al.	2010	Education Evaluation	Journal
Nilashi & Janahmadi	2012	e-Learning	Journal
Li et al.	2012	e-Learning	Conference
Soba	2012	Higher Education	Journal
Kiarazm & Koohkan	2013	Performance Evaluation	Journal
Yigit et al.	2014	Course Content	Journal
Chen et al.	2015	University Administrators	Journal

Van Laarhoven and Pedrycz carried out the first theoretical study on FAHP in 1983. FAHP emerged due to the combination of the fuzzy relationship and pairwise comparison concepts (Toksarı, 2011). Unlike AHP, which uses clear values, comparison ratios are given within a range in FAHP (Şengül et al., 2013). FAHP is an effective tool for decision-making processes that cannot be quantified with specific data and where uncertainty is great. In this approach, decision-makers are asked to verbally express their evaluation at the stage of identifying the criteria weights. With this aspect, FAHP is a more realistic evaluation technique (Kusakci, 2019). 11 reference studies used the FAHP technique: the first was carried out by Chi et al. (2008) to evaluate higher education departments in the Ministry of Education in Taiwan; the most up-to-date of those studies was a conference paper by Anggrainingsih et al. (2018) using an e-learning FAHP application (Table 3).

Table 3. *Literature table for the studies applying AHP.*

Author Name	Year	Application Field	Publication Type
Chi et al.	2008	Development of University Organizations	Journal
Bo et al.	2009	e-Learning	Conference
Lin	2010	e-Learning	Journal
Jie	2010	e-Learning	Conference
Mehregan et al.	2011a	Evaluating e-learning performance	Journal
Mehregan et al.	2011b	e-Learning	Conference
Syamsuddin	2012	e-Learning Software	Journal
Nagpal et al.	2015	Evaluation of University Websites	Journal
Naveed et al.	2017	e-Learning	Conference
Cebi & Karal	2017	Student Projects	Journal
Anggrainingsih et al.	2018	e-Learning	Conference

ANP is a convenient MCDM technique coined and developed by Thomas L. Saaty (1999) and used to calculate weights and priorities. ANP is a general form of AHP used to consider non-hierarchical structures in MCDM (Chen, 2010). This technique demonstrates problems as networks by determining the relationship between their components (Omurbek, 2014). ANP considers the between- and in-group dependencies and feedback between the criteria. With this characteristic, ANP facilitates the solution of decision-making problems more effectively and realistically (Bo et al., 2009; Goksu, 2008; Jie, 2010; Lin, 2010). Most of the ANP studies were applied to e-learning. Table 4 shows the reference studies using the ANP technique. The first study using ANP was a university program application by Lesmes et al. in 2009. The most up-to-date study was an e-learning application carried out by Choi and Jeong in 2019.

Table 4. *Literature table for the studies applying AHP.*

Author Name	Year	Application Field	Publication Type
Lesmes et al.	2009	University Program	Conference
Sagir & Ozturk	2010	Observer, Exam	Journal
Ozturk	2014	Open and Distance Education System	Journal
Choi & Jeong	2019	e-Learning	Journal

TOPSIS, another method used in this field, is an MCDM technique developed by Hwang and Yoon (1981). Evaluation of alternatives (decision choices) is based on two main points; namely, positive ideal solution and negative ideal solution. In the TOPSİS technique, the target is the decision choice closest to the positive ideal solution and farthest to the negative ideal solution. The positive ideal solution is the solution that makes the cost criterion minimum and the benefit

criterion maximum. Comparatively, the negative solution is the solution that makes the cost criterion maximum and the benefit criterion minimum. There must exist at least two decision choices to apply this technique (Altunok, 2010). The TOPSİS technique is quite simple and understandable, and effective in calculations. It determines the relative performance of alternatives with simple mathematical formulas (Kabak, 2017). In our review study, one reference study used the TOPSİS technique as Subbaiah et al. (2014) determined the criteria for the ranking and evaluation of engineering and education institutes using TOPSİS (Table 5).

Table 5. *Literature table for the studies applying TOPSİS.*

Author Name	Year	Application Field	Publication Type
Subbaiah et al.	2014	Ranking and Evaluation of Engineering and Education Institutes	Journal

VIKOR, another MCDM technique, is a decision-making technique suggested by Opricovic and Tzeng (2004) to solve multi-criteria problems in complex systems; namely, the systems consisting of criteria that might contradict each other (Tezergil, 2016). VIKOR is based on the combination function representing the solution closest to the ideal solution (Opricovic, 1998). The VIKOR technique is mainly used in situations where decision-makers cannot make a selection determinedly or explain their choice (Paksoy, 2015) (Table 6). Our review of the related literature shows that only Chen and Chen (2008) used the VIKOR technique to determine the selection criteria of university type.

Table 6. *Literature table for the studies applying VIKOR.*

Author Name	Year	Application Field	Publication Type
Chen & Chen	2008	University Type Selection	Conference

ELECTRE (Elimination Et Choix Traduisant la Realité), another MCDM technique, is math-based and used for optimization. The ELECTRE III technique developed by Bernard Roy in 1978 is used in ranking problems. The technique selects the best choice among the alternatives asked to be evaluated and ranks the remaining options from the most optimal to the least optimal (Keles, 2019) (Table 7). The reference article by Giannoulis and Ishizaka (2010) used the ELECTRE III technique to compare English Universities.

Table 7. *Literature table for the studies applying ELECTRE III.*

Author Name	Year	Application Field	Publication Type
Giannoulis & Ishizaka	2010	Comparison of English Universities	Journal

COPRAS-F, another MCDM technique, has been obtained by combining fuzzy logic and the classic COPRAS technique to cope with the inability to make effective decisions due to ambiguities. In the COPRAS-F technique, performance values consisting of fuzzy numbers are used. The technique benefits from linguistic scales (Çakir & Ozdemir, 2018). The technique first suggested by Zavadskas and Kaklauskas in 1996 is based on selecting the best alternative by determining a ratio with the positive and negative optimal solution (Yazdani et al., 2011). There was one reference conference paper that used the COPRAS-F technique; namely, Garg et al. (2019) used COPRAS-F in the field of e-learning (Table 8).

Table 8. *Literature table for the studies applying COPRAS-F.*

Author Name	Year	Application Field	Publication Type
Garg et al.	2019	e-Learning	Conference

Some reference studies also used the hybrid technique that combined multiple MCDM techniques. Hybrid studies used the following combination of MCDM techniques: AHP-ANP, AHP-DEMATEL, FAHP-FTOSİS, AHP-Quality Function Deployment (QFD), AHP-Weighted Product (WP) -TOPSİS, The Decision Making Trial And Evaluation Laboratory (DEMATEL)-FANP-TOPSİS, AHP-VİKOR, Multiple Criteria Evaluation of the Quality of Learning Software (MCEQLS)-AHP, TOPSİS-VİKOR, AHP-TOPSİS, Multicriteria Group Decision Making (MCGDM), FAHP- WeighBalited Euclidean Distance Based Approach (WEDBA)-COPRAS, FAHP-COPRAS-VIKOR- Weighted Distance Based Approximation (WDBA), and ANP-TOPSİS. Of the reference studies, 19 used hybrid techniques. Bali O. and Gencer conducted the first study with hybrid techniques in 2005. In their study, they used AHP and FAHP together. Naveed Q. N. et al. made the most up-to-date hybrid-technique study on e-learning in 2020 (Table 9).

Table 9. *Literature table for the studies applying hybrid techniques.*

Author Name	Year	Application Field	Publication Type
Bali & Gencer	2005	Student Selection	Journal
Begicevic & Divjak	2006	e-Learning	Journal
Tzeng et al.	2007	e-Learning	Journal
Tekindal & Erumit	2007	Graduate Student Selection	Journal
Nikoomaram et al.	2009	Performance Evaluation	Journal
Altunok et al	2010	Graduate Student	Journal
Chen & Chen	2010	Innovation Support System	Journal
Wu et al.	2012	Performance Evaluation in Universities	Journal
Kurilovasa & Zilinskiene	2013	e-Learning Quality Assessment	Journal
Omurbek et al.	2014	Performance Evaluation in Universities	Journal
Aly et al.	2014	Prioritizing Performance Indicators in Engineering Education	Journal
Mondal & Pramanik	2014	Staff Selection	Journal
Jain et al.	2016	e-Learning	Journal
Garg	2017	e-Learning	Journal
Garg & Jaina	2017	e-Learning	Journal
Kabak et al.	2017	University	Journal
Ghosh & Pal	2017	Academic Performance	Journal
Mohammed et al.	2018	e-Learning	Journal
Naveed et al	2020	e-Learning	Journal

Application Field: MCDM techniques offer essential decision-making tools for the process in higher education. Considering the reference studies in terms of the application field, e-learning ranks first. Staff selection, performance evaluation, source distribution, and course selection were among the other application fields.

Publication Type: The reference studies in this study are 72 in total, 59 of which are articles and 13 of which are scientific conference proceedings.

Index scanned: Of the reference articles, 59 were published in journals reviewed by significant indices like EBSCO, Google Scholar, ProQuest, SCImago, SCOPUS, Social Science Citation Index (SSCI), Science Citation Index Expanded (SCIE), Science Citation Index (SCI), Emerging Sources Citation Index (ESCI), Web of Science, and Institute of Electrical and

Electronics Engineers (IEEE). Five reference articles were published in journals of SSCI, seven in journals of SCIE, two in journals of SCI, and six in journals of ESCI. Furthermore, seven reference articles were published in journals of IEEE indices. Other reference studies were published in common indices like EBSCO, Google Scholar, ProQuest, SCImago, SCOPUS, and Web of Science.

The present study made a literature review of all studies on MCDM practices in higher education until today. As a result of this literature review, no up-to-date research on this field was encountered. In this regard, the present study is thought to pioneer this field. By putting forward application fields in terms of decision-making in higher education, the present study is believed to direct future studies.

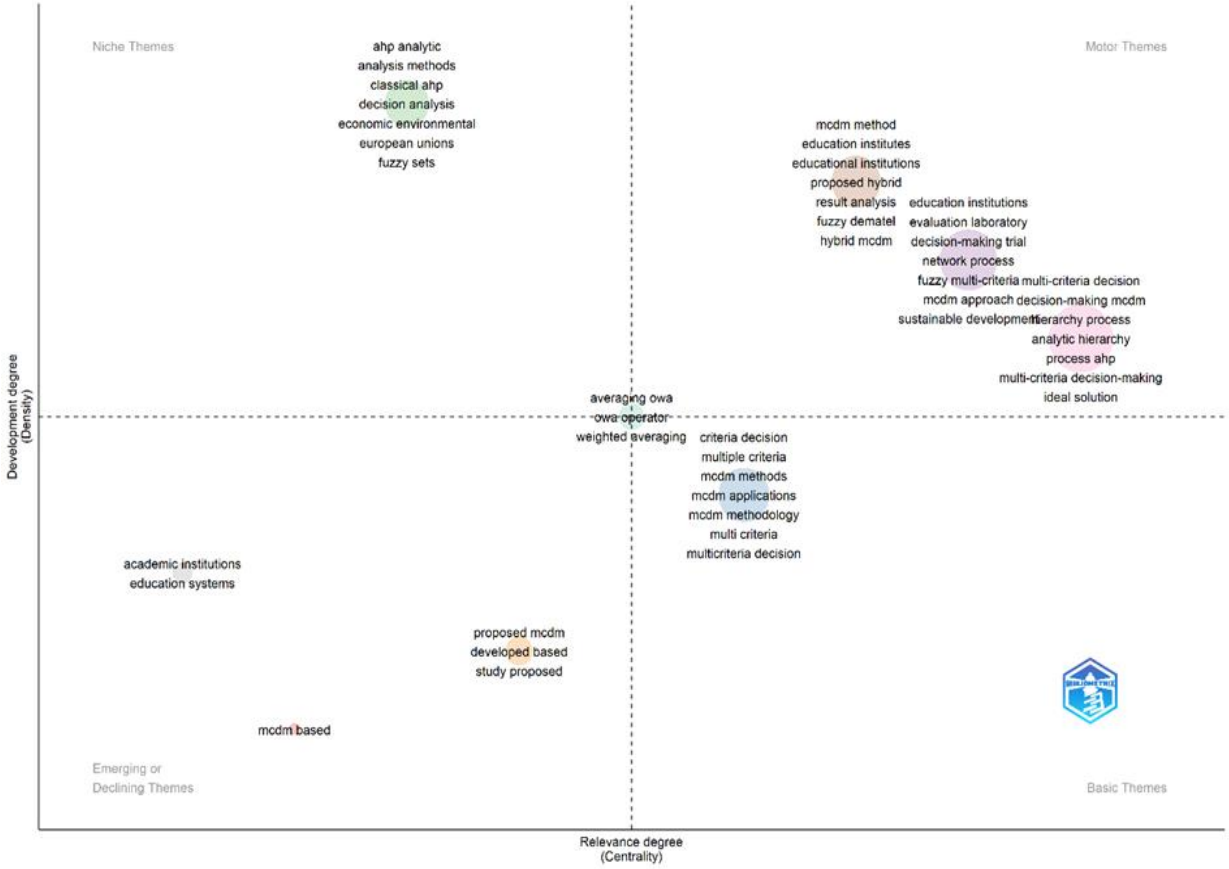
3.2. Thematic Network Analysis

Applying thematic networks is simply a way of organizing a thematic analysis of qualitative data. Thematic Analysis as a method was first developed by Gerald Holton, a physicist, and historian of science in the 1970s (Holton, 1975). The thematic analysis seeks to unearth the themes salient in a text at different levels, and thematic networks aim to facilitate the structuring and depiction of these themes. Thematic Analysis is a method for systematically identifying, organizing, and offering insights into patterns and meanings (themes) across a dataset.

In this study, Thematic Network Analysis was applied to evaluate the development of MCDM studies in the higher education area. The studies assessed by the R-based Bibliometrix Software were mapped thematically (Aria & Cuccurullo, 2017). Four categories; namely, engine, specialty, emerging, and basic themes used to categorize graphs in Thematic Mapping Engine themes are a group of themes that have strong links to other well-developed sub-themes. The most frequently used themes are in the engine themes. Niche themes include well-developed themes that are important in the research field. Emerging themes are low-density less advanced themes. Basic themes include fundamental ideas.

The thematic network map of studies in the higher education area is given in Figure 4. When Figure 4 is examined, it can be said that institutes of higher education are among the most studied themes. Thematic mapping, of which AHP is among the most widely used methods, is also emerging. In addition, it is observed that Fuzzy MCDM models are among the frequently used themes. MCDM studies related to education systems are not among the popular themes. Determination of criteria and evaluation of criteria are among the major themes.

Figure 4. *Thematic network of multi-criteria decision-making in higher education.*



4. DISCUSSION and CONCLUSION

Making accurate decisions is important for higher education institutions that include many intuitions and many employees. MCDM techniques are the tools that help decision-makers make accurate, reliable, and quick decisions. Therefore, it is suggested that MCDM techniques be used in the process of making quick decisions.

The present study addressed the decision-making process in higher education through the lens of MCDM. For this purpose, it presented 72 reference studies that discussed the trends in MCDM techniques in higher education. All the articles were classified by (1) publication year, (2) MCDM technique applied, (3) application field, (4) publication type, and (5) index scanned. Of the 72 articles examined, 35 used the AHP technique. Of the remaining studies, 19 used hybrid techniques and 11 used FAHP. One study for each of the TOPSİS, VİKOR, ELECTRE III, and COPRAS-F techniques was implemented in the higher education area. The AHP technique was the most common technique among MCDM practices in higher education, with 30 scientific articles and five conference papers. The AHP technique was the most common one among MCDM practices in higher education, with 30 scientific articles and 5 conference papers. Thematic Network Analysis also confirms all these results exposed in the study.

Overall, 11 studies, six scientific articles, and five conference papers applied MCDM in e-learning. Thus, e-learning was the most common application field. Due to the spread of the COVID-19 pandemic, universities in many different parts of the world have paused face-to-face education and continued their educational activities online. Therefore, e-learning has become very important. At such a time, MCDM techniques are foreseen to become essential tools to improve e-learning. The articles included in this study were scientific and published in journals that are scanned by significant indices. Of the articles made on MCDM practices in

higher education, 15 were conducted in Türkiye. There existed seven articles that used the AHP method in the field of higher education in Türkiye.

The present study aimed to gather studies on MCDM practices in higher education and guide future researchers in this field. Therefore, future studies can be conducted using MCDM techniques different from those used by the existing studies. Concerning the importance of decision-making today, the authors of the present study hope for an increase in the number of MCDM techniques and approaches in the related literature.

Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research publishing ethics. The scientific and legal responsibility for manuscripts published in IJATE belongs to the authors.

Authorship Contribution Statement

Fatma Seyma Yuksel: Design, Data Collection and/or Processing, Analysis and/or Interpretation and Writing. **Ayse Nilgun Kayadelen:** Concept, Data Collection and/or Processing, Analysis and/or Interpretation and Writing. **Zahide Figen Antmen:** Data Collection and/or Processing and Critical Review. All authors read and approved the final manuscript.

Orcid

Fatma Seyma Yuksel https://orcid.org/0000-0002-8080-2665
Ayse Nilgun Kayadelen https://orcid.org/0000-0002-5442-893X
Zahide Figen Antmen https://orcid.org/0000-0001-8475-1300

REFERENCES

Altunok, T., Özpeynirci, O., Kazancoglu, Y., & Yilmaz, R. (2010). Comparatives of multicriteria decisions making methods for postgraduate student selection. *Egitim Arastirmalari-Eurasian Journal of Educational Research, 40,* 1-15.

Aly, M.F., Attia, H.A., & Mohammed, A.M. (2014). Prioritizing faculty of engineering education performance by using AHP-TOPSİS and balanced scorecard approach. *International Journal of Engineering Science and Innovative Technology, 3*(1), 11-23.

Anggrainingsih, R., Umam, M.Z., & Setiadi, H. (2018). Determining e-learning success factor in higher education based on user perspective using Fuzzy AHP. *MATEC Web Conferences.* 154, 03011. https://doi.org/10.1051/matecconf/201815403011

Aytaç, S., & Bayram, N. (2001). Üniversite gençliğinin iş ve eş seçimindeki etkin kriterlerinin analitik hiyerarşi süreci (AHP) ile analizi [Analysis of university youth's effective criteria for job and spouse selection by analytical hierarchy process (AHP)]. *Öneri Dergisi, 4*(16), 89-100. https://doi.org/10.14783/maruoneri.727643

Badri, M.A., & Abdulla, M.H. (2004). Awards of excellence in institutions of higher education: an AHP approach. *International Journal of Educational Management, 18*(4), 224-242. https://doi.org/10.1108/09513540410538813

Bali, O., & Gencer, C. (2005). AHP Bulanık AHP ve Bulanık Mantıkla Kara Harp Okuluna öğretim elemanı seçimi [Ahp, Fuzzy Ahp, and Fuzzy Logic Selection of Academic Staff to Turkish Military Academy]. *Kara Harp Okulu Savunma Bilimleri Dergisi, 4,* 24-43.

Begicevic, N., & Divjak, B. (2006). Validation of theoretical model for decision making about e-learning implementation. *Journal of Information and Organizational Sciences, 30*(2), 171-184.

Begicevic, N., Divjak, B., & Hunjak, T. (2007). Development of AHP based-model for decision making on e-learning implementation. *Journal of Information and Organizational Sciences, 31,* 13-24.

Bo, L., Xuning P., & Bingquan B. (2009). Modeling of network education effectiveness evaluation in fuzzy analytic hierarchy process. *International Conference on Networking and Digital Society, 2*, 198–200. ICNDS'09, IEEE.

Cakir, E., & Ozdemir, M. (2018). Altı sigma projelerinin bulanık copras yöntemiyle değerlendirilmesi: Bir üretim işletmesi örneği [Evaluation of six sigma projects with fuzzy copras method: An example of a manufacturing company]. *Verimlilik Dergisi, 1*, 7-39.

Cebi, A., & Karal, H. (2017). An application of fuzzy analytic hierarchy process (FAHP) for evaluating students' Projects. *Educational Research and Reviews*, *12*(3), 120-132. https://doi.org/10.5897/ERR2016.3065

Celikten, M., Gilic, F., Celikten., & Yildirim, A. (2019). Örgüt yönetiminde karar verme süreci: Bitmeyen bir tartışma [Decision making process in organization management: An endless discussion]. *Mersin Üniversitesi Eğitim Fakültesi Dergisi, 15*(2), 581-592.

Chao, R.J., & Chen, Y.H. (2009). Evaluation of the criteria and effectiveness of distance e-learning with consistent fuzzy preference relations. *Expert Systems with Applications, 36*, 10657-10662. https://doi.org/10.1016/j.eswa.2009.02.047

Chen, J.F., Hsieh, H.N., & Do, Q, H. (2015). Evaluating teaching performance based on fuzzy AHP and comprehensive evaluation approach. *Applied Soft Computing, 28*, 100-108. https://doi.org/10.1016/j.asoc.2014.11.050

Chen, J.K., & Chen, I.S. (2010). Using a novel conjunctive MCDM approach based on DEMATEL, fuzzy ANP, and TOPSIS as an innovation support system for Taiwanese higher education. *Expert Systems with Applications, 37*, 1981-1990. https://doi:10.1016/j.eswa.2009.06.079

Chen, Y., & Yang, M. (2010). Study and construct an online self-learning evaluation system model based on the AHP method. *2nd IEEE International Conference on Information and Financial Engineering (ICIFE)*, 54–58.

Chena, J.F. Hsieha, H.N. & Do, Q.H. (2015). Evaluating teaching performance based on fuzzy AHP and comprehensive evaluation approach. *Applied Soft Computing, 28*, 100-108. https://doi.org/10.1016/j.asoc.2014.11.050

Chi, H.K., Yeh, H.R., & Liao, L.-H., (2008). Applying fuzzy analytic hierarchy process to explore the university organizational performance in Taiwan. *The Journal of Human Resource and Adult Learning*, *4*(1), 39–46.

Choi, C.R., & Jeong, H.Y. (2019). Quality evaluation for multimedia contents of e-learning systems using the ANP approach on a high-speed network. *Multimedia Tools and Applications, 78*, 28853-28875. https://doi.org/10.1007/s11042-019-7351-8

Cicekli, U.G., & Karacizmeli, A. (2013). Bulanık analitik hiyerarşi süreci ile basarılı öğrenci seçimi: Ege Universitesi İktisadi ve İdari Bilimler Fakültesi örneği [Successful student selection with fuzzy analytic hierarchy process: The example of Ege University Faculty of Economics and Administrative Sciences]. *Ege Strategic Research Journal, 4*(1), 77-103. https://doi.org/10.18354/esam.81730

Colace, F., Santo, M.D., & Pietrosanto, A. (2006). Evaluation models for e-learning platform: An AHP approach. *Proceedings of Frontiers in Education.* 1-6. https://doi.org/10.1109/FIE.2006.322312

Drake, P.R. (1998). Using the analytic hierarchy process in engineering education. *Int. J. Engng Ed., 14*, 191-196.

Dundar, S. (2008). Ders seçiminde analitik hiyerarşi prosesi uygulaması [Analytical Hierarchy Process application in course selection]. *Suleyman Demirel Universitesi Iktisadi ve Idari Bilimler Fakultesi Dergisi 13*(2), 217-226.

Ertugrul, I., & Karakasoglu, N. (2007). Fuzzy TOPSIS method for academic member selection in engineering faculty. *Innovations in E-learning, Instruction Technology, Assesment, and Engineering Education*, 151-156.

Feng, Y.J., Lu, H., & Bi, K. (2004). An AHP/DEA method for measurement of the efficiency of R&D management activities in universities. *Intl. Trans. In Op. Res., 11*, 181-191. https://doi.org/10.1111/j.1475-3995.2004.00450.x

Garg, R., & Jain, D. (2017). Fuzzy multi-attribute decision-making evaluation of e-learning websites using FAHP, COPRAS, VIKOR, WDBA. *Decision Science Letters, 6*, 351-364. http://dx.doi.org/10.5267/j.dsl.2017.2.003

Garg, R. (2017). Optimal selection of E-learning websites using multiattribute decision-making approaches. *J. Multi-Criteria Decision Analysis, 24*, 187-196. https://doi.org/10.1002/mcda.1612

Garg, R., Kumar, R., & Garg, S. (2019). MADM-Based parametric selection and ranking of e-learning websites using fuzzy COPRAS. *IEEE Trans. Educ.*, *62*(1), 11–18. https://doi.org/10.1109/TE.2018.2814611

Ghosh, D., & Pal, A. (2017). Analysis of faculty teaching using a multi-criteria decision-making approach. *International Journal of Engineering & Technology*, *7*, 74-78. https://doi.org/10.14419/ijet.v7i2.28.12884

Giannoulis, C., & Ishizaka, A. (2010). A Web-based decision support system with ELECTRE III for a personalized ranking of British universities. *Decision Support Systems, 48*, 488-497. https://doi.org/10.1016/j.dss.2009.06.008

Grandzol, J.R. (2005). Improving the faculty selection process in higher education: A case for the analytic hierarchy process. *IR Applications, 6*, 13.

Gupta, R., Garg, T.K., Gupta, S., & Goel, A. (2010). Decision Analysis Approach for Quality in Technical Education. *Global Journal of Human Social Science, 10*(1), 14-18.

Ho, W., Dey, P.K., & Higson, H.E. (2006). Multiple criteria decision-making techniques in higher education. *International Journal of Educational Management, 20*(5), 319-337. https://doi.org/10.1108/09513540610676403

Holton, G. (1975). On the role of themata in scientific thought. *Science*, 188(4186), 328-334.

Hsu, C.M., Yeh, Y.C., & Yen, J. (2009). Development of design criteria and evaluation scale for web-based learning platforms. *International Journal of Industrial Ergonomics, 39*, 90-95. https://doi.org/10.1016/j.ergon.2008.08.006

Jain, D., Garg, R., & Bansal, A. (2016). Selection and ranking of E-learning websites using weighted distance-based approximation. *Journal of Computer Education, 3*(2), 193-207. https://doi.org/10.1007/s40692-016-0061-6

Jesus. E.N., Rodrigues, J.C., & Antunes, C.H. (2007). A multicriteria decision support system for housing evaluation. *Decision Support Systems, 43*, 779-790. https://doi.org/10.1016/j.dss.2006.03.014

Jie, C. (2010). Evaluation and modeling of online courses using fuzzy AHP. *2010 International Conference on Computer and Information Application*, 232-235.

Kabak, M., Ozceylan, E., Dagdeviren, M., & Genc T. (2017). Evaluation of distance education websites: a hybrid multicriteria approach. *Turkish Journal of Electrical Engineering & Computer Sciences, 25*, 2809–2819. https://doi.org/10.3906/elk-1512-271

Kara, M., & Karaca, Y. (2010). Üniversite öğrencilerin işletme bölümünü seçmelerinde etkili olan öncelikli faktörlerin analitik hiyerarşi prosesi metodu ile analizi: Bozok Üniversitesi İktisadi ve İdari Bilimler Fakültesinde bir uygulama [Analysis of the priority factors that affect university students' choice of business administration with the analytical hierarchy process method: An application in Bozok University Faculty of Economics and Administrative Sciences]. *Organizasyon ve Yonetim Bilimleri Dergisi, 2*(1), 133-140.

Kiarazm, A., & Koohkan, F. (2013). Performance evaluation in higher education institutes with the use of combinative model AHP and BSC. *Journal of Basic and Applied Scientific Research*, *3*(4), 940-944

Kousalya, P., Ravindranath, V., & Vizayakumar, K. (2006). Student absenteeism in engineering colleges: Evaluation of alternatives using AHP. *Journal of Applied Mathematics and Decision Sciences* 2006. 1–26. https://doi.org/10.1155/JAMDS/2006/58232

Kurilovas, E., & Zilinskiene, I. (2013). New MCEQLS AHP method for evaluating the quality of learning scenarios. *Technological and Economic Development of Economy*, *19*(1), 78-92. https://doi.org/10.3846/20294913.2012.762952

Kurilovas, E., & Serikoviene, S. (2013). New MCEQLS TFN method for evaluating quality and reusability of learning objects. *Technological and Economic Development of Economy*, *19*(4), 706-723. https://doi.org/10.3846/20294913.2013.837112

Kwak N.K., & Lee C. (1998). A multicriteria decision-making approach to university resource allocations and information infrastructure planning. *European Journal of Operational Research*, *110*(2), 234-242. https://doi.org/10.1016/S0377-2217 (97)00262-2

Lee, S.H. (2010). Using fuzzy AHP to develop intellectual capital evaluation model for assessing their performance contribution in a university. *Expert Systems with Applications*, *37*, 4941-4947. https://doi.org/10.1016/j.eswa.2009.12.020

Lesmes, D., Castillo, M., & Zarama, R. (2009). Application of The Analytic Network Process (ANP) to Establish Weights in Order to Re-Accredit a Program of a University. *Proceedings of the International Symposium on the Analytic Hierarchy Process*, 29.

Li, W., Gao, X., & Fu, G. (2012). Fuzzy comprehensive assessment of network environment and learning quality combined with the analytic hierarchy process. *2nd International Conference on Consumer Electrics, Communications and Networks*, 2600-2603, *IEEE*.

Liberatore, M.J., & Nydick, R.L. (1997). Group Decision Making in Higher Education Using the Analytic Hierarchy Process. *Research in Higher Education*, 38, 593–614. https://doi.org/10.1023/A:1024948630255

Lin, H.F. (2010). An application of fuzzy AHP for evaluating course website quality. *Computers & Education*, *54*, 877-888. https://doi.org/10.1016/j.compedu.2009.09.017

Mehregan, M.R., Jamporazmey, M., Hosseinzadeh, M., & Mehrafrouz, M. (2011a). Proposing an approach for evaluating e-learning by integrating critical success factor and fuzzy AHP. *International Conference on Innovation, Management and Service, Singapore.*

Mehregan, M.R., Jamporazmey, M., Hosseinzadeh, M., & Mehrafrouz, M. (2011b). Application of fuzzy analytic hierarchy process in ranking modern educational systems' success criteria. *International Journal of e-Education*, *1*(4), 299-304.

Melon, M.G., Beltran, P.A., & Cruz, M.C.G. (2008). An AHP-based evaluation procedure for Innovative Educational Projects: A face-to-face vs. computer-mediated case study. *Omega*, *36*, 754-765. https://doi.org/10.1016/j.omega.2006.01.005

Mendoza, G.A., Prabhub, R. (2000). Multiple criteria decision-making approaches to assessing forest sustainability using criteria and indicators: A case study. *Forest Ecology and Management*, *131*, 107-126.

Mohammed, H.J., Kasim, M.M., & Shaharanee, I.N. (2018). Evaluating of e-learning approaches using AHP-TOPSIS technique, *Journal of Telecommunication, Electronic and Computer Engineering*, *10*, 1-10.

Mondal, K., & Pramanik, S. (2014). *Neutrosophic Sets and Systems*, *6*, 28-34.

Murakoshi H., Kawarasaki T., & Ochimizu K. (2001). Comparison using AHP Web-based learning with classroom learning**,** *Proceedings of Symposium on Applications and the Internet Workshops***,** 67-73. https://doi.org/10.1109/SAINTW.2001.998212

Mustaffa, W.S.W., Shokory, S.M., & Kamis, H. (2006). The Analytical Hierarchy Process: Multi-Criteria Decision Making for Promoting Academic Staff in Higher Education. *The Journal of Global Business Management*, *2*(2).

Nagpal, R., Mehrotra, D., Sharma, A., & Bhatia, P. (2013). ANFIS method for usability assessment of the website of an educational institute. *World Applied Sciences Journal*, *23*(11), 1489–1498. https://doi.org/10.5829/ idosi.wasj.2013.23.11.790

Nagpal, R., Mehrotra, D., Bhatia, P.K., & Sharma, A. (2015). FAHP approach to rank educational websites on usability. *International Journal of Computing and Digital Systems*, *4*(4), 251–260. http://dx.doi.org/10.12785/IJCDS/040404

Naveed, Q.N., Qureshi, M.R.N., Alsayed, A.O., Muhammad, A., Sanober, S. & Shah, A. (2017). Prioritizing barriers of E-learning for effective teaching-learning using fuzzy analytic hierarchy process (FAHP*). 4th IEEE International Conference on Engineering Technologies and Applied Sciences (ICETAS)*, 1-8.

Naveed, Q.N., Qureshi, M.R., Tairan, N., Mohammad, A., & Shaikh, A. (2020). Evaluating critical success factors in implementing e-learning system using multi-criteria decision-making. *PLoS ONE*, *15*(5), https://doi.org/10.1371/journal.pone.0231465

Nilashi, M., & Janahmadi, N. (2012). Assessing and prioritizing affecting factors in e-learning websites using the AHP method and fuzzy approach. *Information and Knowledge Management*, *2*(1), 46-61.

Nikoomaram, H., Mohammadi, M., Javad Taghipouria, M., & Taghipourian, Y. (2009). Training performance evaluation of administration sciences instructors by fuzzy MCDM approach. *Contemporary Engineering Sciences*, *2*(12), 559–575.

Omurbek, N., Karaatli, M., & Yetim, T. (2014). Analitik hiyerarsi surecine dayali TOPSIS ve VIKOR yöntemleri ile ADIM universitelerinin değerlendirilmesi [Evaluation of ADIM universities with TOPSIS and VIKOR methods based on analytical hierarchy process]. *Selcuk Universitesi Sosyal Bilimler Dergisi*, Dr.Mehmet YILDIZ special issues. 189-207.

Opricovic, S., (1998). *Multicriteria Optimization of Civil Engineering Systems* [Doctoral dissertation, Faculty of Civil Engineering].

Ozdemir, M.S., & Gasimov R.N. (2004). The analytic hierarchy process and multiobjective 0-1 faculty course assignment. *European Journal of Operational Research*, *157*, 398-408. https://doi.org/10.1016/S0377-2217(03)00189-9

Ozkul, A.E., Girginer, N., & Ozturk, Z.K. (2007*). Multi-Criteria Evaluation of Distance Education Implementation Models using Analytic Hierarchy Process*, Proceedings of the 21st Annual Conference Empowering Asia through Partnership in Open and Distance Learning, 87.

Ozturk, Z.K. (2014). Using a multi-criteria decision making approach for open and distance learning system selection. *Anadolu University Journal of Science and Technology– An Applied Sciences and Engineering*, *15*(1), 1-14.

Paksoy, S. (2015). Ülke göstergelerinin vikor yöntemi ile değerlendirilmesi [Evaluation of Country Indicators by Vikor Method]. *Ekonomik ve Sosyal Araştırmalar Dergisi*, *11*(2), 153-169.

Perez Vergara, I.G., Arias Sa´nchez, J.A., Poveda-Bautista, R., & Diego-Mas J.A. (2020). Improving distributed decision making in inventory management: A combined ABC-AHP approach supported by teamwork. *Complexity*, 3–5, 1–13.

Politis, Y., & Siskos, Y. (2004). Multicriteria methodology for the evaluation of a Greek engineering department. *European Journal of Operational Research*, *156*, 223-240. https://doi.org/10.1016/S0377-2217(02)00902-5

Ray, S. (2007). Selecting a doctoral dissertation supervisor: analytical hierarchy approach to the multiple criteria problem. *International Journal of Doctoral Studies*, *2*, 23-32. https://doi.org/10.28945/55

Roy, B. (2005). Paradigms and challenges. In J. Figueira, S. Greco, & M. Ehrgott (Eds.), *Multiple criteria decision analysis: State-of-the-art surveys* (pp. 3–24). Springer.

Saaty, T. L. (1999). Basic theory of the analytic hierarchy process: How to make a decision. *Revista de la Real Academia de Ciencias Exactas Fisicas y Naturales*, 93(4), 395-423.

Saaty, T.L., & Ramanujam, V. (1983). An objective approach to faculty promotion and tenure by the analytic hierarchy process. *Research in High Education*, *18*, 311-331. https://doi.org/10.1007/BF00979603

Sagir, M., & Ozturk, Z.K. (2010). Exam scheduling: Mathematical modeling and parameter estimation with the Analytic Network Process approach. *Mathematical and Computer Modelling*, *52*, 930-941. https://doi.org/10.1016/j.jallcom.2011.02.170

Shee, D.Y., & Wang, Y.S. (2008). Multi-criteria evaluation of the web-based e-learning system: A methodology based on learner satisfaction and its applications. *Computer & Education*, *50*. 894-905. https://doi.org/10.1016/j.compedu.2006.09.005

Soba, M. (2012). Universite öğrencilerinin performanslarinin akademisyenler tarafından analitik hiyerarşi sureci ile değerlendirilmesi [Evaluation of university students' performances by academics through the analytical hierarchy process]. *Electronic Journal of Social Sciences*, *11*(42), 368-381.

Subbaiah, K.V., Shekhar, N.C., & Kandukuri, N.R. (2014). Integrated DEA/TOPSIS approach for the evaluation and ranking of engineering education institutions-a case study. *International Journal of Management Science and Engineering Management*, *9*(4), 249-264. https://doi.org/10.1080/17509653.2014.902758

Syamsuddin, I. (2012). Fuzzy multi-criteria evaluation framework for E-learning software quality. *Academic Research International*, *2*(1), 139-147.

Tekindal, B., & Erumit, A.K. (2007). Analitik hiyerarşi sureci (AHS) ve bulanık AHS yöntemlerinin yüksek lisans öğrencisi seçimi problemi üzerinde karşılaştırılması [Comparison of analytical hierarchy process (AHS) and fuzzy AHP methods on graduate student selection problem]. *Gazi Üniversitesi Endüstriyel Sanatlar Eğitim Fakültesi Dergisi*, *21*, 14-37.

Tezergil, S. (2016). Vikor yöntemi ile Türk bankacılık sektörünün performans analizi [Evaluation of Country Indicators by Vikor Method]. *Marmara Üniversitesi İktisadi ve İdari Bilimler Dergisi*, *38*(1), 357-373. https://doi.org/10.14780/iibd.92056

Timor, M., (2011). *Analitik hiyerarşi prosesi* [*Analytical hierarchy process*]. Türkmen Kitabevi.

Turki, A., & Duffuaa, S. (2003). Performance measures for academic departments. *International Journal of Educational Management*, *17*(7), 330-338. https://doi.org/10.1108/IJEM-09-2014-0129

Tzeng, G.H., Chiang, C.H., & Li, C.W. (2007). Evaluating intertwined effects in learning programs: A novel hybrid MCDM model based on factor analysis and DEMATEL. *Expert Systems with Applications*, *32*, 1028-1044. https://doi.org/10.1016/j.eswa.2006.02.004

Wu, H.Y., Chen, J.K., Chen, I.S., & Zhuo, H.H. (2012). Ranking universities based on performance evaluation by a hybrid MCDM model. *Measurement*, *45*, 856-880. https://doi.org/10.1016/j.measurement.2012.02.009

Yazdani, B.O., Yaghoubi, E.S., & Giri, E.S. (2011). Factors affecting the empowerment of employees (an empirical study). *European Journal of Social Sciences*, *20*(2), 267-274.

Yigit, T., Isik, A.H., & Ince, M. (2014). Web-based learning object selection software using analytical hierarchy process. *IET Software*, *8*(4), 174–183. https://doi.org/10.1049/iet-sen.2013.0116

Zare, M., Pahl, C., Rahnama, H., Nilashi, M., Mardani, A., Ibrahim, O., & Ahmadi, H. (2016). Multi-criteria decision-making approach in e-learning: A systematic review and classification. *Applied Soft Computing*, *45*, 108-128. https://doi.org/10.1016/j.asoc.2016.04.020