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Investigation of the Applications of Multicriteria Methods in Decision-Making for Location of Distance Education Centers

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Abstract The last Census of higher education conducted in Brazil, in 2018, identified an increase of approximately 9% in the modality of distance education. This achievement is due to the decree published by the Ministry of Education, in which it authorizes higher education institutions to offer distance courses without needing to have them physically, and the ordinance that indicates how many face-to-face supports centers the institution can implement, according to the IC – institutional concept. Thus, the question is: what methods have been used for location decision? Is there any application in the educational area, specifically in higher education? It is known that the incorrect choice of location creates obstacles to productivity or service, so this study aims to verify which methods are used in the decision-making for the location of distance education centers, that is, a method of investigation. As a result, 9 articles related to the location decision were found, but none of them related to Distance Education.

Keywords: Multicriteria Methods, Support Decisions, Location Decision, Distance Education.

1 Introduction

In 2018, roughly 3.4 million students entered in higher education courses, according to the Synopsis of Higher Education, conducted by the National Institute of Educational Studies and Research Anísio Teixeira (INEP). Between 2017 and 2018, there was an increase in the number of entrances to distance education modalidy, which represented a positive variation of 27.9%, whereas face-to-face modality had a decline of 3.7% [3].

Also, according to the same Brazilian survey conducted by INEP [3], in 2018, for the private education network, there was a total of 10,310 support centers for distance education, and in 2009 there were 4,426 units, that is, there was an increase of 57.1%. In 2017, there were 5,656 centers compared to 2018, an increase of 45.1%. Thus, there is a strong trend in expansion of distance education, so it is necessary to think about strategies that can meet the high demand of potential students.

The increase in the implementation of center is justified by decree 9,057/2017, in which the Ministry of Education (MEC) withdrew the obligation to offer face-to-face courses so that HEI (Higher Education Institutions) could offer the distance education. Thus, Ordinance No. 11/2017 was established authorizing HEI to create distance education centers, respecting the maximum number established, according to the Institutional Concept - IC, for example, for an HEI with CI 5, the annual quantity is a maximum of 250 centers. For a CI 3, the maximum number is 50 centers [4].

This study is justified by its contribution to the scientific community, through the survey and analysis of the results derived from the numerical tools applied to location decision, furthermore, it is necessary to understand what level the applications of the numerical methods is in the decision-making for location of

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distance education centers and what approach has been used. Aiming to identify which methods are used in decision-making for location of distance education centers. The following questions were asked:

- What methods have been used for localization decision?
- Is there any application in the educational area, specifically in higher education?

Therefore, the specific objectives were defined: (i) selecting a portfolio of published articles used in the decision-making for location of distance education centers. (ii) Making the analysis of the portfolio and its applications. The importance of this study is emphasized, in view of the high demand of students seeking this teaching modality.

2 Theorical framework

This section introduces fundamentals of the relevance of PAP (Face-to-Face Support Pole) and conceptualizes issues related to Multicriteria Decision Support, subdividing into Decision-Making Processes.

2.1 Face-To-Face Support Center - PAP

The propagation of distance education is due to the democratization of access to knowledge, on the need to answer the demand required by the market and the current social scenario. For this, there was the creation and implementation of policies for access and permanence to higher education [9].

In Brazil, the practice of distance education is based on the need to carry out face-to-face activities and assessments, so PAPs play an important role in this modality. With the legislation approved in 2017, which removes the obligation of HEI to have a face-to-face course to offer distance education, there was an increase in the facility and flexibility for the installation of these PAPs [12].

In small counties, the offer of courses and admission to higher education contribute to the propagation and internalization of possibilities for study and qualification, this is possible through the implementation of PAPs [10].

Therefore, the installation and progression of PAPs provide the local population the opportunity to access higher education and, thus, their professional qualification [10]. Consequently, social results are positive, such as improvement in development rates [10].

2.2 Multicriteria Decision Support

The Multicriteria Decision Support (AMD) has a different approach, it does not present a decision or decision-makers for the problem, showing a single optimal solution, that is, it aims to support decision-making, recommending actions or courses of action for the decision-maker, thus the selection of the possible best option occurs [13; 5].

As a differential, several points and actions are considered - formed by grouping of criteria, derived from a mathematical function, in which it serves to measure the performance of each action [5]. So, through its methods, AMD is the intermediary by which the link between the quality of information and the excellence of support for decision-making can be carried out [13].

They are multicriteria decision characteristics, situations in which it is shown alternatives to be chosen, ordained, or classified, from the conflicting criteria. Moreover, the presence of a decision-maker is required, with a sort of preference already structed. These problem characteristics differs the application of multicriteria methods from the application of common optimization problems in operational research [6].

3 Methodology

For the conduction of this study, it was used as a guideline Falbo's [11] work which demonstrates its phases. Initially, a planning with the definitions of the objectives and the protocol, was made. The purpose of this phase is to verify the need for carrying out the investigation.

For this, the articles published between 2014 and 2019 were browsed, through the Scopus and Web of Science databases, using the search strings presented in Table 1.

Table 1 Research Strings

Keywords
((multivariate analysis) OR (multicriteria analysis) OR (cluster analysis) OR (decision multivariate) OR (decision multicriteria)) AND ((decision criteria) OR (decision methods)
((decision criteria) OR (decision methods) OR (location of facilities)) AND ((distance learning) OR (distance education) OR (e-learning) OR (franchise opening))
((multivariate analysis) OR (multicriteria analysis) OR (cluster analysis) OR (decision multivariate) OR (decision multicriteria)) AND ((distance learning) OR (distance education) OR (e-learning) OR (franchise opening))

First, a spreadsheet was created in which all found data was recorded. Initially, the articles found were registered, with the following information: keywords, database, title, abstract, repetition, inclusion and exclusion. Inclusion and exclusion criteria were carried out as:

- 1st step - EC1: removing duplicate articles.
- 2nd step - CI1/CE2: reading the title and abstract of the article, to verify familiarity with the theme, that is, the ones that are used in the decision-making for location. Articles that did not fall under CI1 were automatically excluded (CE2). If in the preliminary analysis there was any doubt regarding the article, it was included to be checked later.
- 3rd step - CI2: selection and detailed analysis (introduction, methodology and results) of articles that present application of numerical method and/or cluster analysis, according to the defined search terms, and practical application of decision-making for location.
- 4th step - CE4: when performing CI2, it must be checked if the article is in Portuguese and/or English. Otherwise, it is disregarded.

It was found 244 articles. The search process took place between October and November 2019. The search was performed in both languages: Portuguese and English. There was no definition of publication area.

4 Methodology

After the preparation of the investigation protocol, the research was conducted. Having that, it was found 244 articles, from which 91 were duplicates. After reading the abstracts, 14 articles were selected, because they had familiarity with the location decision.

Continuing the application of the protocol, all the 14 articles were analyzed, according to the 3rd and 4th steps. The excluded articles are shown in Table 2.

Table 2 Excluded Items - Final Round

Database	Year	Author	Title	Why is that?
Scopus	2014	[18]	Utilization of the multicriteria decision-making methods for the needs of mining industry	It is an article that explains the development of software for localization decision.

Scopus	2015	[20]	The effects of photovoltaic electricity injection into microgrids: Combination of Geographical Information Systems, multicriteria decision methods and electronic control modeling	The focus of the study is on micro-network calculation.
Web of Science	2016	[1]	A multicriteria decision making approach for evaluating renewable power generation sources in Saudi Arabia	The study is not focused on location, but rather the use of renewable energy.
Scopus	2017	[16]	Investigating utility level of waste disposal methods using multicriteria decision-making techniques (case study: Mazandaran-Iran)	The study does not address localization
Web of Science	2019	[22]	Selection of sites for allocation of waste disposal objects based on the multicriteria decision-making methods	Another language, other than English and Portuguese (Russian).

Source: author.

The selected articles are shown in Table 3.

Table 3 Selected Articles - Final Phase

Database	Year	Author	Title	Methodology
Scopus	2014	[17]	Biogas plants site selection integrating Multicriteria Decision Aid methods and GIS techniques: A case study in a Portuguese region	GIS and ELECTRE TRI
Scopus	2014	[15]	A comparison of fuzzy multicriteria decision making methods for intelligent building assessment	AHP and FUZZY TOPSIS
Scopus	2015	[5]	Multicriteria decision-making method: Application to the spatial location of a 24-hour Emergency Care Unit-UPA	AHP
Web of Science	2015	[21]	Application of multicriteria decision methods for electric supply planning in rural and remote areas	AHP and VIKOR
Scopus	2016	[14]	Multicriteria decision-making method for sustainable site location of post-disaster temporary housing in urban areas	SWOT and AHP
Scopus	2017	[2]	Aid application multicriteria the decision based on AHP method and Fuzzy Logic in commercial land selection	AHP and Fuzzy Logic
Web of Science	2017	[19]	Select of alternative landfill site in Kanchipuram, India by using Gis and multicriteria decision analysis	GIS and AHP
Web of Science	2018	[7]	Evaluation of ecotourism sites: a GIS-based multicriteria decision analysis	GIS, AHP and PROMETHEE
Scopus	2019	[8]	Application of Mixed Multicriteria Decision-making Methods to Determine the Optimal Development Industries for the Taoyuan Aerotropolis, Taiwan	Delphi fuzzy and ANP

Source: author.

4.1 Quantitative portfolio analysis

The number of articles selected per year is represented by Figure 1.

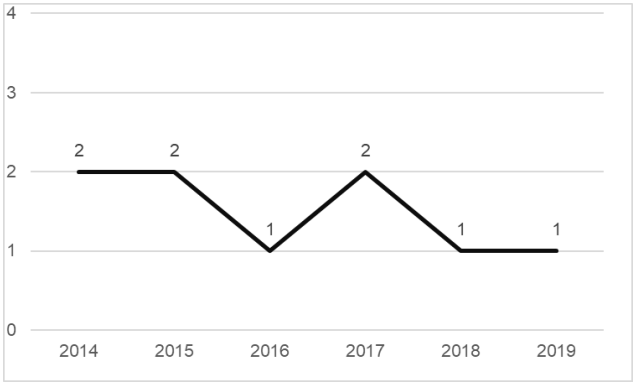

Fig. 1 Number of articles per year. Source: authors (2020)

From the selected articles, per country the number of included articles is Figure 2.

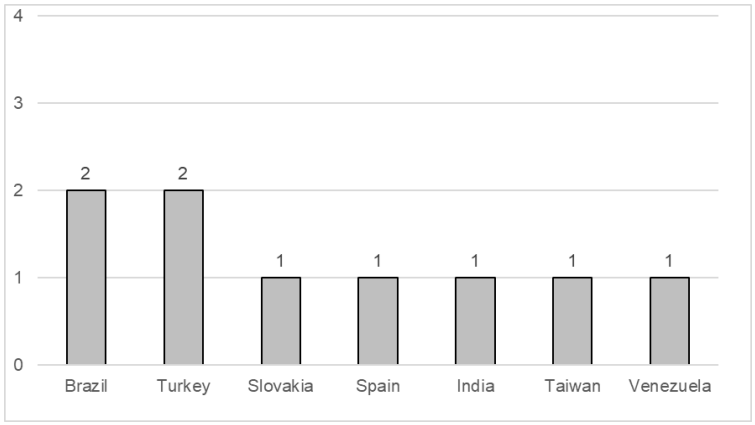

Fig. 2 Number of articles by country. Source: authors (2020)

In terms of method the number of articles is Figure 3.

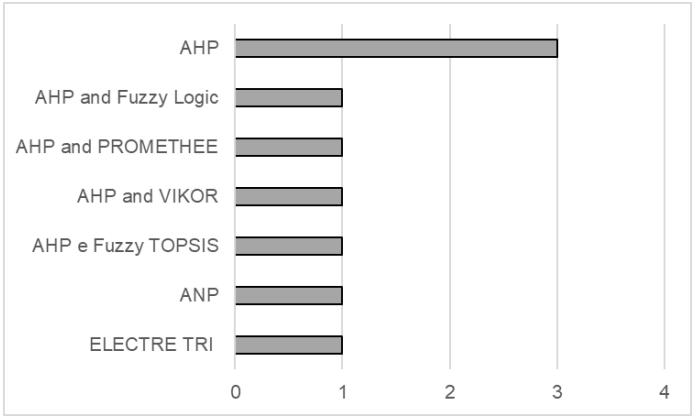

Fig. 3: Number of articles by multicriteria method. Source: authors (2020).

4.2 Qualitative portfolio analysis

After presenting the articles found, TABLE 3, with the identifications: database, year of publication, title and MCDM method, respectively, information found were consolidated.

For the year 2014, initially, we have the article by the authors [17], published in Biomass and Bioenergy, in which the objective was to determine the most appropriate place for the installation of biogas plants. After using the ELECTRE TRI method, the results showed that the multicriteria method was satisfactory to solve the problem of land adequacy, leading to a flexible and integrated evaluation [15], from the Journal of Civil Engineering and Management, used the AHP and FUZZY TOPSIS methodology in the preparation of an evaluation of intelligent buildings. Thus, the methods used converged to the same site option, among the three used in the study.

In 2015, [5], from Management & Production, published a study in which aimed to identify the best place to install an Emergency Care Unit - UPA 24 h. The application of the AHP method allowed to hierarchize the candidate sites, presenting "Site 1" as the best ranked, serving as a subsidy for the municipal manager to make the decision for the installation of the UPA.

While [21], from Renewable and Sustainable Energy Reviews, the study aimed to facilitate the selection of the best solution for electrical supply of distant rural locations. The results revealed that the combination of AHP and VIKOR methods with various criteria facilitates decision-making in a robust, comprehensive, transparent and consistent manner with the requirements established by sustainable development. Therefore, the Compacted Distributed Generation resulted in the best model of electrical supply.

In 2016, the authors [14], Journal of Construction Engineering and Management – ASCE, developed a model to support decision-makers in choosing places for temporary housing using the SWOT and AHP methods. The model and the requirements tree proposed in the study are generic for any temporary post-disaster housing site.

To [2], Management & Production, in 2017, the focus was to select land for commercial buildings in the city of Rio de Janeiro using multiple decision-making techniques, being AHP and Fuzzy Logic. The methods used can be considered satisfactory in the selection of commercial land in the city. In the same year, [19], published in Applied Ecology and Environmental Research, a study to identify the most appropriate method for waste disposal, considering the environmental, geographical, and climatic aspects of the Mazandaran city, India. The criteria were evaluated as residential area, road network, geology, geomorphology, and soil. Thus, the developed system covers social, environmental, geological and accessibility conditions. The research sought to introduce a model to select an appropriate landfill in the counties, with the help of AHP and the geographic information system.

In 2018, [7], published in Kybernetes a study of possible geographical locations for ecotourism activities. As a result of the study, the west of Sinop and east of Artvin were determined as very suitable sites for ecotourism among 27 alternatives, using the GIS, AHP and PROMETHEE methods. In the latest article of 2019, [8], from the International Regional Science Review, determined the ideal location for allocation of the economic sector within Aerotropólis. The industries evaluation was carried out applying delphi fuzzy and ANP methods.

Finally, after the investigation of the literature and with the synthesis from the 9 selected articles the methods found were: AHP, ANP, Fuzzy Logic, ELECTRE, PROMETHEE, TOPSIS and VIKOR, in which the AHP is the most used.

5 Final Considerations

To aid in the decision-making for location of distance education centers you should use the multicriteria method because the problem has the following characteristics: for location, more than one location is used as an implementation alternative, location A, location B and location C, for example: it is a problem of choice in which the criteria are conflicting; and it depends on a decision-maker, which means that no matter how much the method demonstrates the best alternative, the decision will always be up to the decision-maker.

The aim of this study was to identify which methods are used in decision-making for location of distance education centers, that is, a method of investigation.

Finally, after investigating the literature and concluding with the synthesis from the 9 selected articles, it was found that:

- in line with the research questions, the methods that have been used in the decision for location are AHP, ANP, Fuzzy Logic, ELECTRE, PROMETHEE, TOPSIS and VIKOR, with predominance in the AHP method, it is believed that this method is the most used due to its easy use and for being a hierarchical method and compensatory, as well as transforming empirical data into numerical models.

- as no application was found in the educational area, specifically in higher education, so, the suggestion is to raise the criteria used in the articles found and apply the multicriteria method AHP, an validate the application with the HEI decision maker.

Thus, before the criteria established for the research, it was not possible to find a study that applied directly to the distance education centers. Therefore, it is suggested applying multicriteria methods when it comes to decision-making for location.

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