MULTICRITERIA ANALYSIS AND DISTANCE LEARNING. CONCEPTS AND SYNERGIES THROUGH A LITERATURE REVIEW AND BIBLIOMETRIC ANALYSIS

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Abstract

Nowadays higher education and especially universities deal with an extensive range of challenges. Students' inclusion and satisfaction as well as educational quality and efficiency are main aspects of interest. These objectives are called to respond to increased dropout rates, and the ineffectiveness of a traditional "one-size-fits-all" approach to education. Educational efficiency significantly depends on the cooperation and communication of students and instructors. Institutions are called to make decisions on all aspects of the provided courses from design to implementation. In this context, multicriteria analysis is implemented throughout this educational process to provide the best end result for the students and educators. In the context of the current study, Distance Education is the focus of the research. It is generally accepted that Distance Education is sustainable and flexible and therefore, it is capable to accommodate the needs and timetable of the students and educators, without compromising the teaching and learning experience, quality and efficiency. The current study provides an extensive literature review focusing on multicriteria analysis and its applications in the field education in general and more specifically in distance education. The investigation took place mainly through Scopus database and covered all years reaching up to 2023. The literature review investigation, after a focused screening, returned 177 documents. These were recorded in a Mendeley database. Literature review highlighted that multicriteria analysis is widely used in all aspects of education and especially in distance education, which is the theme of the current paper. Multicriteria decision analysis is implemented in all stages of realization of a distance education system. It successfully enabled decision makers and distance education stakeholders to make educated decisions regarding organization and operation of online learning courses. Furthermore, a bibliometric analysis has taken place, through the use of VOS-viewer, and identified fundamentals concepts that are representative of the association of multicriteria analysis to distance learning. The analysis has highlighted Analytic Hierarchy Process, Goal Programming and Resource Allocation as a number of core concepts.

Keywords: Distance Education, Multicriteria Analysis, VOS-viewer.

1 INTRODUCTION

In the early studies of multicriteria analysis, a lot of effort focused on defining the field, highlighting the decision process and expectations. Special attention was provided to analyzing the available tools, with emphasis on Analytic Hierarchy Process (AHP), as it was one of the most widespread approach for decision making. The initial steps for multicriteria analysis focus on the profile of the multicriteria analysis.

As the years pass, multicriteria analyses is becoming an established approach for decision making problems and meeting the needs of distance education. At a certain point in time, both multicriteria analysis and distance education have matured enough to cooperate and integrate. Therefore, a lot of research and studies, analyzed decision making needs, processes and capabilities in the context of distance education and show aspects of how various decision aids support each step of the process. It is safe to support that in the early years, there is not a significant association between multicriteria analysis and distance education. As the years pass, a strong association between these two fields is building up and developing continuously. In the centre of the synergies among these fields, one could highlight the user satisfaction. Moreover, a vast amount of studies are focusing on web- based evaluation models which implement a multiple criteria methodology.

In the following sections literature review is presented in detail. The methodology is then highlighted to analyse the approach followed in the current study. Finally, conclusions, limitations and future research are presented.

2   LITERATURE REVIEW

The literature review regarding multicriteria analysis especially in the period up until 2004 did not focus so much on education and more specifically on distance education. In the specific era, multicriteria decision analysis is trying to define its field and optimize its performance. At the same time, a lot of studies have taken place in the effort to evaluate the synergies among MCDA and other scientific fields. Best practices are also discussed and analyzed. In this context, the process of decision-making is frequently analyzed in literature and often accompanied by identified aids and barriers. Individual suggestions and approaches to upgrade the decision-making procedures and tools are also considered and presented. A very interesting aspect of the studies involved the ways and tools that can facilitate learning in the case of decision makers and provide useful feedback to them. It is worth mentioning that a great deal of research focuses on the subjective preferences and values procured by the decision makers. Research is evolving to embrace more fields of application for multicriteria analysis. In the years from 2005 to 2014 Multicriteria analysis and Distance Education are presenting strong cooperation.

An important advantage of multicriteria analysis methods is that they are simple in structure and can be adapted to different kinds of decisions and decision-making processes in higher education. MCDM can handle large amounts of information and aid complex decision-making processes. Multicriteria analysis allows the interested parties to move toward consensus, while it enables them to advocate their concerns in light of everyone else's concerns and see the decision from multiple perspectives (Blanchard et al., 1989).

Weitz et al (1992) presented a multi-criteria allocation decision support system (MCADSS) which was developed for assigning students to groups, describing its rationale, design criteria, the system methodology, and application results. The goal of MCADSS was to maximize the diversity of members within groups, while minimizing the average differences between groups. The implementation of the decision support system demonstrated that it works in a way comprehensible to users, as it provides suitable data presentation and statistical analyses, while it allows the user to adjust solutions and observe the consequences, including also measurements of the solution quality.

In addition, it has been observed that resource allocation has been the most significant reason for multiple criteria decision making (MCDM) applications in higher education administration, followed by planning, evaluation and other purposes (Mustafa et al., 1996). MCDM models have the advantage of being able to simultaneously consider multiple objectives in the decision-making situation, thus being more amenable in higher education administration, compared to other management science techniques.

Decision tools can help students make better choices regarding job decisions and career choices in general, even help assigning undergraduate students to academic major areas (Saber & Ghosh, 2001). There are MCDA tools like "Criterium" which can help the user to decompose a very complex problem (such as the career choice) into a series of much simpler preferences between sets of factors (Mills et al., 1993).

Apart from simplifying the decision-making processes, MCDM methods are appropriate for solving prioritization problems. For instance, Dutta et al (2003) explored the application of the multicriteria method of Simple Multi-Attribute Rating Technique (SMART), to support the IS Department of Leeds University when prioritizing IS projects. The solution resulting from the implementation of the model was welcomed by the Leeds IS managers as an effective way to deal with their project prioritization problem.

Evaluation of research performance is another issue, to which multicriteria analysis methods can contribute. Korhonen et al (2001) used the multicriteria analysis method of analytic hierarchy process (AHP) for the evaluation of the relative importance of various indicators with regard to a set of criteria. They implemented a value efficiency analysis, based on the collected data on the research units and the efficiency of them was defined in the spirit of data envelopment analysis (DEA), complemented with decision maker's preference information. The model of the analytic hierarchy process (AHP) has been used by other higher education institutes, too, such as the Dar Al-Hekma women's college in Jeddah, Saudi Arabia, where it helped the committee to make a complex selection decision (Bahurmoz, 2003). The model was identified as user-friendly, as it was based on simple constructions that conform to what people actually do using logic and discussion to express their opinions before reaching a collective decision.

The AHP approach can also be combined with the Hierarchy Consistency Analysis (HCA), in order to provide a double check for the decision maker's consistency (Guh, 1997). This new hierarchy evaluation methodology was developed, in order to determine the weights in modeling a hierarchy structure. Thus, HCA has been presented as a new weighting methodology to deal with multiple-criteria and multiple-level evaluation problems. The approach is especially suited for large, complex problems where different hierarchy structures occur frequently and naturally.

Of course, there are cases in the multi-criteria group decision-making process, where it is hard to obtain a solution due to the possible conflict preferences from different participants and the non-deterministic weights assigned to each criterion. Regarding these cases, where a compromise weight does not exist, Wei et al (Wei et al, 2000) described a minimax principle-based procedure of preference adjustments with a finite number of steps to find the compromise weight. In this approach, a consistency index is defined for recording each group participant's preference adjustment and measuring the distance between the individuals' preference and the final group decision.

Issues of transparency and participation and their relation with multicriteria analysis methods have been also explored in the literature. For instance, Mustajoki et al (2004) have evaluated the regulation policies in Lake Päijänne in Finland, with the use of Web-HIPRE and specifically through the method of Multi-attribute Value Theory (MAVT). Web-HIPRE is a web-based multicriteria decision analysis software, and its role in the environmental decision making is highlighted. The paper discusses especially the different possibilities that Web-HIPRE provides to support participatory processes in environmental decision making. The paper has underlined that the use of the web-based tools of Web-HIPRE and "Opinions-Online" provided transparency to the process, while they also made it possible to activate people who otherwise would not have the possibility to participate in the public meetings. Thus, the use of the web, teleconferencing, on-line decision support, as well as geographic information systems may improve public participation in general.

Psaromiligkos et al (2014) have presented a detailed description of the findings of a new methodological approach for the analysis of students' preferences in e-learning courses. This proposed course of action is based on the principles of theory of committees and elections and multicriteria disaggregation-aggregation decision aid approaches. The approach proposed by the authors provides a detailed analysis of students' preference models at multiple levels. Within the course level exists a detailed analysis of students' preferences concerning all the modules of the course according to the underlying learning activities. At the macro level there exists a detailed analysis of multiple courses or a whole curriculum according to specific services offered by an educational institution. At a micro level an instructor can obtain analysis of students' preferences in collaborative learning strategies according to the quality of the achieved individual and group learning outcomes.

Other authors have also explored evaluation methods of virtual learning environments. Cobo et al. (2014) explored a new multicriteria approach to evaluate and classify the level of interactivity of students in learning management systems (LMS) and concluded that the behavioural patterns in LMS offer certain indicators as to students' academic performance. Kyriakaki et al (2014) evaluated e-learning Websites in terms of their pedagogical quality, using a multi-criteria evaluation model for e-learning websites based on well-known pedagogical principles, namely Bloom's taxonomy of six cognitive objectives (Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation).

Evaluation of e-learning environments and tools has been further explored in literature. Islas-Pérez, et al. (2012), have compared learning technologies based on multi-criteria decision making, aiming at assisting e-learning users and developers for developing a system for management of resources, courses and learning objects. Zaied (2012) has analyzed multi-criteria evaluation approaches for e-learning technologies selecting criteria based on AHP, concluding that security, contents quality, on-line resources, student/instructor satisfaction and level of interactivity criteria have high impact on e-learning technology selection process. According to Sheng-li Xu et al. (2023) choosing a decent teaching technique is not an easy option, and it is even more difficult when it comes to selecting the approach. Therefore, the authors focused on multi-criteria decision making for determining best teaching method using fuzzy analytical hierarchy process. Toan et al (2021) have supported that identifying critical factors and evaluating e-learning websites are essential to e-learning service providers and system developers and researchers, in order to improve online educational platforms as well as to e-learners who pursue their knowledge via the Internet. Thus, they proposed a multi-criteria decicion making approach for evaluating e-Learning platforms.

Other authors exploring e-learning in higher education have proposed interesting models based on users/learners/students'satisfaction. For instance, Ozkan & Koseler (2009) have proposed a conceptual

e-learning assessment model, HELAM (Hexagonal e-Learning Assessment Model), suggesting a multi-dimensional approach for LMS evaluation via six dimensions on overall e-learning perceived satisfaction based on student perceptions only. Shee et al (2008) proposed a multi-criteria methodology from the perspective of learner satisfaction to support evaluation-based activities taking place at the pre- and post-adoption phases of the web-based e-learning system life cycle. Mahdavi et al. (2008) proposed a heuristic methodology for multi-criteria evaluation of web-based E-Learning Systems based on user satisfaction, and supported that the use of the e-learner-satisfaction perspective and a large-sample, learner-based innovative heuristic method (AET) contribute to adapting the conventional Multi-Criteria Decision Making paradigm to problems that are highly user-oriented. Multicriteria approaches have been also proposed in order to evaluate and classify the level of interactivity of students in learning management systems (LMS) (Cobo et al., 2014).

The field of cooperation among multicriteria analysis and distance education is nowadays vast. The integration of approaches, techniques, tools and applications provides an added value to the field of distance education. In this context, the synergy among Visual Interactive Modelling and Decision Support Systems facilitates the learning process of decision makers. Furthermore, within virtual learning environments, multicriteria analysis has combined with data mining to identify learning preferences of students. Focusing on distance education a lot of studies have examined approaches to evaluate all aspects of e-learning environments and considered the criteria and principles to apply to the evaluations. Pedagogical principles were employed to facilitate assessment. Moreover, multicriteria analysis methods are employed to redesign university courses.

Researchers proposed to standardize digital content for e-learning systems and at the same time evaluate the quality of digital content and its performance in an e-learning platform. In this context, all the approaches, to assess e-learning environments, have focused on the users (students, instructors) and the platform itself.

Investigation has moved towards the user, and tried to identify what is the most important or influential factor to learners in online education, based on a quality model. Studies also focus on the people supporting the educational process. It seems true, that personnel with a collectivist culture were more likely to be committed to learning organizations.

Furthermore, people in education have to be evaluated as well, especially faculty. Faculty could be evaluated based on:

a) The comparison of the performance of academic staff with performance targets

b) The definition of the multicriteria value profile of each faculty member

c) The computation of an overall value score for each faculty member

d) The assignment of faculty members to rating categories

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a) The comparison of the performance of academic staff with performance targets

b) The definition of the multicriteria value profile of each faculty member

c) The computation of an overall value score for each faculty member

d) The assignment of faculty members to rating categories.

3 METHODOLOGY

The current study is based on an extensive literature review focusing on multicriteria analysis and its applications in the field education in general and more specifically in distance education. The investigation took place mainly through Scopus database and covered all years reaching up to 2023. The literature review investigation, after a focused screening, returned 177 documents. These were recorded in a Mendeley database. Literature review highlighted that multicriteria analysis is widely used in all aspects of education and especially in distance education, which is the theme of the current study.

Multicriteria decision analysis is implemented in all stages of realization of a distance education system. It successfully enabled decision makers and distance education stakeholders to make educated decisions regarding organization and operation of online learning courses. Furthermore, a bibliometric analysis has taken place, through the use of VOS-viewer, and identified fundamentals concepts that are representative of the association of multicriteria analysis to distance learning. The analysis has highlighted Analytic Hierarchy Process, Goal Programming and Resource Allocation as a number of core concepts.

For the literature review, the authors investigated the scientific databases Scopus and Google Scholar, using the following keywords: "Multicriteria Analysis", "Multicriteria Decision Analysis", and "Distance Education". The inquiry focused on "Article Title" for all the years until 2023. This investigation was necessary in order to examine the evolution of the literature around distance education, and multicriteria analysis through the years.

The final set included 177 papers. They were imported in the reference manager Mendeley and in addition, the software Vos Viewer was used to create three types of maps: Network visualization, Overlay visualization, Density visualization. In the following sub-sections, various visualizations will be presented. The complete methodological approach is presented in the following flowchart:
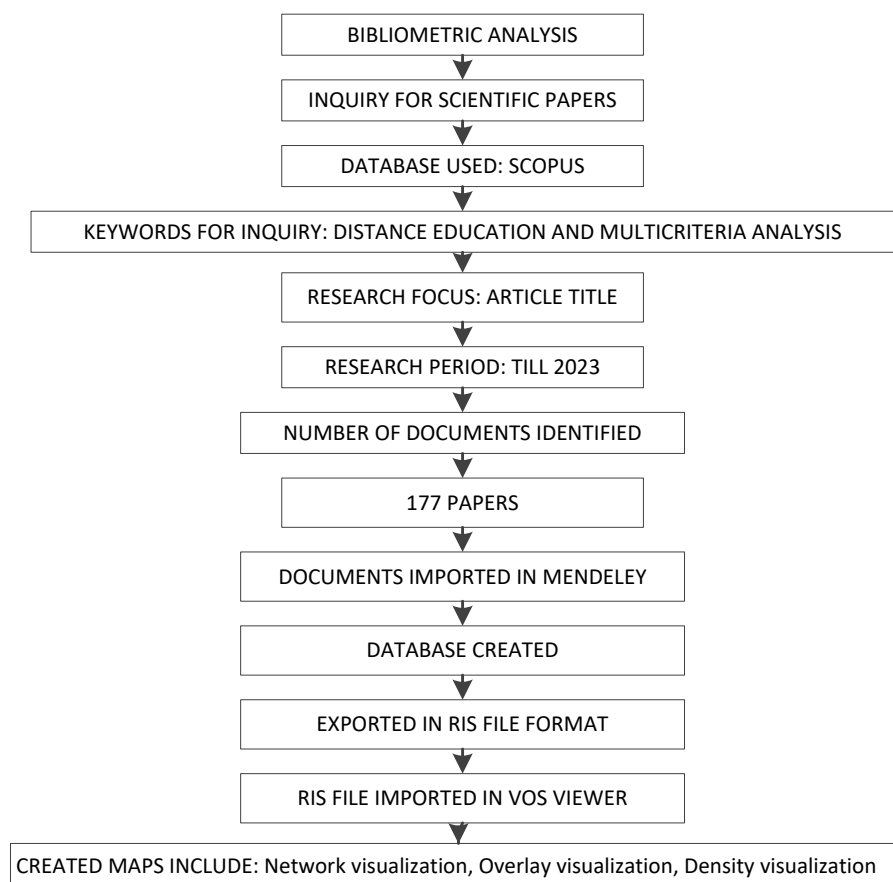
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Figure 1. Flowchart of the process for the literature review

4   VISUALIZATION OF THE RESULTS

The bibliometric analysis took place with the aid of Vos Viewer. The following figures present the Network Map (Figure 2), Overlay Map (Figure 3) and Density Map (Figure 4).
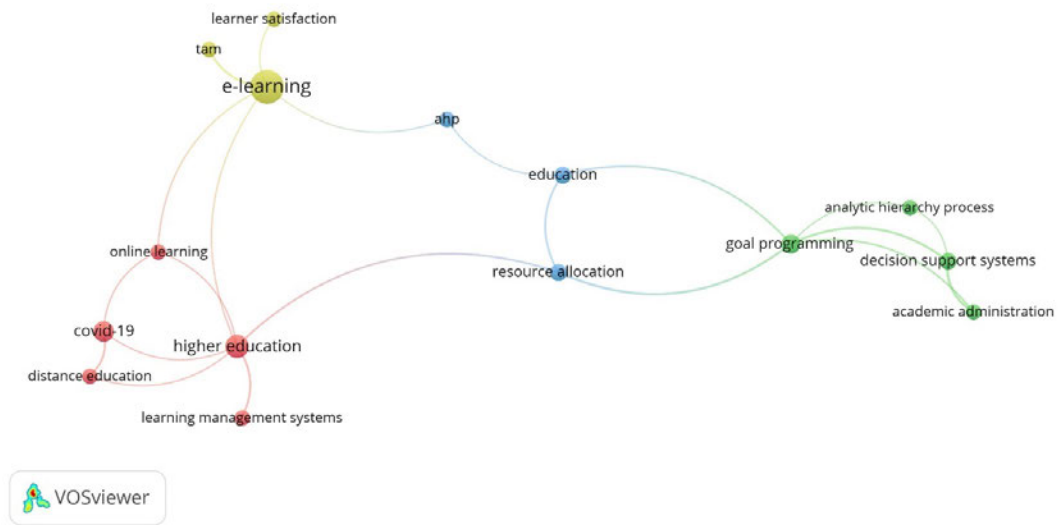
4.1 Network map designed for occurrences of keywords

Figure 2 Network Map Designed for Occurrences of Keywords

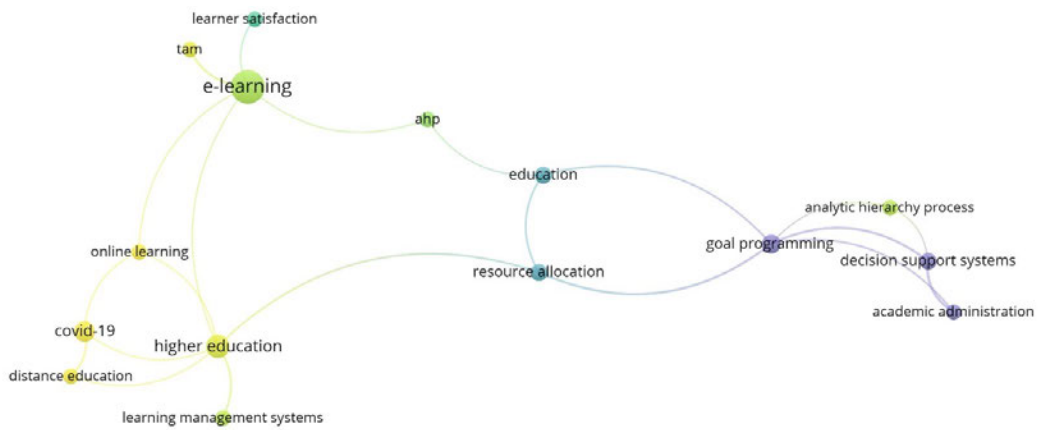## 4.2 Overlay map designed for occurrences of keywords

Figure 3 Overlay Map Designed for Occurrences of Keywords

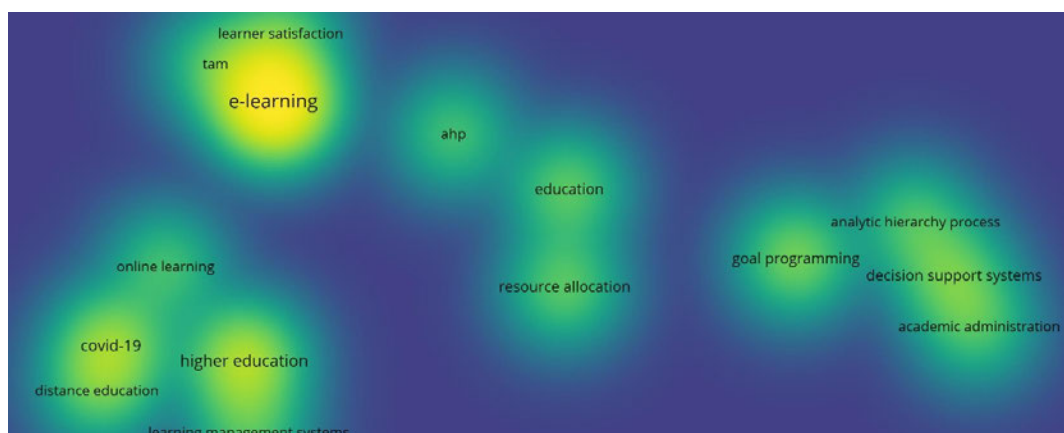## 4.3 Density map designed for occurrences of keywords

Figure 4 Density Map Designed for Occurrences of Keywords

5 CONCLUSIONS

Nowadays higher education and especially universities deal with an extensive range of challenges. Students' inclusion and satisfaction as well as educational quality and efficiency are main aspects of interest. Institutions are called to make decisions on all aspects of the provided courses from design to implementation. In this context, multicriteria analysis is implemented throughout this educational process to provide the best end result for the students and educators. In the context of the current study, Distance Education is the focus of the research. It is generally accepted that Distance Education is sustainable and flexible and therefore, it is capable to accommodate the needs and timetable of the students and educators, without compromising the teaching and learning experience, quality and efficiency.

The analysis of the papers on Multicriteria Analysis and the consideration of the bibliometric analysis led to a number of conclusions, which could be summarized as following. It should be mentioned that the findings are based on the collection of the specific sample of papers:

- E-learning, Covid -19 and Higher Education are among the core concepts
- This analysis has identified some new concepts such as learner satisfaction, technology acceptance model and learning management system.

Based on the **Network Map**, the concepts that seem to be dominant and connected, include:

- Academic Administration, Goal Programming, Decision Support Systems and Analytic Hierarchy Process
- Education, AHP and Resource Allocation
- E-learning, TAM and Learner Satisfaction
- Higher Education, Learning Management Systems, Online Learning, COVID 19, Distance Education

The analysis for occurrences of keywords based on the **Overlay map** identified similar results.

Density Map based analysis identified certain concept clusters:

- Academic Administration, Decision Support Systems and Analytic Hierarchy Process
- Education and Resource Allocation
- E-learning, TAM and Learner Satisfaction
- COVID 19, Distance Education
- Higher Education, Learning Management Systems

There are certainly various limitations especially with regard to multicriteria methods. The Analytic Hierarchy Process has received major criticism over the years and therefore future work is needed to address these issues and despite the fact that it is the most popular method used today. Moreover, goal programming is actually linear programming, therefore a strong background in linear programming is necessary for further research in the field.

Future research could focus more on other challenges, such as enhanced integration of mathematical models in information systems in the form of decision support systems. Better documentation and exploratory texts in multicriteria analysis are also necessary for developing and evaluating new tools in distance learning.

ACKNOWLEDGEMENTS

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