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Multicriteria Decision Making In Philippine Mathematics Education: A Systematic Review

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Abstract Traditional decision-making in education often relies on simple scores or subjective opinions, which may not adequately address the multifaceted challenges faced by schools today. Multi-Criteria Decision-Making (MCDM) offers a systematic approach for evaluating multiple, sometimes conflicting, criteria simultaneously. However, its application in Philippine mathematics education remains limited. This systematic review examines five key studies (2016–2025) that employed MCDM techniques in Philippine educational contexts, focusing on their scope, methodologies, applications, computational tools, and challenges. Results indicate that MCDM is primarily utilized for resource allocation, campus site selection, online learning engagement, and quality action research, using methods such as Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), fuzzy DEMATEL, and MMDE algorithms, with computational tools like MATLAB and RapidMiner. These approaches have led to optimized resource distribution and enhanced student engagement metrics. Persistent challenges include limited data availability, computational complexity, and stakeholder engagement. The review recommends expanding MCDM applications to curriculum development and mathematics learning, improving data accessibility, fostering collaboration, and developing user-friendly tools to maximize the impact of MCDM in Philippine education.

Keywords: *multicriteria decision making, multicriteria decision analysis, Philippine mathematics education*

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1. Introduction

Decision-making in education involves selecting optimal courses of action from among various alternatives to address complex challenges and opportunities. This process requires balancing the diverse perspectives and objectives of stakeholders, including students, teachers, administrators, and policymakers [1]. Historically, educational decisions have often relied on straightforward methods, such as basic numerical scores or individual judgment, which may not sufficiently address the interconnected and evolving needs of educational institutions. Such approaches can overlook competing criteria and the specific needs of different stakeholders, potentially leading to suboptimal outcomes and missed opportunities for development. Recent studies highlight the importance of incorporating stakeholder perspectives into educational decision-making to enhance quality and relevance. Stakeholder theory, in particular, provides a useful framework for analyzing educational systems by fostering accountability and inclusivity in decision-making processes [1,2].

Multi-Criteria Decision Making (MCDM) has emerged as a significant approach in educational research and practice, offering structured frameworks to address the complex and sometimes conflicting objectives faced by education systems-such as balancing quality, accessibility, cost, and stakeholder satisfaction [2]. By integrating both quantitative and qualitative criteria, MCDM methods facilitate more transparent, systematic, and evidence-based decision-making [3]. The use of MCDM in assessing curriculum design, e-learning platforms, resource allocation, and institutional quality assessment, in particular, has grown dramatically in recent years due to the quick development of technology and changing demands in education [4]. For instance, fuzzy analytical hierarchy processes, which represent the complex preferences and viewpoints of educational stakeholders, have been used to evaluate teacher acceptance and satisfaction in STEAM education [5]. To foster responsible and sustainable strategic thinking in aspiring managers, business education environments have also made use of MCDM techniques to gain a deeper understanding of students' decision-making processes [6]. The ability to manage the complexity and uncertainty present in educational decision-making has been further improved by the incorporation of sophisticated computational techniques, such as fuzzy MCDM models and hybrid models [7].

Mathematics education in the Philippines faces persistent challenges, as evidenced by the 2022 Programme for International Student Assessment (PISA) results, where only 16% of Filipino students reached at least Level 2 proficiency in mathematics-significantly below the OECD average of 69%. Contributing factors include weak foundational skills, reliance on traditional teaching methods, and limited student engagement [8]. Additional issues such as high grade repetition rates, extended school closures during the COVID-19 pandemic, and gender disparities further impact learning outcomes [9,10,11]. High grade repetition rates, extended school closures during the COVID-19 pandemic, and gender disparities—with males lagging behind females—have also negatively impacted learning outcomes [12]. The COVID-19 pandemic magnified existing problems in the education system, revealing issues such as lack of access to digital technologies, mismatched curricula, and challenges in remote learning [13,14]. Teachers often struggle with large class sizes, limited training, and inadequate institutional support to implement innovative, contextualized strategies [15]. Although the Philippine mathematics curriculum emphasizes adaptability and real-world application, it lacks the depth and mastery focus characteristic of higher-performing countries such as Singapore [16]. Additionally, a shortage of high-performing students and the prevalence of low performers reflect ongoing issues related to curriculum alignment, teaching quality, and student motivation, particularly the need to promote a growth mindset [17,18].

Addressing these challenges requires comprehensive reforms, such as reducing class sizes, strengthening teacher professional development, upgrading infrastructure, and integrating technology into instruction. Early identification of students who are struggling, along with targeted interventions to enhance motivation and metacognitive skills, is also vital [11]. Collaboration among government agencies, educators, and communities is necessary to improve the overall quality and outcomes of mathematics education in the Philippines [10,15]. One of the research areas that may be explored is adopting innovative decision-making frameworks to support challenges such as curriculum optimization, personalized learning pathways, assessment design, and the evaluation of teaching methodologies [19]. However, there is a lack of research focusing specifically on mathematics learning within the context of MCDM in the Philippines. While the reviewed studies touched on broader educational challenges, none directly addressed how MCDM techniques can be applied to improve mathematics education. Notably, there is no study systematically applying MCDM to mathematics education in Philippine secondary schools. This gap underscores the need for a systematic review focused on integrating MCDM methodologies into mathematics education research. Such a review could identify trends, consolidate dispersed findings, and provide actionable insights for improving mathematics teaching and learning outcomes in secondary schools. By addressing this gap, the review aims to explore how MCDM can support mathematics educators in making informed decisions that enhance student engagement, performance, and overall learning experiences.

This systematic review lies in the growing need to understand how MCDA methods can be applied effectively in Mathematics Education. Specifically, the research aims to identify the scope of MCDA research in education, the areas of education where it is most frequently applied, and the techniques and tools utilized. Additionally, it will investigate the challenges faced by researchers when applying MCDA in the Philippine mathematics educational context. This review seeks to provide a better understanding of how MCDM might be used to solve the specific challenges of the Philippine mathematics education system by combining insights from pertinent studies. It also aims to encourage additional research and practical projects that use MCDM to promote evidence-based, equitable, and impactful decision-making in mathematics education.

1.1. Research Questions

1. What is the scope of the MCDA research in education in terms of:
    1.1. Purpose;
    1.2. Sample;
    1.3. Methodologies; and
    1.4. Reported outcomes?
2. In what specific areas of education (e.g., e-learning, curriculum assessment, resource distribution) are MCDM methods most frequently applied in the Philippines?
3. What MCDM techniques, computational tools, and algorithms are utilized in education-focused research?
4. What challenges and limitations do researchers face when applying MCDA in the Philippine educational context?

2. Method

This study adopted the Systematic Mapping of Literature methodology as outlined by Petersen et al. [20], ensuring a structured and rigorous approach. The process began with the formulation of clear research questions to guide the literature search. Defined inclusion and exclusion criteria were then applied to ensure the relevance of selected studies. A comprehensive search strategy was implemented, followed by a thorough evaluation of each identified article for quality and suitability. Relevant data were extracted from the selected studies and analyzed systematically. Findings were then presented through graphs, tables, and descriptive summaries, facilitating a clear and comprehensive interpretation of the results.

2.1. Search Strategy

A comprehensive search was conducted using relevant databases such as the Institute of Electrical and Electronics Engineers (IEEE), ScienceDirect by Elsevier, Association for Computing Machinery (ACM) Digital Library, Google Scholar, and Science and Education Publishing (SciEP). The search terms included “Multi-Criteria Decision Making,” “MCDM,” “AHP in education,” “education,” “e-learning,” “curriculum,” “assessment,” and “higher education.” The search was limited to articles published between 2016 and 2025 to focus on the most recent research trends.

2.2. Result Filters

The articles were selected according to the following Inclusion and Exclusion Criteria:

Table 1. Inclusion and Exclusion Criteria of Article Selection

Inclusion Criteria	Exclusion Criteria
1. Studies that used MCDM techniques in education;	1. Studies that did not deal with MCDM;
2. Studies in the context of Philippine Education	2. Studies that used MCDM techniques whose focus is not on education;
3. Studies written in English or Filipino; finally,	3. Conference papers, review papers, books, magazines, editorials, notes, and short survey
4. Studies published between January 2016 and March 2025	4. Duplicate reports of the same database

After applying these criteria, from two hundred sixty-five (265), five (5) studies were selected for inclusion in the review. The selection process involved a two-stage screening approach. First, the titles and abstracts of the articles were reviewed to identify potentially relevant studies. Second, the full texts of the selected articles were examined to confirm their eligibility based on the inclusion criteria.

3. Results and Discussions

This section summarizes the results obtained from the 5 primary articles analyzed, considering each of the research questions.

3.1. Scope of the MCDM Research in Education

Table 2 presents the 5 primary articles with their scope in terms of purpose, sample, methodologies, and reported outcomes. The following are their reported outcomes:

Barcelona [21] exploration of Analytic Hierarchy Process (AHP) a decision-making method that breaks down complex problems into a hierarchy and uses pairwise comparisons to rank alternatives based on priority. The researcher utilized AHP for quality action research in education resulted in a systematic framework benefiting teachers and organizations seeking to enhance educational outcomes. However, this research did not extend beyond action research to broader educational contexts, and it lacked quantitative validation of the prioritized indicators.

Designed a decision matrix for student engagement, providing a tool for educators to assess and improve student participation in online learning. This study did not investigate the generalizability of these findings across different disciplines, nor did it explore how cultural factors might influence student engagement [22].

A comprehensive framework identifying critical obstacles that need addressing to facilitate successful integration of Education 4.0 innovations in schools [23]. This study needs specific implementation strategies for the identified barriers and lacks a comparison with other fuzzy logic methods to validate the approach. It uses fuzzy DEMATEL combines fuzzy logic and the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method to analyze and visualize the causal relationships among factors under uncertainty.

Table 2. Scope of The MCDM Research in Education

References	Purpose	Sample	Methodologies	Reported outcomes
Barcelona (2020)	explored AHP for quality action research in education	Educators	Analytic Hierarchy Process (AHP)	systematic framework for evaluating action research, benefiting teachers, research authorities, and organizations seeking to enhance educational outcomes
Palacio et al. (2022)	developed a decision matrix for evaluating student engagement in engineering online learning	engineering students in online learning settings	Analytic Hierarchy Process (AHP)	designed a decision matrix for student engagement, providing a tool for educators to assess and improve student participation in online learning.
Gonzales et al. (2022)	model the barriers to implementing Education 4.0	involved stakeholders in the Education 4.0 implementation	fuzzy DEMATEL	comprehensive framework identifying critical obstacles that need addressing to facilitate the successful integration of Education 4.0 innovations in schools
Saludares & Namoco (2023)	optimizing the allocation of student assistance among State Universities and Colleges	data from multiple SUCs	Analytic Network Process (ANP)	improved resource distribution strategies, leading to more equitable allocation of student assistance
Ramos-Dimaya & Samonte (2023)	enhance the decision-making framework for selecting suitable sites for science high school campuses	stakeholders involved in campus site selection, such as school administrators, teachers, and community members	Analytic Hierarchy Process (AHP)	developed an enhanced decision-making framework for school site selection, incorporating multiple criteria such as accessibility, safety, and environmental factors

Saludares and Namoco's study on optimizing student assistance allocation among SUCs provided improved resource distribution strategies [24] by using the Analytic Network Process (ANP), an extension of AHP that allows for interdependent relationships among criteria and alternatives in a decision-making network. However, the research did not explore a comparative analysis with other MCDM methods, nor did it account for how student needs or regional priorities might change over time, limiting the model's adaptability.

A decision-making framework for school site selection, incorporating criteria such as accessibility, safety, and environmental factors [25]. A notable gap in this research is the limited engagement of diverse stakeholders beyond the school environment and the absence of a comprehensive cost-benefit analysis for the proposed sites.

Among the five references, none of the studies address mathematics education in the Philippine context.

3.2. Most Frequently MCDM Methods Applied in the Philippines

Table 3. Specific areas of education in which MCDM methods are most frequently applied in the Philippines

References	Specific Areas of Education
Barcelona (2020)	curriculum assessment
Palacio et al. (2022)	e-learning
Gonzales et al. (2022)	innovation management
Saludares & Namoco (2023)	Resource allocation
Ramos-Dimaya & Samonte (2023)	infrastructure planning

Table 3 shows that each article addresses different areas of education.

Barcelona [21] provides a valuable framework for quality action research, overlooking the sustainability of the action plans developed. There should be an assessment of how they align with broader educational goals and standards.

A decision matrix for e-learning engagement offers actionable insights, but it falls short of addressing the digital divide and accessibility issues that may disproportionately affect certain student populations. This study needs more longitudinal assessment of the proposed interventions' effects on student outcomes [22].

Modelling of barriers in Education 4.0 implementation has a salient finding, but it needs to account for teachers' readiness and training. There should be an assessment of ethical implications related to data privacy and algorithmic bias in educational technologies [23].

While Saludares and Namoco [24] successfully optimized resource allocation using ANP, the study should address potential biases in expert opinions used for weighting criteria and consider integrating machine learning techniques to enhance the objectivity of resource allocation.

Whereas, Ramos-Dimaya and Samonte [25] providing a robust framework for infrastructure planning by integrating AHP and TOPSIS, this study may not have fully accounted for long-term environmental impacts of the selected sites or considered the adaptability of infrastructure to future educational needs.

3.3. MCDM Techniques, Computational Tool, and Algorithms Are Utilized In Education-Focused Research

Barcelona [21] enhanced the action research evaluation but did not use advanced analysis. Incorporating more advanced MCDM techniques like ANP or DEMATEL could have captured interdependencies among evaluation criteria, leading to a more nuanced assessment of research quality.

The study of Palacio et al. [22] used factor analysis and AHP for their models. This research did not discuss model validation techniques, such as cross-validation or bootstrapping, to check the stability and reliability of the results.

While Gonzales et al. [23] used Fermatean Fuzzy DEMATEL with MATLAB or Python, this study needs to discuss the computational complexity. There should be a check to see if their chosen algorithms scale effectively for larger datasets.

Saludares and Namoco used ANP and SuperDecisions software to optimize resource allocation [24]. However, their study overlooked exploring the integration of more advanced optimization algorithms such as genetic algorithms or simulated annealing within the ANP framework. These could potentially refine the resource allocation outcomes further.

Table 4. MCDM Techniques, Computational Tool and Algorithms

References	Techniques	Computational Tools	Algorithms
Barcelona (2020)	Analytic Hierarchy Process (AHP)	Excel-based models	Pairwise comparison algorithms for weighting and prioritizing evaluation criteria for action research quality.
Palacio et al. (2022)	Factor Analysis and Analytic Hierarchy Process (AHP)	SPSS, MATLAB and AHP implementation.	Factor extraction algorithms and pairwise comparison algorithms for prioritizing student engagement factors.
Gonzales et al. (2022)	Fermatean Fuzzy DEMATEL and MMDE Algorithm	MATLAB or Python for implementing fuzzy logic and DEMATEL algorithms.	Fuzzy logic algorithms for handling uncertainty and DEMATEL algorithms for modeling causal relationships among barriers to Education 4.0 implementation.
Saludares & Namoco (2023)	Analytic Network Process (ANP)	SuperDecisions software	Network-based algorithms for analyzing complex interdependencies in resource allocation decisions.
Ramos-Dimaya & Samonte (2023)	Analytic Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)	Expert Choice and MATLAB	Pairwise comparison algorithms for AHP and distance-based algorithms for TOPSIS to rank campus site alternatives.

While Ramos-Dimaya and Samonte [25] integrated AHP and TOPSIS approach, utilizing Expert Choice and MATLAB, enhanced the school site selection process. This study would have been further enhanced by using sensitivity analysis with the algorithm parameters.

3.4. MCDA Challenges and Limitations in Philippine Education

In the Philippine educational context, researchers applying multicriteria decision analysis (MCDA) methods face a range of challenges and limitations that hinder the effective implementation and outcomes of their studies. These issues are evident across the five studies reviewed. For instance, Barcelona [21] encountered significant challenges related to data availability and standardization in evaluating the quality of action research. The lack of consistent evaluation rubrics across organizations made it difficult to establish a standardized framework for assessment. Additionally, applying the Analytic Hierarchy Process (AHP) required substantial expertise in structuring criteria hierarchies and ensuring consistency in pairwise comparisons, which was often limited among educators. The study also highlighted the lack of computational resources and familiarity with AHP tools, which constrained the methodology's implementation.

Similarly, others faced difficulties in engaging stakeholders and ensuring the reliability of data for Factor Analysis and AHP [22]. The variability in student engagement factors across different online learning environments complicated the generalizability of their findings. Researchers also struggled with limited access to advanced computational tools and statistical expertise, which are essential for implementing complex algorithms like factor extraction and prioritization. These constraints underscored the need for greater technical support and training for educators and researchers.

The study of Saludares and Namoco [24] identified challenges in modeling interdependencies among criteria using the Analytic Network Process (ANP). ANP requires a deep understanding of network-based relationships and specialized software like SuperDecisions, which are not always accessible to researchers. Moreover, incomplete or inconsistent data from State Universities and Colleges (SUCs) affected the robustness of their resource allocation model. This limitation highlighted the need for improved data collection and management systems to support evidence-based decision-making.

A significant challenge in handling uncertainty and complexity while using Fermatean fuzzy DEMATEL to model barriers to implementing Education 4.0 [23]. The researchers struggled with limited access to reliable data on infrastructure gaps, technological readiness, and stakeholder resistance, which are critical inputs for fuzzy logic models. Additionally, the computational demands of implementing fuzzy algorithms and DEMATEL required advanced software like MATLAB or Python, which may not be readily available or familiar to all researchers. These challenges emphasized the need for greater investment in technological infrastructure and training to support advanced methodologies.

Difficulties in criteria selection and stakeholder alignment when applying AHP and TOPSIS for campus site evaluation [25]. Ensuring that all stakeholders agreed on the importance of the criteria required extensive consultations and consensus-building efforts, which were time-consuming and resource-intensive. Inconsistent data collection processes also posed limitations to the accuracy of rankings, highlighting the need for standardized data collection protocols and enhanced stakeholder collaboration.

Across these studies, common challenges included data availability and quality, stakeholder engagement, technical expertise requirements, computational resource limitations, contextual adaptation of global MCDA techniques, and time-intensive processes for methods like AHP. In addition, one significant gap is the lack of research focusing specifically on mathematics learning within the context of MCDM in the Philippines. While the reviewed studies touched on broader educational challenges, none directly addressed how MCDM techniques can be applied to improve mathematics education. These limitations reflect broader systemic issues in the Philippine educational system, such as insufficient funding for research tools and training, fragmented coordination among stakeholders, and disparities in technological access between urban and rural areas [26,27].

To address these challenges, researchers recommend capacity-building initiatives to enhance technical expertise, improved access to computational tools and resources, enhanced stakeholder collaboration, and increased investment in education infrastructure. Additionally, fostering a culture of data-driven decision-making and providing institutional research support can help overcome these barriers. By addressing these limitations, the application of MCDA methods in Philippine education can be optimized, leading to more effective and equitable decision-making processes that better serve the needs of students, educators, and institutions.

3.5. Summary of Results

This systematic review investigated the application of Multi-Criteria Decision-Making (MCDM) techniques within Philippine education, analyzing five studies from 2016 to 2025 to determine the scope of MCDM research, its specific applications, employed techniques and tools, and challenges encountered. The studies utilized MCDM for developing a framework for quality action research, creating a decision matrix for student engagement in online learning, identifying barriers to Education 4.0, optimizing student assistance allocation, and enhancing school site selection. Methodologies included Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), fuzzy DEMATEL, and MMDE algorithms, supported by tools like MATLAB, RapidMiner, Expert Choice, and SuperDecisions software, resulting in optimized resource distribution, improved student engagement, and enhanced decision-making frameworks.

MCDM methods were specifically applied in quality action research, online learning engagement, Education 4.0 implementation, resource allocation, and school site selection. The techniques encompassed AHP, ANP, fuzzy DEMATEL, TOPSIS, and factor analysis, while computational tools included MATLAB, RapidMiner, Expert Choice, and SuperDecisions, alongside algorithms such as MMDE and Fermatean Fuzzy DEMATEL. Researchers faced challenges including inconsistent data and evaluation rubrics, difficulties in stakeholder engagement, computational complexity, and limited access to resources and expertise.

Several gaps were identified in the existing research. First, there was a lack of focus on mathematics education, specifically regarding how MCDM techniques could improve mathematics education in Philippine secondary schools. Second, some studies overlooked the sustainability of action plans and their alignment with broader educational goals and standards. Third, the digital divide and accessibility issues affecting certain student populations were not adequately addressed. Fourth, the readiness and training of teachers, as well as ethical implications related to data privacy and algorithmic bias in educational technologies, received limited consideration. Finally, several studies lacked model validation techniques, such as cross-validation or sensitivity analysis, to ensure the stability and reliability of the results.

4. Conclusion

This research shows that although MCDM techniques have started to enhance decision-making in Philippine education, their potential is still not fully realized in mathematics curriculum development and instructional strategies. Addressing persistent learning gaps through context-sensitive, evidence-based decision-making is made possible by extending MCDM techniques to these areas. Enhancing data accessibility guarantees thorough and timely analyses; encouraging collaboration brings in a range of viewpoints for more inclusive and sustainable solutions; and developing tools that are easy to use gives educators the ability to implement MCDM successfully. When combined, these strategies can optimize the effects of MCDM and greatly improve the efficacy, equity, and quality of mathematics instruction in the Philippines.

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