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Optimization with Fuzzy Multiple Criteria Decision Making for Integration, Governance, and Management Study Programs

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ABSTRACT

The purpose of this research is to optimize the integrated modeling of master and doctoral study programs in postgraduate faculties with linear scientific fields needed to deal with changes in higher education governance management using Fuzzy Multiple Criteria Decision Making (F-MCDM). In this study, we propose a novelty for the study program integration model by modifying the MCDM model. FMCDM is used to evaluate the performance of forecasting. Thus, it can handle qualitative criteria that are difficult to explain in the form of sharp values. The results obtained are as expected. Fuzzy Multi-Criteria Decision Making (FMCDM) is a decision-making method for determining the best alternative from many alternatives based on certain criteria. As a result, several study programs in Master (Basic Education, Language and Literature Education, Arts and Culture Education, as well as Technology and Vocational Education) and Doctoral programs (Language and Literature Education, Basic Education, as well as Vocational Education) are still in the Management of Postgraduate Management, while there are 24 master and doctoral study programs integrated with faculties. National Universities continue to reform their public service bureaucracy by submitting proposals to become State Universities Legal Entities (known as PTN-BH in Indonesia).

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1. INTRODUCTION

Since the issuance of the Decree of the Minister of Finance Number: 50/KMK.05/2009 dated 27 February 2009, National University is a state university in the Ministry of Education and Culture that implements the Financial Management of the Public Service Agency (BLU). The application of BLU financial governance is a form of bureaucratic reform in the public sector to serve the needs of society. Until now, various performance achievement indicators show that National University can realize public services that are accepted by the community, including several points:

(i) National University financial audits by the Public Accounting Firm (KAP), which have earned the WTP title (unqualified) 8 times in a row;
(ii) in 2021 National University won 1st place in Government Agencies Performance Accountability System (or Sistem Akuntabilitas Kinerja Instansi Pemerintahan (SAKIP));
(iii) the number of registrants for National Selection to Enter State Universities (or Seleksi Nasional Masuk Perguruan Tinggi Negeri (SNMPTN)) in 2022 ranks 4th out of all universities in Indonesia, below Universitas Negeri Semarang, Universitas Brawijaya, and Universitas Diponegoro, with 30,389 applicants;
(iv) Registrants in Joint Selection to Enter State Universities (or Seleksi Bersama Masuk Perguruan Tinggi Negeri (SBMPTN)) also increased by 32.5%, from 30,017 in 2021 to 39,776 in 2022;
(v) included in the top 10 universities in Indonesia in the Scimago Institution Ranking (SIR), and
(vi) implementation of remuneration has entered its eighth year and has been widely used as benchmarking by other universities.

The various successes above have encouraged National University to continue reforming the public service bureaucracy by submitting a proposal to become a Legal Entity State University (PTN-BH). By becoming a PTN-BH, Universitas Negeri Surabaya (Unesa) will be more flexible in managing its resources. Thus, it can produce quality education, can increase the nation's competitiveness in facing globalization, and generate added value that can improve the welfare of its employees with management based on the principles of accountability, transparency, nonprofit, quality assurance, effectiveness, and efficiency. As of April 2022, the planned Presidential Regulation regarding the National University's status as PTN-BH has entered the final discussion, and the harmonization stage, just waiting for the official signing. Because of that, all organs at National University must start organizing themselves according to the PTN-BH framework. Postgraduate as one of National University organs, is also required to prepare themselves to be able to contribute optimally towards National University as PTN-BH. There have been various changes as National University changed from BLU to PTN-BH, including changes in vision-mission and governance. The Postgraduate as a National University organ must also immediately review the strategic plan and its management system. Thus, it is in sync with the National University strategic plan and management as a PTN-BH. Based on the urgency above, the researcher proposes strategic policy research with the title Development of Strategic Plan and Postgraduate Management to welcome National University as PTN-BH.

2. METHODS

Fuzzy Multiple Criteria Decision Making (FMCDM) is a method for deciding on problems that involve evaluation/selection with many criteria. With the Fuzzy Multiple Criteria Decision Making (FMCDM) method we can solve various problems, one of which is

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forecasting the integration of master and doctoral programs to faculty from postgraduate school. This is possible because FMCDM offers problem-solving in determining the priority of choices with many criteria or it can be called making decisions with more than one choice. And one of the advantages is handling criteria that cannot be classified/qualitative. Thus, the results are quite reliable.

The FMCDM method processes complex multi-criteria problems into a hierarchical model. Hierarchy is defined as a representation of a complex problem in a multi-level structure where the first level is the objective, followed by the criteria level, sub-criteria, and so on down to the last level, namely the alternative level. With a hierarchy, a complex problem can be described. Thus, the problem will appear more structured and systematic.

The FMCDM method is used to determine weight criteria from the subjective assessment of each group because these evaluation criteria have various connotations and meanings.

Furthermore, FMCDM is used to evaluate the performance of forecasting. Thus, it can handle qualitative criteria that are difficult to explain in the form of sharp values. Thus, the results obtained are as expected. The process stages in the FMCDM method are:

(i) Define the problem and determine the desired goals.
(ii) Creating a hierarchical structure beginning with general objectives, followed by criteria and choices.
(iii) Establish a pairwise comparison matrix that describes the effect of each element on each criterion.
(iv) Test the consistency of the hierarchy. If the value of the consistency of the resulting ratio does not meet the standards set, namely the Consistency Ratio (CR) <0.1, then the assessment must be repeated.

2.1 Basic Principles of Fuzzy Multiple Criteria Decision-Making (FMCDM)

Fuzzy Multi-Criteria Decision Making (FMCDM) is a decision-making method for determining the best alternative from many alternatives based on certain criteria (Aruldoss *et al*., 2013). MCDM has two categories, namely Multiple Objective Decision Making (MODM) and Multiple Attribute Decision Making (MADM). Multiple Objective Decision Making (MODM) is a method by taking many criteria as the basis for decision making which includes design problems, where mathematical techniques for optimization are used and for a very large number of alternatives (up to infinity) (Brauers *et al*., 2008). Whereas Multiple Attribute Decision Making (MADM) is a method by taking many criteria as a basis for decision-making, with a subjective assessment regarding the selection problem, where mathematical analysis is not too much and is used for selecting alternatives in small quantities. Several techniques from Multiple Attribute Decision Making (MADM) such as AHP (Analytical Hierarchy Process), MAUT/MAVT (Multi-Attribute Utility Value Theory), Promethee (Preference Ranking Organization Method for Enrichment Evaluation), Electre, etc. Decision-making from several criteria is an analytical method for evaluating the advantages and disadvantages of alternatives based on several criteria. five principles must be considered when determining criteria, the following must be considered:

(i) Completeness. That is, the criteria must embrace all the important characteristics of the decision-making problem.
(ii) Operational capabilities. That is, the criteria must be meaningful to decision-makers and available for open study. This principle means making judgments about the relative importance of two elements at a certain level concerning the level above it. This assessment is the core of FMCDM because it will affect the priority of the elements. The results of this assessment will look better if presented in the form of a matrix called the

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pairwise comparison matrix. To obtain a useful scale when comparing two elements, the person providing the answer needs a thorough understanding of the elements being compared and their relevance to the criterion or objective being studied.

(iii) Decomposability. That is breaking down the whole problem into its elements. Solving is also carried out on the elements until it is impossible to do further solving. Thus, several levels of the problem are obtained. For this reason, the process of analysis is called hierarchy (hierarchy).

The steps are to solve or divide the whole problem into elements in a hierarchical form, where each element is interconnected. The form of the decomposability structure is:

(i) The first level: The purpose of the decision (Goal).
(ii) Second level: Criteria – criteria
(iii) The third level: Alternatives - alternatives

Figure 1 shows the conditions and situation of the master's and doctoral study programs in 2022. There are three integrated study programs in the faculty due to scientific linearity.

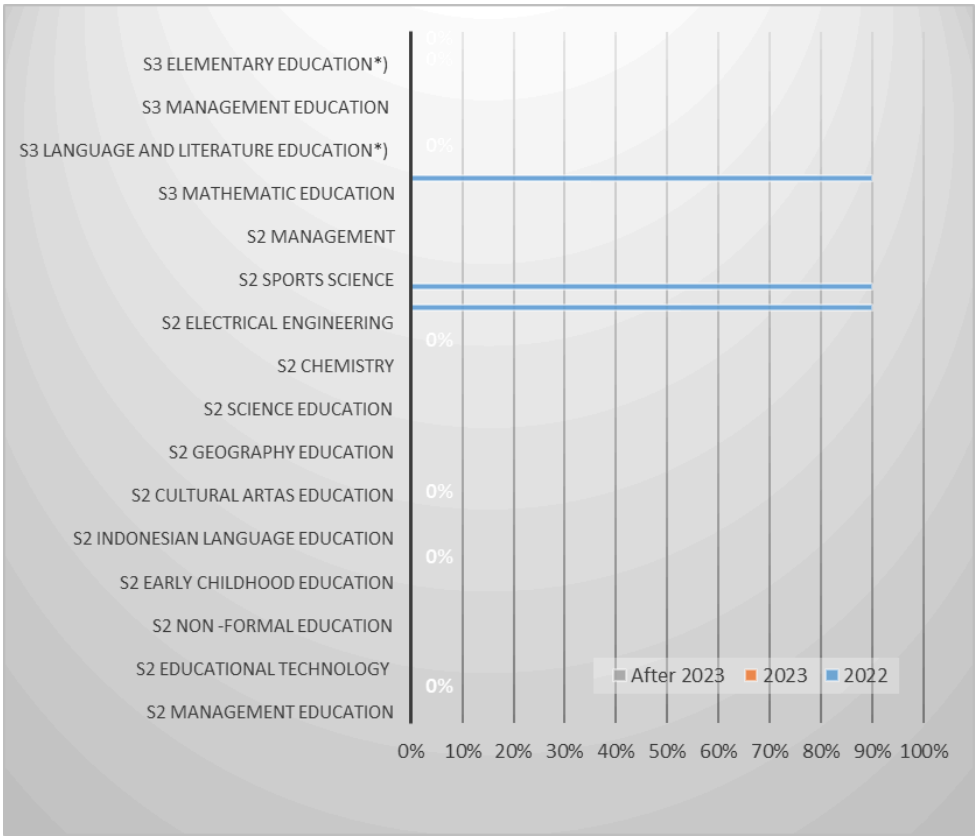

Figure 1. Conditions of the postgraduate study program.

2.2 Fuzzy Sets and Fuzzification

A fuzzy set is a set containing elements that have varying degrees of membership in the set (Torra, 2010). And the fuzzy numbers are the fuzzy subset of real numbers representing the expansion of the confidence. The fuzzy number $\tilde{X}$ be a fuzzy number set, of which the membership function is $\mu_{\tilde{B}}(x)$: $R \rightarrow [0, 1]$, and it comprises the following features:

(i) $\mu_{\tilde{N}}(x)$ is the continuous mapping from R to the interval of [0,1]

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(ii) $\mu_{\tilde{N}}(x)$ is the convex fuzzy subset

(iii) $\mu_{\tilde{N}}(x)$ is the normalization of a fuzzy subset which means that there exists a number

(iv) x_0 makes $\mu_{\tilde{N}}(x)$ is amount 1.

$$\left[1\ \tilde{b}_{12}\ \tilde{b}_{13}\cdots\tilde{b}_{1m}\ \tilde{b}_{21}\ 1\ \tilde{b}_{23}\cdots\tilde{b}_{2m}\ \tilde{b}_{31}\ \tilde{b}_{32}\ 1\cdots\tilde{b}_{3m}\cdots\cdots\cdots\ddots\cdots\tilde{b}_{m1}\ \tilde{b}_{m2}\ \tilde{b}_{m3}\cdots 1\right]=\left[1\ \tilde{b}_{12}\ \tilde{b}_{13}\cdots\tilde{b}_{1m}\ \frac{1}{\tilde{b}_{12}}\right.$$

Thus, if those numbers fulfill the aforementioned mathematics method requirements then they are called fuzzy numbers. The characteristics and membership function of the triangular fuzzy number (TFN) should possess the following basic features. The fuzzy number *A* on $\Re$ to be the triangular fuzzy number if its membership function $\mu_{\tilde{A}}(x)$: $R\rightarrow[0,1]$ is equal to

$$\mu_{\tilde{A}}(x)=\{\frac{(x-Z)}{(Y-Z)}\quad,\ Z\leq x\leq Y\ \frac{(x-x)}{(x-Y)}\quad,\ Y\leq x\leq x\ \ 0,\qquad\qquad otherwise,$$

(1)

where *Z* and *x* stand for the lower and upper bounds of the fuzzy number $\tilde{A}$ and Y is the modal value. The triangular fuzzy numbers (TFNs) can be denoted by, $\tilde{A}=(Z,\ Y,x)$ and the following are the operational laws of two the triangular fuzzy numbers $\tilde{A}_1=\left(Z_1,\ Y_1,x_1\right)$ and $\tilde{A}_2=\left(Z_2,\ Y_2,x_2\right)$.

3. RESULTS AND DISCUSSION

3.1. University in Education

The university is one of the highest educational institutions at the education level, namely tertiary institutions after the senior high school period has been completed. Education is a basic need in everyone's life. Education is inseparable from the academic field, namely teaching and learning. Learning is a theory and knowledge that cannot be separated from education. Education is learning to gain knowledge in all fields. To gain knowledge. By getting a theory in a particular field. For this reason, a university that has high quality is needed to create quality and reliable human resources in all fields and be able to get involved in the community to apply their knowledge. Along with the development of time, universities/colleges continue to grow and compete in the academic and non-academic fields. Each university has different rules and requirements. Superior human resources are those who are creative, innovative, productive and have noble character. Therefore, the importance of tertiary institutions or universities through the Tri Dharma of Higher Education, higher education will become the backbone of future economic, social, and community development. Amid today's very rapid technological changes, higher education institutions must be able to prepare human resource competencies, with good and quality competence, it will be easier to get a job with a good position as well.

One of them is through the Merdeka Learning Campus Merdeka program, which is a breakthrough for the future of college graduates. And currently, our universities are preparing superior, creative, productive, and noble human resources. Higher education has three important things, namely quality, relevance, and attractiveness. "Quality is very important because if the quality is not maintained then public trust in tertiary institutions

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will fade and they will be abandoned. For tertiary institutions to be of high quality, management must be professional. In terms of relevance, in organizing higher education far from the needs of the community, the relevance of higher education is very important. Thus, higher education is still needed by the community. "Relevance means an independent campus, how do we bring professionals, and business actors into the class, we bring modern farmers into the class, we bring the class into the best learning problems and best learning projects. Meanwhile, regarding attractive campuses, he emphasizes that currently what students expect is space for discussion, interaction, building dialectical spaces, interacting between students and lecturers, making the campus dynamic.

3.2. Legal Entity State University (or PTNBH)

PTNBH is a tertiary institution management pattern that is considered well-established in the management of academic and non-academic fields which includes the management of organizational, financial, student affairs, manpower (staff), and infrastructure (Astridina *et al*., 2018). Law No. 12 of 2012 articles 62 to 67 are the basis for the autonomy of higher education management and PP No. 4 of 2014 is the basis for the Implementation of Higher Education and the Management of Higher Education which is contained in article 27 paragraph (1) point (c). The government's goal in forming PTNBH is so that PTNBH can be more flexible in managing its resources. Thus, it can produce quality education, can increase the nation's competitiveness in facing globalization, and generate added value that can improve the welfare of its employees with management based on the principles of accountability, transparency, nonprofit, quality assurance, effectiveness, and efficiency (Andayani, 2019). National University since February 27, 2009, is a state university that organizes BLU. After 13 years at BLU, National University's various performance indicators show successful public services, among others marked: a) the achievement of the WTP title (unqualified) in financial management; b) the number of interested people who register with the National University continues to increase, and c) achievements in various national and international rankings. Because of this, National continued to reform its public service bureaucracy by submitting a proposal to become a Legal Entity State University (PTN-BH).

3.2.1. Postgraduate strategic plan (renstra)

Renstra is a planning document for an organization or institution that determines the strategy or direction used as a basis for making decisions to allocate resources including capital and human resources in achieving the desired goals. The Strategic Plan describes the goals, objectives, policies, programs, and activities which are a continuous process of decision-making. The decision is taken by utilizing as much anticipatory knowledge as possible and organizing it systematically to implement and measure the results through systematic feedback. The benefits and importance of the Strategic Plan are for several points: (i) planning changes in an increasingly complex environment; (ii) the basis for managing success; (iii) future-oriented; (iv) is adaptive; and (v) guidelines for providing excellent service. The National University Postgraduate Strategic Plan currently in use is the 2021-2025 Strategic Plan. Even though the validity period is still until 2025, when Unesa becomes a PTN-BH, a synchronization must be carried out immediately. Moreover, National University PTN-BH's vision and mission are different from the vision and mission when it was still BLU. Changes in vision and mission are of course followed by changes in activities, strategies, and priorities, as well as more optimal governance.

3.2.2. Postgraduate Governance

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Higher Education governance is a pattern of relationships, systems, and processes used by Higher Education organs to provide added value to stakeholders on an ongoing basis in the long term while remaining based on applicable laws and norms. Good governance has several main elements, namely:

(i) Transparency, where the policy of every regulation, program, various activities, and budget is carried out transparently. Thus, it is known and understood by various parties, therefore it is expected that all components can participate actively;
(ii) Organizing is related to the extent to which leaders can apply principles in organizing, for example establishing details of various main tasks, work relationships, duties, or authority and providing direction (directing);
(iii) Participation is related to the extent to which the process of making various strategic decisions involves policy makers both internally and externally, therefore there is active support from stakeholders;
(iv) Responsiveness is related to the extent to which various policies and regulations as well as allocations in the budget receive positive responses and support from various parties. Effectiveness and efficiency, where the efforts of the leadership make various parties understand and can provide a high enough commitment to the decisions of the leadership such as policies, regulations, and various programs;
(v) Leadership accountability is responsible for the tasks it carries out; and
(vi) Leadership is related to the extent to which leadership can create a conducive work environment and can motivate various parties to work more productively to achieve the existing vision and mission.

In its implementation, governance requires an assessment of how far the development the implementation of the principles has been implemented and its impact on the operational activities and performance of Higher Education. The main assessment is to measure and map the condition of Higher Education in implementing governance. Through assessment, it can identify areas of improvement making it easier for Higher Education to take follow-up steps to move forward (Wijayanti & Selawati, 2020). Currently, Postgraduate manages 31 study programs (8 Masters programs and 23 Masters programs) where 2 study programs are accredited Excellent (S3 TP and Masters in PLB), 3 study programs are Very Good accredited (S3 Mathematics Education and Science Education Doctoral Degree, and Masters in Geography Education), 9 study programs are accredited A and 9 study programs are accredited B and there are still 8 new study programs that are in the process of accreditation. Apart from that, the Unesa Postgraduate Program is also preparing 6 study programs to be submitted for international accreditation (Master and Doctoral Degrees in Mathematics Education, Master and Doctoral Programs in Science Education, and Master and Doctoral Programs in Education Management). To have good governance, Postgraduate needs to align with the PTN-BH governance framework, primarily for the following points:

(i) monitor and ensure the course of the contract and annual performance evaluation of the leadership
(ii) monitor and ensure that operational, development, and investment cost efficiency programs are implemented
(iii) monitor and seek improvement of governance and information systems
(iv) monitor the development of leadership regulations
(v) review and provide input on the Strategic Plan

Several issues need to be considered related to study program management, for example, the linear integration of master's and doctoral study programs with undergraduate study programs. Partial management of liner study programs at the Faculty and Postgraduate level

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raises several problems, especially related to scientific development, for example, curriculum continuity, arrangement of Homebase lecturers, development of scientific priorities, and efficient use of facilities and infrastructure.

This research aims to optimize the governance integration management of master and doctoral study programs to faculties according to their respective fields of study dealing National University as a legal enterprise higher education by using fuzzy multiple criteria decision-making modeling

3.3. Findings

This session discussed the analysis of modeling the integration of study programs at the Postgraduate to the Faculty. Modeling using Fuzzy Multiple Criteria Decision Making (FMCDM) is divided into three steps: (1) Topology for the included design is included in the FMCDM model (2) Integration Model (3) Testing and Training model (Wijayanti & Selawati, 2020). It is shown in **Figure 2** which explains the process of modeling linear integration of study programs with study programs at the faculty. The purpose of this section is to build a hierarchical structure to address the problem of evaluating integrated master and doctoral study programs with existing study programs in the faculty. This section consists of four sub-sections: investigates the parameters that affect forecasting the knowledge load, constructs a hierarchical structure of evaluation criteria, determines the weights of the evaluation criteria's weights, and determines the possibility of integration values containing any results from the study programs integrated into the faculty (**Figure 2**). This explains the FMCDM modeling to determine doctoral and master study programs that will be integrated with the faculty. Where is The first condition that in Postgraduate there are 32 study programs.

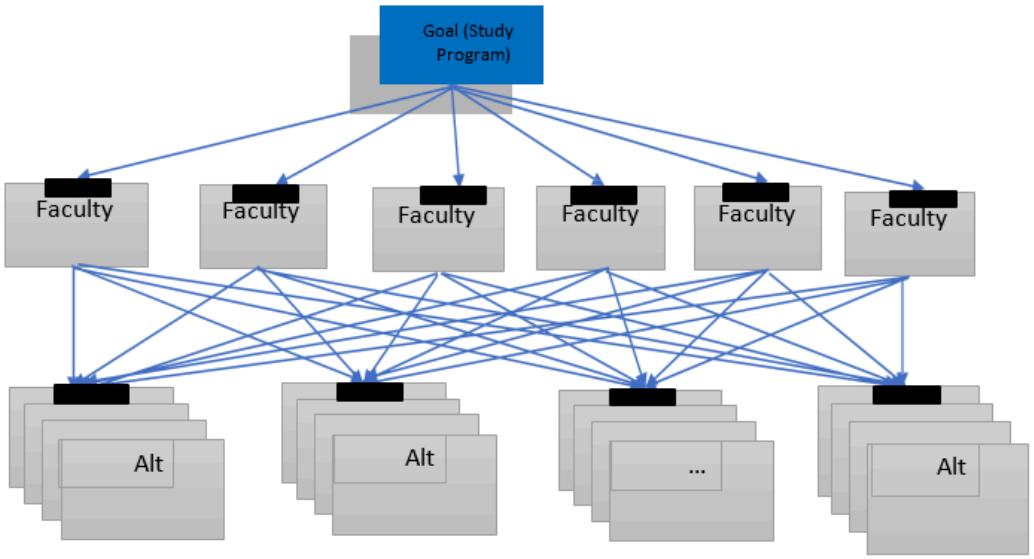

Figure 2. F-MCDM modeling for study program integration in faculties.

Figure 3 shows the integration modeling process from various study programs in Postgraduate to faculties with linear knowledge because the integrity of linear knowledge in a field of study has shown high quality in the study program. In this research, the Fuzzy Multiple Criteria Decision Making (F-MCDM) method has been applied to modeling the integration of study programs in Postgraduate to faculties with the requirement that one of them has a linear scientific field, to deal with changes in university governance management

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that become universities or colleges with legal entities. Shown explained in **Figure 4** explains the relationship between data input and output with the Fuzzy Multiple Criteria Decision Making modeling for the study program integration model.

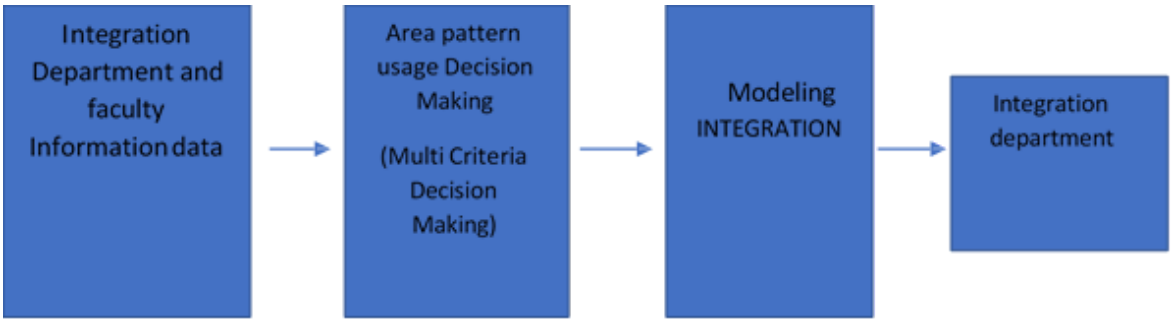

Figure 3. Integration modeling process.

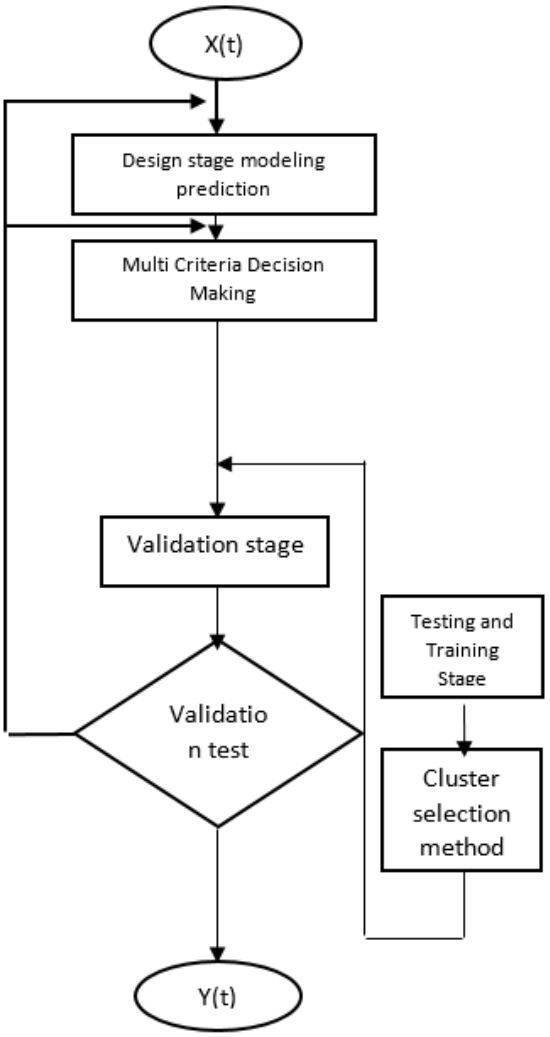

Figure 4. The flowchart of the fuzzy multiple criteria decision making model of the integration process.

The results of the analysis of training simulations and testing of modeling using Fuzzy Multiple Criteria Decision Making for the integration model of masters and doctoral study

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programs are shown in **Figure 5**. This is an illustration of the integration mapping of master and doctoral study programs at Postgraduate to faculties and there are seven masters and doctoral study programs that remain at the Postgraduate level because they are not linear with study programs in any Faculty.

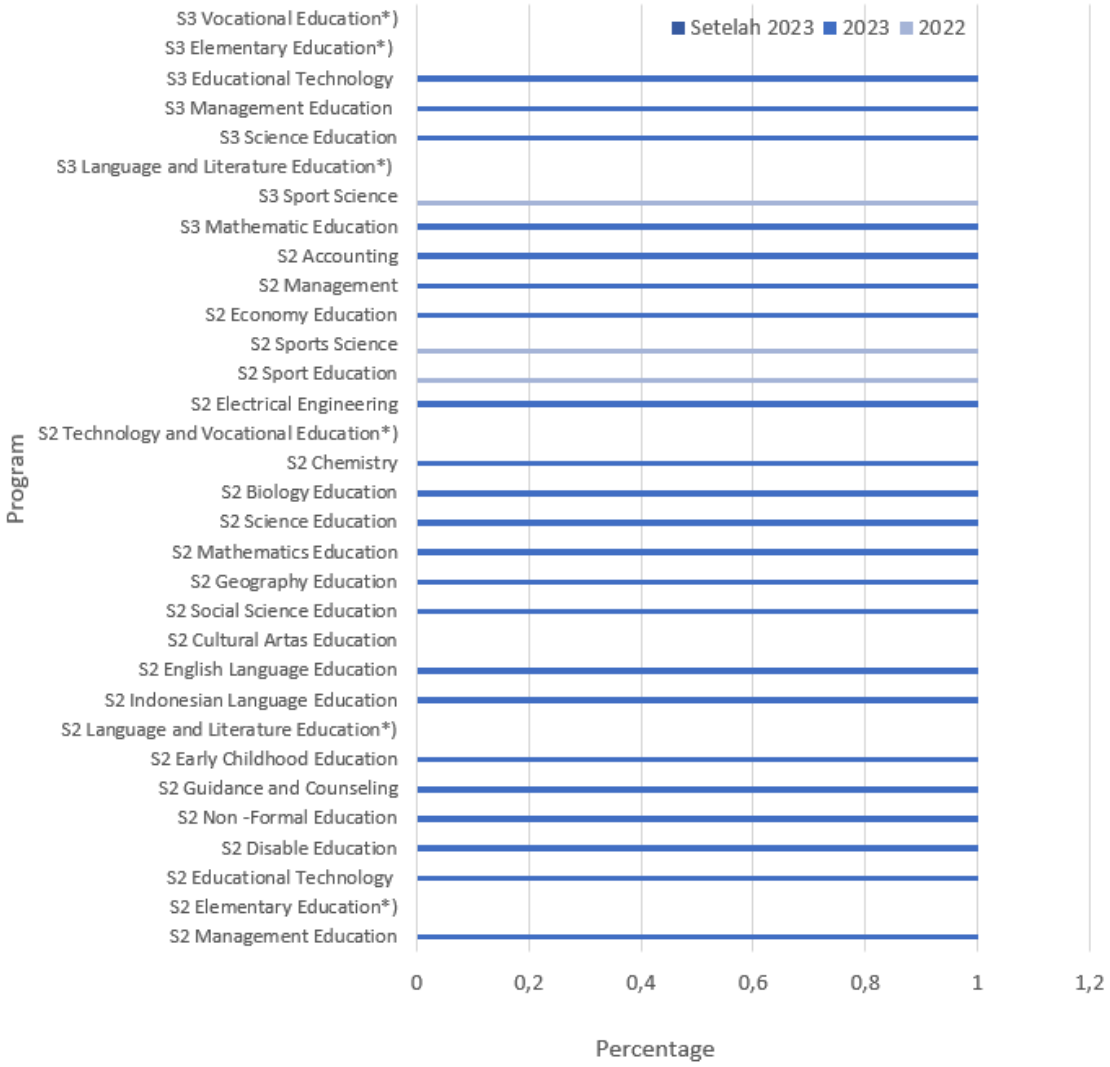

Figure 5. Study program integration using the F-MCDM model.

Figure 6 explains the pattern of integration at the Postgraduate Program at Surabaya State University, regarding semi-integration, which is one of the selection and graduation administrative processes that have been carried out at the Postgraduate level while the academic process will later become the authority of the respective faculty of study programs, and full integration, where all processes starting from the selection of students, the academic process, up to the graduation process have also become the authority of the faculty for integrated study programs. as well as explaining leadership for the master's and doctoral study programs, which will later regulate the management of the implementation of the teaching and learning process and students. The graph also explains services to students and academic management for each study program that has been integrated.

Figure 7 explains some of the needs provided by each faculty, consisting of rooms that are used for lectures, administrative staff, and governance for postgraduate study programs that have been integrated. **Figure 8** explains the percentage of linear study programs integrated

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into each faculty, which includes multi-disciplinary study programs as well as Master and Doctoral study programs that do not yet have an undergraduate study program.

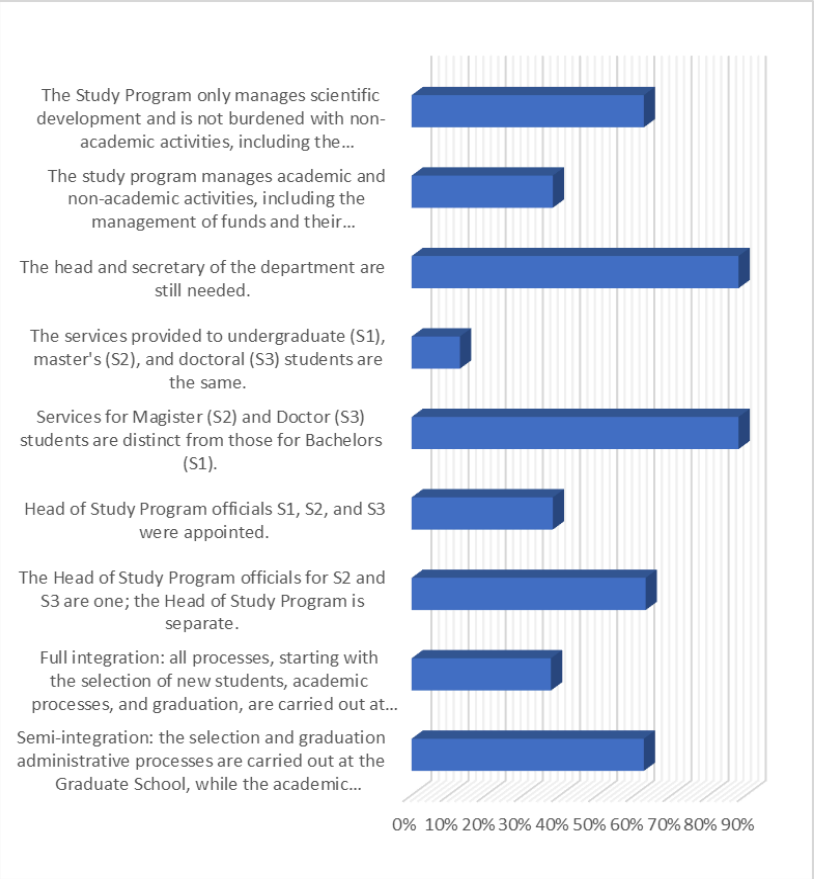

Figure 6. The pattern of integration of unesa doctor (S3) and masters (S2) study programs.

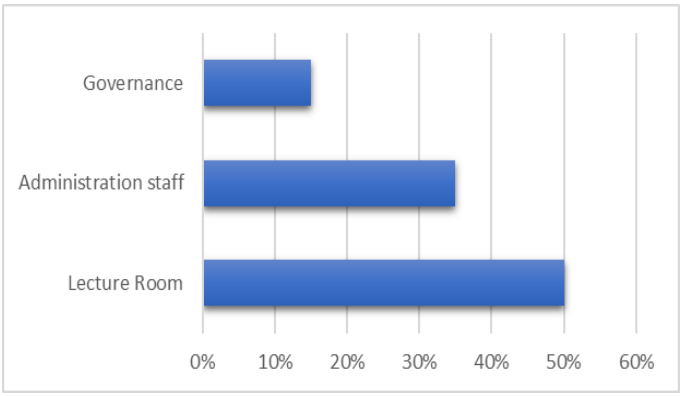

Figure 7. The need for implementation of learning after the integration of study programs.

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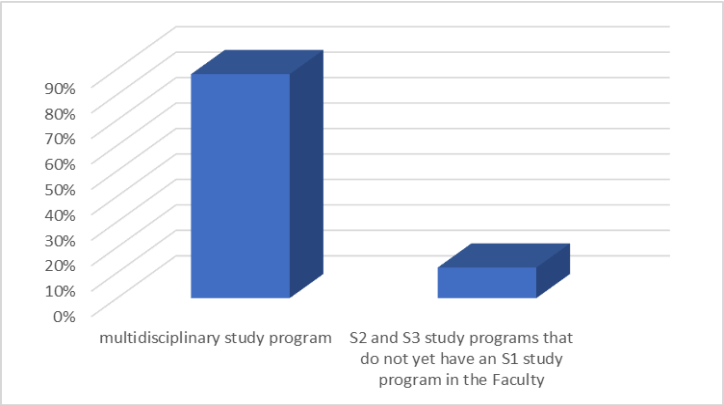

Figure 8. Postgraduate management after being integrated with the faculty.

4. CONCLUSION

The renewal of the Fuzzy Multiple Criteria Decision Making (F-MCDM) for modeling the integration of master's and doctoral study programs at Postgraduate to Faculties with linear scientific fields to deal with changes in the governance management of universities or higher education institutions that are legal entities. In this study, we propose a novelty from the integration model by modifying the MCDM model. As a result, there are 7 study programs, namely Masters in Basic Education, Masters in Language and Literature Education, Masters in Arts and Culture Education, Masters in Technology and Vocational Education, Doctoral in Language and Literature Education, Doctoral in Basic Education and Doctoral in Vocational Education are still in the Management of Postgraduate Management, while there are 24 master and doctoral study programs integrated with faculties.

5. ACKNOWLEDGMENT

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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