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OPTIMIZING TEACHING STRATEGIES IN LARGE GROUPS THROUGH MULTIPLICATIVE MCDM METHOD

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ABSTRACT

Delivering lectures in large student groups at higher education institutions, particularly at technical faculties, presents considerable pedagogical and organizational challenges. Individualized attention is significantly limited, making it difficult for instructors to adequately address the diverse learning needs of all students. Progressing too quickly may confuse students with insufficient background knowledge, while moving too slowly may demotivate advanced learners. Moreover, large class sizes reduce opportunities for interaction through questions, discussions, and active student participation.

This paper examines these challenges in the context of the Faculty of Technical Sciences Čačak, University of Kragujevac, where general education courses are delivered to large, multi-program groups, while professional courses in the later years are conducted in small, focused groups. The study presents a structured approach to evaluating the quality of the teaching process using the multiplicative MCDM method introduced by M. Žižović et al. (2016). A set of qualitative and quantitative criteria, including class size, has been defined and weighted based on expert assessments and student feedback. The results provide valuable insights into the effectiveness of current teaching practices and highlight specific areas for improvement, particularly in high-enrollment courses.

Keywords: Multi-criteria analysis, higher education, instructional strategies, large groups.

INTRODUCTION

In every multi-criteria decision-making process, several necessary steps are highlighted. First, it is necessary to clearly define the problem of multi-criteria decision-making (MCDM), as well as the goals to be achieved, that is, to identify and describe all relevant alternatives that participate in the process, and then to clearly define the criteria, attributes or performance indicators that will serve to evaluate the effectiveness of each alternative.

In order to evaluate the alternatives according to the criteria, it is necessary to conduct appropriate analyzes and collect data for the most objective assessment possible, and then to form a decision-making matrix in which the alternatives will be displayed in relation to the selected criteria. Furthermore, it is necessary to determine the weight coefficients for the criteria, using subjective methods (eg expert assessment) or objective methods (eg entropy method, CRITIC method). Finally, based on the obtained values, the alternatives are ranked using the appropriate MCDM method, and with the participation of all interested parties, experts and decision makers, the best alternative choice is determined.

Multi-criteria decision-making methods can be classified based on the way information is processed, the type of data required, the logic of decision-making, etc. It is known that the ELECTRE and PROMETHEE methods have found a wide range of applications because they are suitable for qualitative and quantitative criteria. They are based on mutual comparison of alternatives and their ranking based on the degree of preference. The AHP method makes it possible to solve complex problems in a structured way, provides transparency and a clear logical sequence of decisions, is intuitive and easy to apply. Distance-based methods, such as TOPSIS and VIKOR, evaluate alternatives based on their distance from the ideal and anti-ideal solutions, so they are suitable for ranking problems because they emphasize closeness to the best and distance from the worst solution. With the development of mathematical models for the description of uncertainty and inaccuracy, fuzzy sets are applied in decision-making, so today various fuzzy MCDM methods are known, such as fuzzy AHP, fuzzy TOPSIS or fuzzy VIKOR, which enable more flexible modeling of preferences. Nowadays, methods based on artificial intelligence such as genetic algorithms, neural networks and evolutionary algorithms for multi-objective optimization are very popular since they are suitable for large and complex decision problems (Belton, & Stewart, 2002). Abrishamchi et al. (2005) state that selecting an appropriate multi-criteria decision-making method (MCDM) from a long list of available methods is itself a multi-criteria decision-making problem.

In this paper, we will present the multicriteria multicriteria decision-making method introduced by Žižović, Damljanović & Žižović (2016). The results presented in Žižović, Damljanović & Žižović (2017) and Žižović, Damljanović, Nikolić, & Vujičić. (2016) also serve as a foundation for this work.

MULTIPLIKATIVNA MCDM METODA

The multi-criteria decision-making (MCDM) problem can be described using a decision matrix, as shown in Table 1.

Suppose there are m alternatives, $A_1, A_2, \ldots, A_m$, to be assessed based on n maximisation criteria, $K_1, K_2, \ldots, K_n$. A decision matrix is an $m \times n$-matrix with each element a_{ij} being the j-th criterion value of the i-th alternative; that is, a_{ij} is the degree in which alternative A_i satisfies criterion K_j $(0 \le a_{ij} \le 1)$. Notice that we assume that all criteria are of the maximisation type (because all criteria of the minimisation type can be transformed into the maximisation type).

Table 1. Decision matrix.

	K_1	K_2	$\cdots$	K_n
A_1	a_{11}	a_{12}	$\cdots$	a_{1n}
A_2	a_{21}	a_{22}	$\cdots$	a_{2n}
$\vdots$	$\vdots$	$\vdots$		$\vdots$
A_m	a_{m1}	a_{m2}		a_{mn}

In multiplicative multi-criteria method, each criterion K_j is associated with a degree of importance ρ_j $(0 < \rho_j \le 1)$ of the decision. Here, we assume that all the criteria are arranged in strictly descending order, in the sense that the first criterion has the greatest importance and each following criterion has less importance for the decision than the previous one.

Given a decision matrix for a particular multi-criteria problem, it is naturally assumed that all alternatives are usually efficient, there being no alternative dominated by any other. When an alternative is better according to one criterion, the other is better according to the other criterion. Therefore, incomparability holds for all pair-wise comparisons.

To decide which alternative is the best solution, it is necessary to have some additional piece of information on the preference relation of the decision-maker. For example, it can be a reference point or minimal suitable value. To develop a multiplicative model that describes the preference relation, we use one hypothetical alternative $A(a_1,a_2,\ldots,a_n)$, where $a_1,a_2,\ldots,a_n$ are degrees in which hypothetical alternative A satisfies criteria $K_1,K_2,\ldots,K_n$, respectively.

Each alternative A_i from the starting set of alternatives $\{A_1,A_2,\ldots,A_m\}$ is compared with the hypothetical alternative A. Using appropriate calculation, its position with respect to this hypothetical alternative, whether it is better than the hypothetical alternative or not, is determined. Also, we calculate how much each alternative A_i is better or worse than the hypothetical alternative A and in that way we decide the final rank of alternatives from the starting set of alternatives $\{A_1,A_2,\ldots,A_m\}$.

In a multiplicative multi-criteria value model, the decision-maker's preference relation on the set of alternatives is given by the function v_n which maps the set of alternatives $\{A_1,A_2,\ldots,A_m\}$ into real numbers. For each alternative A_i, we have:

$$v_n(A_i)=\left(1+\frac{a_{i1}-a_1}{a_1}\cdot\rho_1\right)\cdot\left(1+\frac{a_{i2}-a_2}{a_2}\cdot\rho_2\right)\cdots\left(1+\frac{a_{in}-a_n}{a_n}\cdot\rho_n\right). \quad (1)$$

This can be expressed as:

$$v_n(A_i)=\prod_{k=1}^{n}\left(1+\frac{a_{ik}-a_k}{a_k}\cdot\rho_k\right). \quad (2)$$

If A_p and A_q are two alternatives from the starting set of alternatives $\{A_1,A_2,\ldots,A_m\}$, then we say that alternative A_p is preferred over alternative A_q if and only if $v_n(A_p)>v_n(A_q)$. For this, we use the following notation:

$$A_p \succ A_q \quad \Leftrightarrow \quad v_n(A_p)>v_n(A_q). \quad (3)$$

If $v_n(A_p)=v_n(A_q)$ for two alternatives A_p and A_q, then we can omit the last criterion (which is the criterion of the lowest importance for the decision since all criteria are arranged in descending order) and the function v_{n-1} is given by:

$$v_{n-1}(A_i)=\prod_{k=1}^{n-1}\left(1+\frac{a_{ik}-a_k}{a_k}\cdot\rho_k\right). \quad (4)$$

This procedure is repeated until the first (most important) criterion is taken into account.

TEACHING STRATEGIES IN LARGE GROUPS

Lectures at faculties in large groups of students represent a significant challenge, and at the same time bring several shortcomings in teaching. In large groups, it is difficult to provide individual attention to each student because the professor is not able to devote himself to each individual in the same way as in smaller groups. The teaching pace should be adjusted to meet the needs of all students. Progressing too quickly can confuse those who are not fully prepared, while progressing too slowly can bore more advanced students.

Also, in large groups, the opportunity for interaction between professors and students decreases. Questions, discussions and active participation of students in class are often reduced to a minimum, and this can negatively affect the depth of understanding of the material. Less interaction and anonymity in groups can lead to passivity and less engagement, as students do not feel immediate responsibility or connection to the group.

In large groups, it can be challenging to maintain a high level of motivation among students. It is more difficult for professors to monitor the progress of all students, spot possible learning problems or clarify misunderstandings.

When students from different study programs are mixed, organizing group consultations and colloquiums becomes more complex. Different programs have different consultation needs, and coordinating times when all students are available can be nearly impossible.

Larger groups require more time to answer questions and solve problems with students. In such circumstances, professors make an extraordinary effort to ensure that all students are noticed and receive the help they need.

When classes include hundreds of students, teachers and teaching assistants are burdened with tasks that include checking and reviewing homework assignments, quizzes, tests, and exam notebooks. For the organization of exams in large groups, there is often not enough time to do everything efficiently, and oral exams are especially problematic because they can last longer than written ones.

This paper examines the aforementioned challenges in the context of the Faculty of Technical Sciences in Čačak, University of Kragujevac, where general education courses are taught in large, multi-program groups, while professional courses in the later years of study are conducted in small, focused groups. The results provide valuable insights into the effectiveness of existing teaching practices and indicate specific areas for improvement, especially in subjects with a large number of enrolled students.The set of criteria is given by Table 2.

Table 2. Criteria.

Kriterijum		**Opis**
K_1	Quality of individual attention	To what extent can the teacher devote himself to the individual? High in small groups, lower in large ones. In very small groups,the professional distance is too reduced.
K_2	Effectiveness of monitoring andevaluation	How realistic is it to organize an oral exam under the given conditions? How much time and resources does the assessment require?
K_3	Teacher workload	How long does it take to review assignments, tests and other activities? Larger groups mean more administrative burden.
K_4	Motivation and engagement	Does group size affect motivation and involvement? Small groups are more likely to encourage engagement.
K_5	Organization of consultations	Is it possible to organize group or individual consultations? Is the course easily adaptable to the number of students?
K_6	Quality of oral exams	Does the teacher have enough time to give each student a high-quality oral examination?
K_7	Involvement and interactivity	How actively can students participate in class? Is there room for discussion and questions?
K_8	Pragmatism and sustainability	Do all students receive the same material and information? One professor can impart knowledge to a large number of students, which saves the institution time and money.

Using method given in Žižović, Damljanović & Žižović (2017), we propose weighted coefficients by Table 3.

Table 3. Weighted coefficients.

ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	ρ_8
0.25	0.20	0.18	0.12	0.10	0.08	0.05	0.02

The set of alternatives is presented by Table 4, and the example of evaluation one criterion is given by Table 5.

Table 4. Alternatives.

Alternative	**Veličina grupe**	**Opis**
A_1	>300	Maximum group
A_2	241-300	Too large a group
A_3	181-240	Very large group
A_4	121-180	Larger group
A_5	61-120	Medium group
A_6	41-60	Small group
A_7	15-40	Very small group
A_8	<15	Minimum group

The other criteria were evaluated similarly (it is important to note that some criteria will have a different evaluation logic because, for example, for "Pragmaticity", larger groups may be better).

Taking into account all the previously defined parameters, the alternatives were evaluated according to the given criteria, and the resulting decision matrix for this model is presented in Table 6.

Table 5. Evaluation according to criterion K_1.

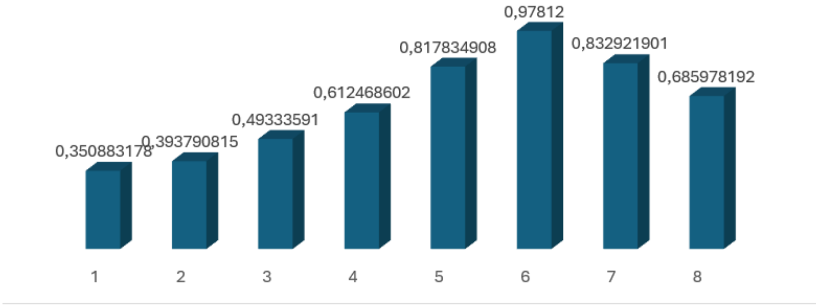
Veličina grupe	**Ocena**	**Obrazloženje**
>300	0.0	No individual attention at all.
241-300	0.1	Very little individual attention
181-240	0.3	Partially possible individual attention
121-180	0.5	Good individual attention
61-120	0.7	Very good individual attention
41-60	1.0	Excellent individual attention
15-40	0.8	Even better attention, but the risk of reducing the professional distance starts to appear
<15	0.6	Too small group – possibly too reduced professional distances

Table 6. Decision matrix of the model.

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8
K_1	0.0	0.1	0.3	0.5	0.8	1.0	0.7	0.4
K_2	0.0	0.1	0.3	0.5	0.8	1.0	0.9	0.7
K_3	0.0	0.1	0.3	0.5	0.7	1.0	0.9	0.7
K_4	0.1	0.2	0.4	0.6	0.8	1.0	0.9	0.8
K_5	0.1	0.2	0.4	0.6	1.0	0.9	0.8	0.8
K_6	0.0	0.1	0.3	0.5	0.8	1.0	0.9	0.7
K_7	0.1	0.2	0.4	0.6	0.9	1.0	0.8	0.8
K_8	1.0	0.9	0.8	0.7	0.6	0.4	0.2	0.1

Table 7. Function v_n, for $n = 8$

$v_8(A_1)$	$v_8(A_2)$	$v_8(A_3)$	$v_8(A_4)$	$v_8(A_5)$	$v_8(A_6)$	$v_8(A_7)$	$v_8(A_8)$
0.350883	0.393791	0.493336	0.612469	0.817835	0.97812	0.832922	0.685978



Applying the method [3], we obtain the following ranking of alternatives:

$$A_6 \mapsto A_7 \mapsto A_5 \mapsto A_8 \mapsto A_4 \mapsto A_3 \mapsto A_2 \mapsto A_1$$

So the best alternative is A_6.

CONCLUSION

Based on eight selected criteria and their relative weights, the analysis indicates that the optimal class size ranges from 41 to 60 students. This group size ensures sufficient individual attention without unnecessary over-personalization, enables effective monitoring and objective assessment, reduces the workload of instructors, making their work more sustainable, enhances student motivation and engagement, facilitates the organization of consultations and oral exams, and preserves interaction while encouraging active student participation. It avoids both extremes, not too large and not too small, remaining pragmatic and sustainable within the constraints of available resources and logistics.

It should be noted that many other criteria could be included in the analysis. However, the aim here is not to cover all ever possible aspects, but rather to demonstrate the methodology presented in the work of Žižović, Damljanović & Žižović (2016) through a concrete example.

This methodology can also be applied to the evaluation of class sizes at faculties outside the field of technical sciences, taking into account the specific characteristics of teaching in those contexts.

DECLARATIONS OF INTEREST STATEMENT

The authors affirm that there are no conflicts of interest to declare in relation to the research presented in this paper.

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