
EDUCATIONAL PROGRAMS PERFORMANCE RANKING BY USE OF TOPSIS METHOD

РАНЖИРОВАНИЕ ОСУЩЕСТВЛЕНИЯ ОБРАЗОВАТЕЛЬНЫХ ПРОГРАММ С ПОМОЩЬЮ МЕТОДА TOPSIS

TOPSIS YÖNTEMİ KULLANARAK EĞİTİM PROGRAM UYGULAMASININ SIRALAMASI

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ABSTRACT

Evaluation of an educational program is a complex task and its solution requires the analysis of data obtained on the basis of relevance to both quantitative and qualitative research. The collection of these data should be carried out using properly developed key performance indicators. The paper shows that such a task can be successfully completed using the TOPSIS method of multi-criteria decision analysis well known in information systems theory. The evaluation criteria can be positive or negative. The higher the rating value for a positive criterion, the better the alternative decision is. As for the negative criterion, the smaller the corresponding rating value, the better the alternative is. The TOPSIS method is based on the concept that the best solution among the available alternatives is the one that has the minimum distance from the positive ideal solution and, at the same time, the maximum distance from the negative ideal solution. The paper presents both positive and negative criteria developed to evaluate the performance of educational programs. For the data relevant to the above criteria, the appropriate data of the four higher educational programs of Gori State Teaching University are used. Using the TOPSIS method, the rating evaluation of the programs was carried out. The paper indicates that in the same way it is possible to assess the performance of one of the educational programs

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using data obtained at different intervals in relation to this program, and thereby determine the degree of success or failure of the program by comparing the results.

Keywords: Educational Program, Evaluation Criteria, TOPSIS, Ranking Evaluation, Multi-Criteria Decision

АННОТАЦИЯ

Оценка реализации образовательной программы является сложной задачей, и для ее решения требуется анализ данных, полученных на основе соответствующих количественных и качественных исследований. Понятно, что сбор этих данных должен осуществляться с использованием правильно разработанных индикаторов. В работе показано, что такая задача может быть успешно решена с помощью метода анализа многокритериальных решений TOPSIS, хорошо известного в теории информационных систем. Естественно, что критерии для принятия решения, как правило, могут быть двух типов - положительные или отрицательные. Чем выше значение рейтинга для положительного критерия, тем лучше альтернативное решение, а для отрицательного критерия справедливо противоположное, т. е. чем меньше соответствующее значение рейтинга для отрицательного критерия, тем лучше альтернатива. Метод TOPSIS основан на концепции, согласно которой наилучшим решением среди доступных альтернатив является то, которое имеет минимальное расстояние от положительного идеального решения и, в то же время, имеет максимальное расстояние от отрицательного идеального решения. В статье представлены как положительные, так и отрицательные критерии, разработанные для оценки реализации образовательной программы. В качестве данных, относящихся к вышеуказанным критериям, используются соответствующие данные четырех образовательных программ одного из факультетов Горийского Государственного Учебного Университета. На основании упомянутых данных была проведена рейтинговая оценка программ по методу TOPSIS. В работе указано, что таким же образом можно оценить реализацию одной из образовательных программ используя данные, полученные в разные промежутки времени по отношению к этой программе, и тем самым, определить степень успеха или неудачи осуществления программы путем сравнения результатов.

Ключевые слова: Образовательная Программа, Критерий Оценки, TOPSIS, Ранжирование, Мульти-Критериальное Решение

ÖZ

Bir eğitim programının uygulamasını değerlendirmek kolay değildir. Zorluğu çözmek için ilgili nicel ve nitel araştırmalara dayanarak elde edilen verilerin analizini yapmak gerekir. Bu verilerin toplanmasının doğru tasarlanmış göstergeler kullanılarak yapılması gerektiği açıktır. Çalışmada böyle bir sorunun bilişim sistemleri teorisinde iyi bilinen TOPSIS çok değişkenli çözüm analiz yöntemi kullanılarak başarılı bir şekilde çözümlendiği gösterilmiştir. Doğal olarak, karar verme kriterlerinin iki tür – olumlu veya olumsuz - olma ihtimali vardır. Olumlu bir kriter için derecelendirme değeri ne kadar yüksek olursa, alternatif çözüm o kadar iyi olur ve olumsuz bir kriter için tam tersidir. Yani negatif kriter için karşılık gelen derecelendirme değeri ne kadar düşük olursa, alternatif o kadar iyidir. TOPSIS yöntemi, mevcut alternatifler arasında en iyi çözümün, pozitif ideal çözümün minimum mesafeye sahip olduğu savına dayanmaktadır ve aynı zamanda, negatif ideal çözümden maksimum uzaklığa sahiptir. Makalede eğitim programının uygulanmasını değerlendirmek için geliştirilen olumlu ve olumsuz kriterler sunulmuştur. Yukarıdaki

kriterlere ilişkin veriler Gori Devlet Eğitim Üniversitesi fakültelerinden birinin dört bilim dalından elde edilerek kullanılmıştır. Yukarıdaki verilere dayanarak, programlar TOPSIS yöntemi kullanılarak derecelendirilmiştir. Çalışmada aynı şekilde, bu programla ilgili farklı aralıklarda elde edilen verileri kullanarak eğitim programlarından birinin uygulanması ile değerlendirilmesinin mümkün olduğu gösterilmiş ve böylece sonuçları karşılaştırılarak programın başarı veya başarısızlık derecesi belirlenmiştir.

Anahtar sözcükler: Eğitim Programı, Değerlendirme Kriteri, TOPSIS, Sınıflandırma, Çok Kriterli Çözüm

Introduction

In recent decades, the concept of quality in higher education has attracted the special attention of all stakeholders of the higher education institution. Consequently, caring for the development of the quality of education is one of the most important issues for a modern higher education institution. Internal Quality Assurance in higher education represents one of the main mechanisms for quality development and management at the institutional level (Martin, 2018; Bollaert, 2019). In accordance with the Standards and guidelines for quality assurance in the European Higher Education Area (ESG) the important component of the internal quality assurance is periodic monitoring and evaluation of educational programs (Standards, 2015). Through it, the institution should ensure that the goals of the educational program are met, as well as respond to the current needs of students and other stakeholders. The frequency of monitoring and evaluation processes ensures the continuous development of the educational program, the creation of a supportive environment for teaching and research activities that will ensure that the program is in line with public expectations. According to ESG, this process should include evaluation of the following components of the educational program:

- Content of the program in light of recent scientific research;
- Changing community needs;
- Students' academic workload and their academic achievements;
- Effectiveness of student assessment procedures;
- Students' expectations, needs and satisfaction of the program;
- Learning environment and student support compliance with program requirements.

Thus, evaluating the performance of an educational program is a complex task and its resolution requires the analysis of relevant data, both quantitative and qualitative, which characterize various aspects of a given educational program.

It is clear that the above data should be collected using properly developed key performance indicators (Alsarmi and Al-Hemyari, 2014; Ogunleye, 2013; Parmenter, 2010; Rajkaran and Mammen, 2014). Based on the data obtained from each of these indicators, it is possible to assess above-mentioned certain aspects of the educational program, identify shortcomings and take appropriate measures to eliminate them. As the evaluation of the program should be carried out periodically, after the period specified by the institution's internal quality assurance system, the re-evaluation of the program will again reveal the strengths and weaknesses of the program. A comparative analysis of the results of previous and

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new evaluations can reveal which aspects/components of the program have been developed during this period and which have been weakened. Clearly, based on the obtained results, program development-oriented activities need to be re-planned and implemented. Obviously, if the latest evaluation data show improvement for all components of the program, it can be said unequivocally that the program has made progress over the period. However, if along with the improvement of certain components, some components were found to be degraded during the evaluation phase of the program, then it is impossible to determine whether the program developed or weakened as a whole only on the basis of evaluations of its particular aspects. The presented paper shows that a conclusion on the development of the program as a whole can be made by a rating evaluation performed using data collected from periodic evaluations of the program.

The paper also shows that rating evaluations can be performed for several different programs if their performance is evaluated with the same set of key performance indicators.

Methods

Thus, evaluating the performance of an educational program involves making decisions based on data obtained using multiple key performance indicators. Such a task can be successfully solved by a multi-criteria decision analysis technique TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), which is well-known in information systems theory (Hwang and Yoon, 1981; Yoon, 1987; Hwang, Lai and Liu, 1993). This method is based on the concept that the best solution among the alternatives is at the minimal distance from the positive ideal solution and at the maximal distance from the negative ideal solution.

The paper presents the possibility of using the TOPSIS method to evaluate the performance of educational programs. One of the most important objects used by the TOPSIS multi-criteria decision-making method is the decision matrix (Hwang and Yoon, 1981; Yoon, 1987; Hwang, Lai and Liu, 1993), which consists of A_1, A_2, \dots, A_m alternatives with ratings x_{ij} against the evaluation criteria C_1, C_2, \dots, C_n :

$$D = \begin{matrix} & C_1 & \dots & C_n \\ A_1 & x_{11} & \dots & x_{1n} \\ \cdot & \cdot & \cdot & \cdot \\ A_m & x_{m1} & \dots & x_{mn} \end{matrix}$$

The weight vector $W = (w_1, \dots, w_n)$ consists of the weights w_j ($j = 1, \dots, n$) of evaluation criteria C_j , respectively, which obey the condition $\sum_{j=1}^n w_j = 1$.

The evaluation criteria for the alternatives are generally of two types - positive and negative. The higher the rating value relative to a positive criterion,

the better the alternative is, and the lower the rating value relative to the negative criterion, the better the alternative is.

Because the data type of the decision matrix is not uniform, it needs to be normalized. The elements of normalized matrix $R = R(r_{ij}), i = 1, ..m; j = 1, .., n$ are calculated by the formula

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}}, i = 1, \dots, m; j = 1, \dots, n$$

The weighted normalized decision matrix $P = P(p_{ij}), i = 1, ..m; j = 1, .., n$ is calculated by formula

$$p_{ij} = w_i \cdot r_{ij}, i = 1, \dots, m; j = 1, \dots, n$$

Based on the TOPSIS method, alternatives are evaluated using the following steps:

Step 1. Identify the positive ideal solution and the negative ideal solution as follows:

$$A^+ = (p_1^+, p_2^+, \dots, p_m^+)$$

$$A^- = (p_1^-, p_2^-, \dots, p_m^-)$$

where

$$p_j^+ = \left(\max_i p_{ij}, j \in J_1; \min_i p_{ij}, j \in J_2 \right)$$

$$p_j^- = \left(\min_i p_{ij}, j \in J_1; \max_i p_{ij}, j \in J_2 \right)$$

and J_1 and J_2 correspond to positive and negative evaluation criteria, respectively.

Step 2. For each alternative A_i , calculate the Euclidean distances to a positive ideal solution A^+ and to a negative ideal solution A^- with the following relationships:

$$d_i^+ = \sqrt{\sum_{j=1}^n (d_{ij}^+)^2}$$

$$d_i^- = \sqrt{\sum_{j=1}^n (d_{ij}^-)^2}$$

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where

$$d_{ij}^+ = p_j^+ - p_{ij}, i = 1, \dots, m; j = 1, \dots, n$$

$$d_{ij}^- = p_j^- - p_{ij}, i = 1, \dots, m; j = 1, \dots, n.$$

Step 3. For each alternative A_i , calculate the relative proximity ξ_i to a positive ideal solution by the formula

$$\xi_i = \frac{d_i^-}{d_i^+ + d_i^-}$$

Step 4. Rank the alternatives according to the magnitude of the relative proximity.

Results

To illustrate the rating evaluation of educational programs, suppose that a higher education institution implements four academic higher education programs, namely - undergraduate educational programs in Mathematics, Biology, Sports and Information Technology. Let us evaluate the performance of the mentioned educational programs during the period of time specified by the University Internal Quality Assurance System using the TOPSIS method with the following key performance indicators:

1. The ratio of the number of scientific papers published and reports presented at the conferences by the program implementing staff to the number of staff;
2. Percentage value of program staff attrition rate;
3. The ratio of the number of entrants wishing to enroll in the program (the first three choices) to the number of contingent to be admitted to the program;
4. Percentage of students transferred from the program by external and internal mobility;
5. Percentage of students transferred to the program by external and internal mobility;
6. GPA (Grade Point Average) for graduates of the program;
7. The ratio of the number of students involved in research projects (e.g. scientific papers, conferences, workshops, exhibitions, etc.) to the number of students;
8. Percentage of employment of graduates;
9. Level of staff satisfaction with organizing the learning process (percentage);
10. Level of student satisfaction with the program (percentage);
11. Average score for evaluating program components performance.

To simplify the calculations, we have limited ourselves to 11 indicators. It should be noted, however, that the selection of key performance indicators, as well as their number, should comply with the criteria set for the evaluation of the

performance of the educational program through the internal quality assurance system of the institution.

Table 1 below shows the relevant information for Gori State Teaching University’s educational programs against the above evaluation criteria based on the data of the last 5 years.

Educational Program	Evaluation Criteria										
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Mathematics	14.4	13	0.31	6	33	3.1	2.26	87	4.5	90	27.2
Biology	11.5	6	0.5	11	32	2.6	1.8	57	4.58	100	26.7
Sport	7.25	20	0.79	3	34	2.1	0.6	60	4.75	100	25.6
Information Technology	14.1	15	1.24	12	43	2.5	1	60	4.75	100	27.1

Table 1. Educational program’s evaluation criteria

Assume that each component of the weight vector is equal to $\frac{1}{11}$, i.e.

$W = \left(\frac{1}{11}, \dots, \frac{1}{11} \right)$. If we take into account that the second and fourth evaluation criteria are negative in the context of the problem under consideration, while the rest of the evaluation criteria are positive, then, using the calculations with software package "MATLAB", the following ranking evaluation of the alternatives given in Table 2 will be obtained:

Educational Program	Evaluation	Ranking
Mathematics	0.54106	1
Biology	0.4749	3
Sport	0.40357	4
Information Technology	0.48351	2

Table 2. Educational program’s ranking

Thus, the obtained results can be formulated as follows:

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1. Positive and negative criteria have been developed to evaluate the performance of the educational program.
2. Based on the data collected by using indicators of the developed criteria, a ranking evaluation of the performance of four academic higher educational programs of Gori State Teaching University has been carried out using the TOPSIS method.

Discussion

Above we have presented the example of a rating evaluation of the realization of several different educational programs. It is easy to see that in the same way it is possible to assess the development of one concrete educational program. In particular, by ranking the previous and subsequent evaluation data of the program, it is possible to form a conclusion about the development of the program as a whole in the period between evaluations.

As mentioned above, the selection of key performance indicators for evaluation of the performance of an educational program should be done in accordance with the internal quality management policy of an educational institution (Alsarmi and Al-Hemyari, 2014; Ogunleye, 2013; Parmenter, 2010; Rajkaran and Mammen, 2014). In the illustrative example above, for the simplicity of the problem, each component of the weight vector was $1/11$. It should be noted that the selection of components of this vector, which has a significant impact on the outcome of the ranking, should be carried out taking into account the mission and strategic goals of the higher education institution. Accordingly, for the criteria that meet the priority areas of the institution (for example, research, internationalization and so on), the relevant components of the weight vector must be appropriately high in number.

Thus, the presented method of ranking educational programs makes it possible to evaluate complex information about the performance of programs, to identify success or failure in the development of the program as a whole, and therefore, it may be used by higher education institutions as a useful tool in the internal quality assurance. At the same time, the availability of ranking results for stakeholders enhances accountability towards stakeholders and thus provides increased confidence in higher education institutions, which is in accordance with the public demand of better education quality.

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