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The Application of Fuzzy Multi-Criteria Methods for the Selection of Digital Platforms for the Improvement of the Learning Process at Universities in the Brčko District of BiH

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Abstract: The selection of appropriate digital platforms (DPs) for enhancing the learning process at universities in the Brčko District, Bosnia and Herzegovina (BiH), was explored through the application of fuzzy multi-criteria decision-making (MCDM) methods. This region, with a rich academic heritage, presents a complex landscape of available DPs, each offering varying features and functionalities. Given the diversity of platforms and evaluation criteria, expert-based fuzzy methods were employed to assess and rank potential DPs. Specifically, the Simple Weight Calculation (SiWeC) method was utilized to determine the relative importance of the evaluation criteria, while the Compromise Ranking of Alternatives from Distance to Ideal Solution (CRADIS) method was applied to rank the platforms based on their proximity to an ideal solution. Expert evaluations from three universities in the region indicated that key characteristics of effective DPs include high interactivity, customizable user interfaces, and advanced tools for monitoring student progress. The results highlighted that DPDL 4 emerged as the highest-ranked platform, followed closely by DPDL 1. These findings underscore the significance of integrating interactive and customizable features in DPs to enhance the educational experience. This research contributes to the optimization of e-learning environments at universities in the Brčko District, thus supporting the region's efforts to improve academic competitiveness and attract prospective students.

Keywords: Digital platforms (DPs); E-learning; Brčko District; Fuzzy methods

1. Introduction

Changes in information technologies affect all aspects of life (Chege et al., 2020), including the development of new systems in education. Educational institutions are increasingly using DPs (Decuypere et al., 2021) to improve their work process, thereby enhancing the quality of teaching and supporting services provided to students. These platforms encourage collaborative learning and allow the content to be adapted to the individual needs of students (Secundo et al., 2021). They provide access to information necessary for the improvement of teaching and enable interaction between teachers and students in real time. In addition, teachers can monitor the progress of students on these platforms in terms of mastering the teaching content.

Universities around the world are increasingly using DPs to improve their business (Toan et al., 2021). This practice shows that these platforms support educational activities and help optimize administrative processes, increase transparency, and strengthen communication within the academic community and communication within the university, both between employees and students. To implement DPs, they should be adapted to the needs of universities, which is challenging (Ma et al., 2024).

Universities in the Brčko District face the challenges of adapting educational processes to the requirements of the labor market. The basic activity of every university is to transfer certain knowledge to students that can serve them in the process of work and business (Secundo et al., 2021). That is why special attention must be paid to how to transfer knowledge to students in the best possible way. DPs help universities because new generations of

students actively use new technologies. These platforms represent tools and software solutions designed to support the work of universities in terms of educational content, administrative work and research activities. They enable the integration and automation of processes at universities, improve communication between students, teaching and administrative staff and provide access to all the content that a particular university offers. The application of these platforms enables learning management, student management, research and collaboration at universities, financial and administrative support for university management, certain consultations, access for students to digital libraries, and monitoring of the quality of university work and the development of other processes at universities. In addition, universities must adapt to different demographic and economic factors to approach each student (Akargöl et al., 2024). The implementation of DPs supports inclusiveness and accessibility of education for all categories of students. Therefore, it is crucial to choose a suitable DP for universities.

When choosing a DP, several platforms need to be analyzed using different criteria. In this study, a MCDM approach was employed to evaluate the importance of these criteria, specifically in the context of improving the operations of the universities of Brčko District. The extent to which individual DPs meet these criteria was also assessed. The assessment of criteria and alternatives can be carried out in different ways. In practice, there are several methods, and the most commonly used are numerical ratings and linguistic terms. Numerical ratings are used when it is known exactly how important a criterion or alternative is. Linguistic terms are used when experts do not have all the data necessary to assess criteria and evaluate alternatives. Then they have incomplete information and make decisions under conditions of uncertainty. In order to solve this problem of decision-making, a fuzzy approach was developed. This approach allows for decision-making with incomplete information. Decisions were made by experts giving their assessment in the form of linguistic terms that were used by applying a fuzzy approach, determining the importance of criteria and evaluating alternatives. The fuzzy approach is easier to use when qualitative criteria are used. Since such criteria were used in this research, this approach was also used. These methods were first used to analyze the importance of certain criteria with which DPs are viewed, and then these platforms were compared to each other through ranking. The application of these methods provides a systematic approach to solving such problems. When using these methods, there are various approaches depending on the type of data used to evaluate criteria and alternatives (Güldeş et al., 2022). In this research, qualitative indicators of these DPs were used, so it is logical to use a fuzzy approach. This approach makes it possible not to give concise but approximate assessments in the form of linguistic terms. This approach includes subjectivity and uncertainty in the evaluation process. Based on this approach, the decision is based on subjective assessments of the users of these platforms.

DPs enable a wide range of solutions to facilitate the distribution of educational content to students and the use of Learning Management System (LMS) tools for organizing video conferences or organizing online lectures by professors from any part of the world, allowing them to monitor the progress of students through these platforms. This is the motivation for conducting this research. There are many different platforms and each of them has its advantages and limitations, so the process of choosing DP is very difficult. The specificity of the Brčko District and the universities located in this area make this process even more difficult when choosing which platform best suits this area to achieve the best effects in terms of educational development.

The goal of this study is to use the fuzzy MCDM method to select the most appropriate DP that would improve the teaching process and the learning process at the universities in the Brčko District. These methods can be used to evaluate the criteria and DPs, and a decision can be made based on the results. This approach makes it possible to make decisions about the choice of platforms that would best suit the local needs of universities in the territory of the Brčko District. In this way, the modernization and improvement of the educational process can be carried out. To achieve all this, individual goals were set, namely:

- Identification of criteria for the evaluation and selection of DPs in university education, taking into account the specific needs of these universities.
- Determining the importance of criteria using the fuzzy SiWeC method.
- Evaluation of DPs using the CRADIS method to determine which platform would give the best results for this area.
- Proposing which DP would give the best results considering the technical, pedagogical, and practical requirements of universities and students in the Brčko District.

Contributions of this study are as follows:

- Development of a methodology that combines the fuzzy methods, providing an innovative approach to the evaluation of DPs.
- Providing practical guidelines to universities in the Brčko District when choosing DPs to improve educational processes and their work.
- Improving the decision-making with fuzzy methods that take into account uncertainties and subjective assessments in the educational sector.
- Expanding theoretical frameworks for the application methods in education.

2. Literature Review

According to Decuypere et al. (2021), DPs have been gradually integrated into university education, but the COVID-19 pandemic has significantly accelerated their implementation due to university closures. Nuere & De Miguel (2021) proposed that the pandemic has highlighted the willingness of teachers to use innovative methods to transmit teaching content via DPs. Numerous researchers have analyzed how the COVID-19 pandemic stimulated the development of these platforms. For example, Secundo et al. (2021) identified key challenges faced by university teachers and students during this period and illustrated this with an example of the entrepreneur's teaching.

Rodríguez-Abitia & Bribiesca-Correa (2021) emphasized that another factor influences the development of DPs at universities and the new generation of students is a digital generation growing up with these technologies. In addition, the new generations of students are looking for a different way of presenting course content and administration at universities. Furthermore, Al-Adwan et al. (2023) emphasized that the development of DPs is influenced by a whole series of information technologies that are united in the Metaverse, which could set future trends in the development of the application of DPs in education.

However, these DPs are increasingly used in other sectors. Therefore, Jin & Wang (2024) studied how these platforms can be used in business through a fuzzy-set qualitative comparative analysis. Nikulchev et al. (2021) studied the application of DPs in virtual simulation infrastructures and used mathematical models for evaluation. Maretto et al. (2022) emphasized that with the transition to the Industry 4.0 system, DPs are increasingly important for the company's operations. Through the fuzzy Analytical Hierarchy Process (AHP) method, they emphasized the advantage of adopting technologies and their mutual connection.

DPs are used as e-learning systems in universities. Atıcı et al. (2022) applied the interval type-2 fuzzy AHP method to determine the importance of criteria for evaluating these systems during the COVID-19 pandemic. Akargol et al. (2024) analyzed four e-learning platforms using the Pythagorean fuzzy AHP and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), concluding that universities should consider the requirements of their educational programs when selecting a platform. Güldeş et al. (2022) determined the importance of criteria and subcriteria for evaluating e-learning platforms using the AHP method.

Toan et al. (2021) used gray numbers in combination with AHP and TOPSIS methods to select the platform that best supports e-learning. Al-Gerafi et al. (2024) applied an innovative approach based on the integration of the Inter-Valued Fuzzy (IVF) method with the complex proportional estimation (COPRAS), the estimation based on the distance from the average solution (EDAS) and the proximity indexed value (PIV) methods. Adem et al. (2022) evaluated criteria and platforms for e-learning through human-computer interaction using a spherical fuzzy extension of the AHP method. Ma et al. (2024) used the fuzzy AHP method to prioritize criteria, analyzing four criteria for prioritization and 14 criteria for evaluating e-learning platforms.

This literature review shows the importance of DPs in the development of universities, especially for the e-learning application system (Bonina et al., 2021). These systems experienced a boom in use mostly due to the COVID-19 pandemic, where universities had to switch from classic to online classes to protect the health of teachers and students. After that, these platforms began to be applied in modern business too, because it was also affected by the COVID-19 pandemic. A further review of the literature shows that MCDM methods can be used to evaluate DPs, and that is why this approach was chosen in this research.

3. Materials and Methodology

This section presents a case study and the methods used in this research.

3.1 Case Study

The Brčko District has a rich tradition in the development of education dating back to 1883 when the Trade School was founded. After that, the first higher education institutions and then universities were founded. There are currently three universities and four university branches that do not have their headquarters in Brčko. Since the Brčko District covers 493 km² and has about 90,000 inhabitants, it is logical that the universities located in the area have to look for students from other local communities and even from other countries to carry out their activities. This is why these universities have distance learning platforms that allow students anywhere in the world to access teaching materials and acquire the necessary knowledge.

The research was conducted in collaboration with three universities in Brčko. The reason why these universities were selected instead of the universities with branches is that these universities use their own university DPs and cannot choose other platforms. Universities based in the Brčko District can choose which platforms they will use to improve their business. In collaboration with these universities, this research was conducted to evaluate the DPs used at universities and to provide suggestions on how to improve their work with these platforms. These universities were contacted and provided with primary contacts through which communication with these

universities was established. Through these contacts, potential experts were identified for the purposes of this research. In order to avoid imposing the opinion of any university, it was ensured that all universities provided the same number of experts. In the end, it was agreed that there would be two experts from each of these universities. These experts had a scientific title that classified them as potential experts, and then their experience in this field determined their selection as experts. In this way, a total of six experts were included in this research.

This research is focused on the evaluation of DPs for distance learning, which of course can also be used by regular students to acquire new knowledge. Full-time students can access these platforms, although these platforms are primarily intended for distance students. In practice, there are numerous DPs for distance learning, and five of them were evaluated in this study. In order not to promote one of these platforms in this study, only the labels, namely DPDL from 1 to 5, were mentioned instead of their names. In this research, the following DPs that support e-learning were evaluated:

- DPDL 1 is an open-source platform that provides a flexible learning environment and the ability to adapt to the needs of users.
- DPDL 2 is a platform that represents an LMS. Planning tools and interactive discussions among users are included within this platform.
- DPDL 3 is a platform designed for simple and flexible management of educational processes. This platform enables the creation and sharing of various tasks.
- DPDL 4 offers a lot of options for managing educational content, and it is also possible to adapt this platform according to the needs of the institution. It supports various tools that enable collaboration between teachers and students.
- DPDL 5 platform is specialized for teamwork and team collaboration. It offers the possibility of organizing meetings, exchanging documents, and enabling real-time communication between the participants on this platform.

In the first step of this evaluation, the criteria were assessed. The choice of criteria was made together with the selected experts in this research. Based on their opinions, a total of eight criteria were taken, namely:

- Interactivity (C1) as a criterion measure how dynamic the application is and allows the user to interact with the content. Interactivity in platforms implies communication between teachers and students to make the process of adopting teaching content and learning more successful (Girish et al., 2022). The success of a DP is focused on the interactivity of the platform between participants and includes feedback, forums and groups, suggestions, and recommendations (Alsoud et al., 2022). The greater the interactivity, the easier it is to access certain information.
- User interface (C2) refers to the simplicity and functionality of the DP for easier use. If the user interface is too difficult, then users cannot find what they are looking for and then it can be a problem to perform a certain task (Alomari et al., 2020). For these reasons, it is necessary for the user interface of these platforms to be as simple as possible (Miraz et al., 2021) so that users can more easily perform certain activities.
- Support for mobile devices (C3) implies the optimization of DPs so that they can be used on different mobile devices. This support helps to make the e-learning process flexible and that these platforms can be used in any location using mobile devices (Eom, 2023). In this way, the e-learning process is not limited to a specific room, but these platforms can be used anywhere (Neffati et al., 2021).
- Data security and privacy (C4) refer to how well the DP protects user data and ensures privacy. It is very important to understand the problem of information security in e-learning systems because these platforms are subject to risks from internal and external attackers (Korać et al., 2022). For this reason, it is important to protect these platforms to keep data safe and to protect privacy on these platforms (Husain & Budiyantara, 2020).
- The availability of analytics tools (C5) refers to the collection and analysis of how much students use these platforms and what results they have achieved. In addition, by applying these tools, strategies can be adopted to improve the quality of e-learning (Mukred et al., 2024). These tools make it possible to analyze how much time students spend on these platforms and what kind of results they achieve (Susnjak et al., 2022). By applying this data, it is possible to adapt the teaching content to the students to achieve the desired results.
- Price/license (C6) as a criterion refers to the costs of using DPs. If the costs of acquiring certain platforms are higher, it can be more difficult for universities to decide to acquire them (Chaudhuri et al., 2021). Especially if universities have limited budgets, it is necessary to take into account their operating costs (Riinawati, 2021). For this reason, it is necessary for the DP to be as favorable as possible and to give good results in the teaching process.
- Adaptability and flexibility (C7) refer to the ability of a DP to adapt to user needs. Adaptability and flexibility are necessary to improve e-learning and to achieve better results (Veeramanickam & Ramesh, 2022). Platforms should have the ability for users to adapt them to their needs so that it would be easier for them to work on these platforms (Liang et al., 2021).
- Support (C8) as a criterion refers to measuring the quality of technical support to users in case of problems. This criterion also applies to the support of users during their work if they have certain ambiguities. Support should be available at all times so that problems on the platforms are quickly resolved (Veeramanickam & Ramesh, 2022).

Once the alternatives and criteria were determined, the experts evaluated the importance of the criteria and the alternatives themselves by using linguistic terms. These terms were taken since it is not possible to give a completely precise assessment. Therefore, it is easier to give experts a linguistic value than a precise assessment.

Linguistic terms move through ten levels from the worst to the best grade, which ranges from absolutely bad to perfect. These values were used to determine the importance of criteria and ratings of DPs through the fuzzy methods.

3.2 Research Methods

The fuzzy SiWeC method was used to determine the importance of the criteria. This method was developed to determine the weight value of the criteria simply, taking into account the evaluations of the experts themselves (Puška et al., 2024). If the evaluations of individual experts are uniform, the importance of these evaluations can be lower, and vice versa. This method has the following steps:

Step 1: Evaluation of the importance of criteria.

Step 2: Transformation of linguistic terms into fuzzy numbers.

Step 3: Normalization.

$$\tilde{n}_{ij} = \frac{x_{ij}^{l}}{max\ x_{ij}^{u}}, \frac{x_{ij}^{m}}{max\ x_{ij}^{u}}, \frac{x_{ij}^{u}}{max\ x_{ij}^{u}} \tag{1}$$

where, $max\ x_{ij}^{u}$ is the maximum value.

Step 4: Calculation of standard deviation ($st.dev_j$).

Step 5: Weighting of normalized scores with standard deviation.

$$\tilde{v}_{ij} = \tilde{n}_{ij} \times st.dev_j \tag{2}$$

Step 6: Calculation of the sum of weight criteria.

$$\tilde{s}_{ij} = \sum_{j=1}^{n} \tilde{v}_j \tag{3}$$

Step 7: Calculating criterion weights.

$$\tilde{w}_{ij} = \frac{s_{ij}^{l}}{\sum_{j=1}^{n} s_{ij}^{u}}, \frac{s_{ij}^{m}}{\sum_{j=1}^{n} s_{ij}^{m}}, \frac{s_{ij}^{u}}{\sum_{j=1}^{n} s_{ij}^{l}} \tag{4}$$

Given that the fuzzy CRADIS method was applied to create the ranking list of DPs, the weights of the criteria retained their fuzzy form. This method was chosen because its steps were adapted from other older methods such as the TOPSIS, Additive Ratio Assessment System (ARAS), and Measuring Attractiveness by a Categorical Based Ranking Order of Similarity (MACBETH) methods. Therefore, the advantages of those methods were used in this method. In addition, some new steps were added to this method. The Fuzzy CRADIS method first uses the calculation of deviations from ideal and anti-ideal solutions and then the membership functions, forming the ranking of alternatives (Puška et al., 2022). The steps of this method are as follows:

Step 1: Creating an initial decision matrix.

Step 2: Normalization.

$$\tilde{n} = \left(\frac{x_{id}^{l}}{x_{ij}^{u}}, \frac{x_{id}^{l}}{x_{ij}^{m}}, \frac{x_{id}^{l}}{x_{ij}^{l}} \right) \tag{5}$$

Step 3: Multiplication with weights.

$$\tilde{v}_{ij} = \tilde{n}_j \times \tilde{w}_j \tag{6}$$

Step 4: Finding the ideal and anti-ideal solution.

$$t_i = \max \tilde{v}_{ij} \tag{7}$$

$$t_{ai} = \min \tilde{v}_{ij} \tag{8}$$

Step 5: Application of deviation from the solution.

$$d^+ = t_i - \tilde{v}_{ij} \tag{9}$$

$$d^- = \tilde{v}_{ij} - t_{ai} \tag{10}$$

Step 6: Cumulative deviations.

$$s_i^+ = \sum_{j=1}^{n} d^+ \tag{11}$$

$$s_i^- = \sum_{j=1}^{n} d^- \tag{12}$$

Step 7: Defuzzification.

$$s_i^{\pm}{}_{def} = \frac{d_i^l + 4d_i^m + d_i^u}{6} \tag{13}$$

Step 8: Calculating the utility function.

$$K_i^+ = \frac{s_0^+}{s_i^+} \tag{14}$$

$$K_i^- = \frac{s_i^-}{s_0^-} \tag{15}$$

Step 9: Ranking of alternatives.

$$Q_i = \frac{K_i^+ + K_i^+}{2} \tag{16}$$

The best alternative has the highest value Q_i, while the worst one has the lowest value Q_i.

4. Results and Discussion

As previously stated, the SiWeC and CRADIS fuzzy methods were used to obtain the results. In the first step of applying the SiWeC method, the importance of criteria was calculated using linguistic expressions (Table 1). Based on these linguistic concepts, experts should assess the importance of the criteria, and evaluate how much the DP meets the set criteria or how the alternatives meet the set criteria. If some of the criteria are not important at all, experts would give a rating of absolutely bad, very bad or bad, depending on the degree of unimportance of that criterion. On the other hand, if some of the criteria are considered very important by the expert, they would give a rating of extremely good, absolutely good or perfect, depending on the degree of importance. In this way, experts determined the importance of the criteria and the DPs.

Table 1. Values of linguistic terms and membership functions (Puška et al., 2024)

Linguistic Terms	Membership Function
Absolutely bad (A-B)	(1, 1, 1)
Very bad (V-B)	(1, 2, 3)
Bad (B)	(2, 3, 4)
Medium-bad (M-B)	(3, 4, 5)
Equal (E)	(4, 5, 6)
Medium-good (M-G)	(5, 6, 7)
Good (G)	(6, 7, 8)
Extremely good (E-G)	(7, 8, 9)
Absolutely good (A-G)	(8, 9, 10)
Perfect (P)	(9, 10, 10)

Based on the defined conditions, the experts evaluated the importance of the criteria, and the results are shown in Table 2.

This was followed by the use of the membership function and the determination of fuzzy numbers based on these terms. For example, the linguistic term absolutely bad was transformed into the fuzzy number (1, 1, 1), while the linguistic term equal was transformed into the fuzzy number (4, 5, 6). In this way, these values were transformed for both the criterion evaluation and the DP evaluation. Since the largest fuzzy number was 10, then all values were divided by that number within the normalization framework. On the example of expert 1 for criteria *C*1 (Table 2), normalization was carried out as follows:

$$n_{11} = \frac{7}{10} = 0.7;\ \frac{8}{10} = 0.8;\ \frac{9}{10} = 0.9$$

It was done in the same way for all other values of fuzzy numbers. The standard deviation for the individual expert assessments was then calculated, and the resulting values were multiplied by the normalized fuzzy numbers. At the end of the procedure, the individual criterion values were summed to determine the final weight of each criterion. In the same example, the final weights were calculated as follows:

$$w_{11} = \frac{0.61}{6.19} = 0.112;\ \frac{0.78}{5.56} = 0.140;\ \frac{0.85}{4.87} = 0.175$$

Table 2. Evaluation of criteria by experts

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
Expert 1	E-G	G	M-G	A-G	G	E-G	A-G	G
Expert 2	G	E-G	G	A-G	M-G	G	E-G	M-G
Expert 3	A-G	M-G	E-G	G	E-G	G	G	E-G
Expert 4	M-G	A-G	E	E-G	G	E-G	E-G	M-G
Expert 5	G	E-G	G	A-G	E-G	M-G	E-G	E-G
Expert 6	E-G	G	M-G	E-G	G	A-G	G	G

The results show that the most important criterion is *C*1 (interactivity), followed by criteria *C*2 (user interface) and *C*5 (availability of analytics tools). As shown in Table 3, the results show that DPs should be interactive to enable communication and support between teachers and students; the user interface should be simple; and professors have good tools for analytics that enable monitoring of student work. According to these results, the least important criterion is *C*6 (price/license). However, when compared to other criteria, its importance is less than a third of the criteria that received the highest rating.

Table 3. Criterion weight value

C1	**C2**	**C3**	**C4**
(0.112, 0.140, 0.175)	(0.112, 0.140, 0.172)	(0.090, 0.116, 0.150)	(0.103, 0.131, 0.167)
C5	**C6**	**C7**	**C8**
(0.110, 0.138, 0.175)	(0.069, 0.092, 0.123)	(0.082, 0.107, 0.140)	(0.108, 0.136, 0.170)

Table 4. Evaluation of DPs

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
DPDL 1	E-G	G	G	A-G	E-G	A-G	A-G	E-G
DPDL 2	G	M-G	M-G	E-G	A-G	M-G	E-G	G
DPDL 3	M-G	EG	A-G	G	M-G	A-G	G	M-G
DPDL 4	E-G	A-G	E-G	A-G	A-G	G	E-G	E-G
DPDL 5	G	G	A-G	A-G	G	G	G	E-G

The assessment of DPs proceeded below. First, the experts were sent questionnaires where they gave their evaluations. When the ratings were collected, the average values of these ratings were calculated and returned to the experts. They then had to explain why their grades differed from the average and if they had changed their mind to correct their grades. After that, everything was collected from the experts. The average grades were recalculated and sent to them with explanations as to why some experts gave a lower or higher grade. Based on this, the experts filled out the questionnaires again and the assessment was adjusted again. After the three steps, the experts' assessments were harmonized (Table 4). These ratings were used to calculate the rankings of DPs.

The first step in the fuzzy SiWeC method involved transforming linguistic expressions into fuzzy numbers using

a membership function. This was done in the already explained way in the fuzzy SiWeC method. This was followed by normalization and multiplication of the obtained values with the weights of the criteria. Using the example of DPDL 1 and criterion *C*1, the calculation of these steps is as follows:

$$n_{11} = \frac{7}{9} = 0.78;\ \frac{8}{9} = 0.89;\ \frac{9}{9} = 1.00$$

$$w_{11} = 0.78 \cdot 0.11 = 0.09; 0.89 \cdot 0.14 = 0.12; 1.00 \cdot 0.17 = 0.17$$

Then, ideal and anti-ideal solutions were determined. The ideal solution obtained the largest value of the weighted matrix, which was (0.09, 0.13, 0.18), and the anti-ideal solution was (0.03, 0.06, 0.09). Now it is necessary to first subtract all the weighted values from the ideal solution, and then subtract the value of the anti-ideal solution from the weighted values. In the same example, the calculation is as follows:

$$d^{+} = (0.09 - 0.09 = 0.00; 0.13 - 0.12 = 0.01; 0.18 - 0.17 = 0.01)$$

$$d^{-} = (0.09 - 0.03 = 0.06; 0.12 - 0.06 = 0.06; 0.17 - 0.09 = 0.08)$$

During this calculation, it is necessary to ensure that the first fuzzy number is less than or equal to the second, and the second is less than or equal to the third fuzzy number. As shown in Table 5, aggregate values for alternatives, including ideal alternatives, were then calculated. After that, crisp numbers were calculated from fuzzy numbers using defuzzification, and the utility functions and values of the fuzzy CRADIS method were calculated.

Table 5. Results of the fuzzy CRADIS method

	s^{+}	s^{-}	$Def\ s^{+}$	$Def\ s^{-}$	K_i^{+}	K_i^{-}	Q_i	Rank
DPDL 1	(0.14, 0.18, 0.21)	(0.30, 0.39, 0.50)	0.178	0.393	0.632	0.857	0.745	2
DPDL 2	(0.22, 0.27, 0.33)	(0.22, 0.30, 0.38)	0.273	0.298	0.413	0.650	0.532	4
DPDL 3	(0.22, 0.28, 0.34)	(0.22, 0.29, 0,38)	0.279	0.293	0.405	0.638	0.522	5
DPDL 4	(0.12, 0.15, 0.18)	(0.32, 0.41, 0.53)	0.154	0.418	0.732	0.910	0.821	1
DPDL 5	(0.18, 0.22, 0.27)	(0.26, 0.34, 0.44)	0.225	0.347	0.502	0.756	0.629	3
S_0	(0.09, 0.11, 0.13)	(0.35, 0.45, 0.58)	0.113	0.459				

The results show that DPDL 4 obtained the best results, followed by DPDL 1. The reason for these results is that DPDL 4 is more modern and offers more options than DPDL 1, which is why it was rated better by experts.

5. Conclusions

This study aims to determine which DP should be used at universities in the Brčko District to achieve better results for them. The pandemic of the COVID-19 virus has drawn attention to the importance of using DPs for learning at universities. This was also the case at the universities in the Brčko District when they had to go exclusively online. In addition, to increase the competitiveness of these universities, it is necessary to open these universities to a wider range of students through distance learning. To conduct such classes, it is necessary to have a DP that can help in this. The choice of the DP was made in such a way that experts from three universities in the Brčko District, which have their headquarters in this city, were taken. Two experts were taken from each of these universities in such a way that these experts were determined in cooperation with the rectors.

The DP was selected in such a way that the decision-making model was first set up. In the decision-making model, eight criteria were determined with which five DPs were evaluated. Evaluations of criteria and DPs were made using linguistic terms that were at the level of ten evaluations. These ratings were then processed using fuzzy methods. Two methods were selected, the fuzzy SiWeC and the fuzzy CRADIS. The fuzzy SiWeC method was chosen to determine the importance of the criteria. Unlike similar methods that subjectively determine the weights of the criteria, the implementation of this method does not require comparing the criteria with each other or ranking them by importance. In this method, experts evaluate the importance of each criterion individually, independent of other criteria. In addition, the SiWeC method evaluates the importance of experts based on the dispersion of their ratings. The greater the dispersion, the greater the importance of the expert, and vice versa. A further

advantage of applying the fuzzy SiWeC method is that it is not necessary to harmonize expert ratings or establish consistency in the assessment, as it is sufficient to simply evaluate the criteria and not take into account how much better or worse one criterion is than another. By applying this method, it was found that according to experts' evaluations, these DPs have good interactivity and a good interface and teachers are provided with good analytical support for monitoring student learning.

The fuzzy CRADIS method was chosen for the reason that this method uses corrected steps of other methods and also uses specific steps only for this method. This method is relatively new but has been used in over 100 papers so far. These are just some of the reasons why this method was used. By applying the steps of this method, results showed that DPDL 4 has the best results, followed by DPDL 1. The exact names of these platforms were not used in order not to promote certain platforms. However, this research was conducted in a narrower area and with a smaller number of respondents. If the research area and the number of experts could be expanded, it would be possible to obtain different results. Due to the specificity of this research, it is recommended that these three universities in the Brčko District use DPDL 4, and if they are not able to use it, then the second choice is DPDL 1. What sets these two DPs apart from the others is that DPDL 4 has a modern look and supports various tools that enable the improvement of the work of the university. It is then possible to monitor individual processes at the university through reporting. As for DPDL 1, this platform is characterized by low maintenance costs and the possibility of personalization and integration with other content within the university. These and other characteristics determined that the experts chose this DP to improve the work of the university in the Brčko District.

The contribution of this research is reflected in the decision-making model, the integration of MCDM methods, the application of the fuzzy approach, and the concrete application of all that. Therefore, in future research, it is necessary to build on this research. Thus, one study could be focused on the criteria for evaluating DPs for universities, and other studies could be focused on other platforms not covered. In addition, it is necessary to apply other MCDM methods to obtain differences in decision-making, because perhaps some other methods are simpler and more flexible than the methods used in this research. In future research, it is possible to focus only on methods that could be used when choosing DPs for e-learning.

In addition to all of the above, it is necessary to mention the limitations of this research. These limitations mainly relate to the small sample, narrow geographical area, selection of experts, the possibility of bias in assessment, and various other limitations that are an integral part of any work. Looking at the sample of universities taken, it can be said why the sample was not expanded to other local communities that have higher education institutions. However, this research is focused on the area of the Brčko District and other local communities were not taken into account. In future research, it is necessary to increase the sample and take other universities into account, which solves the problem of the narrow geographical area of the research. It should be noted that this work is intended as a methodological work that provides the foundation for the development of similar research on this basis. This research should therefore be an incentive for new similar research. The selection of experts was made in order to avoid bias so that the opinion of one university does not prevail over others. In future research, it is possible to look at individual universities and thus decide which DP would be most suitable for them.

Author Contributions

Conceptualization, E.P. and A.P.; software, E.P. and A.P.; validation, E.P. and A.P.; formal analysis, E.P. and A.P.; investigation, E.P. and A.P.; resources, E.P. and A.P.; data curation, E.P. and A.P.; writing-original draft preparation, E.P. and A.P.; writing-review and editing, E.P. and A.P.; visualization, E.P. and A.P.; supervision, E.P. and A.P.; project administration, E.P. and A.P.; funding acquisition, E.P. and A.P.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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