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COMPUTER-AIDED SYSTEM FOR ASSESSING AND SELECTING EFFECTIVE MASTERS' LEARNING TRAJECTORY IN VARIABILITY OF EXTERNAL FACTORS CONSIDERING THE UNIVERSITY INDUSTRIAL PARTNERS' OPINION

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Abstract

The modern education system development is characterized by many uncertain, dynamically changing factors. The purpose and originality of the study presented in the article is to develop an automated system for building an effective educational trajectory in the conditions of external factors' uncertainty. The developed system is a tool for assessment and dynamic adjustment of the educational process in accordance with the ongoing and possible future changes in external factors.

The university industrial partners get a real opportunity to participate directly in the creation of a valuation criteria set and in the selection of educational trajectories. The developed automatized system integrates decision support methods, namely analytic hierarchy process, payoff matrix method, to consider the viewpoint of experts, and *k*-means clustering method for analyzing the students' opinion.

The experimental study of the system involved more than 100 master's students: sixty 1st year students and forty six 2nd year students. The analysis showed that the application of the developed decision support system allowed to increase class attendance by 24 % and academic performance, while the proportion of students receiving excellent grades increased by 9 %.

The system application enables the experts (Universities administration and teachers as well as industrial program partners) to modernize the educational trajectory promptly. Lecturers can prepare in advance for a potential reorganization of the educational process in the event of changes in external conditions.

The novelty of the proposed approach is to integrate into a single learning management system a variety of modern and traditional methods: interviewing, clustering, decision support, forecasting changes in external factors, building an educational trajectory considering the opinions of all participants in the educational process.

Keywords: effective educational trajectory, master's learning, computer-aided system, decision making methods, uncertainty of external factors.

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АВТОМАТИЗИРОВАННАЯ СИСТЕМА ОЦЕНКИ И ВЫБОРА ЭФФЕКТИВНОЙ ТРАЕКТОРИИ ОБУЧЕНИЯ МАГИСТРОВ В УСЛОВИЯХ ИЗМЕНЧИВОСТИ ВНЕШНИХ ФАКТОРОВ С УЧЕТОМ МНЕНИЯ ИНДУСТРИАЛЬНЫХ ПАРТНЕРОВ УНИВЕРСИТЕТА

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Аннотация

Развитие современной системы образования характеризуется множеством неопределенных, динамично меняющихся факторов. Целью и новизной представленного в данной статье исследования является разработка автоматизированной системы построения эффективной образовательной траектории в условиях неопределенности внешних факторов. Разработанная система

является инструментом оценки и динамической корректировки образовательного процесса в соответствии с текущими и возможными в будущем изменениями внешних факторов.

Индустриальные партнеры университета получают реальную возможность непосредственного участия в процессах формирования набора критериев оценки и выбора образовательных траекторий. Разработанная автоматизированная система объединяет методы поддержки принятия решений, а именно метод аналитических иерархий, метод платежной матрицы для учета мнения экспертов и метод кластеризации k -means для анализа мнения студентов.

В экспериментальном исследовании системы приняли участие более 100 магистрантов: 60 студентов 1-го курса и 46 студентов 2-го курса. Анализ показал, что применение разработанной системы поддержки принятия решений позволило увеличить посещаемость занятий на 24 % и академическую успеваемость студентов, при этом доля студентов, получающих отличные оценки, увеличивается на 9 %.

Применение системы позволяет экспертам (администрации и преподавателям университетов, индустриальным партнерам образовательной программы) оперативно модернизировать образовательную траекторию. Лекторы могут заранее подготовиться к возможной реорганизации учебного процесса в случае изменения внешних условий.

Новизна предложенного подхода заключается в интегрировании в единую систему управления образовательным процессом множества современных и классических методов: интервьюирования, кластеризации, поддержки принятия решений, прогнозирования изменения внешних факторов, построения образовательной траектории с учетом мнения всех участников образовательного процесса.

Ключевые слова: эффективная образовательная траектория, обучение магистров, автоматизированная система, методы принятия решений, неопределенность внешних факторов.

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1. Introduction

The improvement of education quality is one of the most important tasks. Quality refers to various parameters, namely academic performance, professional competencies, and practical skills, and graduates' adaptation in a professional environment. It is also important to influence the motivation and students' involvement in the learning process [1,2], maintaining students' interest in successfully completing their studies and considering exposure risk [3].

Researchers offer many approaches to solving these problems along with classical forms of learning, both through the introduction of new learning technologies, new management techniques, and through predicting student behavior. Different researchers are trying to build a learning trajectory based either on analyses of some current state of the educational environment, on the students' opinion, or on prediction of student performance to improve the educational quality. Forecasts can be built based on:

- lesson plans clustering (comparable to learning trajectories) and a selection of technologies combination types used in the classes [4];
- decision-making by students in accordance with to the theory of planned behavior and self-regulated learning model [5];
- the exploration of instructors' trajectories and student diversity in higher education [6];
- and predictive modeling as a means of early detection of students at risk based on the analysis of academic performance or other characteristics [3, 7].

Adaptive models [8], experimental trial and error methods [9] and other methods for determining personalized educational trajectories can also be used to create an educational trajectory [10, 11]. The effectiveness of the adopted educational trajectory largely depends on its compliance with environmental conditions.

However, the current post-pandemic stage of society's development is characterized by dynamic changes affecting the organization of education for students, especially master students. Therefore, we need a method of generating, evaluating and choosing an educational trajectory, considering possible changes in external conditions. The masters' education is more sensitive to changing conditions for some reasons. Masters usually are already working actively in specialized companies. They confidently apply modern information technologies. Masters have a certain social status. The masters' training period is quite short: one or two years. Therefore, the actual task is to develop quick search methods for a reasonable compromise between the students' wishes, teachers' opinion and University staff position in the conditions of predicted changes of external environment. That demands modernizing the educational process in advance. Such environmental conditions include degree implementation of new information and educational technologies [12], artificial intelligence systems development speed [13], demand for on-line education [14], the average age of undergraduates¹, the number of international students from developing countries, ability to access high-quality broadband, number of applicants with a specialized diploma and others. Changes affecting the educational process can occur both at the University level and at the level of countries and the world. Earlier we touched upon the topic of choosing an educational trajectory and proved the effectiveness of its construction based on students' assessment [15]. The solution to this problem was considered under determined external conditions. Meanwhile, the solution to this problem in conditions of variability or uncertainty of the external factors requires another approaches and methods application. For

¹ Mironova M. Portrait of an online graduate student. The results of the research (In Russian.). *Forbes Education*. <https://education.forbes.ru/authors/portret-studenta-online-magistratury>

example, the emphasis is shifted to the online learning format with the possible number of working students increasing. If the share of foreign students increases, joint forms of classes should be used more often for their integration.

This study offers a comprehensive automated system for the formation, assessment, and selection of the most preferred educational trajectories in the conditions of uncertainty of the external factors. The use of the system is advisable if we can indicate only a probable set of factors that may change in the nearest future. These factors changing may affect the organization of the educational process. At the same time, we consider the opinions of four parties involved in the learning process: teachers, students, the University administration represented by the head of the educational program and potential employers. The system allows for setting the criteria for evaluating the educational trajectories effectiveness and possible future environmental conditions.

The educational trajectory (masters' learning trajectory) is understood as a list of educational elements formed by university staff) and the alternatives for the most preferred types of their implementation [15]. Implementation options for educational elements can be, for example: number of students in the study group, course materials reception method, types of classes, teaching technology, additional training types, feedback, the sequence of different types of classes... This list can be changed by means of the system at the request of the user, depending on the requirements of the university.

The developed system is based on a Decision-making method of comprehensive assessment and selection of possible alternatives in the conditions of uncertainty [16]. Our research additionally uses the following technologies and methods of organizing the educational process:

- students' feedback consideration [2, 17];
- the implementation of learning management systems [18];
- data science for analyzing and improving educational processes [19];
- clustering procedure [7].

2. Materials and methods

2.1. Participants

This study was conducted at the 1st and 2nd year master's program in 2023/2024 at Higher School of Economics University (HSE), Russia¹. The participants for this study were sixty 1st year students and forty six 2nd year students from three majors, tracks, the Head of the master's program, company representative/ employer, lecturers and programmers. The number of working students was 80%. The survey of 1st-year students was conducted during the admission campaign

and 2nd-year students — at the end of the first year of study.

2.2. Tools and procedures

The multi-stage procedure for choosing the main educational trajectory involves the participation of the Head of the master's program and experts (teachers, university administration and representatives of industry enterprises) at all stages. All experts can contribute to the creation of a comprehensive set of educational elements and options for their implementation.

First stage of the study.

A survey of students was conducted regarding their preferences for the implementation of educational elements' options. This procedure can be done by means of an online questionnaire (using University LMS, using third-party survey systems such as Google forms, and specially developed software). We conducted a survey through the Online Test Pad System on the educational master's program website (see Figure 2, stage 1). It also was necessary to survey applicants (who had no access to the University LMS) along with the master's students already enrolled in the program. Every student had set the degree of preference on a 10-point scale for each implementation option of each educational element. As a result of the first stage, two data sets were obtained for applicants and students.

Second stage of the study.

The analysis of survey results by clustering method was conducted. Clustering methods are quite popular among other researchers [7], because they allow them to form patterns of behavior. The main steps of the clustering procedure are:

- Uploading a file with survey dataset results (see Figure 2, stage 2a).
- Launching the clustering procedure in the system.
- Forming a set of educational trajectories in accordance with the number and characteristics of the clusters obtained, including a list of educational elements' options corresponding to each trajectory (see Figure 2, stage 2b).

We have investigated the specifics of the task context and various variants of clustering algorithms and their requirements:

- The absence of an algorithm operation time limits due to the small number of respondents (100-200).
- No need to scale data before clustering because the system offers to evaluate the preference of all educational elements on a scale of 0 to 10.
- The ability to obtain the coordinates of cluster centers that characterize the desired trajectories.
- The algorithm's ability to set a limit on the number of clusters to avoid analyzing too many educational trajectories.
- The algorithm usability.

The final choice was the k -means method [20] that best meets the above requirements for the decision support system being developed. K -means requires

¹ Website of Higher School of Economics University. <https://www.hse.ru/>

a pre-known number of clusters. Therefore, we have implemented two approaches in the system:

- 1) Automatic selection of number k clusters implemented by sequentially iterating through k in a certain metric segment.
- 2) The Head of the program had set the number of clusters convenient to select from a certain number of trajectories if the automatic selection produced an undesirable result.

Let us show how the metrics for selecting the k value were calculated in the first case (Figure 1). The number of clusters k was postponed on the abscissa axis. Our system recommended the most suitable k .

The first metric Cluster silhouette index [21] is used to calculate the goodness of a clustering technique and provides a succinct graphical representation of how well each object has been classified (Figure 1, top chart). The second metric CH Calinski-Harabasz Index [22] is a measure used to evaluate the quality of clustering in a dataset by considering both the inter-cluster and intra-cluster variations, with higher values indicating better-defined clusters (Figure 1, bottom chart). The final value of k is calculated as the average value between the values of k , at which both metrics take the maximum values.

Third stage of the study.

It is necessary to form a set of possible in the future external factors for the next academic year. A variety of options for possible external factors can be considered. An example of external factors may include:

1. Quarantine measure's introduction (restrictions on face-to-face classes or on the students' number in a classroom).
2. Difficulties/restrictions on movement between countries or between regions in the country.
3. Changes in the students' economic status (the number of working students and the average age of undergraduates increasing).

4. Large-scale introduction of the artificial intelligence systems in society and education and general reduction of students' knowledge level.
5. Changes in the number of students who are fluent in the language used at the university.

The issue of forecasting changes in the external environment is not the subject of this article. To solve the problem, one can use the following data processing methods from various sources, including internal documents of the University, documents of the Government of the country, and other data from open sources:

- web crawlers [23];
- prediction systems based on artificial neural networks [24];
- data analysis systems [25];
- intelligent open-source systems [26].

When performing the calculations, we selected two external factors (see in Figure 2, stage 3).

Fourth stage of the study.

Experts (teachers, university administration and representatives of potential employers — industrial program partners) performed a comparative analysis of alternative trajectories by calculating their value/effectiveness for each possible state of the external factors according to the selected quality criteria. They suggest the set of criteria, for example:

- C1 — education quality (academic performance, professionalism);
- C2 — accessibility of educational program elements;
- C3 — the trajectory implementation costs for teachers;
- C4 — the trajectory implementation costs for the university;
- C5 — the trajectory implementation complexity/costs for students.

The experts can change the list of criteria by means of the system, depending on the specifics of the task

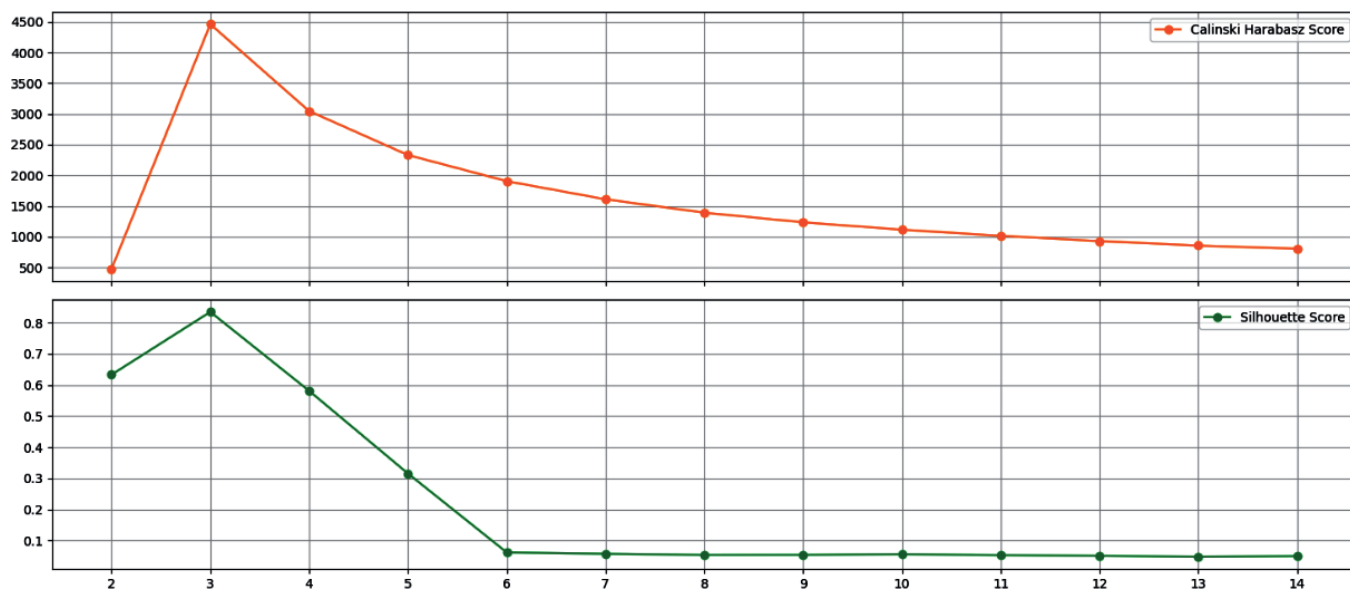


Fig. 1. Graph of metric values for k clusters

being solved (Figure 2, stage 4a). Any of the experts can use the developed system if desired. As a rule, the head of the educational program performs on behalf of the experts. He/she acts as a user of the system and operates in close contact with all experts.

The method of analytical hierarchies is used — AHP (analytic hierarchy process) [27] is used to calculate the trajectory effectiveness. AHP is easy to understand for an unprepared user. The method allows us to make decisions with qualitative and quantitative values of the criteria and does not require large computational procedures. Based on the AHP, the following are calculated:

- Weights of criteria for evaluating the effectiveness of educational trajectories (Figure 2, stage 4b).
- Value/effectiveness of each educational trajectory for each criterion for each possible state of the external environment (Figure 2, stage 4c).
- The total value/effectiveness in the implementation of each educational trajectory according to a set of criteria for each possible state of the external environment.

Fifth stage of the study.

The system marks the most preferred educational trajectory for the next academic period based on the payoff matrix method [16]. First, our software system obtains the value/effectiveness of each educational trajectory from the previous stage (as the elements' decision matrix elements) and calculates several characteristic estimates:

- the maximum indicator of each i -th trajectory effectiveness/usefulness H_i^{\max} ,
- the minimum indicator of each i -th trajectory effectiveness/usefulness H_i^{\min} ,
- the arithmetic mean value of each i -th trajectory effectiveness/usefulness H_i^{mid} ,
- the maximum risk value when implementing the i -th trajectory R_{\max} .

Then, the system computes several criteria (see Table) according to the payoff matrix method [28–32].

The Head of the educational program or an expert makes a decision on values of λ , λ_i and the final choice of the most rational educational trajectory based on

the analysis of the specified criteria (Cr1÷Cr5). Also, if necessary, trajectories can be ranked according to the degree of preference. We can see an example of the system operation sequence in Figure 2.

2.3. System architecture

The developed system has the following architecture (Figure 3). The software was developed as a client-server application. The system has a modular structure.

The client part includes a graphical user interface module, and the server part includes a clustering module and modules that implement the decision-making methods, i. e., AHP and payoff matrix. The system works interactively. Users can change parameters and track intermediate and final calculation results. The interface of interaction with the system is shown in Figure 2. One can interact with the system by a web interface in any modern web browser. The server receives data with the results of the student survey and the necessary input parameters, such as the maximum number of educational trajectories, external factors, and the criteria for evaluating educational trajectories (Figure 2, stage 4, 5). The data obtained from the survey is processed on the server side by the clustering module, sending in response a description of the selected clusters, which represent the analyzed educational trajectories (Figure 2, stage 2b). Next, the system evaluates the obtained trajectories based on the specified environmental factors and evaluation criteria in a dialog with the user (Figure 2, stage 1–5).

The trajectory comparison data is sent to the server, where the trajectory evaluation and selection module, using the sequential execution of the AHP and payoff matrix method, selects the final trajectories according to various decision-making criteria (Figure 2, stage 5). The result is displayed in the user interface. The system offers a list of trajectories, each of which is recognized as the best according to one of the criteria. Users choose a single trajectory based on their understanding of the situation. The program manager chose trajectory 2 using the recommendations of the system based on a generalized criterion.

Table

Criteria according to the payoff matrix method

No	Name	Value	Comment
1	Wald criteria	$Cr_1 = \min[H_i^{\max}]$	Maximum pessimism in the unfavorable state of the external factors
2	Laplace criteria	$Cr_2 = \max[H_i^{\text{mid}}]$	Maximum optimism under equally probable conditions of the external environment
3	Savage criteria	$Cr_3 = \min[R_i^{\max}]$	The minimum of the greatest risks
4	Hurwitz criteria	$Cr_4 = \lambda_4 H_i^{\max} + (1 - \lambda_4) H_i^{\min}$	Linear combination of minimum and maximum values of educational trajectories effectiveness
5	Generalized criteria	$Cr_5 = \lambda_i \sum_{i=1}^4 \lambda_i Cr_i$	Weighted sums of characteristic estimates

Selection of effective educational trajectories

Upload the student survey data file:*

Choose File **survey_data.xlsxm** **stage2.a**

☐ Automatic selection of the number of trajectories

Desired number of educational trajectories

3

Enter the possible states of the external environment and their probabilities of occurrence (if they are known):

☒ Without probabilities

stage3

Quarantine measures introduction

Changes in the students' economic status

Enter the criteria for evaluating educational trajectories:

stage4.a

The strategy implementation costs for teacher

The strategy implementation costs for the university

The strategy implementation complexity/costs for students

Determine trajectories

Educational trajectories calculated by clustering:

	Trajectory 1	Trajectory 2	Trajectory 3
Course materials reception method	Internet resources	Internet resources	Internet resources AND/OR Electronic materials and documents prepared by teachers (text files, presentations, multimedia materials)
Types of classes	Online homework assignments	Online lectures	Online seminars AND/OR Online group work of teachers and students
Number of students in the study group	Study in a small group	Study in a small group	Individual learning option
The way the learner perceives the learning material	Visual (textual, numerical, graphical) information dominates	Visual (textual, numerical, graphical) information dominates	Visual (textual, numerical, graphical) information dominates
Knowledge control	Prepare and present homework	Online testing	Prepare and present homework AND/OR Online testing

stage2.b

Compare the criteria for evaluating trajectories:

Criterion 1 - The strategy implementation costs for teacher

Criterion 2 - The strategy implementation costs for the university

Criterion 3 - The strategy implementation complexity/costs for students

Criterion 1 **fundamentally better** criterion 2 **stage4.b**

Criterion 1 **fundamentally better** criterion 3

Criterion 2 **fundamentally better** criterion 3

State of the external environment

Quarantine measures introduction

Criterion The strategy implementation costs for teacher

Trajectory 1 **fundamentally better** trajectory 2

Trajectory 1 **fundamentally better** trajectory 3

Trajectory 2 **fundamentally better** trajectory 3

Confirm **stage4.c**

Best trajectory by criterion Laplace: Trajectory 1 [Show/hide trajectory](#)

Best trajectory by criterion Wald: Trajectory 1 [Show/hide trajectory](#)

Best trajectory by criterion extreme optimism: Trajectory 1 [Show/hide trajectory](#)

Best trajectory by criterion extreme pessimism: Trajectory 3 [Show/hide trajectory](#)

Best trajectory by criterion Hurwitz: Trajectory 1 [Show/hide trajectory](#)

Best trajectory by criterion Savage: Trajectory 1 [Show/hide trajectory](#)

Best trajectory by criterion multiplication: Trajectory 1 [Show/hide trajectory](#)

stage5

Fig. 2. An example of the system operation sequence

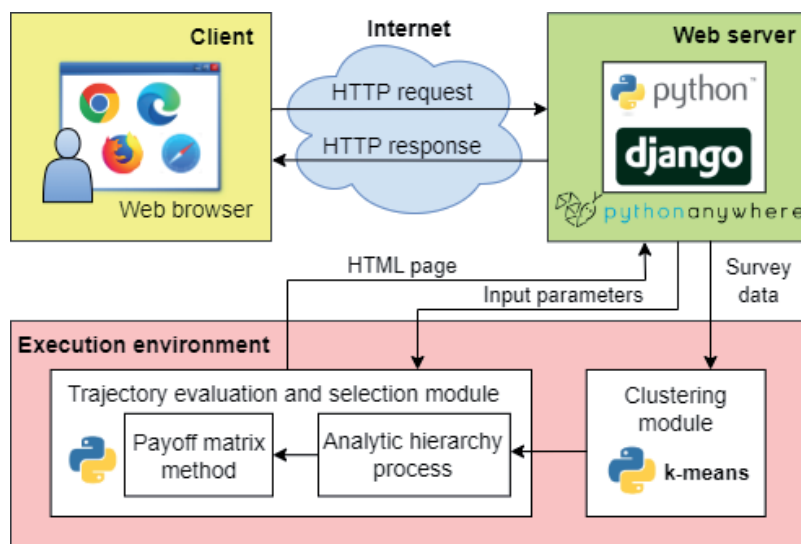


Fig. 3. The developed system architecture

3. Results

The research was conducted in 2023/2024. We interviewed sixty applicants entering the HSE Computer Systems Master's program and forty-six students entering the second year of the program. An educational trajectory like the 1st course of the master's degree in the 2022/2023 academic year was offered for evaluation to the applicants. The full list of educational elements submitted for discussion can be found in [15]. The three most preferred educational trajectories were identified based on the survey results and clustering of students' opinions (see Figure 2, stage 2b). A comprehensive assessment of the identified educational trajectories was carried out for the following possible external conditions in the 2023/2024 academic year:

1. The focus shift tendency from face-to-face education to online
2. A rise in the number of applicants with a specialized diploma and working by the profession
3. Increasing the number of students from developing countries

Comparative evaluation of educational trajectories was carried out according to the following criteria:

- C1 — quality of education (the best academic performance);
- C2 — accessibility of the elements of the educational program;
- C3 — complexity/cost of trajectory implementing for the teacher;

- C4 — complexity/cost of trajectory implementing for the university;
- C5 — complexity/cost of trajectory implementing from the student's point of view.

The result of the developed system interactive analysis was chosen as the most preferred educational trajectory definition (see Figure 2, trajectory 1).

The implementation of this educational trajectory has provided the following results:

- academic performance rise that continued a year later (Figure 4);
- students' satisfaction increase, which is partly due to online learning introduction; one can see that satisfaction has decreased with the transition to a blended learning format in post-pandemic period (Figure 5);
- class attendance growth (Figure 6).

The companies' representatives — educational program's partners participated in shaping the trajectory in the 2024/2025 academic year, and suggested the following.

- To limit the implementation options for the "Number of students in the study group" element in the chosen specialization by 20–25 members.
- To give preference to the online implementation of the "Lectures" and "Practical exercises" elements.
- To add such options for the implementation of the element "Number of students participating in the project" as 4 and 5 developers (previously there was a limit of 3 developers).

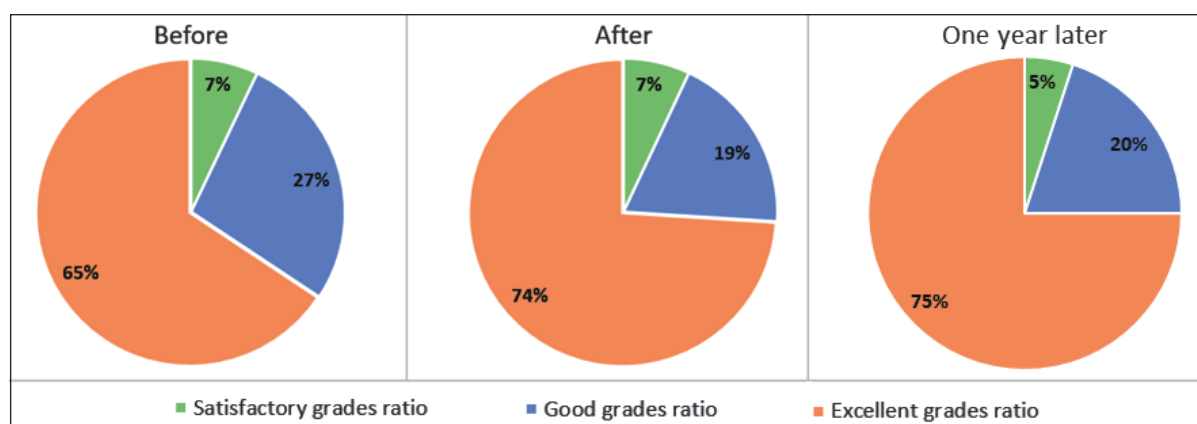


Fig. 4. Academic performance changing

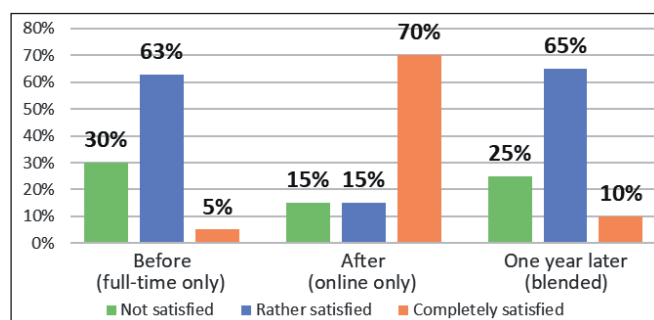


Fig. 5. Students' satisfaction changing

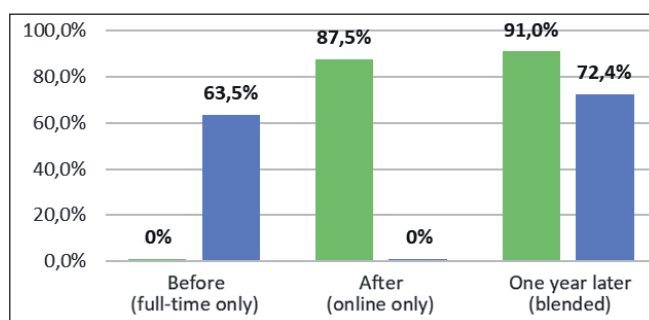


Fig. 6. Class attendance changing

- To limit the options for implementing the element “Online platform of the special course” by using the educational platform of the enterprise.
- To use the only option for implementing the “Project” element — full-time participation in the company’s departments activity.

These suggestions were adopted when forming the initial set of educational elements.

4. Discussion

One can note that the obtained results are very interesting while comparing our system with other solutions. Researchers are concerned with the issue of educational trajectory design. The topic of the work seems relevant as many articles explore some aspects of this problem. Various studies offer short-term forecasts for improving the quality of education, which are based on the analysis of specific learning environment parameters or the students’ opinion. We propose to analyze educational trajectories according to longer-term assessments of the entire range of possible external factors in the future combined with the opinion of students/teachers and university requirements.

There are also studies devoted to the construction of educational trajectories [8–11] but most often they are talking about individual trajectories. The adaptive model [8] implements the construction of multiple individual learning trajectories to influence the external and internal causes of student motivation. As our system, it uses questionnaire technology but determines the way to implement only some educational elements (the space of educational materials, perception features). The article [9] proposes an automated trial and error method for individual educational trajectories formation as a composition of pedagogical experiments. It is suitable only for small groups but seems laborious for a big one. The recommendation service [10] builds an individual educational trajectory for studying online courses based on a mathematical model using Boolean programming according to the student’s preferences. Meanwhile, the elements of each studied discipline remain unchanged. Even though «trajectory» implies a slightly different concept, this method is close to our study in terms of meeting the specified criteria (prerequisites, pace and schedule of training). Article [11] presents a model for adapting educational content, which contains an algorithm for constructing an individual educational trajectory based on a modified ant algorithm. It provides a personalized selection of the sequence of educational materials/elements as in our study. However, the authors point out that this model is effective in passing academic disciplines with a significant duration, whereas our system can be used for any courses.

Some modern authors also use automated systems in the educational process. The areas of their application are predicting student academic performance [7]; detecting at-risk students [3, 33]; automated feedback

systems [34]. However, their research is mostly focused on internal instructional conditions only.

Other studies concern certain aspects of external conditions: for example [35] investigate time spent at work; [36] estimate the students’ contingent (number of geographically remote students); [34] analyzes the availability and legitimacy of the software and computer online learning environments, video conferencing systems, online testing systems, and automated feedback systems.

The author of another study [6] analyzes the influence of external factors on the settings of a single type of training, i. e., blended. In addition, the author uses quite labor-intensive research methods: oral interviewing of the instructors, primary and repeated coding by multiply rereading transcripts and analyzing transcript data and compiling matrices for reviewing the participants’ opinions. On the contrary, our system also involves collecting students’ opinions, but the survey method is realized via Online Test Pad System¹ or Google-forms², which greatly simplifies data analysis.

Our method is quite simple to understand and apply. It allows one to consider a variety of interesting new practices when choosing an educational trajectory. It is easy to adjust according to the individual student’s characteristics and allows researchers to dynamically consider the teacher’s opinion or requests of the head of the educational program. This is provided by:

- expanding or narrowing of the set of educational elements or their implementation options;
- the possibility of changing the relative importance of both criteria for evaluating the effectiveness of the educational trajectory and options for implementing educational elements;
- the justification of using a clustering algorithm, which allows one to choose an educational trajectory in advance, analyzing the preference patterns of each cluster. Clustering methods are quite popular among other researchers [7], because they allow them to form patterns of behavior.

5. Conclusions

1. The conducted research shows that development of system for assessing and selecting effective masters’ learning trajectory can be based on integration of decision theory methods.
2. The developed method makes it possible to consider the opinion of all educational process participants: students — in generating possible educational trajectories, teachers — in generating the composition of educational elements and the University administration — in the final expert selection of the most preferred educational trajectory.

¹ Free multifunctional service for testing and training. <https://onlinetestpad.com/>

² Google Forms. <https://www.google.com.co/intl/ru/forms/about/>

3. The proposed approach makes it possible to analyze in one system several different variants for possible changes in external conditions when choosing the most rational educational trajectory for the next academic period.
4. The application of the proposed approach in practice has shown its application expediency to improve student academic performance, attendance and students' satisfaction with the training organization.
5. The proposed approach can be developed in the direction of creating an integrated decision theory methods of and machine learning methods.

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