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Information System for Monitoring and Management of the Quality of Educational Programs: Development of Functioning Algorithms

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The study develops a method for monitoring and management of the quality of educational programs using software instruments. The method describes each of the monitoring implementation stages in detail specifying the input and output data, as well as the controls that affect the time and quality of the implementation of the corresponding stage. Algorithm programs in the form of flowcharts reflecting all the content aspects are developed and formalized for the automatization of monitoring. The presented algorithm models allow implementing the program complex of the system for monitoring and management of the quality of educational programs using the modern object-oriented design and programming environments. The goal of the study is to develop a model of algorithms for the organization of monitoring and managing the quality of educational programs, which allow reducing the time costs of these processes while increasing the objectivity of quality assessment. The obtained results are intended for the audit of educational services, public control over the implementation of educational activities, accreditation of directions of training, or licensing of educational organizations. The developed algorithms provide for evaluating the content of each stage of the audit of an educational program, generate a list of notes ranked by importance, and ensure the rational allocation of resources for the implementation of each stage of the educational process.

Keywords: structural analysis, education, business process, modeling, design, flowchart

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INTRODUCTION

Each educational organization in Russia designs a quality management system based primarily on the series of educational standards ISO 9001 (Ovchinnikov, 2018). Nevertheless, a universal model of quality management in educational organizations is currently lacking. This obliges each organization to develop its model for education quality management based on different parameters (for example, students' learning outcomes, the results of their participation in professional competitions, publication activity, the content of educational programs, etc.) (Myshkina, 2017; Kolb, 2020). A key object in the ecosystem of an educational organization is the educational program. The educational program determines the content of education, the methods of achieving the planned results, requirements for the material, technical, and personnel support of the learning process, etc. (Ilina, 2017; Maslova, 2021; Shiriaev, 2017; Diaz et al., 2016). When auditing any educational organization (internal education quality management, state or public accreditation, etc.), it is the content of educational programs that determines most of the quality assessment of educational activities (Myshkina, 2017; Ovchinnikov, 2018). The content of any educational program has to correspond to educational and professional standards, as well as, if possible, the WorldSkills international standards of professional mastery (Shiriaev, 2017; Oduaran, 2017). The creation of software instruments for objective quality assessment of an educational program and the highest possible level of automation of such audit processes, in this case, are not only in demand, but also highly significant (Kotsuba, 2021).

The attained indicators allow not only determining the effectiveness of the teaching staff but also developing managerial decisions to improve the educational process quality (Ostudin, 2018; Gomez et al., 2020). One of the methods of addressing this problem is creating an effective system of management of the processes of the educational organization based on the use of modern mathematical and software instruments supporting the mechanisms of assessing the performance of all educational process subjects (Grigorash, 2020; Lagreca & Kang, 2020).

The present study demonstrates **theoretical significance** as it allows to formalize the processes of educational program quality management. The conducted study results in the models providing for the development of theoretical foundations for further studies on educational process quality management, its automatization, and ensuring the possibility of making prompt managerial decisions for all actors involved in the process.

The practical significance of the study lies in reducing the degree of subjectivity in decision-making in the quality management system both in the context of the entire educational process and particular educational programs, decreasing labor costs for monitoring the quality of educational programs, and lessening the share of printed documentation in the educational organization ecosystem.

The goal of the study is to demonstrate the algorithms providing for the functioning of an information system for monitoring and management of the quality of educational programs.

Literature Review

The outcome of any study in the sphere of education is obtaining the results that ensure the global competitiveness of education (National Project "Education", 2019). An information system for monitoring and management of the quality of educational programs should be no exception. The algorithms of its functioning need to provide highly competitive results in a variety of areas found in the ecosystem of an educational organization. This obliges us to consider a multitude of aspects of educational activity, which have been studied by many different researchers, and interpret their findings in the ecosystem of our study.

The first aspect to be considered is the study of the methods of education and upbringing, the educational technologies that provide a high level of students' motivation for learning and involvement in the educational process (Al-Gabri, 2018; Garcia & Hoelscher, 2010) and indicate upbringing and learning as its main components (Isik, 2020; Van Melle, 2016). The findings describe the ways to influence the consciousness, will, feelings, and behavior of students to develop the given qualities in them. Many researchers conclude that information technologies developed for any software instruments affect the change in goals, content, methods, and means of education, the specifics of the implementation of its didactic principles (Maksiutova, 2020; Supriyadi et al., 2020; Tungkunanan, 2020).

The second aspect of an education system is the development of a system of vocational guidance for students and their parents based on the principles of fairness, universality, and accessibility providing psychological and pedagogical, methodological, and counseling support (Sidelev, 2018; Atkinson, 2012; Gibb & Taylor, 2016; Pit-ten Cate et al., 2020). A major problem of educational organizations indicated by researchers is the wrong choice of the direction of training (Diiazitdinova, 2019). For this reason, algorithms are developed that allow information systems to "identify the latent links between the individual characteristics of a student (applicant) and their results upon graduation with the subsequent use of the obtained information to help the applicant in choosing a direction of training at the stage of applying to the university" (Diiazitdinova, 2019, p. 9). Scientists address the problem through using intelligent data analysis technologies in decision support systems (De Mello & Pedro, 2017; Wang et al., 2020) from different positions:

- the opportunity to improve the effectiveness of the process of students' learning;
- creating methodologies, models, and methods to support decision-making in managing the educational process;
- creating an automated decision support system for various processes in an educational organization (Diiazitdinova, 2019; Topper; Lancaster, 2016; Yun, 2016; Agustini et al., 2020).

The obtained results affect the content of any educational program and, therefore, are fundamental for the information system we are developing).

The third aspect of the conducted research is the creation of a digital education environment that ensures the quality and accessibility of education. Research is divided into the topics of organization and support of training (Borovkova, 2019; Pronin, 2020; Oduaran, 2017). Scientist Dobrynin (2020) notes the applied nature of such studies utilizing the methods of the active systems theory, organizational systems management theory, schedules, vector optimization, set theory, and computer modeling. Researchers develop model-algorithmic complexes that control various processes (Davlatov, 2021; Dobrynin, 2020; Dudin et al., 2018). Particular attention is paid to the peculiarities of managing students' educational trajectories within the implementation of educational programs. The features of the development of special mathematical methods for finding admissible solutions (Chugunov, 2018) and the need to consider the human factor must be accounted for in our development.

The fourth aspect is the modernization of vocational training. The use of special software instruments influences the introduction of adaptive, practice-oriented, and flexible educational programs (Maslova, 2021; Afanaseva et al., 2017; Kathleen et al., 2020). The obtained results shape the system of continuing education for working citizens or citizens who have decided to improve their professional qualifications (Logachev, 2017; Diaz et al., 2016). The implementation of the research provisions allows citizens to not only update the existing professional knowledge or skills but also develop new ones including the competencies of the digital economy. The solution to the problem of professional growth proposed in scientific research is the use of the distribution of incentive payments based on the comprehensive consideration of indicators that meet the requirements of market relations (Diusekeev, 2017; Freire-Seoane et al., 2020; Isip & Li, 2017). Such indicators are identified by means of macroeconomic, microeconomic, and agent-based approaches with the development and application of mathematical models that assess the effectiveness of the educational organization management mechanisms (Daniels & Adonis, 2020; Muljana et al., 2020). However, these works do not take into consideration the critical need to meet a certain set of indicators in the context of monitoring educational organizations (Diusekeev, 2017; Daniels et al., 2020; Stockard et al., 2020; Muljana et al., 2020).

Without a doubt, the results obtained in such studies need to be considered in the development of algorithms for the functioning of an information system for monitoring and managing the quality of educational programs.

To draw a summary, the accumulated experience of the organization and management of education is of great theoretical and practical significance. Nevertheless, researchers examine particular processes without considering the degree of their influence on education as a whole. Thus, the methods, algorithms, or software products being developed most often exist in isolation in the ecosystem of education.

The study hypothesis suggests that the process of assessing the quality of any educational program can be presented as a formalized model allowing for future automatization of the corresponding process with a lesser degree of subjective assessment.

METHOD

The development of functioning algorithms is primary and defines the specific features of the stage of designing the life cycle of any information system. With the help of various graphical notations, it is possible to describe business processes of any complexity at the design stage. The resulting graphical models present a structured representation of the functions of the system or environment and the information and objects linking these functions (Stain, 2018; Vazquez & Amaya, 2016). The main objective of such modeling is the analysis and development of functional requirements for the information system being developed. The requirements obtained in this way further become the instructions for specialists who implement the software code of the system's functionality.

The model of the algorithm of a process (or of any of its tasks) allows authors to visualize the following characteristics of the process:

● Discreteness, i.e., the separate simple interconnected iterations;

● The indicator of completion of each iteration (i.e., getting a specific result after the corresponding action);

● Executability of each iteration and the totality of all iterations;

● Massiveness demonstrating the possibility of using the algorithm to solve a certain class of problems (Belov, 2019; Fernandez, 2016).

To formalize the results, we developed flowcharts with a specific set of graphic elements, reflecting the nature of the iteration in progress (Katilmis et al., 2017).

Analyzing the processes that are involved in the monitoring and management of the quality of educational programs, we found that the main graphical elements of the algorithm models are decisions, input or output data, actions, limiters, and cycles. The types of graphical blocks and their content were established using the method of step-by-step refinement.

The method of step-by-step refinement allowed to decompose the process into separate parts. In addressing this problem, the fine details of the process (unimportant within the given part) were not considered (Lazarides et al., 2020), but each part of the overall structure was refined. The refinement continued until the elementary objects with an exact detailed structure were obtained. The method of step-by-step refinement allowed to allocate and form the modules to be transformed into independent interconnected software products in the future (when developing an information system including its programming) (Al-Gabri, 2018; Bryk, 2020). Thus, we utilized the modular programming principle which allowed us to independently process the large data streams available for a particular module. The use of modular programming methods allowed us to accelerate the overall process of information system development since different specialists worked on several independent tasks simultaneously and the access to the libraries of functions and data was delimited (Nasonova, 2017; Daddow et al., 2020).

The information system for monitoring and management of the quality of educational programs has a modular structure (determining the structure of the system and the number of modules (Logachev, 2017)). For the functioning of each module, the algorithms are implemented based on the following methods:

The method of assessing the competence of the expert. The precision of expert assessments depends on a multitude of objective and subjective factors. This gives rise to systematic or occasional mistakes, which can be identified with certain accuracy and taken into consideration when developing algorithms. At the same time, the presence of such factors does not distort the results of the study, since only one specialist participates in the process of manual verification of any educational program. In this case, the presence and level of subjective factors increase significantly. The implementation of the algorithm for assessing the content of an educational program requires the availability of benchmark data. Obtaining such reference data involves experts.

The study needs to determine the level of the expert's interest and objectivity. The interest depends on the employment, the use of the results of the expert evaluation in their interests, the individual characteristics of the expert, the purpose of the assessment, etc. The objectivity of the expert is based on their professionalism and the content of the audited object (Rubtsova, 2020; Davis et al., 2020). These characteristics are identified in the study using the method of statistical assessment of the expert's competence. This requires making calculations using specific formulas.

If the expert opinions were equal, the calculation of indicators was carried out according to Formula 1 (Logachev, 2017; Tsvelik, 2018).

$$k_j = \frac{mn - S_j}{0{,}5mn \cdot (n-1)}, \tag{1}$$

where m — the number of experts,
n — the number of competencies,
S_j — the sum of the ranks assigned by the experts to the jth module with respect to a particular structural unit.

If the authority of the expert opinion was considered, S_j was calculated by Formula 2 (Fitzpatrick et al., 2015; Logachev et al., 2021).

$$S_j^{'} = S_j \cdot k_{a_g} \cdot m. \tag{2}$$

Consequently, the indicator for the criterion is calculated using Formula 3, if the experts' competence is equal — Formula 4, considering the authority of expert opinion — Formula 5 (Gevorkian et al., 2020; Fitzpatrick et al., 2015; Logachev et al., 2021).

$$k_j = \frac{mn - S_j^{'}}{0{,}5mn \cdot (n-1)}. \tag{3}$$

$$k_{j_0} = \frac{mn - S_j}{mnn_0 - \sum_{j=1}^{n_0} S_j}. \tag{4}$$

$$k_{j_0} = \frac{mn - S_j^{'}}{mn n_0 - \sum_{j=1}^{n_0} S_j}. \quad (4)$$

The ranking method was used to create algorithms for obtaining a benchmark value for each criterion. When using this method, each of the experts ranked the objects under study according to their importance following certain attributes (Logachev et al., 2021). The highest rank was assigned to the most significant element, while the lowest rank was assigned to the least significant element. Based on the results of the ranking of each expert, rank matrices were formed and further used to calculate the level of the experts' consistency, as well as to determine the randomness of the obtained result (Bulla et al., 2016; Logachev et al., 2021).

The integral indicator method allowed us to obtain a final grade for the entire structure and content of the document. This method involves using all the obtained ranking results, establishing the boundaries of evaluation, and introducing the evaluation scale and its interpretations (or possible recommendations for corrections by the developer of the educational program).

The results of using each method provide algorithms for the modules of the information system, based on which it should be developed.

FINDINGS

Based on the analysis of research conducted by various scientists, professional experience, and teaching experience of our team of authors, the following method for the functioning of the information system presented in Table 1 was developed.

Table 1
The method for the functioning of the information system for monitoring and management of the quality of educational programs

№	Stage	Description
1	Obtaining the file of the educational program for assessment	1. Checking the correspondence of the processed file format; 2. Determining the identification data (for example, the direction of training, specialty code, etc.).
2	Identifying and uploading benchmark files	Benchmark files contain fixed data that must necessarily be present in an educational program. The content of the file is determined based on a survey of experts. Uploading a file presupposes temporarily converting the data for it to be assessed.
3	Automatically identifying the block for assessment in the educational program file	Uploading the criteria (markers) corresponding to the identified block.
4	Matching each element of all blocks with the reference values of the criteria (benchmarks)	Correspondence options: 1. The content of the marker completely matches the benchmark: increase the value of the criterion by one. 2. Only the beginning of the marker completely matches the benchmark: increase the value of the criterion by zero. 3. The beginning of the marker or any other part of it does not match the benchmark: increase the value of the criterion by zero. 4. The marker completely matches the benchmark and additional elements are absent (for instance, blank lines or sentences not transferred to new lines for technical reasons): check the following lines for symbols. The search ends when the missing content is found, or the first five lines are empty. 5. The end of the range of search for the marker is reached: increase the value of the criterion by zero.
5	Generating and saving recommendations	The following files are generated: ● a text file with recommendations for markers that have deviations from the norm; ● report file with radar charts showing quantitative characteristics of the markers grouped by blocks.
6	Determining the quantitative result of the assessment of all blocks	Conducted based on the results obtained using the methods of expert assessment, ranking, and the significance and authority of experts.
7	Obtaining the integral indicator of the quality of the educational program	Weight coefficients for the completeness of the educational program are determined based on the initial assessments of the blocks from Stage 4. The integral indicator is calculated based on the weight coefficients and further interpreted.
8	Saving the obtained results	The data saved for further use and operational decision-making: ● the integral indicator, ● the report file with radar charts.

As we can see, a specific feature of this technique is the use of benchmark values formed based on expert opinion when assessing the aspects of the criteria. Obtaining the corresponding results calls for performing the following algorithm demonstrated in Figure 1.

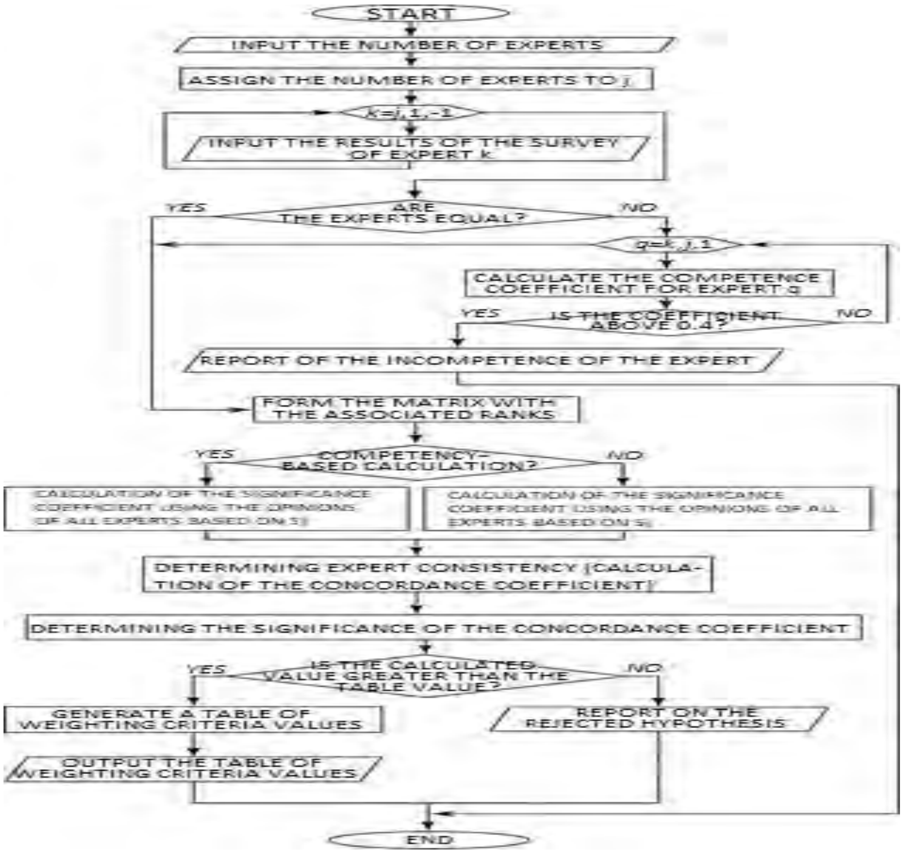

Figure 1
Flowchart of the algorithm for obtaining the results of the expert evaluation (Logachev, 2017)

The algorithm presented in Figure 1 results in the generation of the matrix of significance (weight) of each educational program quality criterion. The main principle of this algorithm is the opportunity to evaluate the competence of each expert (obtaining the C_E competence coefficient): the opinions of experts can be either equal for the system or of varying significance.

Each expert performs ranking:

- If the mode of equality of expert opinions is selected in the information system, the indicators are calculated by Formula 1 (Logachev, 2017; Tsvelik, 2018).
- If the authority of expert opinion is considered, S_j is calculated by Formula 2 (Fitzpatrick et al., 2015; Logachev et al., 2021).

Consequently, the indicator for the criterion is calculated by the formula (3) (Fitzpatrick et al., 2015).

For n_0 important blocks, the algorithm calculates the significance coefficients without taking into account the disregarded (as unimportant) blocks: Formula 4 is used when the competence of experts is equal and Formula 5 is deployed given the relative authority of the expert opinions (Gevorkian et al., 2020; Logachev et al., 2021).

In addition to determining the significance coefficients, the consistency of expert opinions is evaluated via the concordance coefficient W and the evaluation of the obtained results using Pearson's criterion.

The assessment of the educational program based on the obtained values for each criterion has to follow the algorithm the flowchart of which is presented in Figure 2.

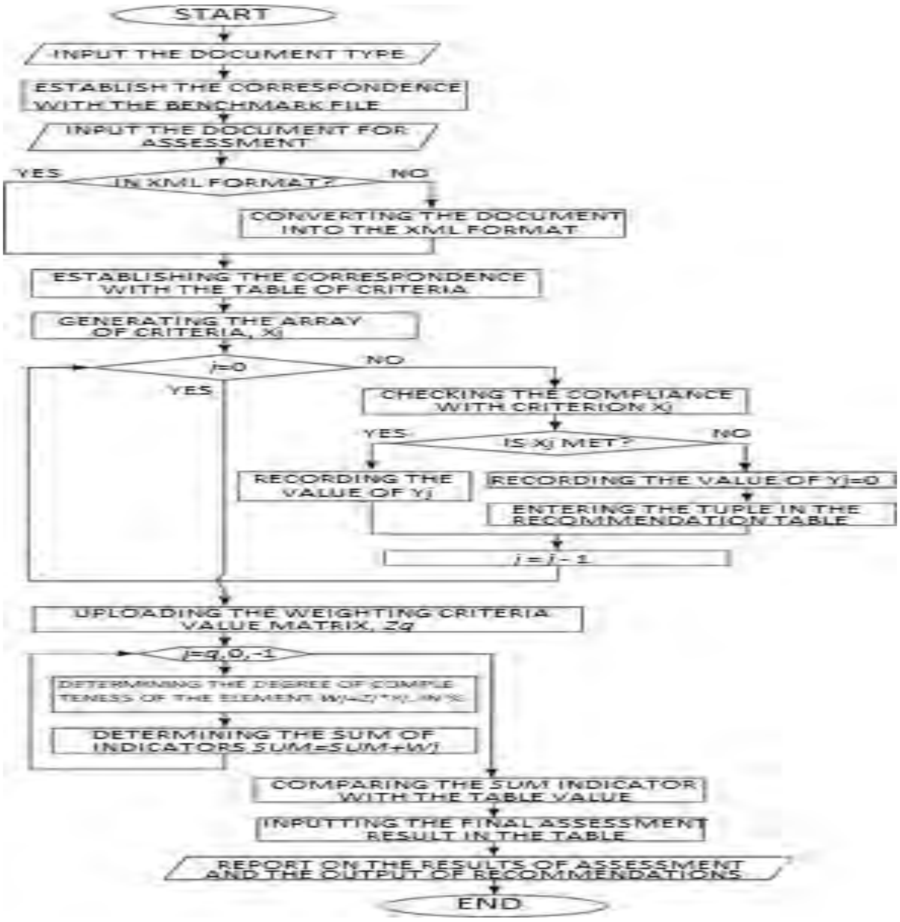

Figure 2
Flowchart for the algorithm of assessment of the educational program by the established criteria

The assessment process starts with selecting the type of document to be checked and uploading it into the system. For further assessment, the system requests the benchmark file corresponding to the identified document type. The assessment is possible if the uploaded document is in the *xml* format, otherwise, the system starts the process of conversion into this format (Logachev et al., 2017, 2021).

The foundation for the presented algorithm is the method demonstrated at the beginning of this section of the article. To explore the assessment process in greater detail, we present an example of testing whether the professional competencies indicated in the educational program correspond to normative documents. The flowchart of this algorithm is presented in Figure 3.

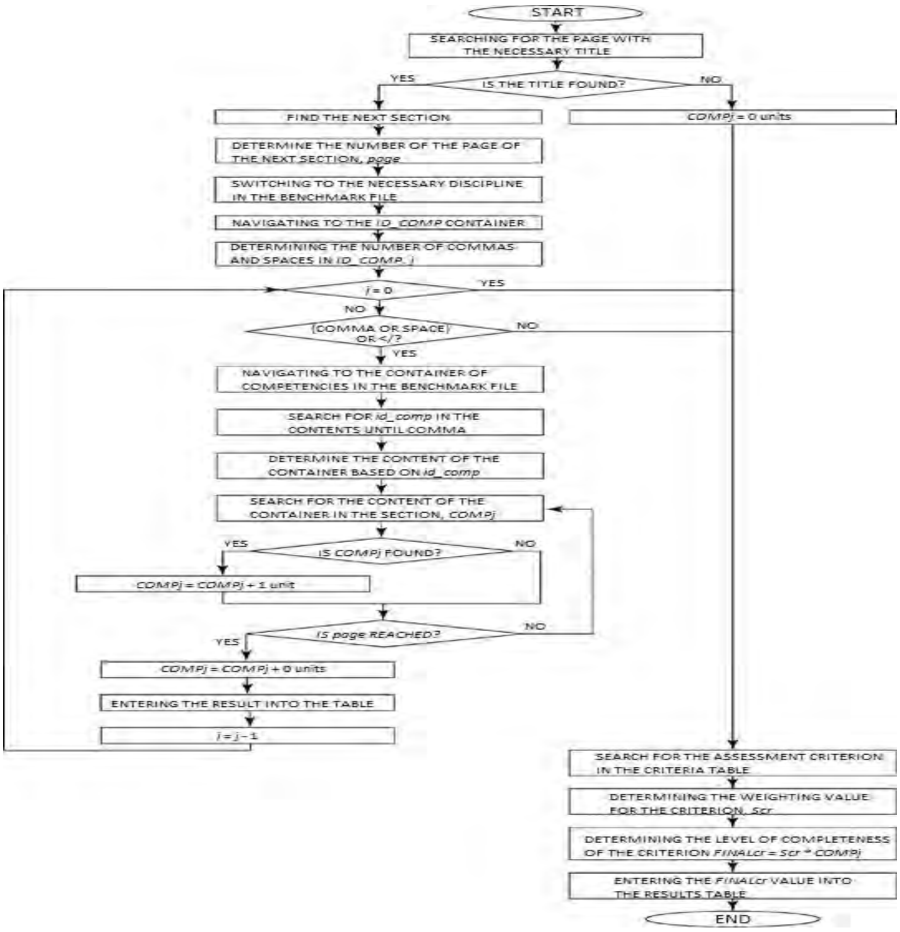

Figure 3
Flowchart for the algorithm of assessing the educational program section according to the benchmark file criteria

According to the algorithm, it is necessary to determine the location of the corresponding section in the document based on the template of the educational program. For this purpose, the system checks the markers that allocate the beginning of each sheet and compares the title of the first line. If the title matches the required content, the next step is to find the corresponding marker on the page.

The effectiveness of the developed methodology and the use of algorithms can be tested by comparing the results of the assessment of the quality of educational programs carried out by a methodologist with the results obtained by the information system.

There are no restrictions for this experiment, as any educational program is publicly available on the website of the educational organization or published in methodological collections.

The educational programs were divided into three groups:

- *Block 1*: Educational programs in the sphere of IT (e.g., information systems training direction (Maksiutova, 2020));
- *Block 2*: Educational programs in pedagogy (e.g., pedagogical activities in educational organizations of secondary vocational education);
- *Block 3*: Public administration education programs (e.g., municipal employee training).

Each block includes 20 analyzed educational programs.

The results of using the developed methodology and algorithms imply a primary result to be further translated into the integral indicator following the developed scale. Table 2 shows the levels of correspondence of educational programs' content to the benchmark values.

Table 2
Completeness of the sections of educational programs

No. п/п	Title of the educational program section	Degree of completeness of the section, %		
		Block 1	Block 2	Block 3
1	2	3	4	5
1	Title page	55.9	100.0	33.3
2	The back of the title page	100.0	77.3	77.3
3	Table of contents	78.6	52.4	52.4
4	"Passport" section	65.4	48.7	65.4
5	"Results of mastery" section	100.0	100.0	100.0
6	"Structure and content" section	100.0	56.0	39.5
7	Distribution of hours	100.0	100.0	0.0
8	"Conditions of implementation" section	100.0	58.9	17.8
9	"Control and assessment of the results of mastery" section	100.0	100.0	100.0

Table 3 presents the results of converting the primary result to the integral rating scale. The results of the conversion are determined using the expert assessment algorithm.

Table 3
Completeness of the educational program

No.	Title of the educational program section	Coefficient, %	Block 1		Block 2		Block 3	
			Section, %	Document, %	Section, %	Document, %	Section, %	Document, %
1	2	3	4	5	6	7	8	9
1	Title page	14.5	55.9	8.1	100.0	14.5	33.3	4.8
2	The back of the title page	14.5	100.0	14.5	77.3	11.2	77.3	11.2
3	Table of contents	5.6	78.6	4.4	52.4	2.9	52.4	2.9
4	“Passport” section	9.5	65.4	6.2	48.7	4.6	65.4	6.2
5	“Results of mastery” section	8.3	100.0	8.3	100.0	8.3	100.0	8.3
6	“Structure and content” section	13.6	100.0	13.6	56.0	7.6	39.5	5.4
7	Distribution of hours	21.4	100.0	21.4	100.0	21.4	0.0	0.0
8	“Conditions of implementation” section	6.3	100.0	6.3	58.9	3.7	17.8	1.1
9	“Control and assessment of the results of mastery” section	6.3	100.0	6.3	100.0	6.3	100.0	6.3
Total				89.1		80.6		46.3
Grade				4		4		2

The results presented in Tables 1 and 2 show the values obtained as a result of automated assessment. The effectiveness of this assessment should be considered to be the ratio of the obtained result on the number of allocated mistakes and the time spent on it.

It is possible to determine the time needed for allocating the mistakes. The intensity of the document review by a methodologist is calculated by Formula 6.

$$\beta = PV, \tag{6}$$

where P — the probability of finding mistakes in the educational program;

V — proofreading speed; symbols per second.

A detailed review of the results on the number of errors found after the first and second checks can be found in the work of Logachev (2017). This paper will only provide the overall result (Table 4).

Table 4
The results of the assessment of educational programs by the information system and the methodologist

Assessment element	Characteristic	Result		
		Block 1	Block 2	Block 3
1	2	3	4	5
Educational program	Number of symbols in the educational program	50,480	43,756	46,032
	Number of mistakes in the educational program	23	37	58
	Probability of allocating a mistake	0.00046	0.00085	0.0013
	The intensity of assessment by the methodologist	0.0046	0.0085	0.013
	The intensity of assessment by the information system	0.657	1.214	1.856
	Working time of the methodologist, in seconds	10,000	8,706	8,923
	Working time of the information system, in seconds	70	61	62,5
	Effectiveness of the information system	142.9	142.7	142.8

The educational program from Block 1 of the information systems direction of training has a high level of completeness. It can be utilized in the educational process. The recommendations that can be provided by the system are as follows: the title page does not signify the level of training; attention should be paid to listing the professional and general competencies in the "Passport" section in the format "code – name of competency". The table of contents has to indicate the page numbers for each section.

The educational program from Block 2 on pedagogy shows a high level of completeness and can be deployed in the educational process. The following recommendations can be offered: it is necessary to fill in the "Approved" block and the records of professional and general competencies in the "Passport" section in the form "code – name of competency". The table of contents has to indicate the page numbers for each section. The number of academic hours has to match the curriculum.

The educational program from Block 3 has a low level of completeness. For this reason, it cannot be used in the educational process until the mistakes identified in the assessment are corrected. The document does not meet the formal requirements of the educational and professional standards. The recommendations for corrections can be derived by the developer from the inconsistencies presented in the radar charts for each section.

DISCUSSION

The information system implementing the presented algorithms delivers precise results much faster than the methodologist. In this case, we refer only to the time required for the assessment including the process of proofreading. What is not taken into account is the time required to prepare for the assessment: in the case of the information system – starting the program and uploading the document, and in the case of the methodologist – selecting the required curriculum, educational and/or professional standards, preparing the workplace (for instance, setting up lighting). The obtained result does not contradict the conclusions of Russian and foreign scientists (Logachev, 2017; Chugunov, 2018; Stockard et al., 2020; Pit-ten Cate et al., 2020).

The evaluation of the possible recommendations for corrections shows that the information system is a strict examiner. Most probably, the methodologist either did not notice the technical mistakes and/or typos due to great workload or negligence (the document is present, and its contents are not that important). The next iterations of the information system development can include adding a module that would provide for automated correction of technical mistakes (for example, typos, errors in titles, etc.).

The use of the developed methods and algorithms allows integrating the system with the following objects in the educational process, as per the study goal and objectives:

- *With the schedule of classes*. The educational organization administration can conduct monitoring to determine compliance of the schedule with the workload (whether the correct disciplines described in the educational standard, educational program, competency matrix, etc. are indicated).
- *With the score-rating system*. This integration allows automatically uploading, controlling, filling, and generating reports on the milestones determined in the educational program or operational programs of each of the academic disciplines. The obtained result goes in line with the educational conceptions of not only Russian but also foreign researchers (Stain, 2018; Fernandez, 2016; Hidayah, 2020).
- *With the electronic grade book* (if the educational organization uses one). The lesson topics recorded in the electronic grade book must fully correspond to the wording in the calendar-thematic plan in the operational programs. Accordingly, the monitoring system uses data from the database utilized by the electronic grade book and checks the compliance of each topic. In this, the so-called rigid assessment is carried out: the topic either does or does not match. In the absence of an electronic grade book, the compliance of topics can be checked with assignment completion control systems (for example, Moodle) employed in the ecosystems of Russian and foreign educational organizations (Grigorash, 2020; Kotsuba, 2021; Maksiutova, 2020; Kerr et al., 2020).

CONCLUSION

The developed algorithms for an information system for management monitoring and monitoring itself are “flexible” and allow setting the parameters of the criterion complex, determining the weighting values for the parameters and the degree of their importance, and specifying the number and quality of experts. All of this requires minimal involvement of specialists in the process of assessing the content of educational programs. The resulting information system is an independent unit in the material and technical base of an educational organization but also presents an element that unites several information systems of different types. Thus, it presents an integrated information system capable of ensuring the full and competitive functioning of the educational organization in the contemporary market conditions at a high level.

To conclude, we can state that the established objectives are realized and the goal of the study is reached. The formulated hypothesis is confirmed. It should be noted that a promising direction for further research in this area is studying the issue of improving the objectivity of the educational program content assessment, developing algorithms for automated generation of particular elements of an educational program, and improving the algorithms for the assessment of the content of educational programs to reduce the time costs of this process, as well as studying the system’s capability to learn.

LIMITATIONS

The methods deployed in the study are universal and common in designing and modeling information systems of any complexity, including corporate ones. No difficulties were faced in the process of using them, and the obtained results are unambiguously interpreted and applied in practice. One of the main advantages of the resulting models is their flexibility and openness for adjustments depending on the conditions of both the educational organization itself and the state regulatory documents. The developed algorithms allow to unequivocally convert any input data (regulatory documents, educational programs, etc.) into the format suitable for the information system. Moreover, the conversion process does not entail any loss of data and is carried out with minimal influence of the human factor on the final result. The deployed mathematical apparatus allows for quick adjustment of different coefficients to account for trends in education, economy, the social sphere, etc. The algorithms presented in the study can be reproduced by any executor and implemented with any currently available means of object-oriented design and programming. All of the above allows us to state that the developed algorithms and models can be used in developments for both the Russian education system and foreign education.

In conclusion, it should be noted that we did not intend to develop a model for the system that would achieve the result in a minimal amount of time. We believe that with the technology change, the time costs of the final result can be reduced even further.

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CONTRIBUTION

Mikhail Sergeevich Logachev — study design, structural analysis, and formalization of models, writing the main body of the article.

Yuliya A. Laamarti — data collection and analysis, results interpretation.

Svetlana Evgenievna Rudneva — literature review and structural analysis.

Anisim Ivanovich Ekimov — literature review, formulation of the problem, hypothesis, goal, and objectives of the study.

Dmitry Nikolaevich Zemlyakov — data collection and analysis, formalization of models.

Alexey Barkov — data collection and analysis, formalization of models.

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