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DEVELOPMENT OF A MODEL FOR IMPLEMENTING A CASE METHOD FOR INTERACTIVE STUDY PROCESS MANAGEMENT MONITORING

Abstract: The importance of this research topic lies in the need to gather, store, analyze and disseminate accurate information on the management status of educational institutions to guarantee the provision of quality educational services. This is particularly crucial in the current trend towards digitalizing educational work and utilizing the internet to facilitate practical management tasks. The study aims to construct a case method model to supervise educational process management outcomes. For that purpose, the study scrutinises the implementation methodologies of existing case models to monitor and analyse the situation without human intervention. Also, the investigation entails creating an implementation algorithm and a simulation model of an interactive case method to monitor educational activities. The formalized logical-semantic apparatus is used to address the research problems. The algorithm development and simulation modeling enabled correlation of the obtained answer with the assigned task, automating the results output. Generating answers in the case method involves considering rules based on the base word, answer keywords, and constraints (true/false). These elements are part of the thesaurus specific to the survey domain and are included in the test's base vocabulary. To test an answer against a question, each inductive step is

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viewed through a logical formula. Logical statements such as conjunction, disjunction, logical negation, implication, and equivalence are represented by formulas. This method enables the evaluation of the respondent's answer based on the nodes within the statement tree integrated into the test. The progression from the initial word to the node-connection generates an automated assessment of individual educational process management standards. This study enables the enhancement of automated monitoring capabilities for the University's educational process results. The research suggests the potential for developing models and algorithms to form question sets and enable individualized assessments based on the respondent's performance. As a consequence, the devised algorithm and simulation model for the interactive case approach are showcased. During the testing, the key words and example words were compared with the responses of the participants and specific results were obtained. Additional case vocabulary terms need to be added to address the limitations encountered during the model testing and the testing period.

Keywords: keyword; base dictionary; reference word; induction step; tree model.

Introduction

The case method is an educational tool [1] that utilizes situational analysis and model building at its core to solve problems or analyze their nature [2]. It presents a problem situation in the form of a case or situational task based on factual scenarios [1]. The tasks within the case have no predetermined answer template, and thus, it helps to determine whether the participant of the educational process can solve the given situation with the use of their own knowledge. At the same time, the foundational information for the case may present contradictions, and the apparent structure of real facts may not provide further insight into the issue, instead acting as a barrier to its solution.

Based on the educational process monitoring objectives [3], the case method's characteristic makes it a useful tool to recognize peculiarities, difficulties, and outcomes of an educational institution's academic process.

The use of a case study in this situation allows to:

a) collect information about the educational process in this institution. Determine if the respondents have the necessary analytical skills, understand their tasks, and are willing to learn new information;
b) process the obtained results, formalize them to be able to use them for verification of pedagogical process models;
c) save formalized information from the case study to use later in predicting the development of the learning process;
d) identify if students are prepared for autonomous work, specifically in their capacity to conceive unconventional solutions and utilize information learned through their educational journey;
e) analyze the effectiveness of students' collaboration within their academic groups through evaluating their soft skills. Utilize this information to enhance future educational experiences.

If monitoring an educational system involves gathering, storing, processing, and distributing information [4] about the state of educational institution management to guarantee educational quality, then the question of automating these processes is a pressing one. That is because creating an interactive case method using information technology involves more than just testing and program development. The process entails developing a mechanism to randomly select a task from a given set, automating the determination of the answer's alignment with the task using an algorithm or scenario [5], and conducting test modeling to assess the degree to which the results will remain unaffected by external factors. Implementing the case method on an internet platform appears justifiable considering the trends in educational digitalization and adapting learning technologies for the web environment.

The above statement underscores the importance and the necessity of exploring the opportunities to analyze academic process data, with the goal of enhancing and creating new technologies that enrich the quality of higher education institution (HEI). The study's scope pertains to the integration of information technology in the educational process.

Literary review

The case method is a proven teaching and educational process control technology within Western educational systems [6]. While this teaching method has been known since the mid-1980s in Russia and Kazakhstan, a close interest in case usage for education only emerged during 2008-2010 [7]. In general, the local educational environment adopts foreign developments and existing cases adapted to local educational processes that do not fully correspond to local goals and objectives [2]. Foreign researchers have observed that the current approach to creating and utilizing case studies is primarily action-focused, lacking room for critical reflection [8]. To counteract this, various alternative approaches have been suggested for the training and supervision of intricate educational processes [6].

The rise of information technology has ushered in new approaches to implementing case studies [9], with emphasis on monitoring quality and exploring problem scenarios in higher education [10]. [11] recommended the case method for personal information-gathering and assessment, proposing a business case development scheme to resolve a specific issue. As shown in [12], information technologies are utilized to implement the following case types:

- with the participation of an examiner who checks answers to obtain critical information or assess the case because the answer is open-ended or controversial;
- automated, to obtain specific information by extracting the most accurate from the data set, because the answer is definite and can be selected from a drop-down list of options;
- simulators that enable users to transition seamlessly between tasks in order to update their knowledge.

The paper [13] defines an electronic case method as a methodological complex for practically describing a case and identifying issues in the information and educational field. It suggests adopting a standard approach to designing electronic teaching materials, as proposed in study [12].

Current IT developers indicate that automation of the case method is being developed [14]. It remains uncertain whether human involvement will be necessary during the analysis of answers and processing of acquired information. Previous studies on the development of interactive cases [15] have only presented partial information, mostly in the form of theoretical calculations and overall information models.

The above information establishes the research problem: the necessity for creating interactive case-testing technology to analyze academic process data and enhance monitoring of educational services in HEIs with minimal human intervention in result processing.

Purpose and objectives of the study

The study aims to propose a case method to monitor educational process management outcomes, aiming to eliminate human intervention in result processing to enhance the dependability and certainty of observation.

Objectives of the study:

1. To examine the model for implementing the case method and use it as the basis to introduce the formula for the interactive case method. The interactive case method allows to process the results of the situation analysis without human participation.

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2. To demonstrate the implementation algorithm and simulation model for the interactive case method.

Methods and Materials

The approach [12] could be utilised to generate an interactive case study that tracks the outcomes of education process management whilst considering the usual user behaviour when operating web resources. It is crucial to highlight the logical-semantic framework of the process under study [16], to develop a logical formula by which the case will allow to make a conclusion about the state of the research problem. It is also essential to develop an algorithm for correlating the obtained answer with the task at hand [17]. Consequently, we can present a generalized interactive case implementation scheme as illustrated in Figure 1.

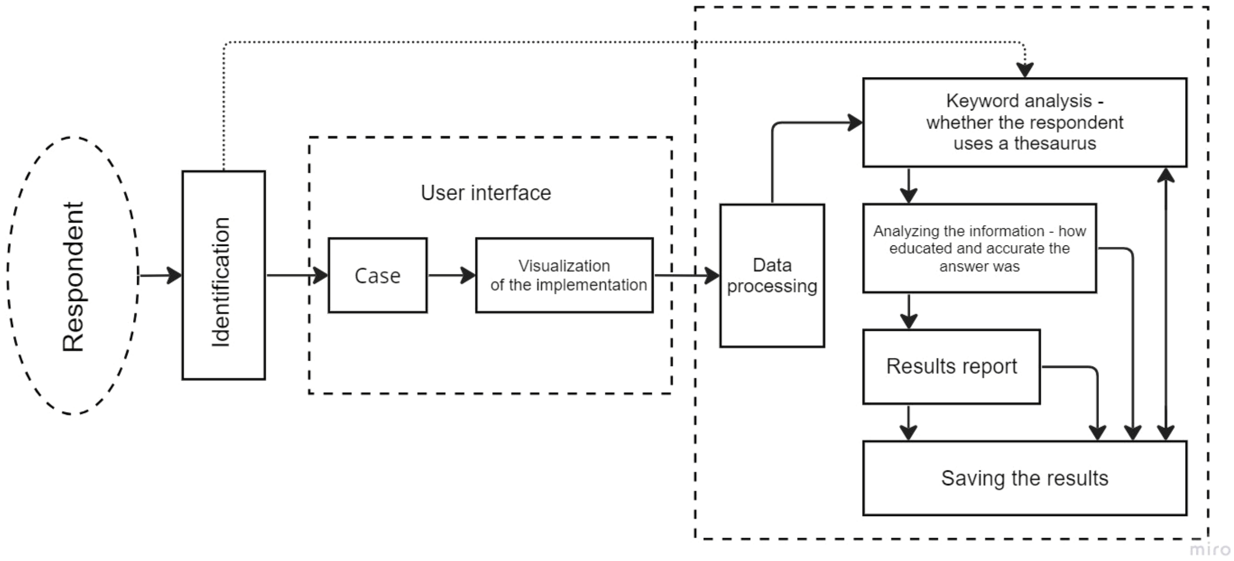

Figure 1. Generalized scheme for implementing an interactive case.

In the above scheme, identification pertains to verifying the user's correspondence to the entered data and visual image. Existing data about the user, such as grade point average and achievements in science and the field, is compared during identification. This comparison generates a compliance scheme that enables the system to correlate the gathered information. Certain input parameters in the result processing unit necessitate multiple identification. This approach enables one to measure the advancement or decline of a learner's educational journey.

The test can be taken with or without prompts. When responding to the case, one may select options from the list or provide a personal answer. Accuracy is determined by the correspondence to a reference word or character mix. Success is achieved by matching the answer to the reference, while failure prompts another skill test task.

The presented option is a typical one [18], common to most information systems, from Internet search tools to routine tests with a list of possible answers. Identification of responses is achievable through the implementation of four correction algorithms that offer multiple options for subsequent actions based on the processed data:

- The problem is found, identified, and a point corresponding to the amount of correctness of the given answer is provided;
- The problem is found, not identified, additional question is given;
- The problem is found, misidentified, a block of similar questions is given;

- The problem is not found, the answer is correct, and a corresponding point is provided.

According to the given scheme, the task can be based on the standard questionnaires of the university's internal system for improving the quality of the educational process. The interactive case method has a distinctive algorithm that enables the creation of a logical scheme based on a keyword to select a set of words from the case database. This determines the accuracy of the answer. Using reference words by the respondent corresponds to higher grades. This indicates the subject matter of the test. For instance, the study of results in educational process management can be exemplified by the following task: "Describe your personal trajectory upon graduation from university in a single sentence." Generating an array of keywords from the existing case database is the next step. It will serve as the foundation for the initial keyword search and reference words. This step is crucial in determining non-keyword-based matches for the output. The result of this process is an automated summary, where a score of "1" indicates a match and "0" indicates a lack of alignment with the reference word range.

By utilizing this method, human bias is eliminated as the data analysis is conducted through standard comparison algorithms [19]. These algorithms can be executed sequentially. For instance, it is assumed that a specific accurate answer is represented by a collection of m words $A_j = (a_1, \dots a_i, \dots a_m)$, where $(j = 1, \dots, N)$, the absence of one or more reference words in the comparison set is considered as an error and described by $B = (b_1, \dots b_k, .. b_n)$. In this case the comparison $P_A(A_j) = B$ takes place, and the result given is either "rather yes then no" or "rather no than yes" based on the number of points scored. This analytical matching algorithm can be implemented through a direct search using various values based on combinatorial analysis [20] and following the prescribed rules and logic programming approaches [21]. A fundamental component in developing a case method implementation model [22] is crafting a case formula based on a logical statement.

Results

When implementing a case method an answer is formed according to certain rules:

A baseline refers to a term or expression that is part of the survey domain's lexicon and is acknowledged as a formula.

The induction stage assumes that particular keywords in the respondent's answers are formulas. In this instance, formulas are logical statements: conjunction, disjunction, logical negation, implication, and equivalence.

Rules are limited by the fact that only the base and the induction step are used to determine truth or falsity. Following this rule involves advancing through a network of statements represented by a tree structure. The first node of the tree is the starting word and subsequent nodes are interconnected in a way that enables us to determine the relevance of each node to the task at hand. This process can be depicted using the following formula:

$$(p \land (q \lor r)), \tag{1}$$

where the labels p, q, r are a variety of possible statements on the case assignment. The induction step is used twice in (1) – first, when creating the initial statement $(q \lor r)$, and then when linking it with the statement p from the task conditions.

If, while building a reasoning model, a certain element (word) X is associated with an element (word) Y through induction (i.e., based solely on the coincidence of word arrays), then Y becomes a unified statement. Relations can be displayed using the formula's tree model, which is the foundation of the developed case method (Fig. 2).

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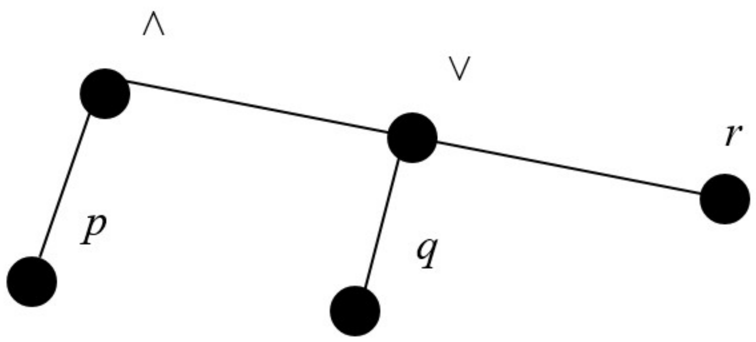

Figure 2. Tree model formula of case method.

To implement this particular method, a database must be created by compiling a basic dictionary and incorporating essential terms. The dictionary is then utilized to establish logical circuits by following induction steps based on formula (1) (see Fig. 2). The basic dictionary must adhere to two requirements: organized reference words and data redundancy. The mechanism for this base dictionary is expressed as follows:

$A_j = (a_1 \dots a_i \dots a_n)$-$j$-$e$ – word from the base dictionary;

$i = \overline{1, n}$; $j = \overline{1, N}$;

– q – keywords and reference words.

Each keyword and reference word a_i is correlated with a certain number $\alpha_{k_i} = \{\alpha_{0_i} \dots \alpha_{k_i} \dots \alpha_{(q-1)_i}\}$, given $\alpha_0 = 0$; $\alpha_{q-1} = q - 1$ $\alpha_{k+1} = \alpha_k + 1$. That is, we assign a sequential number q to correspond to the keyword and reference word of each task in the system. The dictionary will be structured upon implementation of the model:

$$\sum_{i=1}^{n} \left(\alpha_{k_i} \cdot q^{n-i}\right)_j \rangle \sum_{i=1}^{n} \left(\alpha_{k_i} \cdot q^{n-i}\right)_{j+1}. \quad (2)$$

The set of reference words outlined in (2) is formed through the prioritization of decreasing values $\frac{\alpha_{k_i}}{\alpha_{k_{i+1}}} = q$. It is suggested that the previous term indicates a satisfactory answer, leading to the next step in the current test. Data redundancy requires q^n diverse combinations of n words for a correct task response, using only $N!$ combinations, which represent the dictionary time of the system q^n $(q^n >> N)$.

The algorithm for finding the correspondence of the answer given by the respondent and the reference words is:

1) the beginning of the algorithm: respondent entered the answer: $a_1, a_2, \dots, a_i$
2) the current set m_i of keywords and reference words from the base dictionary is formed: $a_1,\ a_1 a_2,\ a_1 a_2 a_3, \dots, a_1 a_2 \dots a_i$. It is worth noting that when answer words $a_1, a_2, \dots$ are introduced, the search area decreases $m_1 \rangle m_2 \rangle \dots \rangle m_i$, due to the order of keywords and reference words. The perfect case for basic dictionary is $m_i / m_{i+1} \approx q$, that is the existence of random in distribution of keywords and reference words among q^n possible answer word variations $a_1 \dots a_n$.
3) a set of m keywords and words-examples is provided for matching identification, when entering an answer word a_i from the current dictionary m_i;
4) if the required match is absent in the set m, then the search for a match with a lower probability takes place, which allows to narrow the search area to the set m_{i+1}. The process of searching for a match is performed until the search word is found;
5) if a match is not found the next word is being considered;

6) the algorithm is considered finished when every answer word was analyzed. The result is the answer according to the identified matches, with $m_v \leq m$, or the answer is "zero" when no match is found. This process is shown on Figure 3.

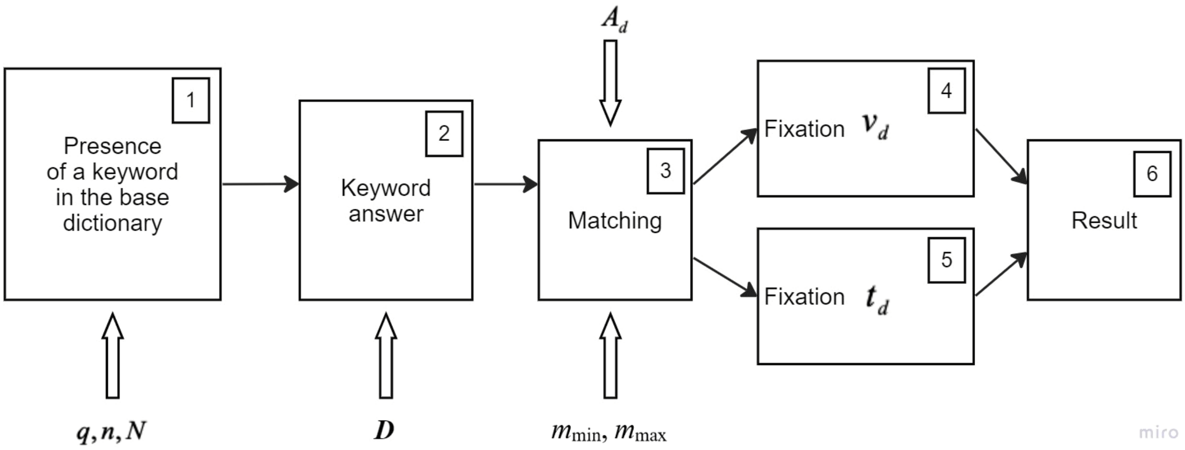

Figure 3. The scheme of implementation of a case method using keywords and reference words.

Imitative modeling and testing of a case study method were conducted using Visual Basic for Applications programming language in MS Excel. The indicators for this method include the average value of $\bar{v}_1$ which represents the number of symbols the respondent enters to identify the reference word, and the average value of $\bar{m}_1^{(1)}$ which represents the general number of words the user enters to answer the test.

The imitation model implemented a basic dictionary, formed as a file, which consists of N ordered keywords on the topic of the case task, having n characters of the alphabet q. The file also represents the number D of reference words that can be used in the answers, where:

- a_i – a set of reference words whish are identic to $a_1, a_2, \dots, a_i$;
- $\hat{a}_i$-box – parts of words which meaning is similar to $a_1, a_2, \dots, a_i$;
- $m\left(\hat{a}_i\right)$ – a number of words $\hat{a}_i$-box that are often used as answers on this subject;
- $AD^H\left(\hat{a}_i\right)$ – number of the first word of the $\hat{a}_i$-box;
- $AD^K\left(\hat{a}_i\right)$ – number of the last word of the $\hat{a}_i$-box;
- $A_o^H\left(\hat{a}_i\right)$ – the word $a_1 a_2 \dots a_i 00\dots0$ (minimal number of answer words);
- $A_o^K\left(\hat{a}_i\right)$ – the word $a_1 a_2 \dots a_i (q \cdot 1)(q \cdot 1)\dots(q \cdot 1)$ (maximum number of answer words);
- $A[j]$ – whether or not the word corresponds to the case task j.

That is, when the keyword A_d is entered, there is a corresponding array keyword $(d = 1\dots D)$. In this case, the value $i := 1,2, \dots$ for which the condition is satisfied, is found:

$$m_{min} \leq m\left(\hat{a}_i\right) \leq m_{max}$$

In other words, if the answer consists of $m = 10$ words, the keyword can be one or more of the arrays of keywords and reference words. In this case the answer is accepted. Identifying one word as a keyword is sufficient for a correct answer.

Experimental testing was conducted using an imitation model of the case method, which involved final-year students in technical specialties from a S. Seifullin Kazakh Agrotechnical University who participated voluntarily. The experiment included 100 students who were

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asked to articulate, in one sentence, their vision for professional development following graduation. The study utilized keywords and reference terms pertaining to career advancement, professional development, and specialized terminology. Conventional academic sections and author and institution formatting are also maintained. Word counts ranged from 100 to 2000. The results of the calculation and experiment are shown in Table 1.

Table 1. The results of calculation and experiment in testing of the presented simulation model of case method implementation

Signature	$\bar{v}_1$			$\bar{m}_1^{(1)}$
	Calculation $\bar{v}_1^{(1)}$	Experiment $\bar{v}_1^{(2)}$	Calculation/ Experiment	
1. TEXT $N – 2000, r – 10^{-8}$	4,67	4,68	0,998	15
2. TEXT $N – 1000, r – 10^{-6}$	3,29	3,30	0,996	12
3. TEXT $N – 500, r – 10^{-5}$	2,68	2,70	0,992	≤5
4. TEXT $N – 100, r – 10^{-3}$	1,07	1,08	0,995	≤5

The calculation $m\left(\hat{a}_i\right) = AD^K\left(\hat{a}_i\right) - AD^H\left(\hat{a}_i\right) + 1$ can be shown as an implementation of the following numerical interpretation of the algorithm.

Input: $N = 100, q = 32,\ n = 4,\ m = 10, r = \frac{N}{q^n} \approx 10^{-3}$

$A = 00$; Б $= 01$; В $= 02$; …

Hypothetical keyword – GROWTH.

$a_1 =$ Б; $\hat{a}_1 =$ Б; $\mathrm{A}_0^{\mathrm{H}}(\hat{a}_1) = 01.00.00.00 = 1 \cdot 32^3 = 32768$;

$\mathrm{AD}_1^H(\widehat{\text{Б}}) = 32768 \cdot 10^{-3} \approx 32$;

$\Delta_1 = 32768 - 33792 = -1024 \neq 0$.

Reference words: $\mathrm{AD}_2^H(\widehat{\text{Б}}) \approx 32 - 1 = 31$;

$\mathrm{A}(31) = WORK = 33760$;

$\Delta_2 = 32768 - 33760 \neq 0$.

…

$\mathrm{AD}^H(\widehat{\text{Б}}) = 30$;

…

$\mathrm{AD}^{\mathrm{K}}(\widehat{\text{Б}}) = 63$;

$m(\widehat{\text{Б}}) = 63 - 30 + 1 = 34 > 10$.

Further analysis of the response words;

Since $m(\widehat{\text{Б}}) > m$.

$a_2 =$ Я; $\hat{a}_2 = (\widehat{\text{БЯ}})$;

$\mathrm{A}_0^{\mathrm{H}}(\hat{a}_2) = 01.31.00.00 = 64512$;

$\mathrm{AD}_1^H(\hat{a}_2) = 64512 \cdot 10^{-3} \approx 64$;

$\mathrm{A}(64) = PLAN = 2 \cdot 32^3 = 65536$;

$\Delta_1 = -1024 \neq 0$.

$\mathrm{AD}_2^H(\hat{a}_2) = 63$;

$\mathrm{A}(63) = CODES = 65472$;

…

$\mathrm{AD}^H(\hat{a}_2) = 61$;

…

$\mathrm{AD}^{\mathrm{K}}(\hat{a}_2) = 63$;

$m(\hat{a}_2) = 3 < 10$.

Process completed, $v_d = 2$.

The answer of the user is accepted since the keyword "growth" was identified. As well as the reference words "work", "plan", "codes" that are present in the array of data. It was formed to check respondents' answers from basic dictionary.

Discussion

The tree model formula of the interactive case method, presented in Figure 2, serves as the foundation for this study. The implementation of the case approach can include many similar formulas constructed from incoming symbols, words, and phrases. This set of words is finite and corresponds to a thesaurus on the survey's topic. The set of formulas is recursive, allowing for the identification of words that are formulas and vice versa. In this manner, formulas are distinguished based on the criteria of accuracy or error. This permits the handling of intricate scenarios in which a mistake in one task question's response results in supplementary conditions for examining the issue.

Analyzing model (2) and the subsequent simulation modeling actions, it is important to note that the presented simulation model is limited by parameters q, n, and N. The implementation of various cases will require a vast amount of technical vocabulary, including professional terms, foreign words, and relevant expressions. That is why searching for a keyword in the first line of the respondent's answer is a necessary condition for enhancing the interactive case method. Additionally, the experiment's limiting factor was the given time, which was not limited. Nevertheless, constraining the test time and aligning it with the general model of the case method will enable the evaluation of the case from an individual position, as noted in [11]. All of these measures will collectively enhance the accuracy of answer evaluation.

The methodology proposed to implement the interactive case approach will significantly improve our research, which aligns with [2, 4], by providing practical demonstrations of our results. It also allows us to compare with the study done by [5]. The process of execution with the presented algorithm to obtain the final result while reducing human intervention.

The study results differ from the typical approach [12] in that they provide a more detailed breakdown of the functional blocks of the case and fully automate the response analysis process. The proposed development regards the case method as an interactive tool to aid decision-making in educational service quality management, while the work [12] regards the case method as one of multiple tools for automating individual processes within education management.

The results obtained broaden the digital educational environment concept by pushing the boundaries of the model presented in [13]. This is mainly attributed to the emergence of feedback in the educational process. The feedback is not abstract, but rather concrete since it offers a quantitative and qualitative comparison of the outcomes of managing the educational process. It aligns with the work [1], specifically introducing a novel case implementation mechanism utilizing contemporary interactive technologies. This broadens the monitoring toolkit as defined in the study [3].

A promising development in research is the creation of models and algorithms for generating question sets that enable individualization based on the respondent's results. Additionally, monitoring the outcomes of educational process management will facilitate comparison of student performance and activity indicators with those of the case. Based on which it will be possible to make a comprehensive analysis of the state of the educational process of a particular higher educational institution, as well as to compare the results of different higher educational institutions by the efficiency criteria.

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Conclusion

The interactive case method's model reveals its unique development. To achieve this, the logical-semantic approach of the investigative process should be the foundation. Afterward, correlation with the assigned task enables an automatic output of results. A tree model visualizes the presented formula, which enables the search for words that form statements and match them with key and reference terms from the system's base vocabulary. The higher the number of matching words, the higher the result of case completion.

The presented algorithm and simulation model for the interactive case method enabled the comparison of keywords and word-examples with respondents' responses. Although the simulation model had limited parameters and an unlimited task completion time, the results suggest the potential for more advanced identification. This discovery opens the way for creating a distinct interactive system to monitor the results of educational process management.

In the future, this research will significantly enhance the educational testing process, enabling the creation of tests that not only assess proficiency and aptitude but also evaluate a student's understanding of the subject matter. This approach can be used to inform education quality assurance decisions via the development of multitasking tests, which generate systematic conclusions and generalisations.

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