CONTROL PROCESSES

The paper develops a structural model for building a system for developing methodological competence. The structural model is built based on a service-oriented approach to developing large software complexes and includes six subsystems. Each subsystem is implemented as a separate microservice, which allows system scaling. The paper describes a technique that allows you to build a teacher's competency map and evaluate its eight components: cognitive, didactic, project, informational, communication, reflective, monitoring, and personal-motivational. A four-level scale is proposed for assessing the level of competencies. A methodology for evaluating the effectiveness of the methodical competence development system based on the hierarchical expert method has been developed. The system was verified and implemented. According to the results of the system implementation, the intensification of the educational process and the improvement of the training quality of students were recorded. Students' success in studying subjects has increased significantly. Namely, the number of bad students has decreased by 15 %, the number of «excellent» students has increased by 10 %, and the number of «good» students has increased by 18 %.

The paper touches upon creating information technologies adequate for improving the higher education system. The goal is the targeted development and implementation of information technologies in educational institutions and the creation and operation of integrated, flexible software to support a mixed system for organizing the educational process, as well as increasing the efficiency of implementing a mixed system for organizing the educational process

Keywords: structural model, information systems, assessment of methodological competencies, microservices

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A STRUCTURAL MODEL FOR BUILDING A SYSTEM FOR THE DEVELOPMENT OF METHODOLOGICAL COMPETENCE AND METHODS FOR EVALUATING ITS EFFECTIVENESS

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1. Introduction

The analysis of the methodological competence of university teachers, the formation of methodological competence, and the professional readiness of the teacher are the key topics of research in recent years in the field of education and teacher training. Various researchers have carried out research in these areas, and views on these issues may vary

depending on the context, the specific objectives of the study, and the scope of application of the research results.

According to empirical research, using a model for the development of methodological competence built on a single content, consistent with certain types of activities and strategies of pedagogical intervention, contributes to the improvement of methodological competencies among novice teachers. The paper [1] notes significant differences in the developed model's impact on the development of methodological competencies among novice teachers, depending on experience and professional environment. In the study [1], the author used a psychological and pedagogical experiment to identify the influence of the developed model on the development of methodological competencies of novice teachers, during which the level of methodological competence of novice teachers was previously tested and verified. Beginning teachers were asked to fill out the assessment tool twice, before and after participating in the experimental program based on the operating model (OP) application, from June 2010 to July 2011.

Descriptive analysis of these assessments before the experiment and after indicates significant differences in the level of development of methodological competencies. The results of the author's research were the following conclusions: novice teachers have severe changes at the level of all categories of subject areas in relation to the development of methodological competencies under the influence of the experimental program. The second conclusion of the study is related to the influence of some variables of the experimental program on the development of methodological competencies among novice teachers. One of the important variables is the professional experience of novice teachers in the sense that those who have 2 and 3 years of experience have registered more significant changes than those who have taught for only one year in terms of compliance with the requirements of didactic principles. An important variable is the environment in which novice teachers teach. Thus, the long-term experimental work of the authors of the paper allows us to conclude the design of educational materials: novice teachers from an urban environment received higher scores than those from a rural environment, and at the level of developing a lesson plan, novice teachers from a rural environment received higher scores than from an urban environment. The study's conclusions allow us to trace better the changes that we can achieve in developing methodological competencies of novice teachers with the help of the model developed by the authors.

The study [1] shows the relationship between methodological competence and the pedagogical skills of a teacher. Accordingly, it can be argued that the development of methodological competence is an important aspect of improving the quality of teaching at the university.

In general, the research in analyzing university teachers' methodological competence in forming methodological competence needs to be more relevant and described. In addition, the creation of new approaches for assessing and developing methodological competence helps form the methodological competence of university teachers in various environments. For example, the formation of methodological competence of teachers in the Republic of Kazakhstan, Ukraine, or other countries may have some peculiarities concerning cultural characteristics, peculiarities of the legislative field, strategic goals in the respective country's world, etc. This must be considered to ensure the adequacy of teachers' methodological competence formation primarily because the correctness of this process affects the functioning of the state's entire educational system and may have long-term consequences.

Therefore, the development of a structural model for building a system for the development of methodological competence and methods for evaluating its effectiveness is an essential task since it allows you to systematize, formalize, and direct efforts to develop competencies in a single direction, which entails an increase in the efficiency of the country's education system.

2. Literature review and problem statement

A separate area being studied in the pedagogical, scientific environment is the formation of methodological competence of inclusive education teachers. The work [2] shows that higher educational institutions play a significant role, providing conditions for the full-fledged social integration of a large category of people with limited educational needs and personal and professional self-determination. To form an optimal inclusive model, a teacher with a high level of professionalism, including methodological competence in the field of designing educational space and educational products, ready for dynamic changes in the educational process, is needed. The process of formation of methodological competence is a model that can function successfully under the following pedagogical conditions: the active involvement of teachers in the implementation of the network interaction of an inclusive educational environment, the development of an educational and methodological complex that provides step-by-step methodological support for the teacher through the developed individual development program.

The paper [3] investigates the formation of methodological competence among student-teachers. In the work [3], various methods and approaches to developing this competence in the educational environment are proposed, and the need to create conditions for providing practical experience for students in forming their methodological skills is highlighted. Although competence is considered a critical educational goal in [3], there needs to be a consensus on its exact definition, which leads to the ambiguity of educational goals. Adopting competence-based approaches in higher education has shifted the focus toward assessing and developing students' competencies through a combination of various pedagogical technologies. These technologies include practical and seminar training, problem-solving, scientific writing, and participation in conferences and projects. The effectiveness of these pedagogical technologies largely depends on the methodological activities of the university's teaching staff.

Descriptive analysis of these assessments before the experiment and after indicates significant differences in the level of development of methodological competencies. The results of the author's research were the following conclusions: novice teachers have severe changes at the level of all categories of subject areas in relation to the development of methodological competencies under the influence of the experimental program. The second conclusion of the study is related to the influence of some variables of the experimental program on the development of methodological competencies among novice teachers. One of the important variables is the professional experience of novice teachers in the sense that those who have 2 and 3 years of experience have registered more significant changes than those who have taught

for only one year in terms of compliance with the requirements of didactic principles. An important variable is the environment in which novice teachers teach. Thus, the long-term experimental work of the authors of the paper allows us to conclude the design of educational materials: novice teachers from an urban environment received higher scores than those from a rural environment, and at the level of developing a lesson plan, novice teachers from a rural environment received higher scores than from an urban environment. The study's conclusions allow us to trace better the changes that we can achieve in developing methodological competencies of novice teachers with the help of the model developed by the authors.

The main achievement of the authors of this study, who were engaged in the development of methodological competence of university teachers and professional readiness for teaching, can be considered that there is a relationship between methodological competence and pedagogical skills of the teacher, and they come to the conclusion that the development of methodological competence is an essential aspect in improving the quality of teaching at the university.

Despite the impressive list of papers devoted to methodological competence, some researchers note that the methodological competence of university teachers still needs to be fully disclosed, and further research and development on this topic is relevant. It is noted that various approaches to assessing and developing methodological competence can be helpful in forming an effective system of training university teachers. In addition, it is essential to consider the peculiarities of educational programs and working conditions of teachers for the successful development and application of methodological competence.

For example, the formation and development of methodological competence of inclusive education teachers deserves close attention. In [4], this idea is particularly clearly traced. Inclusive education is currently one of the strategically important directions of developing domestic education. A significant role in its implementation is played by higher educational institutions that provide conditions for the full-fledged social integration of a large category of people with limited educational needs and their personal and professional self-determination. To form an optimal inclusive model, a teacher with a high level of professionalism, including methodological competence in designing educational space and educational products, is needed, ready for dynamic changes in the educational process. The training of teachers to work in inclusive education is very much in demand in the domestic higher school. The process of formation of methodological competence is a model that can function successfully under the following pedagogical conditions: the active involvement of teachers in the implementation of the network interaction of an inclusive educational environment, the development of an educational and methodological complex that provides step-by-step methodological support for the teacher through the developed individual development program.

The study conducted by the authors [4] not only sheds light on the importance of methodological competence in educational reform but also provides valuable information on the development of practical tools for assessing and monitoring the competencies of future teachers.

The Ukrainian pedagogical community is actively discussing the competence approach in the context of modernization of educational processes in vocational schools in the country. The paper [5] aims to explore the integration of Ukrainian pedagogical traditions with foreign experience to encourage active independent activity of students, thereby creating a dynamic, mobile, and competitive model of vocational training in various industries and services.

The paper [5] is devoted to innovative processes in the Ukrainian vocational education system. The authors emphasize the crucial relationship between the growth of the innovative competence of a teacher and the effectiveness of the disclosure of his creative potential in the development and implementation of modern educational practices. The study covers various aspects of the development of methodological competence of vocational education teachers, paying particular attention to innovative elements. Through a comprehensive analysis, the paper [5] identifies the key factors affecting the methodological competence of vocational education teachers. It emphasizes the importance of innovative approaches in forming teacher competence, reflecting the changing demands and requirements of the educational landscape.

The conclusions presented in such works offer valuable information for politicians, educators and stakeholders involved in shaping the future of vocational education in the global educational space. The emphasis on innovation and methodological competence contributes to the formation of a qualified and capable workforce, effectively meeting the needs of various industries, making the domestic vocational education system more competitive and responsive to the needs of the labor market.

In the work [6], the division of methodological competence into subject-oriented and professionally oriented is proposed, and the functional components of pedagogical activity for its measurement are highlighted. However, the work [6] does not describe the methodological competence development system or indicate how it can be evaluated.

For a more complete understanding of the methodological competence of university teachers, researchers also turn to the concept of professional readiness of teachers. Professional readiness development is associated with identifying key components, including knowledge, skills, and personal qualities necessary for successful pedagogical activity.

The professional readiness of teachers concerns not only the ability to transfer knowledge effectively, but also the ability to adapt to various situations in the educational environment, effectively use various teaching methods, and evaluate student performance.

To establish a link between methodological competence and professional readiness of university teachers, researchers analyze practical experiences and best practices that are considered successful in the field of teaching. The use of innovative approaches and advanced teaching methods can contribute to the development of methodological competence and increase the level of professional readiness of teachers.

However, despite the studies already conducted, the problem of developing the methodological competence of university teachers remains relevant and requires further research. To do this, it is important to continue working on defining criteria and levels of formation of methodological competence, as well as to develop effective educational programs that ensure the development of this competence among future and current university teachers. Such efforts will help to improve the quality of education and the effectiveness of training at universities.

Many studies turn to various approaches and strategies that contribute to the development of methodological competence among teachers. Some researchers focus on the role of pedagogical practice and internships in improving methodological competence, while other studies assess the impact of

professional development programs and courses on the level of methodological training of teachers. Mentoring support and partnership with experienced teachers are also studied as the key factors in the development of methodological competence.

The paper [7] identified specific skills and competencies that form the methodological competence of university teachers, such as the ability to effectively apply active teaching methods, develop and adapt teaching materials, use innovative technologies in the educational process and effectively evaluate students' academic achievements.

An important area of research is also the analysis of factors that may hinder the formation of methodological competence among teachers, such as limited access to educational resources, insufficient time to prepare educational materials, or insufficient support from the administration of universities.

In general, the analysis of scientific literature suggests that the development of the methodological competence of university teachers is a complex and multifaceted process that requires an integrated approach and consideration of various factors. Further research in this area will contribute to a deeper understanding of the mechanisms of formation of methodological competence and will help to develop effective strategies and techniques to improve the level of methodological readiness of university teachers.

Undoubtedly, the development of methodological competence of university teachers is a crucial factor in improving the quality of education and ensuring successful student learning. Outstanding scientists in pedagogy and higher education have conducted many studies on this topic.

One of the critical studies on the methodological competence of university teachers was conducted in [8]. The author identifies several essential skills and competencies for teachers to effectively apply active teaching methods and create a stimulating learning environment. He also highlights the importance of developing educational materials and using innovative technologies to make the educational process more exciting and understandable for students.

Another critical study is the work [9]. The author explores the theoretical foundations of forming methodological competence among university teachers in this study. It offers an integrated approach to the assessment and development of methodological readiness of teachers and emphasizes the importance of supporting and assisting the university administration in this process.

It is also worth noting the work [10], where the authors consider factors that may limit the formation of methodological competence among teachers, such as limited access to educational resources and insufficient time to prepare educational materials. They offer several recommendations to improve the support of university teachers and increase their methodological readiness.

In conclusion, the analysis of scientific literature on the topic of methodological competence of university teachers shows that this is a complex and multifaceted process that requires a systematic and integrated approach. Further research and development in this area will contribute to the development of effective strategies and techniques to increase the level of methodological readiness of teachers and ensure quality education in universities.

In addition, an important aspect that should be considered when studying university teachers' methodological competence is their professional readiness. The work [11] is devoted to the study of the professional readiness of teachers and its relationship with methodological competence. The authors emphasize the importance of the formation of professional readiness of teachers, as this is the primary basis for developing their methodological competence.

In the study [12], the author examines innovative aspects of the development of teachers' methodological competence in modern education. She highlights the pedagogical university's role in forming the methodological competence of future teachers. She offers some innovative methods and approaches for the development of this competence.

An important aspect is the choice of professional teachers. For this, there are different approaches. One of them is discussed in the papers of the collective of authors [13, 14], where it is proposed to assess the competence level through the teaching staff's publication activity. The authors propose methods for ranking the level of professionalism of scientists, which allows the selection of the most appropriate teachers with the right competencies. This approach will make it possible to form an adequate teaching staff.

The paper [15] emphasizes the critical relationship between the quality of education and the quality of teaching, especially in terms of methodological and didactic competencies. The main argument is that the quality of education, in particular the development of digital literacy of the population, is inextricably linked with the quality of teaching. This, in turn, depends on the development of methodological competence of teachers of IT disciplines.

The research presented in this paper is devoted to assessing the methodological competence of teachers of IT disciplines. This is an important question, given the rapidly developing field of information technology and the critical role that teachers play in forming students' digital skills and literacy.

The main points highlighted in the paper include:

Quality of education: The paper emphasizes that the quality of education is a direct by-product of the quality of teaching. Effective teaching methods and pedagogical strategies are crucial for achieving high educational standards.

Digital literacy. The development of digital literacy is becoming increasingly important in the modern world. Teachers of IT disciplines play a crucial role in transferring these skills to students, prioritizing improving their methodological competence.

Methodological competence: The paper argues that teaching effectively, especially in information technology, requires a high level of methodological competence. This competence includes the ability of the teacher to use pedagogical strategies, teaching design, and assessment methods adapted to the dynamic field of information technology.

Assessment of methodological competence: The research discussed in the paper is aimed at assessing the extent to which teachers of IT disciplines possess methodological competence. This assessment is essential for understanding teachers' readiness in this field.

In general, the paper emphasizes the crucial role of the methodological competence of IT teachers in ensuring the quality of education and the development of digital literacy. This highlights the need for continuous assessment and development of these competencies to keep up with the evolving information technology and education environment.

The paper [16] explores the concept of skills management or competence management as a means of effectively using employees' skills in the workplace. The study highlights the importance of aligning HR management processes with job requirements and organizational strategy to increase employee productivity.

The authors emphasize the relevance of defining competencies in approaches to knowledge management since this can contribute to setting goals and evaluating and distributing teams in knowledge-based organizations. Competencies are considered personal characteristics, including knowledge, skills, and abilities that allow people to act competently in various situations.

In general, the papers pay little attention to the construction of a structural model of the system of methodological competence development, as well as methods for evaluating its effectiveness. The works only indicate specific facts and provide recommendations, but there is a lack of a straightforward, systematic approach to building a system for developing methodological competence.

3. The aim and objectives of the study

The aim of the study is to build a structural model of the system of methodological competence development. Solving this problem will improve the quality of educational services, stimulate the development of digital literacy, and systematize and formalize the development of competency-based methods in education to increase the effectiveness of the country's education system.

To achieve the aim, the following objectives were set:

– to build microservices for the development of methodological competence and describe them;

– to describe the components of methodological competence;

– to describe methods for evaluating the effectiveness of the system being created for the development of methodological competence.

4. Materials and methods

The paper examines the construction of a structural model of the information system for the development of methodical competencies, taking into account the service-oriented approach and the method of evaluating the effectiveness of the created system. With the introduction of the system, the intensification of the educational process and the improvement of the training quality of specialists are expected. The development of the system will contribute to the teacher's self-diagnosis to determine the level of mastery of competencies and increase digital literacy.

The system analysis method was applied to build a structural model of methodological competence development in the research. This made it possible to determine the main elements of the system and the functional connections between them. The studied system analysis became the basis for formulating requirements, technical documentation and software development based on microservices. The university employees, specialists in the relevant disciplines, took part in filling the system.

Expert and hierarchical decision-making methods were used in the research to study the system's effectiveness. Also, the research is based on a competence-based approach to learning.

After implementing the «Assessment of methodological competencies of teachers of IT disciplines» information system, an experimental method was used to verify the positive impact of implementing the research proposals in the educational process.

5. Results of the development of a structural model of the system of methodological competence development

5. 1. Miscroservices and their representation in the system of methodological competence development

In the conditions of adaptation of the educational process of the university to the basics of supporting a mixed system of organization of the educational process, the task of solving the problem of complex automation of the educational process is urgent.

The main goal of creating information technologies adequate to the task of improving the system of higher education is the purposeful development and implementation of information technologies in educational institutions and the creation and operation of integrated, flexible software tools to support a mixed system of organizing the educational process, as well as improving the efficiency [17] of the introduction of a mixed system of organizing the educational process based on the use of the latest technical training tools and document management, ensuring free access of students to educational and methodological resources (including electronic ones), the content and criteria for assessing knowledge in disciplines and modules, data registration, partial compensation for the increase in the workload of teachers and staff by automating the processes of knowledge assessment, registration and analysis of academic performance.

A structural model is the most general and abstract model of a system that reflects objects and relationships between them.

Modern methods of creating large software complexes use a service-oriented approach, that is, using microservices technologies, the main idea of which is to represent a software system through a set of independent entities (services) interacting with each other. Each entity itself is responsible for preserving the information necessary for its life, and, in addition, implements its own behavior. The main idea of a service-oriented approach is the ability to decompose a system into many separate entities, each of which can be multiplied into any number of instances (services) with their own characteristics. Services connected by connections through data exchange APIs describe the system's structure.

For the implementation of the developed software tools, a prerequisite is the possibility of using Internet technologies and services.

Fig. 1 shows the structural model of the microservice architecture of the information system «Assessment of methodological competencies of teachers of IT disciplines», which is based on the principle of microservice architecture and consists of 6 main modules and has a multi-level distributed structure, the main components of which are remote database servers, application servers, specialized automated workstations of teachers, students, employees of deans and departments (clients), web servers and web applications, and auxiliary – software services for designing and interpreting computer tests, regulating access and performing other special functions.

The first microservice is the Competence Bank module, which determines teachers' methodological competencies (Fig. 2).

Administrators of the information system, through their personal accounts, add questionnaires to determine the level of methodological competencies of teachers of IT disciplines. All competencies are divided into components, which allows you to more accurately determine the level of ownership of a particular competence (Fig. 3).

The structural model of the micro-service architecture of an information system, including a graphical user inter-

face and interaction with databases, is usually viewed from the perspective of several levels: two-, three- or multi-level. For object-oriented systems, it is recommended to use a classical three-level structural model, which, after decomposing the application logic level into several smaller levels, will turn into a multi-level structural model without pronounced level boundaries.

To implement the conceptual model under consideration, taking into account the formulated requirements, a structural model of the software package is proposed based on the use of the «Model-View Separation» design pattern (separation of model objects from graphical user interface objects) and provides interaction with the database, models and projects (the level of stored data).

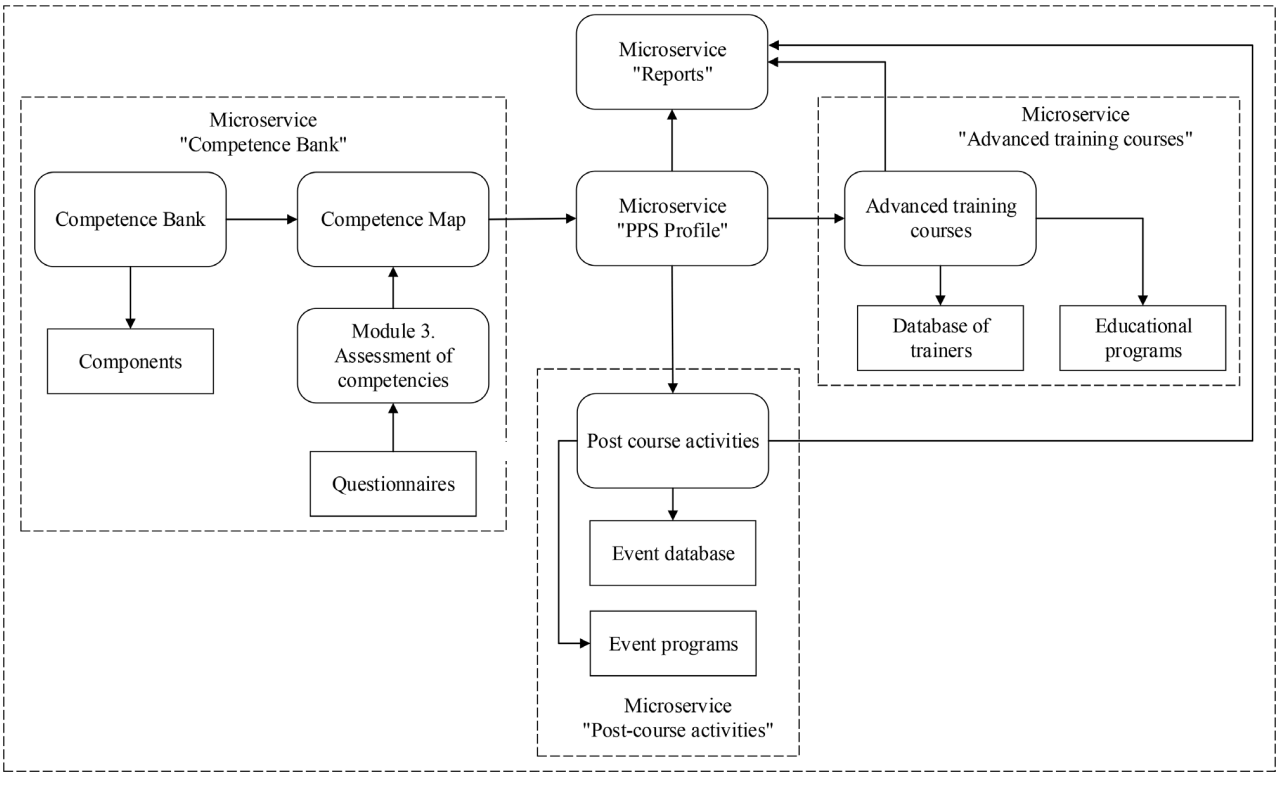


Fig. 1. Structural model of the microservice architecture of the information system «Assessment of methodological competencies of teachers of IT disciplines»

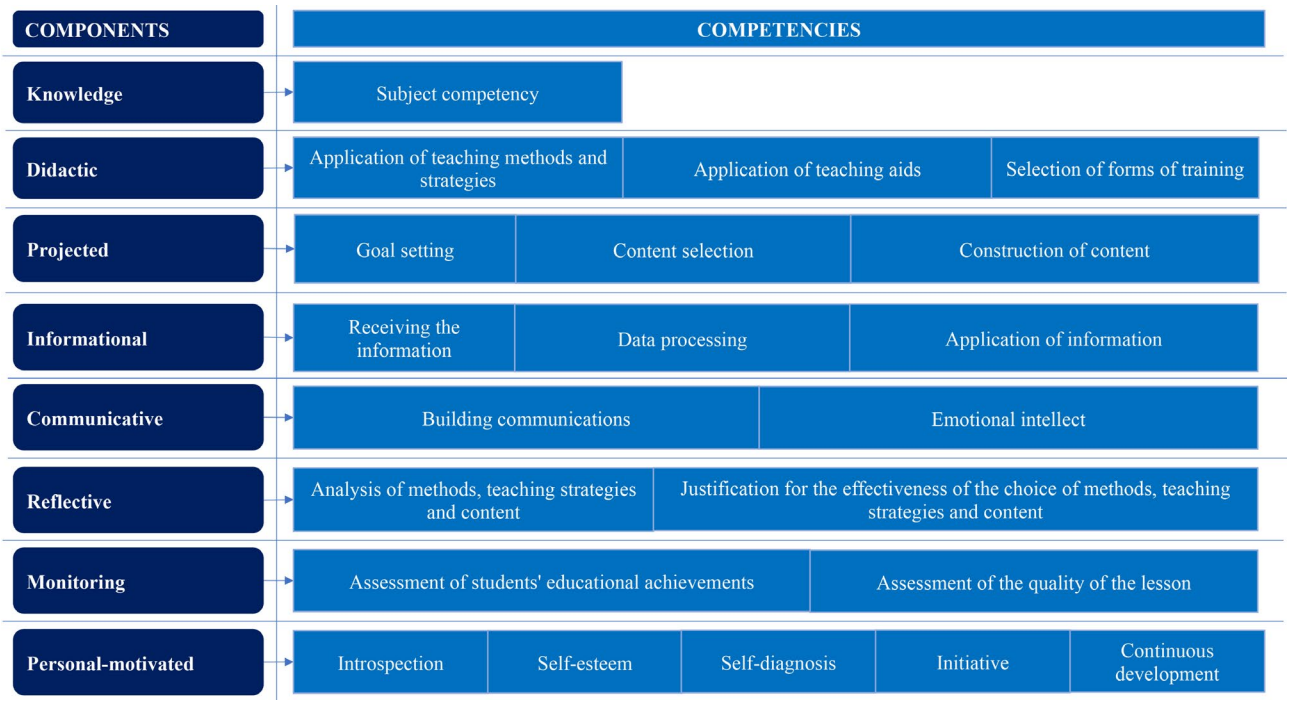


Fig. 2. Module «Competence Bank»

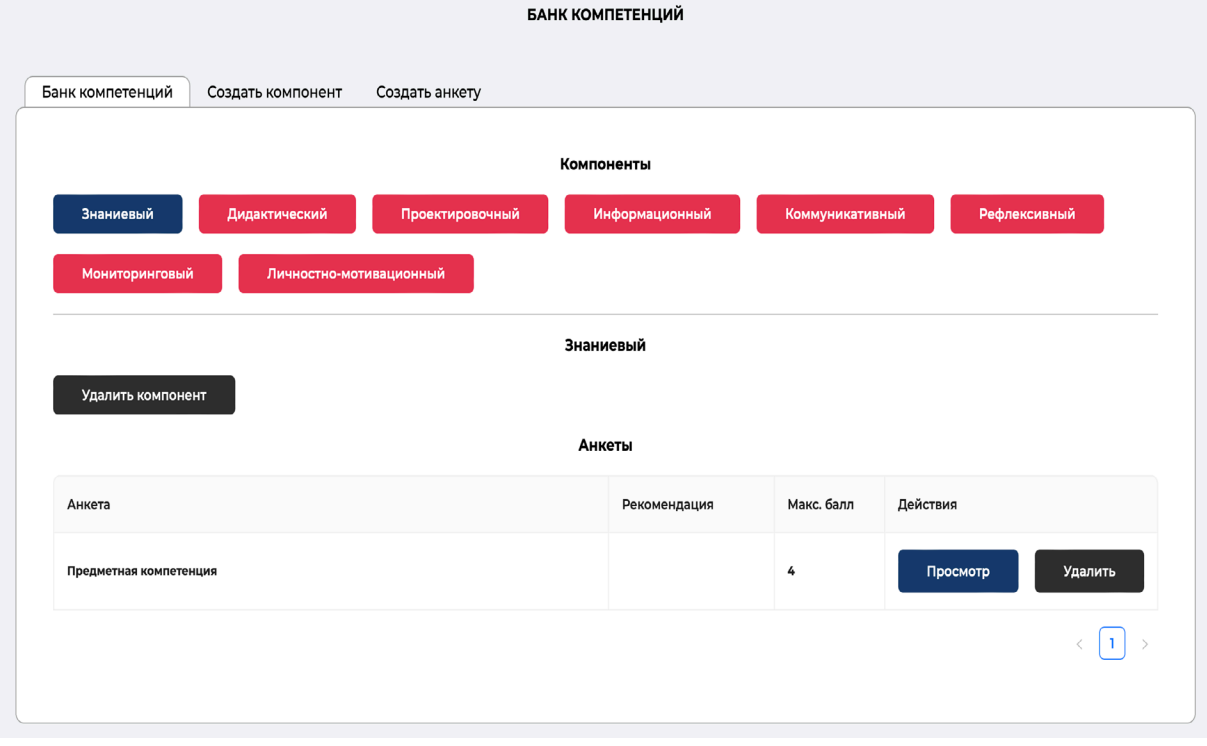


Fig. 3. Competence Bank

The levels are represented by corresponding packages in the graphical notation of the Unified Modeling Language (UML): domain objects and service objects (services). The former belongs to classes that directly describe the concepts and models (artifacts) of the subject area and most fully reflect the specialization of the information system. Service objects are designed to perform auxiliary functions, for example, various transformations of domain objects (high-level services), providing interaction with the database, generating reports, etc.

5. 2. Other microservices of the methodological competence development system

The second microservice, the «Teacher Profile» module, contains the teacher's data, a competency map with the exact level of knowledge for each component, a calendar with upcoming courses, as well as progress in the current course, information about completed courses and completed tasks (Fig. 4).

Personal data can only be changed by the account user. The data of the competence card is stored in the database and is changed when the teacher passes the questionnaire (Fig. 5).

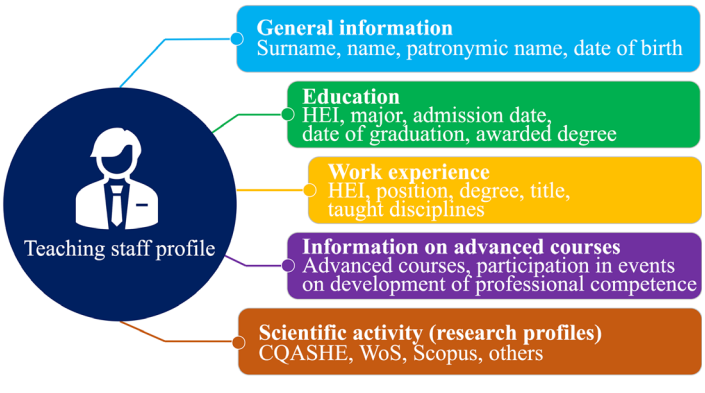


Fig. 4. Personal data of the teacher

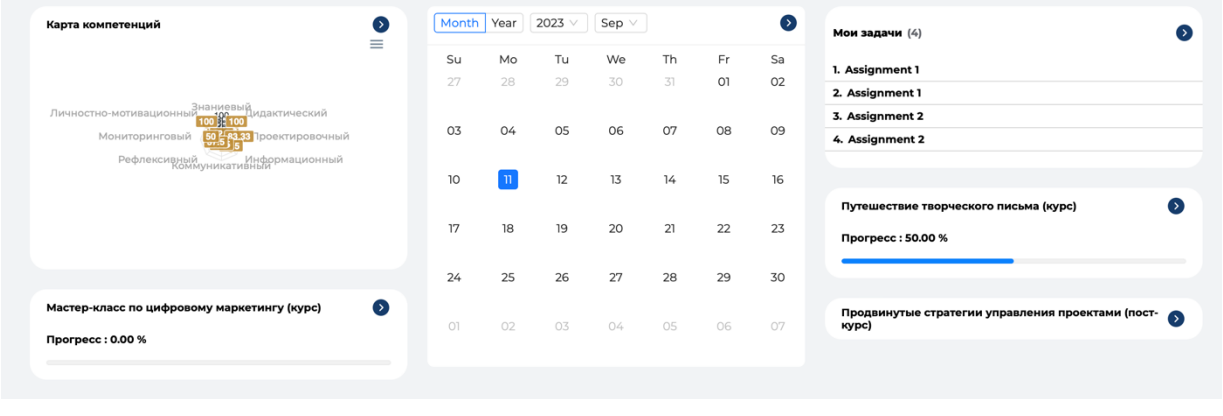


Fig. 5. Teacher's personal account

The third microservice is the Competence Assessment module, which is used to calculate the level of proficiency in components based on the survey results.

All the results obtained during the survey of teachers are recorded in the database, and the system, based on the points received, forms the teacher's level of knowledge for a specific component.

An example of determining the level of the personal-motivational component:

– 5–60 points: Low level of personal motivation component. The teacher may not be motivated to improve his teaching methods continuously, is not always ready to adapt classes to the needs of students, and is inclined to respond to the challenges and difficulties students face rarely.

– 61–70 points: Acceptable level of personal motivation component. The teacher is interested in his development and high-quality teaching, but sometimes, he may need help in creating an inspiring atmosphere and motivating students.

– 71–80 points: Average level of personal motivation component. The teacher has certain motivations for self-development and creating interesting classes. He/she is ready to learn and respond to challenges, but there is room for improvement in creating a positive atmosphere.

– 81–90 points: High level of personal motivation component. The teacher has a strong motivation for self-development and quality teaching. He/she actively creates an inspiring atmosphere in the classroom and successfully responds to students' difficulties by supporting them.

– 91–100 points: Advanced level of personal motivation component. The teacher is a natural leader in the field of personal motivation component. He/she not only constantly develops and motivates students but also contributes to creating a unique atmosphere, inspiring both students and colleagues.

The fourth microservice – the module «Courses for Teachers» – is used for online training of teachers on the development of levels of proficiency in methodological competencies. Administrators in their accounts can create courses, assign a trainer to the course, create a schedule for the start and end of the course, fill in the data of the certificate of successful course completion. Throughout the course, he can view the teachers' current results, monitor the course's organization and conduct, and make adjustments. The teacher, in turn, can contribute course materials, add course sections, presentations, and practical and test tasks (Fig. 6).

The fifth microservice is the «Reports» module, which stores information about the total number of users and their activity, the levels of proficiency of teachers, and created courses and statistics on their completion (Fig. 7).

The sixth microservice is the «Post-course support» module, which organizes teacher training in informal education, including recorded video tutorials, seminars, trainings, etc. (Fig. 8).

This module is required for managing courses, creating and adding video lectures, tests, open tasks to the course.

The knowledge component of a teacher's methodological competence is a knowledge base and understanding of important concepts, methods, and principles related to the learning and teaching process.

The possession of a component of methodological competence provides teachers with the theoretical knowledge and understanding necessary for the development and implementation of effective teaching methods and for maintaining a high level of educational practice.

The didactic component of a teacher's methodological competence is one of the key elements of his professional competence. It covers knowledge, skills, and abilities related to the design, organization, and conduct of the educational process. Didactic competence allows teachers to effectively transfer knowledge and develop students' skills.

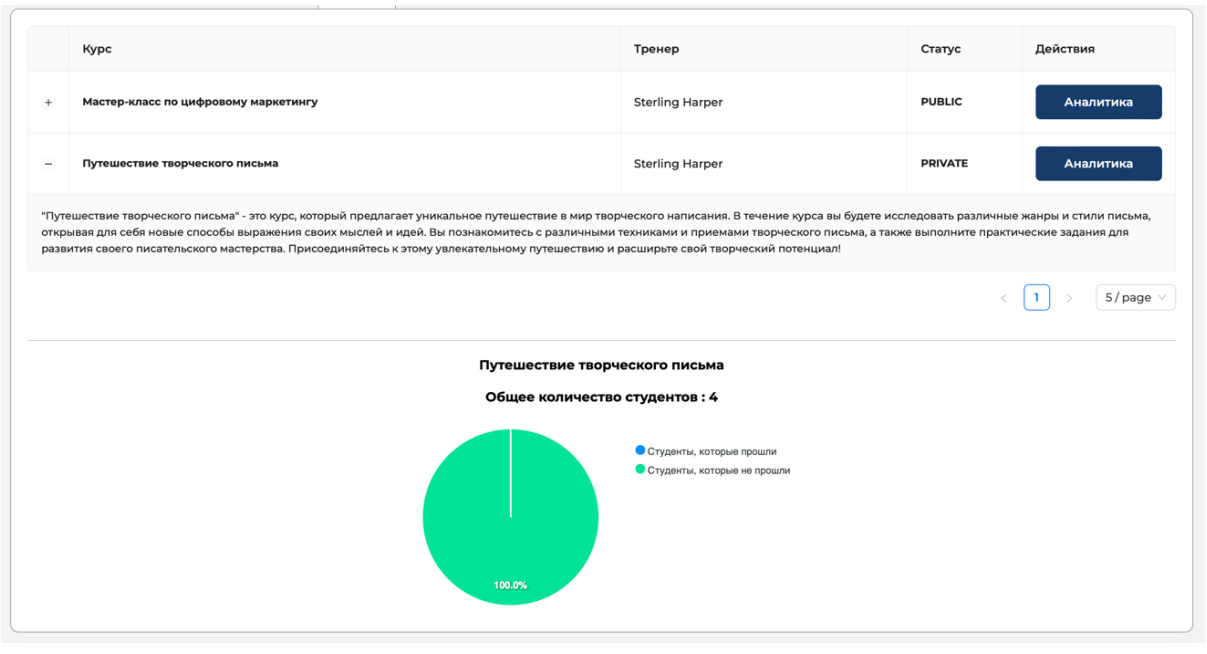
This component allows you to create a stimulating educational environment and contributes to achieving educational goals.

The design component of a teacher's methodological competence plays a key role in preparing and organizing the educational process. This component includes the knowledge, skills, and abilities necessary to develop courses, lessons, training materials, and methodological strategies.

The information component of a teacher's methodological competence plays an important role in the educational process. This component includes knowledge of current educational theories, scientific research, teaching methods and teaching materials.

The information component of methodological competence enriches teachers with the knowledge and information necessary for developing and implementing effective educational strategies. This component allows teachers to be competent and professional in their educational practice.

Fig. 6. Course page



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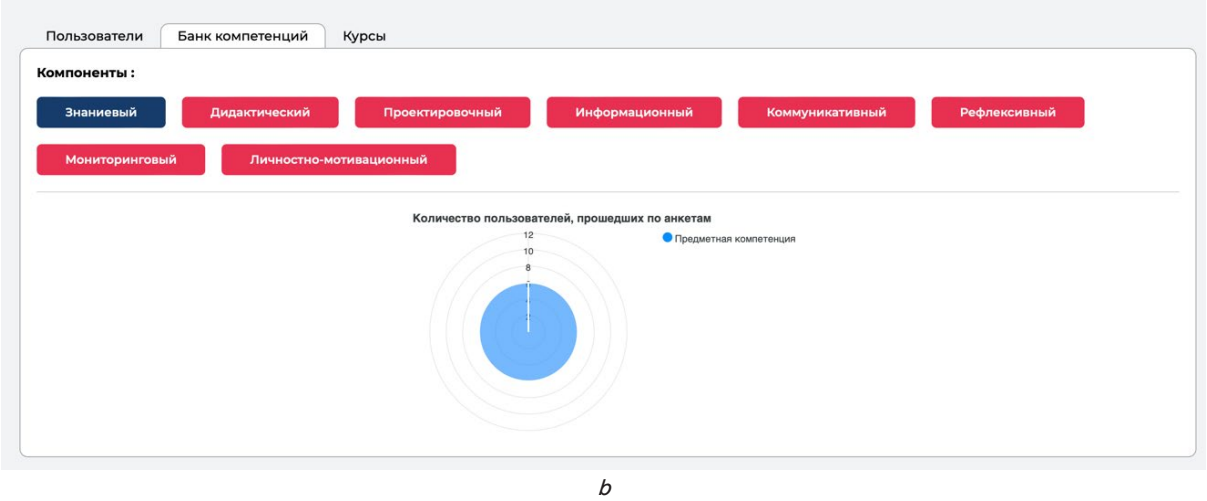

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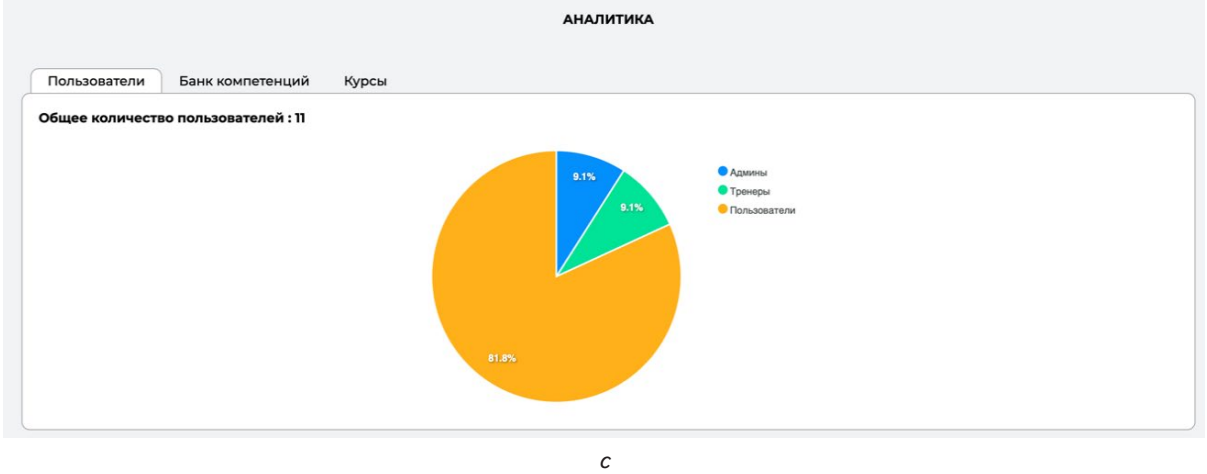

c

Fig. 7. The main signature: *a* — report information about students, *b* — report information about competences, *c* — report information about users

The communicative component of a teacher's methodological competence plays an important role in an effective educational process.

This component covers skills and abilities in the field of communication, interaction and creation of a favorable educational environment.

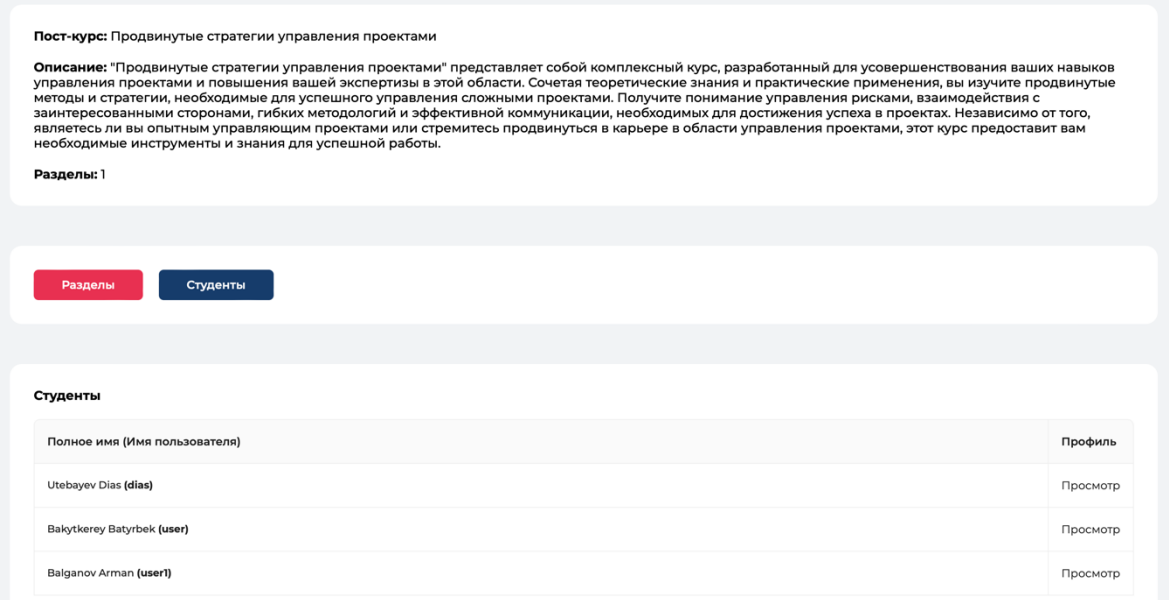

Fig. 8. «Post-course support» module

The communicative component of methodological competence contributes to the successful transfer of knowledge and skills to students and creates a supportive and motivating educational environment. It helps teachers to interact effectively with diverse students and promotes their academic progress.

The reflexive component of a teacher's methodological competence is the ability to introspect and self-reflect, as well as the ability to make informed decisions based on this analysis. This component allows the teacher to constantly improve his teaching methodology and adapt it to students' changing conditions and needs.

The reflexive component of methodological competence allows the teacher not only to be more effective in his work but also to remain relevant and adapt his methods to the changing requirements of the educational environment and the needs of students. This is an important component of successful teaching.

The monitoring component of a teacher's methodological competence plays an important role in providing quality education. This component is related to the teacher's ability to monitor and evaluate the learning process systematically, students' learning outcomes, and the effectiveness of their teaching methods.

The monitoring component of methodological competence allows the teacher to maintain a high quality of education, adapt his approach to learning, and ensure the achievement of students' learning goals. This is an important component of successful teaching.

The personal-motivational component of the teacher's methodological competence plays an important role in the formation of quality education and the impact on the success of students' learning. This component is associated with the teacher's personality traits, motivation, and psychological characteristics, allowing him to perform his educational duties effectively.

The personal-motivational component is vital for the teacher to be not only competent in his field of knowledge but also able to inspire, motivate, and support students on the way to their educational success. This component helps to create a positive and productive educational environment.

The initial questionnaire of the teacher, created by the administrator and stored in the Competence Bank, is used to determine the level of competence of the teacher and display the initial figures on the competence map. After completing the initial questionnaire, the teacher's answers are stored in the database, and the level of his competencies is recorded and displayed on the competence map in his profile (Fig. 9).

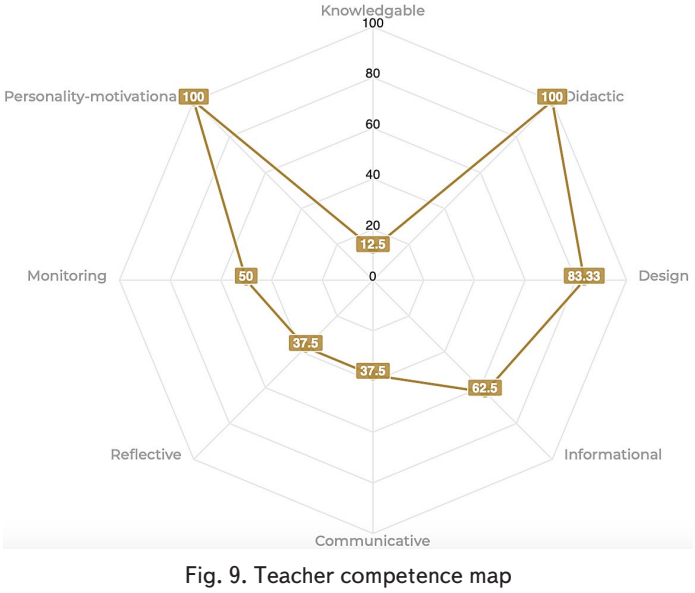

Fig. 9. Teacher competence map

According to the questionnaire results, the teacher is assigned a certain level based on the points he scored.

In total, four levels of proficiency in the skills of understanding curricula and standards have been identified:

1. Entry level: The teacher needs a more comprehensive understanding of curricula and standards at this level. He may need to become more familiar with the basic concepts and principles underlying them. He may have difficulties in interpreting and applying programs and standards in educational practice.

2. Intermediate level: A teacher at this level has a basic understanding of curricula and standards. He is familiar with

their fundamental principles and content but may need help with applying them in practical work. A teacher may require support and additional training to make more effective use of programs and standards.

3. Advanced level: At this level, the teacher deeply understands curricula and standards. He can link various elements of the program and standards, their goals and content, and successfully apply them in educational practice. The teacher demonstrates a creative approach to the use of programs and standards, adapting them to students' specific needs and abilities.

4. Expert level: At this level, the teacher is an expert in understanding curricula and standards. He is not only fully aware of their content and goals but can also analyze them critically and offer innovative approaches and modifications. The teacher successfully adapts programs and standards for different groups of students and ensures a high level of educational results.

5. 3. Methods of evaluating the effectiveness of the created system in the development of methodological competence

The information system «Assessment of methodological competencies of teachers of IT disciplines», created within the framework of a scientific project, inherently belongs to the class of complex systems. Therefore, one of its fundamental features is also the difficulty of determining a single criterion for the effectiveness of functioning and the presence of usually several more or less equivalent criteria depending on external conditions and states of the system. However, to determine a single generalized efficiency criterion specialized for this complex system, the following basic requirements can be formulated. The criterion should:

– characterize numerically and in the most general form the degree of fulfillment of its main objective function;

– identify and evaluate the degree of influence of various factors and parameters, including the costs of various types of its implementation, on the effectiveness of the system;

– be simple and have a small variance, i.e. weakly depend on uncontrolled random factors.

Information technologies bring with them significant improvements only if they are based on the position of correctly defined goals, objectives, incentives and ideas – all that is commonly called «corporate philosophy». Suppose such a basis is present and develops during the implementation of software solutions. In that case, the expected positive economic effect is achieved, and not just the development of funds allocated for the purchase of equipment and software. At the same time, the increase in the efficiency of the enterprise as a result of complex automation of management can manifest itself in different ways. Among the main factors determining the cumulative effect of automation are qualitative improvement of the processes of preparation and decision-making, optimization of working actions, and the ability to see not only the real state of affairs but also to predict the situation in the future reasonably.

Due to the huge variety of institutions, enterprises, the conditions in which they work, and variants of automated information systems, it is impossible to define standards and benchmarks to determine the effectiveness of their implementation. Each company solves this issue independently, comparing it with analogs.

The very concept of efficiency has stayed the same: this is a comparison of the useful results obtained and the corresponding costs of all types of resources.

The possibility of implementing a system that meets certain quality criteria is naturally associated with the provision of resources and technical means. The high cost of complex systems and the long terms of their design are associated with obtaining a given system efficiency and estimating the costs at which one or another efficiency is achieved.

To evaluate complex systems, economic criteria are applied in various forms, almost always taking into account the capital costs of development, acquisition of technical means, and training and operation of the system. In addition, several criteria are proposed to take into account losses due to interference, the degree of completeness of the use of incoming information, the increase in the economic efficiency of the system, and other factors. Incomplete certainty in the efficiency criteria and the possibility of a significant change in the costs of implementing the system while maintaining efficiency within acceptable limits make it necessary to pay special attention to assessing a possible increase in efficiency with a certain cost increase. For complex systems, their feasibility in terms of reliability of operation and probability of results is also important. Interruptions and partial failures of system components can be assessed by their impact on the main quality criterion. The implementation can be enhanced by the use of extensive control and methods of protection against interruptions and partial failures of a complex system, that is, by introducing various types of redundancy into the technical support and algorithms of programs. Thus, realizability in terms of reliability is one of the most important characteristics that determine the system's effectiveness as a whole.

Together with the above criteria, it is necessary to mention the problem of choosing an efficiency criterion, which is an indicator of the advantages of the solution, as well as determining the functional relationship between the values of efficiency and the costs at which it is achieved. The choice of this connection depends on the purpose of the system and is made by logical and mathematical analysis, as a rule, under conditions of considerable uncertainty. Many types of different functions have been proposed to link efficiency and costs, the simplest of which is reduced to drawing up relations or differences between efficiency and costs, presented on the same scale.

A common criterion for the quality of systems is the ratio of efficiency, i.e. the results achieved, to costs. However, it needs to consider the absolute magnitude of the effect and costs, which can lead to fundamental errors in assessing the quality of systems in which the absolute effect of using the system is primarily important.

Economic indicators are known, such as cost savings, information processing, payback ratio and efficiency coefficient, annual profit growth from the introduction of a comprehensive information and educational system in practice is often impossible to calculate. The problem is to assess the beneficial effect of introducing an integrated information and educational system. Clearly, the source data's main part must be somewhat accurate. In some situations, the economic efficiency of automation work in general cannot be calculated with the desired accuracy and persuasiveness.

The problem of obtaining initial data for calculation can be solved using various methods [18]:

– based on the results of the company's activities over the past years, economic methods predict the results for the year of interest and compare them with the actual ones under unchanged working conditions, which is practically impossible.

– normative methods for assessing the expected economic efficiency of an integrated information and educational sys-

tem are possible if there are any standards, but there are none due to the diversity of enterprises, conditions, and systems.

– expert methods; however, the results of such an assessment may depend on the competence of experts, the clarity of the problem statement, the information provided to experts, etc.;

– simulation methods consist of computer modeling of the control object itself, the control system, the main disturbances acting on the object, and based on mathematical models, that is, a rather complex mathematical device.

If the efficiency of the system can be estimated by real income, which is typical for production-economic type systems, then the efficiency criterion can be written in general form:

$$D=E_o-C_s, \quad (1)$$

where D – real income from using the system; E_o – the effectiveness of the system's solution of the main target task or the marginal income that could be obtained under ideal conditions of its functioning without taking into account obstacles and various costs for the development and operation of the system. This efficiency is potential, corresponds to the maximum possible revenue from the system per unit of time, and is called ideal efficiency; C_s – average cumulative losses and costs that reduce the marginal efficiency of the system per unit of time. The costs of processing information using automation tools are reduced by automating cumbersome routine calculations, automatic formation of initial forms, and reducing the time for searching for information, and preparing documents.

The useful effect of the system (1) is called the absolute value of real income per unit of time.

Evaluation of the values of the ideal efficiency E_o of the system, in general, is hardly possible as a result of the huge variety of tasks and difficulties of their typing. Therefore, here is an analysis of the total costs and losses C_s that ensure the solution of the target problem with a fixed efficiency E_o and the components C_s that should be minimized:

$$C_s=C_0-C_1-C_2, \quad (2)$$

where C_0 – unit costs for implementing the materialization of the system, that is, the cost of the technical means necessary for the normal functioning of the system; C_1, C_2 – expenses caused by various factors.

For real computing complexes, the ideal efficiency per unit of time is reduced by the amount of losses C_1, which is a function of the current set of control objects Y, the task flow Z, the performance characteristics of technical means B and memory R, the method of organizing the computing process S and time t:

$$C_1=C_1(Y, Z, B, R, S, t). \quad (3)$$

The parameters allow you to change the losses by applying different options for constructing algorithms and process control methods. Thus, C_1 can be considered in the first approximation as an indicator of the quality of the operating system and the efficiency of the use of technical resources.

The loss of system efficiency due to external and internal C_2 interference can be significantly reduced by introducing algorithms for monitoring and protecting equipment interruptions and failures. Losses C_2, which characterize the reliability of the functioning of the software package with various kinds of interference, depend on the parameters of the flow of tasks and control objects, the probability of receiving false or distorted information pi_{ij}, and the probability of failure or malfunction of the equipment p_{ij} when solving the i-th problem on the j-th object. As a source of internal interruptions and interference, it is necessary to consider undetected errors in programs that lead to distortion of the results when solving the i-th problem on the j-th object with probability P_{ij}:

$$C_2=C_2(Y, Z, pi_{ij}, p_{ij}, P_{ij}, t). \quad (4)$$

The design costs are decomposed into N-samples of applications, which significantly reduces their specific weight in the cost formula.

Thus, the total income is equal to:

$$D=E_o-C_1-C_2-C_3/N, \quad (5)$$

C_3 is cost reduction due to automation of software development and database design using the latest technologies.

At the same time, a positive income D from the implementation should be provided, taking into account all losses and expenses. Additional requirements may also be put forward, consisting in the mandatory solution of all tasks with a given set Z, in the management of all objects with a given set, and in limiting the total costs and losses C_0. These circumstances must be taken into account when assessing the real income from using the system.

Analysis and optimization of software design by the criterion of average income are quite difficult to implement in a general way, especially since not all functional relationships and dependencies on the main parameters are sufficiently known. On the other hand, the variables in this expression can be considered as independent components reflecting particular criteria for the effectiveness of the software.

The accuracy and completeness of the solution of the task are increased without taking into account the relative increase in the costs of their implementation. In some cases, with high costs, a relatively small increase in the efficiency of the system implementation is obtained. In addition, an increase in ideal efficiency in most cases is associated with a simultaneous increase in the probability P_{ij} of errors as a result of an increase in their complexity. Errors, in turn, increase the losses C_2, so that the increase in real efficiency can be offset by an increase in losses due to incomplete debugging. Therefore, when developing and improving software tools, it is necessary to analyze not only the absolute values of efficiency and its components, but also their correlation, which in the first approximation can be represented by the amount of increase in average income per unit of costs:

$$A=\Delta D/\Delta C_0. \quad (6)$$

This allows us to take into account that efficiency, as it grows, requires a significant increase in the costs of implementing the system, and the value of the derivative A in the limit tends to zero with an increase in costs. From here, it is possible to estimate the boundary beyond which the improvement of algorithms and programs is unprofitable, i.e. A becomes small.

The above approach is only sometimes possible to implement quantitatively and correctly, to determine what benefits (in monetary terms) are expected from creating new software. It is possible to calculate how many human resources

will be released or how many hours of working time will be saved after the introduction of new software.

However, automation often does not just speed up a certain process, but allows you to get a result that was only possible with using the system. When developing a database, it processes large amounts of information and receives reports, which needed to be carried out manually due to the great complexity.

Most of the authors [18] who have researched this topic agree that it is impossible to express the full effect of the introduction of an automation system in money. It is proposed to identify indirect performance indicators that are reflected in the results of activities not directly but by increasing the level of management, efficiency, and effectiveness of decisions taken, improving the entire information system of the facility, i.e. it is virtually impossible to evaluate these indirect characteristics in monetary units. When calculating the economic efficiency of a complex information and educational system, the problem arises of turning this effect into economic indicators, which requires special methods.

These indicators include:

– increasing the efficiency and relevance of information;

– shortening the time for solving individual tasks and making management decisions;

– improving the quality of information, its accuracy, detail, and objectivity, including by reducing errors. At the same time, labor productivity and quality of service are increased;

– deepening the analysis, improving the quality of analytical reports, obtaining fundamentally new analytical capabilities;

– reduction of the total amount of time spent on the preparation of documents, the speed of issuance of source documents;

– improving the quality of work by reducing routine operations;

– professional development of employees with the introduction of new technologies;

– improvement of the operation of the control unit;

– improvement of the organization of production.

When evaluating the effectiveness of automated information systems, it is also possible to use Balanced Scorecard, a balanced scorecard system developed in 1992 by Kaplan and Norton. This theory is mainly used to assess the effectiveness of enterprise management. The use of a system of balanced indicators to assess the effectiveness of automated information systems that directly affect management effectiveness is of interest. However, theorists or practitioners still need to develop this topic.

To solve such multi-criteria problems as the evaluation of uncertain models of complex systems, where the formalization of qualitative values of physical quantities on quantitative scales is required, the analytic hierarchy process (AHP) is especially effective. It has the ability to process input information of heterogeneous quality, generally increasing the probability of describing the behavior of an object, in other words, reflecting the total degree of blurriness, incompleteness and inaccuracy of input data at the output, but offering the only solution for this particular situation.

The main idea of the analytic hierarchy process proposed in [19] is based on paired comparisons of alternatives according to different criteria and subsequent ranking of a set of alternatives according to all criteria and goals. The relationships between the criteria are taken into account by constructing a hierarchy of criteria and using paired comparisons to identify the importance of criteria and sub-criteria. The method is simple and gives satisfactory correspondence to intuitive ideas, does not require simplifying the structure of the problem, and, more effectively than other analytical tools, allows you to consider the influence of all sorts of factors on the choice of a solution [19].

From the point of view of mathematical foundations, hierarchy can be considered as a special case of a graph (used as an illustration) or as a special type of ordered sets (used as the basis of a formal definition) with a binary relation that satisfies the laws of reflexivity, asymmetry and transitivity, i.e.:

– reflexivity, $x \le x$ for all x;

– asymmetric, if $x \le y$ and $y \le x$, then $x = y$;

– transitivity, if $x \le y$ and $y \le z$, then $x \le z$.

For any relation $x \le y$ (read: x precedes y) of this type, you can define $x < y$, which means $x \le y$ and $x \ne y$.

There are many ways to define a hierarchy. In this paper, the following is used: let H be a finite partially ordered set with the largest element b. Note though x^- and x^+ such definitions:

– $x^- = \{y \mid x \text{ covers } y\}$;

– $x^+ = \{y \mid y \text{ covers } x\}$for any element x in an ordered set.

– H there is a hierarchy if the following conditions are met:

1. There is a breakdown of H on a subset: L_k, $k = 1, 2, ..., h$, $L_k = \{b\}$.

2. From $x \in L_k$ it follows that $x^- \subset L_{k+1}$, $k = 1, 2, ..., h$.

3. From $x \in L_k$ it follows that $x^+ \subset L_{k-1}$, $k = 2, ..., h$.

For each $x \in H$, there is a weight function (its essence depends on the phenomenon for which the hierarchy is constructed):

$$w_x: x^- \to [0,1], \text{ where } \sum_{y \in x^-} w_x(y) = 1. \quad (7)$$

The sets L_k are hierarchy levels, and the function w_x is a function of the priority of one level for the goal x. If $x^- \ne L_{k+1}$ (for some level L_k), then w_x can be defined for all L_k if it is equal to zero for all elements in L_{k+1} that do not belong to x^-. The hierarchy is called complete if for all $x \in L_k$ the set $x^+ = L_{k-1}$, $k = 2, ..., h$.

We define for any given element $x \in L_\alpha$ and a subset $S \subset L_\beta$, $(\alpha < \beta)$ the function $w_{x,S}$: $S \to [0,1]$ so that it reflects the properties of the priority functions w_x, at levels L_k, $k = \alpha, ..., \beta - 1$, as $w_{b,Lh}$: $L_h \to [0,1]$.

If we imagine an economic system whose main goal is b, and the set of main types of actions L_h as a hierarchy with a maximum element b and a lower level L_h, then it is necessary to determine the priorities of the elements of level L_h in relation to b. For the solution, assume that:

$$Y = \{y_1, ..., y_{mk}\} \subset L_k, X = \{x_1, ..., x_{mk+1}\} \subset L_{k+1}. \quad (8)$$

Let there also be an element $z \in L_{k-1}$, such that $y \in z^{-1}$. Priority functions:

$$w_z : Y \to [0,1], w_{y_j} : X \to [0,1], j = 1, ..., n_k \quad (9)$$

Denoting by $w, w : X \to [0,1]$, the priority function of elements with X relative to z, we set it as follows:

$$w(x_i) = \sum_{j=1}^{n_k} w_{y_j}(x_i) \cdot w_z(y_j), i = 1, ..., n_{k+1}. \quad (10)$$

It is obvious from formula (10) that this is the process of weighing the indicator of the impact of element y_i on the priority of element x_i by multiplying this indicator by the importance of element y_i relative to z. The algorithm can be simplified if we form a matrix B with $w_{y_j}(x_i)$ by putting $b_{ij} = w_{y_j}(x_i)$, and then mark:

$$W_i = w(x_i), W_j^{/} = w_z(y_i), \quad (11)$$

then the formula (11) will take the form:

$$W_i = \sum_{j=1}^{n} b_{ij} \cdot W_j^{/}, i = 1,...,n_{k+1}. \quad (12)$$

As a result, the final formula:

$$W = B \cdot W^{/}. \quad (13)$$

For a complete hierarchy, the following statement is true: the priority of an element of any level is equal to the sum of its priorities in each subset of comparisons to which it belongs.

The resulting set of priorities of elements of this level is then normalized by distributing the sum of the priorities of the elements. The priority of a subset at the first level is equal to the priority of the dominant element at the next level.

With the help of the described mathematical method, it is possible to evaluate the effectiveness of the implementation of the software package developed and presented in the work.

Let the hierarchy graph for evaluating the effectiveness of implementing the developed integrated information and educational system «Smart University» in comparison with possible other solutions to the issue of improving the educational process look as shown in Fig. 10.

Criteria 1, 2, ..., and *N* are the criteria by which any of the considered solutions can be characterized. Let's assume that these will be the following characteristics:

– criterion 1 – cost of software development (*k*_1);

– criterion 2 – automation of obtaining up-to-date summary data on the educational process, creation of schedules, curricula, lists of disciplines, and other information accompanying the educational process (*k*_2);

– criterion 3 – providing a credit-modular and credit-rating system for the organization of the educational process, improving the quality and reliability of all forms of knowledge control (*k*_3);

– criterion 4 – improving the productivity of teachers (*k*_4).

A larger number of criteria can be considered. However, according to psychologists, it is found that it is difficult for an ordinary person to make a rational choice if the number of objects of choice exceeds 7 ± 2. To overcome this limitation, it is necessary to divide a large decision-making task into several small tasks (to conduct an analysis) and, presenting in an understandable form a scheme of interaction of factors influencing the formation of priorities of decisions and the decisions themselves, to synthesize, that is, to draw up a scheme of the decision-making task.

As comparative options for evaluating the effectiveness of methods for improving the organization of the educational process, we choose the following:

– local software tools (*C*_1);

– developed system «Assessment of methodological competencies of teachers of IT disciplines» (*C*_2);

– lack of automation in the educational process (*C*_3).

To achieve the goal of the analysis, each criterion of alternatives is compared in pairs. In [19], a scale of relative importance of criteria was proposed, presented in Table 1.

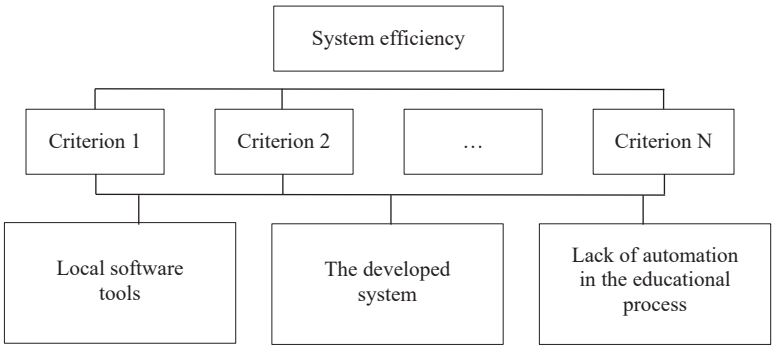

Fig. 10. Hierarchy graph for evaluating the effectiveness of the implementation of the information system «Assessment of methodological competencies of teachers of IT disciplines»

In the analytic hierarchy process, the task elements are compared in pairs concerning their influence («weight» or «intensity») on their common characteristic. The resulting paired comparisons make up an array of numbers arranged in a matrix. Comparing the set of components with each other, we get a square inversely symmetric matrix $a_{ji} = 1/a_{ij}$. When filling out the matrix, you must use the following rules:

1. If $a_{ji} = \alpha$, then $a_{ij} = 1/\alpha, \alpha \neq 0$.

2. If the proposition *C* is such that C_i has the same relative importance as C_j, then $a_{ij} = 1, a_{ji} = 1$; in particular, $a_{ii} = 1$ for all *i*.

3. All matrix cells are filled with the values of the same parameters.

Table 1

Relative importance of criteria proposed

Importance	Definition	Comment
1	Equal importance	Equal contribution of two activities to the goal
3	Moderate advantage of one over the other	Experience and judgment give an easy advantage of one type of activity over another
5	Significant or strong advantage	Experience and judgment give a strong advantage to one type of activity over another
7	Significant advantage	Such a strong advantage of one type of activity is given that it becomes significant
9	Very strong advantage	The evidence of the advantage is confirmed very strongly
2, 4, 6, 8	Intermediate decisions between two neighboring judgments	Used in a compromise case
Inverse values of the above numbers	If, when comparing one type with another, one of the above numbers is obtained, then when comparing the second type of activity with the first, we get the inverse value	

Let us fill in the square matrices of paired comparisons regarding the dominance of one element over another, where the judgments obtained are expressed in integers, taking into account a nine-point scale. To obtain each matrix, the expert makes $n(n-1)/2$ judgments (here, n is the order of the matrix of paired comparisons). The results of the evaluation are presented in Tables 2–7, and the results of the comparative characteristics of the systems are given in Table 8.

Table 2

Relative weights of criteria

Pairwise comparison	*K*_1	*K*_2	*K*_3	*K*_4	Production	*W*
*K*_1	1	7	1/8	1/5	2.275	0.08684
*K*_2	1/7	1	8	4	4.576	0.17464
*K*_3	8	1/8	1	9	9.0	0.18753
*K*_4	5	1/4	1/9	1	0.13875	0.04298
Sum	14.143	8.375	9.236	14.2	15.97975	0.49199

Table 3

System data

Pairwise comparison	*K*_1	*K*_2	*K*_3	*K*_4
*C*_1	3,000 c.u.	0.5	0.01	0.2
*C*_2	1,500 c.u.	0.9	1.0	0.7
*C*_3	100 c.u.	0	0.1	0.1

Table 4

Comparative evaluation of systems according to Criterion 1

Pairwise comparison	*C*_1	*C*_2	*C*_3	*K*_1
*C*_1	1	5	9	2.7097
*C*_2	1/5	1	5	0.1613
*C*_3	1/9	1/5	1	0.0188

Table 5

Comparative assessments of systems according to Criteria 2, 3

Pairwise comparison	*C*_1	*C*_2	*C*_3	*K*_2	*K*_3
*C*_1	1	1/7	5	0.1090	0.1090
*C*_2	7	1	9	3.1688	3.1688
*C*_3	1/5	1/9	1	0.0187	0.0187

Table 6

Comparative assessments of systems according to Criterion 4

Pairwise comparison	*C*_1	*C*_2	*C*_3	*K*_4
*C*_1	1	1/5	5	0.1613
*C*_2	5	1	9	2.7095
*C*_3	1/5	1/9	1	0.0187

Table 7

Standardized assessments of systems by all criteria

Pairwise comparison	*K*_1	*K*_2	*K*_3	*K*_4
*C*_1	2.7097	0.1090	0.1090	3.1613
*C*_2	0.1613	3.1688	3.1688	2.7095
*C*_3	0.0188	0.0187	0.0187	0.0187

To obtain the results, each considered system must sum up the normalized criteria multiplied by their weights *W*. As a result, we get that the *C*_2 system has a three-fold advantage over the *C*_1 system and more than a hundredfold advantage over the *C*_3 system.

Table 8

Comparison results

Criteria	Result
*C*_1	2.7097*0.08684+0.109*0.17464+0.109*0.18753+ +3.1613*0.04298=0.41065955
*C*_2	0.1613*0.08684+3.1688*0.17464+3.1688*0.18753+ +2.7095*0.04298=1.2781058
*C*_3	0.0188*0.08684+0.0187*0.17464+0.0187*0.18753+ +0.0187*0.04298=0.0092089

Of course, these criteria are optional on the one hand and inexhaustible on the other. In addition, another expert can determine other values of the pairwise coefficients of the criteria comparison or give preference to other properties of the systems, but in any case, the analytic hierarchy process makes it possible to accurately select a solution from some alternatives that meet the requirements.

6. Discussion of the effectiveness of the implementation of the information system «Assessment of methodological competencies of teachers of IT disciplines»

A short-term experience in the operation of the Smart University system developed and presented in the work based on the data obtained (using the example of data from the Sanitary and technical faculty in the specialty «Heat and Gas Supply and Ventilation») allowed us to draw the following conclusions:

1. The educational process has been intensified, and the training quality of specialists has been improved.

2. According to statistics, the number of students (1, 2 courses) who have debts after the first attempt in the session has decreased by 15 %.

3. The number of students studying for «excellent» has decreased by 10 %, but the number of students studying for «good» and «excellent» has increased by 18–20 %. In contrast, the number of students with «satisfactory» has decreased.

4. The industrial discipline of both students and teachers has increased.

5. The objectivity of assessing students' training levels and the accuracy in grading have increased.

6. The systematic work of students has been achieved to a certain extent, both independently and during classroom classes during the quarter and semester.

7. A positive trend of healthy competition among students has emerged.

8. During the academic quarter and semester, the Dean's office systematically receives detailed information about the student's curriculum implementation, making it possible to influence and correct the real situation in education.

9. Regular feedback between student and teacher, student and Dean's office, and teacher and Dean's office has become important.

The obtained results can be explained by the successfully constructed structural model of the microservice architecture of the information system «Assessment of methodological competencies of teachers of IT disciplines» (Fig. 1). The developed microservices (Fig. 2–7) successfully complement the educational process and partially automate routine tasks.

The proposed method is a fairly high-quality procedure for finding the weighting coefficients of influencing factors when analyzing systems. However, the criterion for selecting experts that is part of it, at the very least, needs to include additional procedures with corresponding algorithms that require special study. Existing methods, such as the analytic hierarchy process, have their drawbacks, such as the use of transitivity for qualitative indicators. The transitivity relation works well when all the characteristics of the system under study can be represented by numerical values. But as soon as this becomes impossible, the requirement for transitivity often conflicts with the logic of the researcher. The proposed method does not have such disadvantages.

The main limitation of our research is that the development of the structural model of the microservice architecture of the information system «Assessment of methodological competencies of teachers of IT disciplines» was significantly influenced by the features and structure of the educational process in the Republic of Kazakhstan. The results obtained may not be as effective, or even incompatible with educational systems in other countries. Also, a significant limitation is the human factor, which has a significant impact both on filling the system with methodological materials and on evaluating the effectiveness of the system in the development of methodological competence.

The disadvantages of this study are that the testing was carried out within the educational process of the Republic of Kazakhstan and one pilot university, Astana IT University. Perhaps the results at other universities will differ from the experiment conducted at this university.

The development of this research is expected within the framework of the research project «Creation of a system for the development of methodical competence of teachers of IT disciplines based on continuous education». Where it is assumed that a system will be created with the ability to develop pedagogical competencies among teachers of IT disciplines and public administration [20]. This will be achievable through the creation of an assessment methodology and the formation of professional pedagogical competencies with scaling into other professional areas.

7. Conclusions

1. Taking into account the service-oriented approach to the development of large software complexes, a structural model of the information system was built, which reflects six main subsystems. Each of the subsystems is implemented as a separate microservice, and the connections between the subsystems became the basis for defining the interaction protocols of microservices. The proposed structure is much more flexible than a monolithic one. Each of the microservices can be improved separately. The distributed structure facilitates the scaling of the system according to the number of specialized automated workplaces of teachers, students, employees of deans' offices and departments (clients).

2. The proposed method makes it possible to build a teacher's competence map and evaluate its eight components: knowledge, didactic, design, information, communication, reflexive, monitoring and personal-motivational.

A four-level scale is proposed to determine the level of mastery of skills in understanding curricula and standards. This scale helps the teacher in self-diagnosis and setting priorities for self-development.

3. The developed method of evaluating the effectiveness of the created system in the development of methodological competence based on the hierarchical expert method made it possible to evaluate the effectiveness of the implementation of the information system. It was found that the implementation contributed to the intensification of the educational process and improved the quality of specialist training. The success of students in studying subjects has increased significantly, namely, the number of students in debt has decreased by 15 %, the number of «excellent» grades has increased by 10 %, and the number of «good» grades by 18 %.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

The manuscript has no associated data.

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