World Journal on Educational Technology: Current Issues

Volume 13, Issue 4, (2021) 994-1015

www.wj-et.eu

Computational informatics in the training of future informatics teachers in the context of the development of modern education

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Suggested Citation:

Revshenova, M., Guldina Kamalova, G., Kaskatayeva, B., Shekerbekova, S., & Kisselyova, Y., (2021). Computational informatics in the training of future informatics teachers in the context of the development of modern education. *World Journal on Educational Technology: Current Issues*. *13*(4), 994-1015. https://doi.org/10.18844/wjet.v13i4.6293

Received from July 13, 2021; revised from August 23, 2021; accepted from October 15, 2021
Selection and peer review under responsibility of Prof. Dr. Servet Bayram, Yeditepe University, Turkey.

Abstract

It is known that the huge computing resources of modern computers are used primarily to solve problems that arise in various applied areas in the process of mathematical modeling of real objects. The aim of this study is to present a theoretical justification of the need to train informatics future teacher in the field of computational informatics and to develop a methodology for teaching him/her in the context of the development of modern education. The competence-based and contextual approaches to teaching and the concept of pedagogical education funding are used in the research. The necessity of training future informatics teacher in the field of computational informatics has been justified and a methodology for teaching it based on web quests has been developed and experimentally tested.The implementation of the developed methodology for teaching computational informatics on the basis of modern educational technology web-quest will equip him/her with the necessary knowledge and ensure the development of his/her information and computational competence.

Keywords: training of informatics teacher, competence-based approach in teaching, computational informatics, information and computational competence, digitalization of education;

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1. Introduction

During the formation of informatics in the middle of the last century as a science of automating information processing processes and in the early years of development, a significant part of its content consisted of issues related to the study and implementation of computational algorithms on a computer, applied software for computational problems and the methodology of numerical modeling of processes and phenomena. These questions serve as the subject of study of computational informatics - one of the scientific directions of informatics (Ilyin, 1991).

Despite the fact that over the years informatics began to absorb many branches of scientific knowledge related to the study of information processes and structures, as the computing capabilities of a computer improved, this area of informatics, nevertheless, not only has not lost its importance, but even today, in the era of supercomputers, cluster systems and multi-core processors, it occupies a special place in informatics, since even today the most advanced, super-powerful computers are primarily used to solve problems arising in various applied areas in the process of mathematical modeling of real phenomena and processes (Lapchik, 2006). This is evidenced by modern successes in solving such important for society problems as atomic, space, economic, which would hardly have been possible without the use of computers and numerical methods. The use of a computer in solving such problems and the ability to correctly interpret obtained results makes special demands on understanding the essence of both the computational problem being solved and the chosen solution method. And it presupposes knowledge, along with the methodology of mathematical modeling and computational experiment, of the theoretical foundations of algorithms for numerical computations, including the accuracy of the representation of numbers in the computer memory (Bidaybekov, 20017).

Undoubtedly, the inclusion of issues from the field of computational informatics into the training system of a future teacher of informatics allows him to form a holistic view of informatics as a science, its place in the modern world and in the system of sciences. It allows expanding his/her understanding of computer capabilities, the trends and prospects of development of computer and information technologies, ways and methods of using these technologies to solve computational problems encountered in applications (Elsayed & Salama, 2020).

Providing knowledge and skills in the field of solving and teaching the solution of computational problems, contributes to the development of his/her information and computational competence, manifested in the readiness and ability to solve and teach the solution of computational problems on a computer with the possibility of choosing the optimal solution methods and the environment for their implementation, which is necessary for him/her for effective implementation of the tasks of information and computing activities in the framework of future professional and pedagogical work (Kozel, 2012; Bhuyan, & Tamir, 2020). The sphere of information and computing activities of informatics teacher in recent years, in the context of the rapid development of computing equipment and technologies, and the profile differentiation of teaching schoolchildren, with the allocation of the natural and mathematical direction of education in high school, is significantly expanding, which actualizes the need to develop his/her information and computational competence.

The issues of training future informatics teachers in the field of computational informatics have been considered by Bidaybekov (2007, 2005), Kamalova (2010), Lapchik (2006), Palchikova (1999), Stepanova (2003), Fedchenko (2006) and Bairbekova (2012). These works in many aspects have created a scientific, theoretical and practical basis for solving the problem of training teachers for professional activities in this area of informatics. In the studies of the listed authors, the content and methodological aspects of training in this area of informatics are sufficiently deeply discussed,

but not enough attention is paid to the development of information and computational competence in the process of this training, as an important component in the structure of professional competence of a future informatics teacher.

The issues of the development and diagnosis of the professional competence of specialists in higher education institution have been considered by (Kirillova, 2005 & Butina, 2018). The authors note the effectiveness of the use of competence-oriented and project-research tasks to strengthen the practical orientation of the training of graduates, increase their professional competence and its diagnostics.

1.1. Purpose of study

Recognizing the undoubted theoretical and practical significance of these studies, it should be noted that the issues of using such tasks in teaching computational informatics in order to develop the information and computational competence of the future informatics teacher have not been previously considered. The relevance of the problem, its significance, insufficient elaboration determined the topic of this work. The aim of this study is to present a theoretical justification of the need to train informatics future teacher in the field of computational informatics and to develop a methodology for teaching him/her in the context of the development of modern education.

2. Materials and methods

In order to comprehensively study the state of the problem under consideration, to identify the degree of its development, in the course of the study, a complex of mutually enriching and complementary methods was used:

– theoretical and methodological analysis of psychological and pedagogical, scientific and educational-methodical literature related to the research problem;

– studying the professional and pedagogical activity of informatics teacher, analyzing the structure of his/her professional competence, which made it possible to clarify the concept of information and computational competence, as one of the key components in the structure of the professional competence of informatics teacher, and highlight its structural components;

– study of the educational potential of computational informatics, study of the possibility of using modern technologies and approaches in its teaching that ensure the development of information and computational competence of the future informatics teacher;

– studying the experience of introducing the web-quest method into teaching.

As a systematizing method within the framework of the study, the information modeling method was used, due to which the integral process of developing the information and computational competence of a future informatics teacher in the process of training in the field of computational informatics is clearly represented in the form of a structural and logical model.

For diagnostics based on B.Bloom's taxonomy and the requirements of the professional standard of a teacher, the corresponding criteria and indicators of the level of its formation have been determined (Professional, 2017; Khmelnitskaya, 2008).

3. Findings

3.1 Information and computational competence of informatics teacher

Information and computational competence of informatics teacher is an integral quality of a personality that characterizes the level of knowledge, abilities, skills and experience in the field of computational informatics, necessary for the implementation of information and computational activities in the framework of professional and pedagogical work; providing an understanding of the social significance of this type of professional activity of informatics teacher and his/her personal

responsibility for its results; as well as the need and opportunity for constant self-development and self-education in this area.

Among the main typical tasks of information and computing activities, for the implementation of which a future informatics teacher should be ready in the framework of his/her professional and pedagogical activities, it should be noted the solution and training in solving computational problems on a computer, the ability to choose the optimal numerical method and software implementation environment; building a system of tasks focused on the formation of information and computational competence in schoolchildren and the ability to assess their formation.

The information and computational competence of informatics teacher organically combines fundamental knowledge in the field of computational informatics, the readiness and ability to apply them in practice when solving and teaching the solution of computational problems using modern digital technologies.

This competence refers to the special competencies of informatics teacher, formed within the disciplines of his/her subject training. And as a component of the professional competence of informatics teacher, which includes such components of pedagogical activity as motivational-value, cognitive («knowledge and understanding»), activity («knowledge how to act»), as well as communicative and reflective-evaluative components [Bolognskiy, 2006; Professional, 2017], information-computational competence has a similar structure, consisting of five interrelated components: motivational-value, cognitive, activity-based, communicative and reflexive-evaluative and is assessed by the effectiveness of their manifestation in the process of information and computational activity.

The motivational-value component reflects the understanding of the value of knowledge in the field of computational informatics in the professional activity of informatics teacher; the presence of interest and desire for high-quality performance of tasks of information and computing activities in future professional and pedagogical work, a conscious need for active cognitive activity and self-development in this area.Its cognitive component reflects the presence of a system of knowledge and skills in the field of computational informatics, which is necessary for successful information and computational activity; understanding of their worldview significance and interdisciplinary nature.

The activity component reflects the possession of modern methods, means and forms of teaching computational informatics, the ability to update the accumulated knowledge and skills in the field of computational informatics at the right time and use them both in educational activities and in the process of realizing their professional functions.

In the structure of information and computational competence of informatics teacher, it is also important to distinguish the communicative and reflexive-evaluative components. The communicative component includes the ability to effectively use various, including distance, means of communication in the process of teaching computational informatics, the ability to present and defend the results of one's work, to defend one's position reasonably, as well as to master teamwork skills, which is very important in the work of a teacher (Boc, Vidrikova & Blaskovac, 2021).The reflexive-evaluative component of information and computational competence is defined as the ability and readiness for introspection and self-control of one's judgments, the ability to assess the results of one's activities and, on their basis, set goals and objectives for professional development in this area.

The study of the educational potential of computational informatics, the possibility of using modern technologies and approaches in its teaching, made it possible to identify a set of pedagogical conditions that ensure the successful development of this competence of informatics teacher in the process of training in the field of computational informatics. At the same time, the competence-

based and contextual approaches to teaching and the concept of funding pedagogical education were used (Kozyrev, 2004; Verbitsky, 2010; Kuzminov, 2006).

The competence-based approach, as a personality-oriented and practice-oriented activity approach, is used, first of all, with the aim of finding and implementing forms, methods and teaching aids that ensure the development of students' ability to act independently, without outside guidance, in various problem situations arising in professional activities (Kozyrev, 2004). A contextual approach to teaching, the ideas of which are described in the works of Verbitsky et al. (2010) is used to ensure the possibility of including the student in a variety of pedagogically oriented activities, which makes the educational work of the future teacher as close as possible to his/her future profession. And the concept of funding the content of pedagogical education, developed by a team of authors under the leadership of V.D. Shadrikov (Kuzminov, 2006; Smirnov, 2012), to ensure an inextricable connection between the content of training in a pedagogical university and the school course of informatics and its development and deepening throughout the entire period of study.

One of the main pedagogical conditions for the most effective development of the information and computational competence of a future informatics teacher in the process of training in the field of computational informatics is the construction of a professionally oriented educational process based on the integration of educational and professionally oriented design and research activities with the use of specially developed web quests in computational informatics with early clearly defined results of students' activities (Chernyavskikh et al., 2018). Working on them requires students to be able to independently build the logic of research, update and integrate the accumulated knowledge and skills from various subject areas, master new knowledge in computational informatics, study the possibilities of introducing its elements into the school informatics course, discuss emerging problem situations in a group, exchange information. Implementation of these conditions:

– contributes to the development of students' cognitive and professional interest in mastering knowledge and skills in the field of computational informatics, awareness of their relevance in applied fields of knowledge and the need to perform tasks of information and computational activities at school;

– promotes the development of scientific research methods of informatics (modeling, computational experiment), methods of computational mathematics and modern digital technologies; the formation of the skills to apply them in solving computational problems arising in the process of modeling real objects and phenomena, to conduct a computational experiment; to teach this to students, to reflect on their own activities;

– allows nt to develop his/her important social qualities, including communication skills and the ability to work in a team, due to group interaction in the process of completing tasks and the ability to reasonably and concisely express own opinion, speaking in front of each other;

– and, in general, expands the intellectual abilities of future teachers and their understanding of the possible fields of application of the computer.

The knowledge and skills formed, the experience gained in the field of solving computational problems on a computer contributes to the development of almost all components of information and computational competence and will allow the future informatics teacher to organize educational and research work of schoolchildren in the field of computational informatics, including taking into account the interests of vocational guidance of students (Elsayed & Salama, 2020). An equally important condition for the development of information and computational competence of a future informatics teacher in training in the field of informatics is interdisciplinary integration, the actualization of meaningful links with other disciplines of subject training and the school course of informatics.

Computational informatics, presented in the system of training a future informatics teacher mainly by the course «Mathematical modeling and numerical methods», has horizontal interdisciplinary connections with many disciplines of his/her subject training: programming, theoretical informatics, mathematical disciplines, etc., and vertical content connections with the fundamental core of the school course of informatics(Merceron et al., 2018; Farahani & Kaleybar, 2018). This condition is implemented by taking them into account in the used teaching aids and the inclusion of students in educational and design research activities, and contributes to:

– fundamentalization of the content of the training of a future informatics teacher by deepening subject knowledge related to solving computational problems on a computer due to the actualization of horizontal intersubject connections with other disciplines of subject training;

– and the professional orientation of education due to vertical links with the school course of informatics, while influencing the development of almost all components of information and computational competence and, above all, its cognitive component.

The third condition for the development of information and computational competence of a future teacher is the activation of intersubjective relations between a teacher and a student in the process of teaching computational informatics. Such relations between the teacher and the student complement and enrich each other's activities, allow for a combination of methodological guidance with the development of initiative, independence, self-government of the future teacher, his/her creative, organizational and communicative abilities. And at the same time they have a significant impact on the development of its motivational-value and communicative component.

The fourth condition is purposeful work on the development of professional and pedagogical reflection of the future teacher in the learning process. The ability of the future teacher to reflection and knowledge of its mechanisms allow him/her to form his/her own values and determine the strategy of his/her own development, encourage him/her to constant self-development and creative attitude to professional activity. At the same time, in the process of professional training in the field of computational informatics, a constant reflexive analysis of one's own activity «should be carried out by the future teacher from two positions: the student and the teacher, which allows, even during the period of study at the pedagogical university, to join and comprehend future professional activities in teaching, upbringing and personal development of the student» in the considered area (Reichert, 2003; Emelin, 2011).

Purposeful work on the development of professional and pedagogical reflection of the future teacher in the process of training in the field of computational informatics requires the creation of a special learning environment that contributes to the emergence of the need for reflection. In particular, it can be the use of teaching methods and technologies, which:

– focusing attention not only on the content of training, but also to a greater extent on the student's methods of activity;

– contributing to the development of skills in setting and solving problems in the studied area;

– providing the opportunity for the student to act as a teacher explaining the educational material; individually or in a group form, to reflect on their own activities, which, of course, has an impact on the development of the reflexive-evaluative component of information and computational competence.

The holistic process of development of information and computational competence of a future informatics teacher in the process of training in the field of computational informatics can be clearly represented in the form of a structural-logical model, including motivational-value, content, procedural-activity and control-corrective components, the content and nature of the connections between which determined by the totality of the pedagogical conditions described in Fig. 1. The constructed model is based on the use of a set of competence-based, contextual approaches and the

concept of funding pedagogical education. The use of a combination of these approaches allows achieving the goals and objectives.

The basis of the motivational-value block of the model, which ensures the development of the motivational-value component of information and computational competence, is the motives, goals and needs of students that stimulate and direct this process. They are based on the awareness of the importance of the acquired knowledge, skills and experience in the field of solving computational problems on a computer for future professional and pedagogical activities (Franco Caballero & Aguilera, 2019).

The content block provides the development of the cognitive component of information and computational competence and is based on the deepening and systematization of knowledge and skills in the field of computational informatics; provided by the actualization of interdisciplinary connections of computational informatics, represented in the system of training future informatics teachers by the discipline «Mathematical modeling and numerical methods», with other disciplines of their subject training, as well as meaningful links with the school course of informatics (Oshanova et al., 2021).

The procedural and activity block of the model ensures the development of all components of information and computational competence and, above all, its activity component, due to the use of web quests - one of the modern methods of project learning.

The control and correction block is designed for diagnostics and changes occurring in the process of developing information and computational competence. Control methods are combined with self-esteem and self-control, which determines the formation of a reflexive-evaluative component of information and computational competence.

The main means of integrating the listed structural components of the model are web quests. Working on them is the main factor in the development of information and computational competence of a future informatics teacher in the process of training in the field of computational informatics and affects the development of all its components. The influence on the development of the motivational-value component is primarily due to their professional orientation, which makes it possible to realize the value of the acquired knowledge, skills and experience in the field of computational informatics for future professional activities.

The influence on the development of the cognitive component occurs due to the deepening and systematization of the knowledge and skills of students in the field of computational informatics in the process of working on the tasks of the web quest due to the actualization of the meaningful links of computational informatics with other disciplines and acquaintance with the methods of scientific research of informatics.

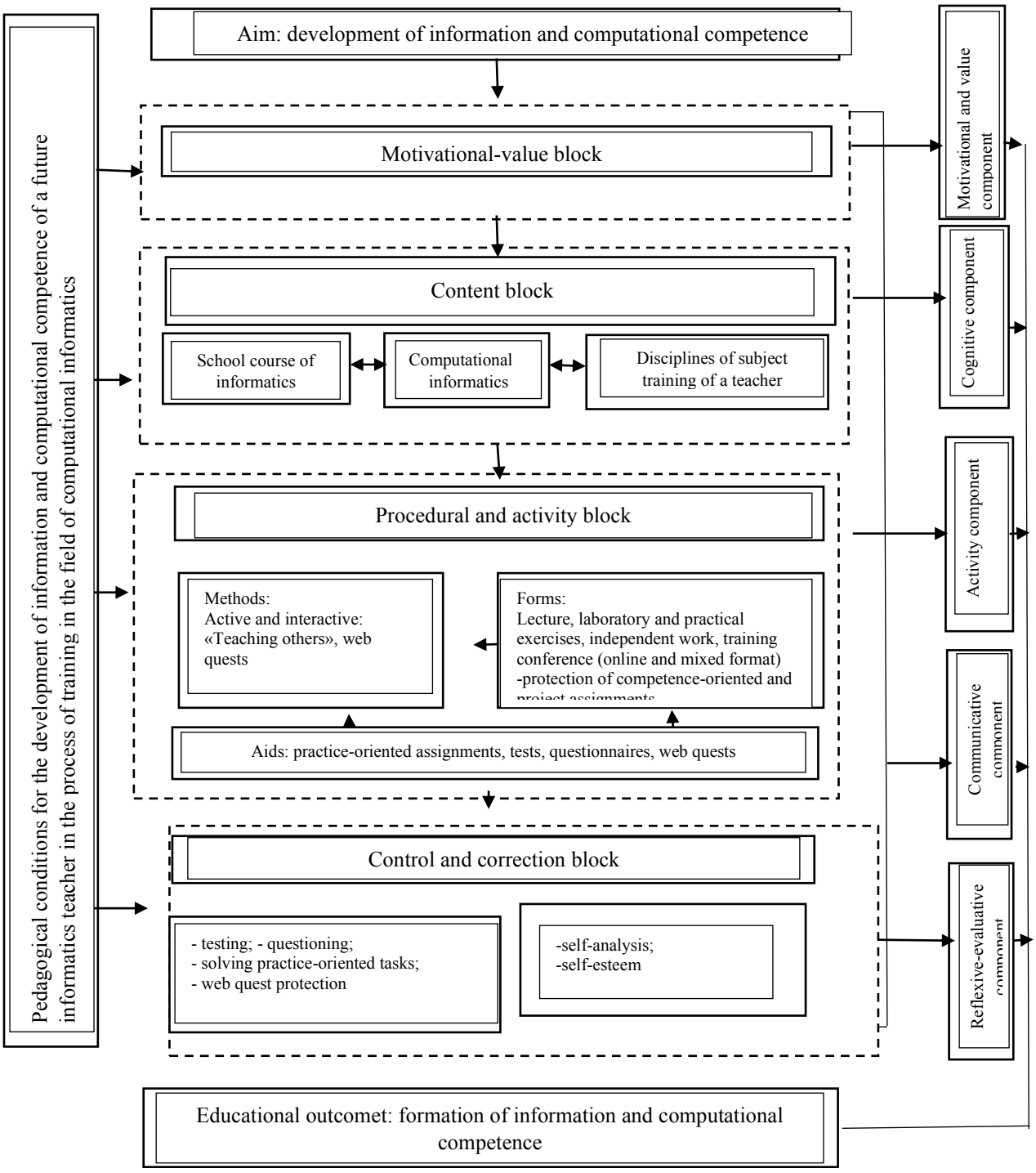

Figure.1. – Model of development of information and computational competence of a future informatics teacher in training in the field of computational informatics

Work on web quests has the strongest influence on the development of the activity component. It contributes to the formation of professionally necessary research, design skills, the ability to apply in practice the main methods of research in informatics – the method of modeling and computational experiment. The influence on the development of the communicative component occurs as a result of the inclusion of students in teamwork, the possibility of performing various roles

in the process of working on a project, explaining the material to other students, presenting the results of the work performed to the group.

The development of the reflective component is significantly influenced by constant introspection and self-assessment of the work carried out on project tasks. The educational outcome of training in the field of computational informatics on the basis of specially designed web quests is the formation of the information and computational competence of the future informatics teacher.

Consideration of the information and computational competence of a future informatics science teacher as a unity of its components allows highlighting the formation of each of its components as criteria: motivational-value, cognitive, activity, communicative and reflective-evaluative component. For each of the selected criteria, it is required to determine indicators that make it possible to judge the degree of their formation in the process of mastering computational informatics.

On the basis of the foregoing, a detailed structure of information and computational competence of informtics teacher is proposed, including the criteria and indicators of the level of its formation, determined on the basis of B.Bloom's taxonomy and the requirements of the teacher's professional standard (Professional, 2017; Khmelnitskaya, 2008) (table 1).

Table 1.: ***Criteria and indicators of the level of formation of information and computational competence of informatics teacher***

Features (descriptors) / Criteria	**Knowledge and comprehension** (25 points)	**Application** (preliminarily requires knowledge and understanding, 35 points).	**Analysis, synthesis, evaluation** (preliminarily requires knowledge, understanding and application, 40 points)
Formation of the motivational-value component of information and computational competence	- understand and be able to explain the importance of knowledge and skills in the field of computational informatics for future professional activities; - understand and be able to justify the need for continuous personal and professional self-improvement in the field of computational informatics	- demonstrate the ability to set and achieve goals; - demonstrate independence in mastering new knowledge in the field of computational informatics	- ability to search and organize information in the field of computational informatics for use in educational and professional activities; - ability to assess the value of information in the field of computational informatics
Formation of the cognitive component of information and computational competence	- describe the stages of solving a computational problem on a computer; - describe methods for solving a computational problem on a computer; - describe the features of software tools used to solve a computational problem	- ability to develop a computational algorithm for solving a problem, describe it in the form of a block charts; - the ability to implement a computational algorithm on a computer: write a program in one of the programming	- ability to analyze available information, create a formalized description of the problem (create a mathematical model); - ability to carry out calculations on a computer (computational experiment), evaluate the result

		languages, debug it and test it; - possession of modern means of solving computational problems	
Formation of the activity component of information and computational competence	- explain the essence of the method for solving a computational problem on a computer; - list the capabilities and advantages of the selected software for solving the computational problem	- demonstrate the readiness and ability to apply the methods of computational mathematics, mathematical modeling and computational experiment, applied software when solving computational problems on a computer	- analyze and select the best methods and means for solving computational problems; - develop practice-oriented and project tasks for use in teaching elements of computational informatics; - create digital resources in computational informatics
Formation of the communicative component of information and computational competence	- explain basic concepts, terms from the field of computational informatics	- demonstrate mastery of speech culture (the ability to speak and write competently and logically); - describe information, ideas, problems and solutions in the field of computational informatics; - formulate clearly and unambiguously their judgments, supported by knowledge and skills in the field of computational informatics	- ability to defend one's position in a reasoned manner, the ability to speak in front of an audience and in detail, clearly prepare report materials; - ability to effectively and professionally participate in discussions in the field of computational informatics; - ability to take responsibility for solving problem situations; - ability to solve organizational issues, distribute work in a group
Formation of the reflexive-evaluative component of information and computational competence	- justify the need for professional development in this area.	- manage own educational and research activities.	- analyze and evaluate the results of own activities and, on their basis, set goals and objectives for professional development in this area; - the ability to independently prepare a job description, conduct a master class, arrange an article, report

The table presents a minimum-sufficient list of indicators for assessing the level of formation of information and computational competence of informatics teacher. If it is necessary, it can be expanded by detailing their possible manifestations and features.

The analysis of the described indicators made it possible to determine three levels of information and computational competence of informatics teacher: low (reproductive), medium

(productive) and high (creative). The complexity of the tasks performed, which students are able to solve independently, was taken as the criteria for decomposition into levels.

Low (reproductive) level of formation of information and computational competence - the level of perception, comprehension, memorization, is limited to the categories «knowledge» and «comprehension» of Bloom's taxonomy of educational objectives. This level is characterized by memorizing and reproducing the issues studied in the field of computational informatics, as well as understanding, explaining the essence of the issues being studied and their significance for future professional activities; the ability to substantiate the need for professional development in this area.

Medium (productive) level is the level of application of knowledge by model, solution of typical tasks, their explanation is characterized by the fact that the intellectual skill «application» of acquired knowledge in practice in a standard situation is added to the categories of «knowledge» and «comprehension» of Bloom's taxonomy of educational objectives.

High (creative) level - the level of application of knowledge in a new situation is characterized by additional, higher intellectual skills, such as «analysis», «synthesis» and «evaluation» of the issues studied and the results of applying knowledge in practice.

For a quantitative assessment of the level of formation of information and computational competence, quantitative estimates of indicators are introduced. Each of the selected criteria (structural components of competence) is evaluated with 100-point scale. And according to table 2, formation level of information and computational competence is determined. To determine the level of formation of information and computational competence as a whole, the final score is preliminarily calculated as the arithmetic mean of the points of its components, and on the basis of Table 2, the level of its formation is determined.

Table 2. *Scale for transferring points to the corresponding level of formation of information and computational competence*

Level	Unacceptably low	Low	Medium	High
Mark in points	0-49	50-74	75-89	90-100

3.*2 Methods of teaching computational informatics, ensuring the development of information and computational competence of the future informatics teacher*

Computational informatics, as one of the areas of informatics, the research subject of which is the application of computing equipment and technologies in the numerical modeling of real processes and phenomena, is completely unthinkable without taking into account modern achievements in the development of computing equipment and technologies, which is mainly reflected in the content of training future informatics teachers in this field (Bidaybekov, 2007). Today it includes the long-established classical methods for the numerical solution of computational problems and the most relevant means and technologies for their implementation at the moment.

Forming a stable content framework, the main content lines of training in the field of computational informatics, identified taking into account the logic of conducting a computational experiment in the numerical solution of problems arising in the process of mathematical modeling of real objects and phenomena, cover the following groups of issues:

- Specificity of machine computing. Elementary theory of errors.
- Mathematical modeling and computational experiment.
- Mathematical apparatus for constructing and researching computational algorithms.

- Modern applied software for computational tasks.
- Implementation of a sequential computational algorithm.
- Issues of parallel computing organization. Parallel generalization of traditional sequential technology for solving computational problems.

These questions are reflected in the content of a number of disciplines of subject training of informatics teacher. First of all, it is «Theoretical informatics» course, in which general theoretical knowledge in the field of informatics is laid, in particular, basic questions concerning the triad «model-algorithm-program», which form the basis for solving a computational problem.

They receive further development in «Mathematical modeling and numerical methods» course. It is «one of the most important disciplines of professional training of a future teacher, which develops ideas for the numerical solution of problems arising in the process of computer mathematical modeling of real phenomena in various subject areas» (Lapchik, 2004). Almost all of the above issues are reflected in its content. These include, firstly, the basic concepts and essence of the technology of mathematical modeling and computational experiment, elements of the theory of errors, as well as numerical methods for solving nonlinear equations in one variable, the main problems of linear algebra, to which, as a rule, the solution of the majority computational tasks. In addition, the main numerical methods of mathematical analysis and differential equations, as well as the processing of experimental data and modern applied software for their implementation. «This minimum is able to demonstrate the broad possibilities of using the mathematical apparatus to study processes and phenomena of reality and at the same time show the richness of the possibilities of computer information approaches to reality and some of their fundamental limitations. And the main thing is to provide the teacher with all the needs of the school course of informatics and other forms of additional and extracurricular work with students» in informatics field (Lapchik, 2004). Mastering it requires fundamental knowledge in basic mathematical disciplines, as well as fluency in modern computer technology and the corresponding software.

Future informatics teachers should be able to search, analyze, evaluate the necessary information to solve computational problems in the framework of information and computing activities, while competently apply digital educational technologies, and engage in self-education. This requires new types and forms of organizing educational activities based on modern technologies, when the teacher becomes the organizer of the cognitive activity of students, and students are required not only to master the ready-made material, but to independently acquire knowledge, solve new problems and be able to apply knowledge in practice. To this end, many teachers have long been using project technology, using the resources of the Internet. But the plenty of information on the web and its quality not only does not simplify the process of working on a project, but also complicates it. Nowadays, a web-quest is increasingly used in the educational process (Duvalina, 2019; Gushina, 2018 and, etc.).

Developed in 1995 by the professor of educational technology at the University of San Diego (USA) - Bernie Dodge, the web-quest is considered to be a teaching method using which students of various levels take part in a specific task, which uses Internet resources prepared in advance. It allows spending less time searching for information and exclude sites with inappropriate content. The basis of web quests is the project method.

In a generally accepted form, the web-quest has the following structure: introduction, assignment, execution of assignment, assessment, conclusion, used materials, comments for the teacher. But this structure is used only as a basis, which can be supplemented with own ideas, in accordance with the level of training of students and the conditions for conducting a web-quest.

In the «Introduction» section, the theme is formulated, the main roles of the participants, the scenario of the web-quest, the work plan, or an overview of the entire web-quest are described. The purpose of this section is to prepare and motivate students to work.

The «Assignment» section explains:

- A problem or riddle that needs to be solved;
- The position to be formulated and defended;
- The product to be created;
- Forms of presentation of the final result (abstract, report or journalistic report, presentation, poster, etc.).

The task should be presented in the form of a problem, clearly formulated, and which has a cognitive value.

In «Execution of assignment» section it is necessary to accurately describe the main stages of work; a guide to action, useful tips for gathering information (checklist for analyzing information, various recommendations for completing a task, «blanks» of web pages for reports, tips for using information resources); the material should be distinguished by the variety and originality of the resources; selection of interesting tasks, their focus on the development of various kinds of skills; the availability of methodological support - auxiliary and additional materials for completing assignments; when using elements of role-playing - a clear and conscious choice of roles and resources for each role.

The «Assessment» section describes the criteria and parameters for evaluating the implementation of the web-quest, which is presented in the form of an evaluation form. The section "Evaluation" describes the criteria and parameters for evaluating the implementation of the web-quest, which is presented in the form of an evaluation form. The assessment criteria depend on the type of educational tasks that are solved in the web-quest. «Conclusion» – is a short and accurate description of what students can learn by completing this web quest. This section should be connected with the Introduction. «Used materials» – resource links, which are necessary for creating web-quest.

«Comments for the teacher» – guidelines for teachers who will use the web-quest:

- history, aims and objectives of a web-quest;
- the age category of students (can it be used by other students if there are additions, adjustments);
- planned outcomes (personal, regulative, communicative, cognitive);
- the process of organizing work on a web-quest;
- necessary resources;
- the value and advantages of the given web-quest.

Today, web-quests are also used in higher education. With a fairly simple method of inclusion in the educational process, which does not require special technical knowledge, they can be used within any training course. In the course of using the web-quest, the teacher fully implements teaching, educational and developmental objectives.

The main meaning of these tasks in the process of teaching computational informatics is to focus the attention of future informatics teachers on the formation of knowledge, skills and abilities in computational informatics necessary for the implementation of computational activities in future professional and pedagogical work. This leads to the awareness of students of their further professional activities in this area. And the fact that when completing the tasks of the web-quest, the main part of the information is obtained through the Internet resources, makes it attractive for students, helps to increase the cognitive activity of students and motivation to study the educational material (Duvalina, 2019).

Using a web quest allows students to gain experience of independent activity and personal responsibility, i.e. key competencies that determine the quality of modern education, and also contributes to the development of teamwork skills, public speaking skills, the development of information and computational competence through practical activities when completing web-quest tasks (Chernyavskikh et al.,2018) .

There are two types of web-quests: for short-term and long-term work of students. Short-term web-quests can be offered when studying specific educational topics for work in the classroom (in subgroups or individually) or independent work at home.

Let's consider some of these web-quests in computational informatics.

Theme: Numerical methods for solving nonlinear equations in one variable (duration 3 weeks).

Many problems of studying various objects and phenomena using mathematical models lead to the need to solve nonlinear equations with one variable. Many of them cannot be solved analytically. In practice, the roots of such equations are calculated approximately, with a given accuracy (error), which is difficult without the use of numerical methods.

Aim: to develop the cognitive interest of students in the theme, to form knowledge, skills and abilities for the numerical solution of nonlinear equations with one variable using modern computer technology and software; the ability to justify the result error; develop information and computational competence.

Before starting to consider this topic, it will be useful to take a short excursion into history, to show where and when a modern person has to solve nonlinear equations. Consider examples that lead in the process of mathematical modeling to solving nonlinear equations with one variable, get acquainted with the most common methods for solving it. For each of the considered methods, draw up a block chart and a program for implementation on a computer (Oshanova et al., 2021). The web-quest includes links to Internet resources containing material on these issues.

Students can work in groups. To do this, the class is divided into several groups according to roles: historians, theorists, practitioners, programmers and designers. Each role presupposes the performance of certain tasks, which will be helped by useful links to Internet resources included in the web quest, for each section separately. After completing all the tasks, each group needs to make a presentation, prepare a message. The final report is formed from the reports of each group. It should be presented as a web page.

The first group prepares a story about the history of the development of methods for solving nonlinear equations with one variable. To this end, they should conduct a study of the material, highlighting the following issues:

1. Definition of concepts nonlinear equation with one variable, solution of nonlinear equation, history of development of these concepts.
2. What scientists have studied a nonlinear equation with one variable?
3. Give examples of problems modeled by nonlinear equations in one variable. Describe the methods for their solution

A group of theoreticians reveals the essence of the main numerical methods for solving nonlinear equations, prove formulas for the solution errors.

The third group of practitioners demonstrates the practical application of numerical methods on applied problems that are actually encountered in practice:

1. A ball of radius *r* is immersed in water to a depth of *d.* Let the ball have a radius of *r = 10 cm* and is made of old pine with density $\rho = 0{,}638$. What part of the ball will be in the water? (Mathematical model: 2552 - 30d^2 + d^3=0) [J. Matthews, 2001]).

2. A hemisphere, of radius 1, divided into two equal parts by a plane parallel to the base (mathematical model, which should be previously built: x^3-3x + 1 = 0)

3. A hemispherical vessel is filled to the brim with water. At what angle should it be tilted so that half of the water flows out? Get the result with an accuracy of e = 0.001 (mathematical model, which must first be built: x^3-3x + 1 = 0, $x = \sin\alpha$).

In addition, they must carry out a selection of practical tasks for schoolchildren.Programmers build block diagrams of computational algorithms and programs for their implementation on a computer.The most promising is the use of specialized mathematical packages (MathCAD, MatLAB, etc.). Possessing a wide range of built-in functions for the implementation of computational algorithms, they allow providing a visual organization of the computational scheme and present the result in various formats. Their use in teaching the solution of computational problems also contributes to an increase in the motivation of learning and the formation of interest in the material being studied. It is also possible to use MS Excel and programming languages, which will allow future informatics teachers, when teaching them in a school course of informatics, to include tasks from the field of computational informatics, in particular, tasks to find a solution to a nonlinear equation.

Designers should systematize all knowledge about nonlinear equations in one variable, methods for their solution and format them in the form of a web page and publish it on the Internet. The task of the teacher is to correctly state the purpose of the work and select good sources of material (links). Thus, students will not only study the topic in detail, but also show independence, resourcefulness and their creative abilities. The most effective forms of protecting a quest-project in computational informatics can be considered an oral presentation (teaching others) with illustrative material based on the presentation. This will ensure better mastering of the educational material by all participants in the educational process (Pulyaevskaya, 2016). Training can be carried out both full-time and in a mixed format.

4. Discussion

The developed model for the development of information and computational competence in the process of training in the field of computational informatics, supplemented by a detailed structure of this competence with criteria and indicators of the degree of its formation, serves as a kind of filter for the selection of competence-oriented training content, allows determining the most effective teaching methodology that ensures the development of this future competence informatics teacher and check the level of its formation.

Practice shows that students - future informatics teachers in most cases do not have sufficient mathematical knowledge, and in this regard, there is a significant variation in the level of their initial readiness for teaching computational informatics, which requires differentiated and individual approaches to teaching. Moreover, in the conditions of the credit technology of education, which is currently introduced into the education system of many countries, a large amount of time during training is devoted to independent educational work, and therefore the process of mastering educational material and developing information and computational competence also requires high motivation and the formation of students' independence. Taking all this into account, and also taking into account the fact that competence cannot be transmitted in the form of information, but is formed directly in the activity, in the process of transforming one's own experience, one of the most effective approaches to the development of the indicated competence in the process of training in the field of computational informatics can there will be the use of web-quests, which together implement competence-based and contextual approaches in teaching, as well as the concept of

funding pedagogical education. This approach most fully takes into account the above learning conditions and the individual level of the initial readiness of future teachers to master computational informatics, and allows all students to be involved in real practice-oriented activities, close to their future professional activities.

For better mastering by students of the basic methods for solving nonlinear equations in one variable and the means of their implementation, as practice shows, the following approaches to teaching are very effective:

- involvement of students in active cognitive activity to master one of the methods for solving a nonlinear equation, which is done in the web-quest, and then to teach the method they mastered to other students at the end of the work on the web-quest, during its defense. Such a teaching method according to the «learning pyramid» proposed by the followers of Edgar Dale at the US National Training Laboratory (Pulyaevskaya, 2016), as a rule, demonstrates a high degree of mastery of the material.
- and since one problem can be solved by different methods, it is much more efficient to use the organization of parallel learning by analogy with the concept of «parallel information processing» in cybernetics, which means the technology of increasing the speed of information processing by parallelizing processes. This approach involves the parallel mastering by each member of the group of theoreticians and practitioners of one of the methods for solving a nonlinear equation, which is different from the methods studied by others, and explaining it to the rest, which makes it possible to master all the educational material in a little time.

So, having received the assignment, each of the groups of students independently, in parallel with the others, works on its implementation. Upon completion of the work when defending the web-quest, they speak to each other, explaining the solution method they have mastered. In the course of the presentation, students not only exchange results, discuss the solution obtained, they learn to present the selected and systematized material; build a proof of a hypothesis; use visual aids during the response; participate in brainstorming; analyze the meaning and nature of the questions; develop thought in the logic of the question posed; argue own position; put counter questions, etc. Explaining, the student tries on the role of a teacher on himself, and this is one of the most effective methods for structuring and better remembering information (Pulyaevskaya, 2016). At the same time, the algorithms of all the considered methods for solving the problem as a whole are firmly mastered by all students much better than if the teacher himself explained it. The use of a parallel method of teaching allows significantly reducing the training time without cutting the volume of the course, which contributes to an increase in the productivity of students' academic work.

The level of assimilation of knowledge and skills at this stage is the basis for the development of the cognitive component of the information and computational competence of the future informatics teacher. At this stage, motivation for learning, interest in the subject and professional pedagogical activity, the ability to self-assess their own activities, interact with an individual and a team, and possession of the skills of self-education and self-upbringing are also laid.

One of the requirements for the task of a web-quest is the possibility of using its results in future professional activities. Therefore, an additional condition for the above task may be the independent selection by students of practical tasks that are feasible for schoolchildren, modeled by a nonlinear equation in one variable and the study of the possibility of their inclusion in the content of the school computer science course. At the same time, the attention of students with the help of such tasks switches from educational-subject material to methodological material. This ensures the transformation of cognitive activity into a quasi-professional one with a corresponding change in motives, goals, actions, means and learning outcomes.

The ability to correctly formulate tasks and questions, as a rule, ensures the success and fruitful communication of teachers with schoolchildren. Such assignments make it possible, when training a future teacher, not to lose sight of this truth. Due to such an organization of training, the learning outcome acquires a subjective (independence, initiative, responsibility) character with meaningful actions of students, and a friendly atmosphere and style of relationships in the training process contribute to an increase in the motives of learning.

In general, such web-quests and the organization of work on them contribute to the development of almost all the selected components of information and computational competence. They also serve as a convenient tool for checking its formation. Therefore, in the future, when organizing current control, each student is given the opportunity to solve such a task in order to develop information and computational competence to the required level, and the teacher to check the level of its formation in a student in accordance with the criteria described above and indicators of the degree of its formation.

Long-term web-quests occupy a special place in the formation of information and computational competence of a future teacher. They also:

– contribute to the formation of the ability to work independently on the development of new knowledge and their application in practice;

– allow including trainees in real practice-oriented activities aimed at solving problems focused on future professional interests;

– allow raising the motivational interest of students in obtaining a result;

– provide creative application of acquired knowledge, practice-oriented results, reflection and self-esteem.

These advantages of long-term web-quests correspond as much as possible to the specifics of teaching computational informatics, contribute to the development of almost all components of information and computational competence, which allows us to speak of their high efficiency in learning. Here are some of the possible topics for similar web-quests under «Numerical methods for solving nonlinear equations in one variable» section:

1. Development of a digital educational resource in Python (or in MathCAD) for the step-by-step solution of a nonlinear equation with one variable using different numerical methods, including reference material, a problem book and a calculator. Working on it will allow summarizing the material to get a holistic view of the topic under study. The result of the work can be applied in practice, both in the educational process and in scientific research.

2. Development and implementation of parallel algorithms for solving nonlinear equations in one variable. Assessment of their effectiveness.

3. Methods for solving nonlinear equations in one variable in school course of informatics. This and similar topics have a more pronounced professional focus.

The use of such web-quests makes training as practice-oriented as possible and allows not only acquiring knowledge, but also to form skills and abilities, realize your potential, exchange experiences, set tasks and find solutions. Working on them contributes to the development of all components of information and computational competence.

Similar web-quests have been developed and are offered to students when teaching all sections of the content of training future teachers in the field of computational informatics. Tasks and all related information are placed in a specially created network information and communication environment for organizing joint activities of students, discussing results and online consultations. All educational and methodological materials necessary for work are also located there.

The positive influence of the developed teaching methodology in the field of computational informatics based on web-quests on the development of information and computational competence of the future informatics teacher in accordance with the above-described indicators and criteria for the level of its formation, is shown during the pedagogical experiment conducted on the basis of Institute of Mathematics, Physics and Informatics, Abai Kazakh National Pedagogical University.

The total number of students studying in the direction of «Informatics» who took part in the pedagogical experiment was 117 people. To carry out an experimental test of the study, the control (58 people) and experimental (59 people) groups were determined.

During the experiment, the following methods of scientific and pedagogical research were used: in order to identify the formation of the motivational and reflexive-evaluative criterion - questioning, in order to identify the level of formation of the cognitive criterion - testing of students. The study of the activity and communicative component was carried out on the basis of solving practice-oriented problems and an oral presentation with a presentation of the solution, as well as statistical processing of the experimental results. The results are shown in Table 3.

Statistical processing of the results obtained during the ascertaining experiment showed that the bachelors had a fairly low level of information and computational competence. At the same time, there were no significant differences in the amount of acquired knowledge and skills among students of the control and experimental groups. The homogeneity of the control and experimental groups was checked using the Student's t-test (Novikov, 2004).

Conducting a formative experiment is aimed at testing and assessing the effectiveness of the proposed teaching methodology based on web quests, taking into account a certain set of pedagogical conditions. For this purpose, in the control group, the classes were conducted in a traditional form, and in the experimental group - according to the proposed methodology using a web-quests. The results of this stage of the experiment are presented in the same table 3.

The verification of the reliability of the results obtained was carried out in MS Excel. The difference between the results of the experimental group and the results obtained in the control group is reliable and statistically significant. To assess the significance of differences, the Student's t-test was also used.

Comparison of the data of the studied indicators based on the results of the ascertaining and formative experiments confirms the dynamics of the development of the levels of formation of information and computational competence among future informatics teachers in both groups (Table 3).

Table 3: *Comparative analysis of the levels of formation of information and computational competence among future informatics teachers of at the ascertaining and formative stages of the experiment, in %*

Criteria	Levels	Control group				Experimental group			
		Ascertaining stage		Formative stage		Ascertaining stage		Quality stage	
		Quality	%	Quality	%	Quality	%	Кол-во	%
Motivational	Very low	9	15,5	9	15,5	11	18,6	0	0
	Low	9	15,5	9	15,5	10	17	8	14
	Middle	31	53,5	30	52	27	45,8	25	42
	High	9	15,5	10	17	11	18,6	26	44
Cognitive	Very low	0	0	0	0	0	0	0	0

	Low	19	33	16	28	17	29	7	12
	Middle	29	50	31	53	33	56	39	66
	High	10	17	11	19	9	15	13	22
Active	Very low	6	10	1	1,7	5	8,5	0	0
	Low	24	42	24	41,3	26	44	12	20
	Middle	25	43	27	47	25	42,4	29	49
	High	3	5	6	10	3	5,1	18	31
Communicative	Very low	7	12	0	0	5	8	0	0
	Low	27	47	24	41,4	27	46	10	17
	Middle	21	36	28	48,3	24	41	31	53
	High	3	5	6	10,3	3	5	18	30
Reflexive-evaluative	Very low	15	26	12	21	14	23,7	0	0
	Low	9	15	9	15,5	8	13,5	11	19
	Middle	18	31	20	34,5	20	34	13	22
	High	16	28	17	29	17	28,8	35	59

5. Conclusion

In conclusion, we would like to emphasize the enormous educational potential of computational informatics - one of the scientific areas of informatics, the subject of research of which is the application of modern computing equipment and technologies in the numerical simulation of real processes and phenomena. On the one hand, it allows strengthening the fundamentality of training a future teacher in the field of informatics by including in the content of methods of computational mathematics and methods of scientific research in informatics, such as modeling and computational experiment, necessary for solving computational problems on a computer, and on the other hand, to strengthen its applied focus, and to ensure the possibility of wide application of the acquired knowledge and skills in practice, thereby expanding his/her understanding of the capabilities of a computer and contributing to the development of information and computational competence and a number of cognitive skills of a future informatics teacher.

Information and computational competence, which manifests itself, first of all, as the ability and readiness of a future informatics teacher to solve computational problems on a computer and teach this to students, is one of the important components in the structure of the professional competence of informatics teacher.

The need for the development of future informatics teacher's information and computational competence is explained by the fact that the huge computing resources of modern computers are used mainly to solve problems that arise in various applied areas in the process of mathematical modeling of real phenomena and processes, and the future informatics teacher should not only have an idea about this, but also know methods and technologies for solving typical computational problems on a computer, have the skills to solve them and be able to teach this to schoolchildren, especially at the specialized level in high school, expanding their knowledge of possible areas of computer application.

During the conducted research pedagogical conditions were identified that ensure the development of information and computational competence of a future teacher in the process of training in the field of computational informatics, a structural and logical model of its development was developed and substantiated, and a teaching method was proposed that ensures its development, based on web-quests, as much as possible activating the student's activity during their implementation.

During the experiment, a number of positive aspects of using web-quests for the learning process were noted. They allow:

– to organize the work of teachers and students more effectively, since the most in-demand resources are pre-collected and systematized on the portals; get access to high-quality educational and teaching materials;

– reduce the time to find the required information.

Separately, we can note the peculiarities of the influence of the use of a web-quest in the educational process on the learning process, motivation for learning and the assimilation of knowledge. Moreover, a web-quest develops the necessary professional qualities of a future teacher, having a number of opportunities, such as: the visibility of data presentation, the use of various forms and methods of presenting educational material, a significant increase in independent activity, rating assessment of material assimilation, differentiation and individualization of teaching. And most importantly, the use of a web-quest in teaching computational informatics had a positive impact on the development of information and computational competence of a future informatics teacher.

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