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**FORMATION OF TEACHERS' ICT-COMPETENCIES IN THE  
FIELD "COMPUTER SCIENCE AND MATHEMATICS"**

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***Abstract***

The article presents the methodical concept of the formation of teachers' ICT-competences based on two components: the invariant core that reflects the importance of ICT-competence for specialists of any profile, including pedagogical and variation part, including elements significant for specialists in this field, including pedagogical. This will help to: streamline the ideas about ICT-competencies offered by different authors; specify the framework characteristics of ICT-competencies formulated in a number of official documents; organize a science-based educational process of ICT-competencies formation. Since the main, universal human activity is the solution of various tasks it is advisable to establish the stages of problem solving information technology, also universal as the basis of the invariant core of ICT-competence.

The content of the invariant core of ICT-competence is defined through the disclosure of the content of each stage according to the three components of ICT-competencies: "knowledge", "skill", "experience". The variable component of ICT-competence, which reflects the features of professional activity, is built on clarification of the stages of information technology for problem solving with special emphasis on symbolic activity.

The article emphasizes the increasing influence of ICT on the learning process, and this requires redefining the goals, content, forms and methods of teaching any academic discipline on a new contemporary level, including the system level.

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**Keywords:** Competence, professional activity of the teacher, stages of solving problems.



## 1. Introduction

Modern information society of global mass communications has undergone major changes in the content and structure of the professional teacher training, primary school teachers in particular. One of the most important trends of such training is the assimilation of information and communication technologies as an effective tool for professional activities.

It is definitely possible to form a general idea of the current teaching state of the subject "Computer Science and ICT" and the formation of ICT competencies of the subject of education. Under conditions of global informatization of social and informational aspects in the scientific and educational sphere, these ideas are further developed and redefined.

A great deal of research of scientists, methodologists and IT specialists in Russia and in most other countries publications and materials of international conferences (Korotkov, 2016; Korotkov, 2014; Kim, Addom & Stanton, 2011; Floridi, 2011; Taylor & Raskin, 2014; Rogers et al., 2012; Allen & Seaman, 2013) emphasizes the increasing influence of ICT on the learning process, and this requires redefining the goals, content, forms and methods of teaching any academic discipline on a new contemporary level, including the system level.

The requirement for systematic training is related to the systemic nature of the surrounding world and is implemented in the process of preparing didactic materials. Its rationale contains two factors:

- the educational material should reflect the system of connections in the surrounding world;
- since the way of reflection depends on the properties of the object being reflected, the cognition process of the learning material must be performed within the system.

## 2. Problem Statement

According to the professional teacher standard, a primary school teacher should particularly: "Possess ICT competence which is necessary and sufficient for planning, implementing and evaluating educational work with children of early and preschool age" (Professional standard RF, 2013).

The need for the formation of ICT competence is prompted by the fact that the SES (State Educational Standard) for primary school (as well as for other levels of general education) contains the professional ICT competence of the teacher particularly; work in the information educational environment as a requirement for the educational process.

The professional pedagogical ICT competence in the professional standard of the teacher is in its turn defined as. "Professional pedagogical ICT competence is the qualified implementation of means of ICT common in this professional field in developed countries for solving professional problems where necessary" ... This competence:

- "is based on the UNESCO Recommendations" ICT Competence Framework for Teachers", 2011;
- is expected to be present in all components of the professional standard;
- is identified in the educational process and assessed by experts, basically in the course of monitoring the activities of the teacher and analysis of its fixation in the information environment. "

Thus, the concept of professional pedagogical ICT competence within the professional standard of the teacher is framework based and requires further clarification.

The current established practice of ICT competence forming is generally limited to its technological component. This is due to the fact that ICT - competence is mostly considered as a necessary condition for the activity of the student and teacher in the information educational environment. This understanding of ICT competencies severely limits their significance in achieving personal, cross-curriculum and educational results formulated in SES.

On the other hand, the above components of ICT competencies, on the whole, reflect the point of view of the authors and do not have a motivated internal logic. This leads to the fact that the very concept of ICT competence becomes vague and indefinite, which makes the process of its formation extremely complicated. Furthermore, the structure of ICT competence largely depends on the nature of the professional activity, in our case the activity of the primary school teacher. Under these circumstances, it is very important to single out the invariant core of ICT competence.

### **3. Research Questions**

Identification through the analysis of psychological pedagogical literature, of the content of information competence as a component of the professional competence of a specialist and determining the invariant core and composition of professionally directed ICT competences of the future teacher on the basis of continuity and consistency principles combination, when various academic disciplines include and require knowledge and skills in the field of ICT means.

### **4. Purpose of the Study**

**The research goal** is to define the concept of pedagogical ICT competence of teachers in the subject field ‘Computer science and mathematics’.

### **5. Research Methods**

The implementation of the principle of consistency involves the mastery of educational material on three levels: reflection; understanding; assimilation.

Teaching computer science (as well as any school subject) consists of a theoretical and practical part and, accordingly, of the study by the subjects of education of the theoretical foundations of computer science as a fundamental science and their study of the application area of informatics (methods and means) which constitute the object of its research. Applied orientation of teaching computer science includes:

- direct immersion of subjects into the information sphere and interaction with objects of this environment, with information systems, resources, technologies;
- learning the theory of informational interaction with information systems, resources, technologies, their content, appropriate methods, algorithms and their computer representations (Abdurazakov, at. al., 2017).

The requirement for the consistency of training is associated with the systemic nature of the surrounding world and is implemented in the process of preparing didactic materials. Its substantiation contains two factors:

- the educational material should reflect the system of connections in the surrounding world;

- since the way of reflection depends on the properties of the object being reflected, the cognition process of the learning material must be performed within the system.

## 6. Findings

At present, there is a significant number of works devoted to the analysis of the concepts of ICT competence and the investigation of the ways of their formation (Asmolov, et. al., 2010; Beshenkov, et. al., 2017; Lapchik, 2007; Mindzaeva, 2013; Rakitina, 2002; Henner, 2008; Semenov, 2008; Shutikova, et. al., 2017). Generally, ICT competence is considered as a widening of computer literacy, by including the ability to receive, process, transmit and evaluate information, as well as make decisions based on it, both in terms of the completeness of the source information and in the situation of uncertainty (Floridi, 2011; Minsky, 1982; Rodogno, 2011). At the same time, the means of information technology are actively deployed.

Of particular interest is the study of E.A. Rakitina (2002) which most fully represents all the components of ICT competence:

*competence in information and analytical activities:* realizing the importance of information at all levels of human life, the ability to take into account and apply the patterns of information processes in various systems;

*competence in the field of cognitive activity:* realizing the essence of the informational description of reality; knowledge of the basic stages of building an information model of this reality;

*competence in the field of communicative activity:* realizing the communications characteristics in the modern information society; knowledge of modern means of communication and the most important qualitative and quantitative characteristics of communication channels;

*technological competence:* comprehension of the essence of the technological process of information processing and transmission; knowledge of the features of modern information and communication technologies; the ability to identify the main stages and operations in the description of the technological process of problem solving;

*competence in the field of social activities:* realizing the importance of information resources of society and ensuring the information security of a person, state, society.

These components of ICT competence cover a wide range of human information activities, which correlates with the comprehension of the ICT competences laid down in the Federal state educational standard.

### 6.1. The definition of the invariant kernel of the complete cycle of solving the problem

The main professional activity of a person is solving problems. The content of these tasks naturally varies significantly; however, as shown by the researchers, the sequence of steps for solving a wide range of problems remains the same. This sequence contains the following steps:

- problem statement;
- construction and analysis of models of objects and processes considered in the problem;
- choice of the method for solving the problem;
- formalization;

- implementation of the selected method;
- analysis of the obtained results, correction of models and method of solution;
- implementation of the obtained results.

Each stage of the solution determines quite definite knowledge, skills and experience, which in aggregate determine the invariant core of ICT competences (Asmolov, et.al., 2010; Beshenkov, et.al., 2016; Zhuravlev, 2005; Mindzaeva, 2013; Semenov, 2000).

According to the prevailing notions, the content of competences is revealed in three dimensions: knowledge, skill and experience. The same applies to ICT competencies. The above information technology for problem solving can be shown in the following components forming ICT competence (Table 1).

**Table 01.** Content of the invariant kernel of the complete cycle of the problem solving

	<b>Knowledge</b>	<b>Abilities</b>	<b>Experience</b>
Problem Statement	Differences between the goals and conditions of the problem. Knowledge of the main types of problems from the subject area "Mathematics and Computer Science"	To set a problem focused on the achievement of a specific goal	Formulating the condition of a problem with different degrees of formalization
The construction and analysis of models of objects and processes considered in the problem	The concept of the model, the properties of models, the adequacy of the model to the modeled object and the purposes of modeling	To construct and evaluate various models: appearance, structure, behavior	Constructing and evaluating various models
The choice of the method for solving the problem	The concept of method and technology, the method and technology of solving the problem. Technologies as an aggregate of stages, operations and actions.	Search for optimal methods for solving the problem, compare various methods	Solve problems using various methods
Formalization	Formalization as a method of bringing the model to a given form	To formalize the given situations using the given forms (graphs, formulas, diagrams, etc.)	Formalization of objects and processes involved in the formulation of the problem
Implementation of the selected method	Program and technology as ways of the solving the problem	To choose a method of solution appropriate to the problem	Writing elementary programs and selecting the appropriate software
Analysis of the obtained results	Methods of analyzing the results for consistency, for the relevance to the conditions of the problem	Analyze the obtained results for consistency, completeness of information, etc.	Analyzing the obtained results for relevance to the problem.
Correction of models and method of solution	Quantitative and qualitative assessments of the model, choice of the model corresponding to the declared parameters	Modify the model in order to eliminate the discrepancy with the goals of the problem	Model correction based on results of the task solution check
Application of the obtained results.	Fields of application of the results obtained and possible limitations.	Determine possible limitations in the results application.	Applying the results of problem solution in learning and practical activities.

This invariant core has particular significance for the preparation of primary school teachers.

According to GEF, the primary school's task is, first of all, the formation of universal educational activities (UEA), which, according to the of E.V. Mindzayeva's research (Floridi, 2011; Kim, Addom, & Stanton, 2011) are mainly informational. On the other hand, primary school teachers should form ICT competence in students, which, as was shown above, has a very vague content. At the same time, it is important to show how the formed UEA and ICT competencies are refracted in the subjects' content. Application of the above scheme of solving problems stages allows:

- to determine the invariant core of ICT-competencies, the formation of which will allow to form the entire system of UEA concurrently;
- mastering the stages of solving problems is an important element of the content of training in the subject area "Mathematics and Computer Science".

Along with the invariant components of ICT competence, it is expedient to identify the components of the problem solution which are especially important for primary school teachers. These components show the following aspects of the table above in detail (Table 2).

**Table 02.** Components of solving the problem and the content of ICT competencies of primary school teachers

Select characters from the set of characters-symbols that refer to different types.	Characters and symbols, the concept of the Frege triangle	Select elements belonging to one system.	Select characters from the set of character-elements that belong to the same character system.
Develop or use existing characters to formalize information about an object, process or phenomenon.	Characters and character systems, bringing the situation to a known character system	To develop or use a system of characters that allows to formalize information about an object, process or phenomenon.	To formalize information about an object or phenomenon using various character systems.
Correct the entered designations when performing a specific activity.	The adequacy of the character system to the modeled object and the purposes of modeling	Correct the system in the process of solving the problem.	Correct the character system in the process of solving the problem.

Formation of ICT - competences of the future teacher of primary classes is carried out within the framework of the methodical system.

## 7. Conclusion

According to the A.M. Pyshkalo's classical scheme, methodical system is an interconnected set of goals, content, methods, forms, teaching aids. The development of each of these elements is performed according to the following methodological principles.

The main goal of teaching is to master the stages of the solution of the problem, which will provide unity in achieving the subject and cross-curriculum results of teaching; i.e. the goal of forming ICT competencies should at the same time contribute to the formation of the UEA and the achievement of substantive results within the chosen subject area.

The content of problems that implement the above stages is retrieved from the subject area "Mathematics and Computer Science", while emphasizing that mathematics and computer science are two subjects that nevertheless have a very similar cross-curriculum component.

The methods of teaching are based on the principle of unity of rational and visual, since visual images play an important role in the formation of the ICT competencies of the primary school teacher and the teaching process in the junior school in general.

Forms of teaching, mostly by games, solving different types of problems, which is typical for the training primary school teachers. Its specific nature lies in the fact that in the process of ICT competences formation, a significant role is assigned to the so called "Semantic" games, where the main actor is the language.

The teaching tools vary wildly, which makes the methodical system an open system.

The implementation of these principles allows to build a training system aimed at the formation of all these components of the teacher's ICT competence.

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