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FORMATION STUDENTS' ICT COMPETENCE: CASE STUDY

Absract. This article shows theoretical foundations and experience of research on the formation students' ICT competence, which was conducted based on the TOTE model. Described criteria of information and communication competence, proposed the model for the formation of ICT competence of high school students during the process of computer science education and to verify its effectiveness by conducting a monitoring study. The results of the experiment determined the impact of way of formation, method of formation and form of assisstance on the formation of students' ICT competence.

***Key words*:** ICT competence; competency tasks; level of competency tasks; model for the formation of ICT competence; criteria of information and communication competence

Introduction. The social and economic impact of technology is widespread and accelerating. The speed and volume of information have increased exponentially. In the light of the widespread reform of education, developed societies today are changing their perspective on what should be the preparation of a graduate school. Along with the formation of subject knowledge and skills, the school should develop the ability of students to use knowledge in various situations, close to reality, to facilitate the acquisition of the necessary vital competencies. In the future, they will contribute to the active participation of a school graduate in the life of society, will help him to study throughout his life.

The concept of a competent approach in education is the basis of meaningful changes in ensuring the relevance of education to the demands and opportunities of society in the period of information and global mass communication (DeSeCo 2002). From the point of view of the competence approach, the essence of education is the development of the ability to solve problems independently in various fields and activities based on the use of social experience, the element of which becomes the own experience.

In many countries around the world, educational programs have now been revised and modified to create a foundation in which the core learning outcomes were based on student achievement in the required competencies (e.g., ISTE 2016).

In Ukraine, the competence approach is implemented at all levels of education, since it is recognized as an effective tool for the development of each person ("Concept of the New Ukrainian School", 2016). In particular, the basis for development the content of teaching computer science and the requirements for general education of students is precisely the competence approach, according to which the final result of teaching computer science is formed on the basis of the acquired knowledge, skills and abilities, the experience of training and life activities, produced value orientations, positive motivation of the subject IC-Competence and key competencies, in particular communication competence, mathematical competence in science and technology, information-digital, educational, Social, civil, health saving ("New Ukrainian School. Conceptual Principles of Reforming High School", 2016).

For many educational systems, one of the main factors in the development of quality education is the possession of objective data on the results of learning in accordance with educational standards. One way of obtaining such data is to organize and conduct monitoring studies, because the monitoring of the essence is the information system, according to the process, the creation of conditions for the adoption of a management decision, by performance - the technology for assessing the current state of the object of management, its regulation and projection development (Kusek 2004).

Quality education, including the ICT competence formation, is the subject of many scientists' research (Wastiau 2013, Selwyn 2010, Brunner 2007 etc.) and remains relevant today, as the modern labor market constantly requires new ICT competences, including soft skills, which are formed in the school. Since as of 2018 Ukraine joins the PISA (Programmer for International Student Assessment), authors conducted research through 2010-2016 on students' ICT competence formation in secondary schools.

The purpose of the current article paper is to design a model for the formation of IC-competence of high school students during the process of computer science education and to verify its effectiveness by conducting a monitoring study.

Theoretical foundations and experience of research authors. Education Technology Standards to transform learning and teaching (ISTE 2016) was considered as one of the indicators for determining learning results. In particular, the definition of competences for students, their features and indicators of measurement (http://www.iste.org/standards/standards/for-students). To determine the digital skills for ICT enriching the standard, the authors have chosen a model that includes the following categories: digital identity, digital use, digital safety, digital security, digital emotional intelligence, digital communication, digital literacy, digital rights (Yuhyun Park 2016).

Information and communication competence implies the ability of a person to solve information (competence-based) tasks (Morze 2010). For its evaluation we can use the criteria, that (Table 1) was developed by the international organization ETS (Educational Testing Service) for assessment ICT competence (Katz 2007), adapted by scientists and practitioners (Burmakina 2007, Morze 2010).

Table 1

Criteria of information and communication competence

Criteria	Results (skills)
Definition (Df)	To identify and formulate an information problem; Identify the necessary information
Access (Ac)	To find the necessary information using different electronic sources; Choose the best of them
Evaluation (E)	To evaluate the quality of the information that was found (relevance, completeness, reliability, helpfulness, etc.)
Administration (Ad)	To organize and structure information in a form that is easy to store, speedy access and further use
Integration (I)	To create integration resources from a given problem (comparative, generalizing, synthesizing tables, charts)
Creation (C)	To create electronic (informational) products in accordance with the purposes of presenting information (solvable problem); choose the appropriate tools
Delivery (Dl)	Adapt the information product developed for a particular audience, transmit it using communication tools with an appropriate annotation (announcement for a specific group of users)

The model of the formation of the IC competence of high school students was developed by the authors of this study and tested at different levels: in the training of students of experimental classes, in the training of future teachers in pedagogical universities and retraining of teachers in the system of advanced training (Morze 2011, Morze 2015, Morze 2016).

The construction of a model for the formation of IC-competence was based on the taxonomy of Bloom's educational goals (Krathwohl 2002).

Determination of the necessary and sufficient set of educational tasks-situations (competence-based tasks), the sequence of which is built according to the growth of completeness, problematicity, concreteness, novelty, vitality, practicality, interdisciplinarity, creativity, reflection and self-evaluation, examination and agreement, the need to combine the fundamental and practical knowledge was carried out on the basis of the system of training tasks (Tolingerova 1970).

To monitor the formation of informatics competencies, case study methods, surveys, testing and construction recommendations were used.

Results-Based Monitoring and Evaluation System (Kusek 2004).

Methods. The analysis of the global sources of research topic, especially teaching Z-generation children, testing and interviewing students and teachers, statistical methods to process the results have been applied.

The research was conducted based on the TOTE (Delaney 2013) model according to the proposed stages:

1. *Test*: determine the current state of the ICT competence of secondary school graduates;
2. *Operate*: the development of an ICT competence model of students in learning computer science;
3. *Test*: students' ICT-competence formation re-assessment;
4. *Exit*: recommendations for ICT competence forming.

Monitoring at each stage of the study was carried out in accordance with the specified stages (Fig. 1).

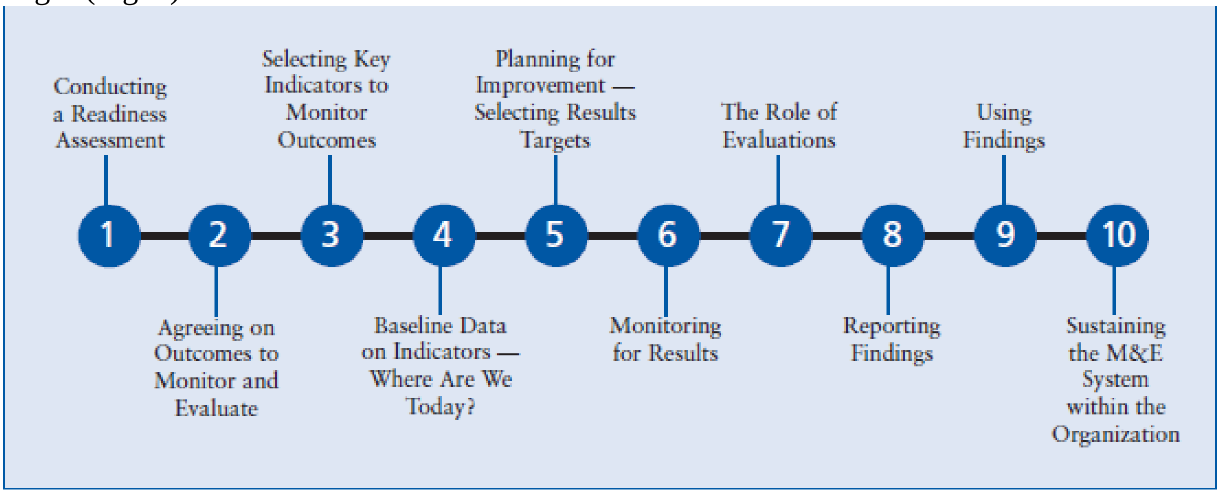

Fig. 1. Stages of monitoring research (Kusek 2004)

The Presentation of the Main Research and Results. In the first stage a *Tests were* conducted to evaluate secondary schools graduates' skills of information and communication technologies (ICT), its use in solving everyday problems and subject problems and soft skills possession. The evaluation covered more than 1,200 students from all regions of Ukraine.

The purpose of this phase was to determine: the readiness to use ICT by graduates for solving unusual practice-oriented learning objectives and tasks of everyday life; formation in the graduates of the 21st century skills.

Conditions of conduction. Monitoring studies in all regions of Ukraine were held based on the same objectives and established procedure, online and through the use of cloud technologies (Microsoft Azure).

The students were asked to solve one competency problem and send its solution and relevant explanation to the server. The proposed objectives were based on the approach used in the PISA (Wheater 2013-2014) in terms of ICT use.

In particular a) reading, understanding and interpretation of the various texts on technology with which they probably will deal in their daily lives; b) the use of knowledge and skills in mathematics to solve different life challenges and problems related to mathematics and where appropriate is to apply ICT; c) solve practical problems of life with which students face every day (ticket purchase, directions, etc.) and are associated with the use of modern devices and technologies; d) resolving financial situations and employment, in which you want to apply effective search or data processing by a computer etc.

The research monitoring *tools* included training materials, contents, criteria and indicators of evaluating its results. For the assessment developed were specific criteria that can be attributed to formative assessment.

To *check* the ICT competence formation based on the proposed complex tasks special tools of formative assessment were developed via which students and teachers had an opportunity to check the accuracy of their solution.

Along with monitoring the students' ICT competence formation, the research to determine the readiness of computer science teachers to the development of students' ICT competence was conducted.

Evaluation of the results involved two groups of indicators: the level of students' achievements in computer science (hard skills) and the level of soft skills were evaluated. At this stage aanalysis of the tasks results showed (Morze 2010) that over 50% of students had not formed the information competence, that belong to table 1:

– access to the information: they can’t exclude inappropriate and non-essential information (53%);
– evaluation of the information: they are not able to correctly identify the required input and output data and their number (53, 5%); they are not able to explain the criteria for the selection of results (67,78%);
– creation of information: they can not substantiate the choice of the form of submission of the result (63,39%); they are not able to choose the right way to submit information for solving a task (79,61%); they do not understand the purpose of diagrams of different types, can’t knowingly choose the type of chart and to argue their choice (60.14%);
– information management: can’t submit information in visual form for comparison (64.90%); not able to take into account the features of the appointment of the final document (56,93%);
– information messages: they can’t summarize and logically correctly formulate conclusions about the results (71.53%); Can’t substantiate their conclusions (62.41%); not able to structure the created document in order to increase the persuasiveness of the findings (66.41%); not able to formalize their thoughts correctly, correctly to construct sentences (59.12%);
– integration of information: not developed critical thinking (68,03%).

At the second stage of the research (*Operate*) the authors developed a model of students’ ICT competence (Morze 2015), a system of competency tasks to implement a transcendent training in computer science, built on the basis of case studies and developed training materials for teachers.

It was investigated that students' IC-competence is formed by three factors:

1) formal, which is connected with the teaching of computer science, the result of which is the formation of subject competence;

2) informal, which is associated with the formation of IC-competence as a key cross-cutting competence in the study of academic disciplines:

3) non formal related to the life competence, which is formed under the influence of the information society and active participation in his life.

In each of the factors, the authors will distinguish three stages of formation of IC competence (Table 2).

Table 2

Model of formation of IC-competence

Factors	Stages		
	Primary	Basic Formation	Applying
Formal	•apply transparent competency-based tasks; • using the ICT environments studied under the program; • tips and examples are available	• using complex competency tasks; • using multiple environments; the basis - the environment being studied by the program; • availability of options; need to justify the choice of the student	• plan and hold projects; • with a free choice of environment; • lack of tips; Only the evaluation criteria are given
Informal	• studying is accompanied by the use of ICT; • during school studies students use ICT to search and present facts; • students use existing knowledge and skills in using ICT	• the solution of objective tasks necessarily involves the independent use of ICT; • students use IC to analysis of data and to find a solution to complex subject tasks; • students use IC tools according to the suggested instructions	• solving creative tasks and projects using ICT; • students use IC to create data and evaluate their effectiveness; • Students independently select

			IC to solve their tasks
Non formal	• students use IC technologies in life situations that are similar to training	• students evaluate how to use IC to improve their own lives	• students can recommend ICs to resolve life situations

The authors created manuals for computer science students of 5-9 grades, containing examples of competency tasks. Methodological support of teachers on student instruction according to the authors conception was carried through blogs, including https://inf5-m.blogspot.com . As a result of this phase of the research, competence objectives included ICT competence formation and soft skills development.

For the third phase of the research (*Test*) the control group was elected, which included students of grades 5-8 who have been selected by a questionnaire at the authors' blog of computer science learning. The total number of participants comprise 120. During the 2015-2016, students were learning computer science projected by the authors' model of ICT competencies formation and were subject to formative assessment, based on competency tasks similar to the tasks of the first phase.

Here is an example of a competency task and indicators for measuring IC competency (Table 3) in accordance with the criteria proposed by the authors of the evaluation criteria (Table 1) and taking into account ISTE standards (Fig. 2).

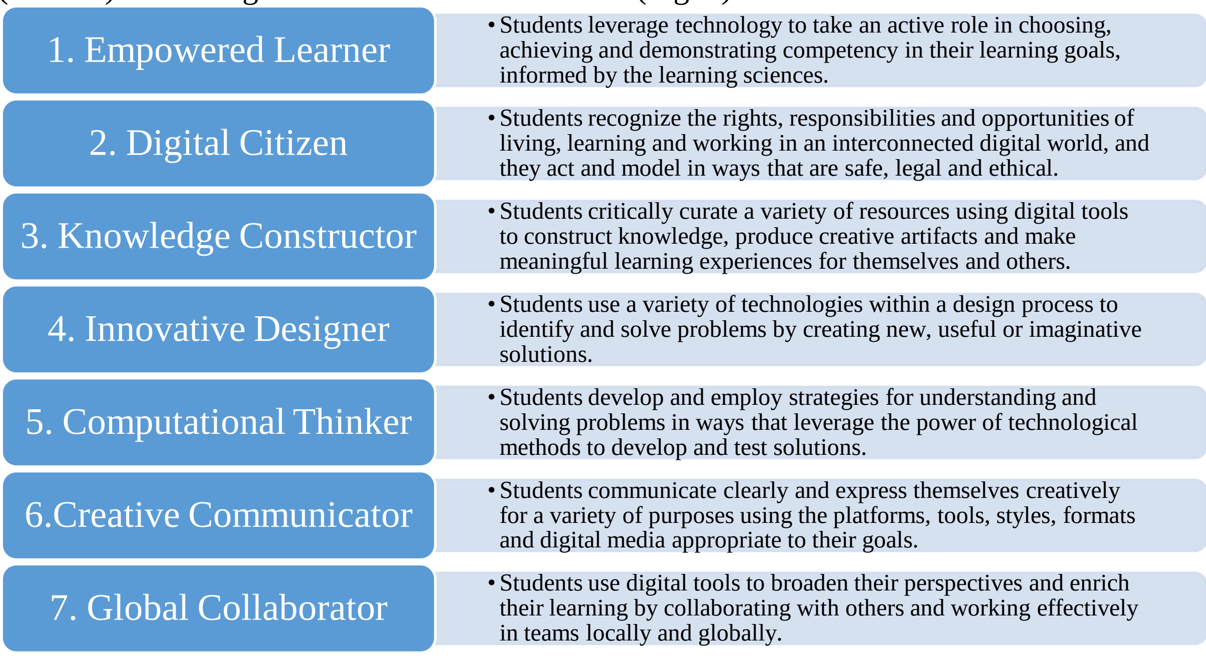

Fig. 2. Categories and criteria for ISTE indicators

Problem specification: *For the extracurricular event "Seven Wonders of Ukraine", you and your classmates were preparing presentation about Arboretum Sofiyivka. Having learned from the Internet about the history of the park and looking at the park map, photos and videos, the students offered a classmate to visit this park with their class.*

To make a trip you need to calculate its estimate - to determine the fare, incoming tickets and additional services offered to visitors to the park. A class manager offered to rent a school bus for a trip. At the same time it is possible to pay only the cost of petrol at the rate: the school bus "Bogdan" for 100 km spends 19 liters of diesel petrol.

You and your classmates Stepan, Ivan, Mary and Peter were instructed to make calculations using a spreadsheet and send them by e-mail to the classmate and class students.

Table 3

Competency Task and Indicators of Measurement of IC Competence

Content of the task	Indicator Code (table.1)	Indicator code ISTE standards (fig. 2)	Indicator
Situation 1. Budgeting. *To organize the trip, you must first plan the costs: determine the fare, incoming tickets and additional services offered to visitors to the park. You and your classmates have decided to distribute roles and use information from the Internet to plan the alleged items of expenses*	**DfAcE**	1.A	articulate and set personal learning goals, develop strategies leveraging technology to achieve them and reflect on the learning process itself to improve learning outcomes.
		3.A	plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.
		5. B	collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.
		5.C	break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving.
		7.D	explore local and global issues and use collaborative technologies to work with others to investigate solutions.
Situation 2. Determination of distance and route planning. *Your classmate Ivanna determined the distance from your living place to Sofiyivka Park using an online map. With the help of the same map, she proposed to build a route for the bus driver*	**AcEAdC**	2B	engage in positive, safe, legal and ethical behavior when using technology, including social interactions online or when using networked devices.
		4.A	know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
		3.D	build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.
Situation 3. Determination of the cost of the travelling. *To determine the cost of travel, provided that the school bus Bogdan spends about 19 liters of diesel fuel on 100 km, Stepan used a table processor.*	**DfEIAdC**	4.B	select and use digital tools to plan and manage a design process that considers design constraints and calculated risks.
Situation 4. Additional services.	**DfEAdIC Dl**	3.B	evaluate the accuracy, perspective, credibility and relevance of information, media, data or

To determine which additional services offered to visitors to the arboretum, would like to use your classmates, you took a poll and created a data table. For the analysis of results Mary and Peter built diagrams by means of the table processor			other resources.
		3.C	curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions.
		4.C	develop, test and refine prototypes as part of a cyclical design process.
		6.C	communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.
Situation 5. Estimation. *To organize a trip to Sofiyivka, you were instructed to make an estimate for 14 teachers and class students. The cost, in addition to transportation costs, consists of the cost of incoming tickets, an order for excursion and additional expenses: boat riding, catamaran, photography, etc. What are the calculations you are planning to implement by means of the table processor. In this case, you assume that the number of pupils, the cost of incoming tickets and additional services may change.*	**DfAcEAdI**	1.D	understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.
		4.D	exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.
		5.A	formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions
		5.D	understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.
		6.B	create original works or responsibly repurpose or remix digital resources into new creations.
Situation 6. Travel Agreements. *For approval the trip, you and your classmates decided to collect all the materials and documents you have created and discuss the benefits of using the table processor when planning a trip.*	**EAdCDl**	1.C	use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.
		2.C	demonstrate an understanding of and respect for the rights and obligations of using and sharing intellectual property.
		2.A	cultivate and manage their digital identity and reputation and are aware of the permanence of their actions in the digital world.
		6.A	choose the appropriate platforms and tools for meeting the desired objectives of their creation or communication.
		7.C	contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal.

The objective of this phase was to determine the effectiveness of the proposed model, factors of ICT competence formation for students of all ages and influence of the proposed method to general learning outcomes for students in computer science and other subjects.

The effectiveness of the author's technique was determined by observations charts of the educational achievements of students, their results were displayed by Google analytics.

Overall results of experimental studies confirmed the effectiveness of the proposed model, while negative values of indicators forming the students' ICT competence decreased on average by 34% (fig. 3).

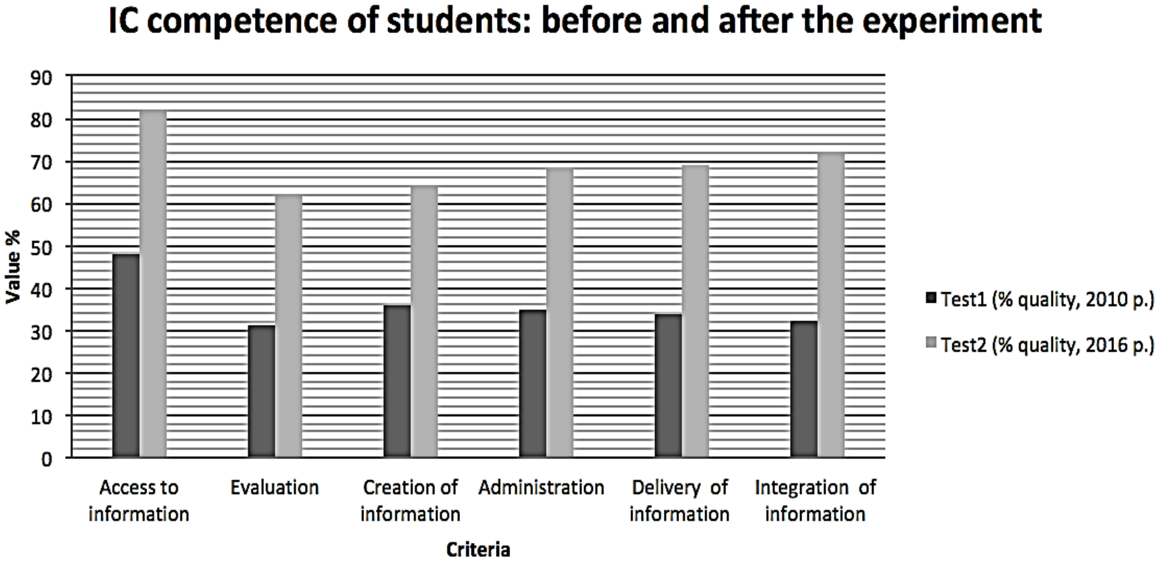

Fig. 3. IC competence of students: before and after the experiment

Discussion and Conclusion. The results determined the impact of these factors on the formation of the ICT competence:

- *way of formation*: a level of IT competence of the participants was higher by 32%, for which the formation of competences through grades 3-6 was carried out by solving proposed comprehensive competence problems within the study of program material for each academic topic, and grade 7-8 - integrated competence task upon completion of program blocks;

- *method of formation*: using the method of projects and method of expedient tasks selection increases the level of ICT competence of students by 14%, compared with explanatory reproductive and partially-search methods;

- *form of assisstance*: presentation of structured data in the form of sub-tasks, checklists, tables of assignment fulfillment increase the level of mastery of ICT competence by 28% compared with description of the problems solving plan.

Questioning teachers whose students participated in the study have found the following factors influence on results of students acquiring ICT competence formation: level of methodological support of teachers and their professional skills on the subject; teacher's use of the innovative tools to support learning activities of students, including e-learning, flipped classroom, project method; students involvement to community activities in solving the problems of educational activity and life.

As the consequences for the interpretation, the authors' proposed a model for large-scale implementation (*Exit*) for discussion, in particular through a series of Web 2.0 services that authors use for methodological support of computer science teaching.

This experience can be implemented in Europe, where students have demonstrated low results in the study of PISA, and post-Soviet countries where the problem of lacking of ICT-competence formation and soft skills development are relevant.

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