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Informatization of technical vocational schools: Theoretical foundations and practical approaches

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Abstract
The aim of this study was an experimental research in vocational schools intended to the development of the system of educational process informatization taking into account the structure of the ICT competence of skilled workers and the trends of the information society. Representative sample of over 800 students of 10 vocational schools from different regions of Ukraine, 80 teachers, 17 specialists of VET centers allowed to study and analyze the state of informatization of VET schools, as well as to determine the degree of influence of education informatization on the quality of workers' training. The system of educational process informatization at a technical vocational school, i.e. the creation of the ICT-saturated educational environment was implemented. This is a set of interrelated activities that comprise learning management systems; information and analytical databases; computer simulation of professional actions; programs of control of knowledge; application of ICT for writing diploma papers; computer methods of competence diagnostics; simulation training complexes; expert and decision support systems. The experiment showed that the use of the developed methods of skilled workers' informational training, of applying pedagogical software tools at technical vocational school and of training vocational school teachers how to use ICT contributes to the improvement of graduates' professional competence.

Keywords ICT competence · ICT-saturated educational environment · Informatization of VET · Learning management system · Technical vocational schools

1 Introduction

The socioeconomic transformations taking place in Ukraine, the processes of globalization and integration into the world community, and the desire of this country to

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become an equal member of the international community place the urgent need to upgrade the educational system, in particular, vocational one. The society requires competent specialists who combine fundamental knowledge and thorough practical training, who are ready to work rationally in complex, unpredictable situations of an industry. Thereby, vocational education should take into account modern demands of labor market, advance the technical reconstruction of industry, and integrate closely with science and production (OECD 2001). The task of vocational education and training (VET) in these conditions is to ensure young people's training for contemporary and future labor markets, to focus on the needs of leading enterprises, and to guarantee the vocational school leavers the competitiveness of the received worker qualification. It presupposes rethinking the structure and content of training at vocational schools, the introduction of multilevel educational process, the use of advanced forms and methods of vocational education, especially while training workers and specialists for high-tech industries.

Nowadays professional activities in the industry are associated with the collection, processing and use of a wide range of information. The production task of the workers is inherent in increasing the share of intellectual labor, processing the information, as well as generating and using new ideas (International Society for Technology in Education 2000). Innovative technologies in the industry are mainly aimed at informatization of production processes. There is a growing need for highly skilled workers able to master these technologies in a short time.

The generalization of the practice of informatization of the VET system and the analysis of the current state of this process in the scientific literature made it possible to identify the main contradiction – between the orientation of educational institutions towards the solution of the current problems of informatization (implementation of ICT into the educational process, training of students in computer literacy – (Anderson et al. 2002; Li et al. 2006) and the urgent needs of determining theoretical foundations of the process of vocational schools informatization, perspectives and strategies for the development of the educational system in the information society, and the formation of a unified informational and educational space (Coughlin 1999; Dexter et al. 2000; Jonassen 1996; Knierzinger et al. 2002; Livingstone 2012; Schacter 1999). Obviously, the extensive way of VET informatization has exhausted itself: the saturation of institutions with computers does not lead to an increase in the quality of specialists' training; the introduction of new ICTs into the educational process is obstructed by the unpreparedness of the pedagogical staff in VET; the developing potential of ICT remains unrealized; consequently, the workers' information training does not meet the demands of employers.

1.1 Theoretical considerations: Concept of the research

The theoretical basis of the research includes the concept of the information society (D. Bell, J. F. Lyotard, H. M. McLuhan, Yo. Masuda, J. Naisbitt, A. Toffler, etc.); the provisions of the theory of information (L. Brillouin, N. Wiener, W. Ashby, H. Haken, C. Shannon); the theory of cognitive (R. Atkinson, J. Bruner) and programmed learning (B. Skinner). At the same time theoretical developments and conceptual methodical approaches towards the process of education informatization have considerable divergences. The theoretical foundations and features of organizational and methodical

support of future workers' training by means of ICTs are not well studied. That is why informatization at vocational schools requires a fundamental restructuring of the content, methods and organizational forms of training, bringing them closer to the real production needs by creating an ICT educational environment to provide learning interaction between students, teachers and ICT tools, as well as the formation of future specialists' cognitive activity. The key issue of educational institutions informatization is the development and implementation of electronic educational and method complexes which combine computer versions of the courses, the database of visual support of the educational process, virtual laboratory workshops, control systems (Ghaleb 2014; Pegalajar 2018; Troter and Ellison 2001), etc.

The concept of the research determines the theoretical foundations and practical approaches to educational process informatization at technical vocational school and contains the following statements:

The strategic task of the education system under the conditions of the information society is to accelerate positive transformations, providing intellectual resources and scientific developments with the informatization of all the spheres of human activity. The challenge of nowadays is to create a holistic computer network of education and science, to develop a system of individualized longlife education based on computer technologies (Cuban 2001; Fuchs and Woessmann 2005; Papert 1997).

According to the person-oriented paradigm of education, the educational process is directed as much as possible towards the formation of a well-developed, self-sufficient person adapted to rapidly changing realities. One of the key competences of a specialist of the twenty-first century is the ICT competence, which implies the ability to navigate in the information space, to operate information data based on the use of modern ICT in accordance with the needs of the labor market for the effective performance of professional duties (Ashworth and Saxton 1991; Cuban 2001).

The informative training of the individual is based on the unity and interdependence of the content, technological and diagnostic functions of all the structural components of the education system (Christmann et al. 1997; Lehtinen et al. 1998; McCoy 1996; Reed 1996; Research Report 2000). By improving the general and professional training of specialists, it is necessary to take into account the development of information flows, methods and means of their processing and possible ways of their accounting in the content of education.

Education informatization involves the introduction of new technical means, the improvement of teaching methods and technologies, and the involvement of modern computer and telecommunication equipment and software tools in the educational process. The introduction and application of ICT in vocational training should be carried out as a didactically grounded, scientifically organized, managed, system process (Markauskaitė 2003). Under these conditions, it becomes possible: to realize a powerful ICT potential in order to present and process the training information, acquire solid knowledge, skills and abilities; to evaluate the results of the students' training effectively; to simulate educational situations related to production activity; to use automated educational systems, pedagogical software tools, systems of artificial intelligence, virtual reality; to control technological processes in the workers' professional training automatically.

To solve the complex problems of vocational technical education, it is advisable to increase the efficiency and productivity of the educational process, to reduce the waste

of time, to minimize the routine, non-creative work of pupils and teachers, and to provide an individual approach, interactivity, and reliable feedback in pedagogical interaction (Pelekh 2009). Thereby, it is appropriate to create an information environment capable of implementing the potential of the latest technologies, as well as eliminating the difficulties associated with their implementation.

Improving the efficiency of skilled workers' training requires the creation of a new didactic system based on ICT, viz., updated content, organizational forms, methods and means of teaching all the subjects, taking into account the state of informatization in the industry; design, maintenance, adjustment and management of the educational process, oriented on the creative level of educational activity of students and teachers and the specifics of using industrial ICT; widespread use of computer-based learning technologies, intensification of all the components of vocational training on this basis. Comprehensive informatization of the educational process (Cotton 1992; Lehtinen et al. 1998; Liao 1998; Reed 1996; Research Report 2000) will allow teachers to coordinate the students' learning activities, to organize and provide proper training of specialists in accordance with the national framework of qualifications and new standards of VET and labor market requirements taking into account the information model of production.

1.2 Problem of research

The rapid development of information and communication technologies at the end of the twentieth century led to the transition to a new social formation, which, in turn, caused the significant changes in social life, connected with the cultural and educational development of a personality. The main task is the informatization of the educational process which allows preparing a person for a full-fledged life in conditions of modern globalization of the world community, productive use of information and knowledge on the basis of computer technology and telecommunication facilities. The informatization of the educational process in pedagogy is considered as the use of ICT, which is the procedural component of computer-oriented pedagogical technologies. Qualitative education is impossible without ICT, their implementation in the field of scientific research and education (Anderson et al. 2002; Andresen and van den Brink 2002; Ashworth and Saxton 1991; Shapiro and Hughes 1996). The investigation of theoretical principles of education informatization proves that informatization stipulates creating the integrated informative and educational environment, which will provide availability and efficiency of the use, integration and standardization of informative and educational resources for all the levels and types of education. Informatization of education is a purposeful process of providing the system of education with methodology, technology and practice of creation and the optimal use of scientific and pedagogical, educational and methodical, programmatic and technological elaborations oriented to the realization of psychological and pedagogical possibilities of ICT.

It should be noted that VET informatization takes place mainly elementally, without taking into account the objective needs and achieved level of introduction of the newest technologies. Therefore the purpose of our study is to determine theoretical foundations and suggest an experimentally tested model, pedagogical conditions and methodical provisions of the educational process informatization in technical vocational schools as a pedagogical system that ensures the improvement of the quality of skilled workers' training.

Modern ICT integrate the achievements of technology, design, content of the subject and teaching methods, and include a large number of different hardware and software, and the unified classification of which does not exist. The main types of computer-oriented educational systems include: mentoring, training, simulation, control, reference and information ones. Most of these systems are interconnected, and computer training programs contain various elements. The potential of ICT application while teaching and learning is determined by speed and reliability of information processing, enhancement of its presentation, design of different processes and phenomena, activation, individualization and differentiation of learning, formation of conditions for organizing independent educational activity, communication facilitation, and creative approach development. Informatization allows to modernize aims, contents, methods, means and organizational forms of teaching and learning; to facilitate the development of students' individual abilities and their personal qualities; to promote forming their cognitive abilities and aspiration for self-perfection; to provide the integrity of studying the phenomena of reality, indissoluble intercommunication between natural and technical sciences, the humanities and art; permanent dynamic upgrade of the content, forms and methods of teaching and learning. It is an urgent problem not only for this country but for other countries as well.

1.3 Research focus

Taking into account the benefits of ICT mentioned in the theoretical foundations of the study, it becomes evident the need to create electronic versions of courses for certain subjects and databases (banks) of visual support of the educational process. Automated training systems, networked learning, interactive simulators are an integral part of the educational technologies of developed countries. It has been proved that ICT contribute to the formation of the intelligence of the individual, encourage person to study and act creatively. Professional training by electronic means is significantly more effective than traditional methods, since it allows one to choose an individual educational trajectory, to regulate the rate of learning, to take into account the wide range of students' individual characteristics. The advantage of ICT to other technical means is that they are informational, educational and monitoring tools at the same time.

The growth of the social role of information in the life of society necessitates the definition of the principles of using ICT in vocational education. Hence, it is important to form a holistic information base, to substantiate and select forward-looking information from the areas of professional training, to structure and create a bank of professionally meaningful information transformed into the content of education.

Current theories of the stuff's training and development show that increasing the level of visibility due to multimedia of ICT develops spatial imagination, imaginative thinking, promotes active learning, and acquiring practical skills. The quality of future specialists' knowledge increases due to the fact that the information is presented in a concentrated and adapted form. However, the positive features of working with ICT (Christmann et al. 1997; Lehtinen et al. 1998; McCoy 1996; Research Report 2000) are accompanied by certain negative aspects (Sinko and Lehtinen 1999) associated with the additional risks to students' health. It requires certain measures to ensure the students'

safety including standardization and implementation of sanitary, hygienic, psychological and pedagogical requirements, as well as norms for technical and software tools.

Education informatization aims at wide and effective introduction and application of ICT while performing educational, scientific and management functions, inherent to educational industry (Bykov 2008). From these positions ***the tasks*** of informatization of an educational establishment in the system of VET were analyzed, in particular – to teach and master basic principles of informatics; to develop students' algorithmic style and culture of thinking; to capture general means of informatization, to form abilities and skills of working on the PC, to master methods of working with ICT; to study and master methods and facilities of using modern ICT in accordance with the needs of future professional activity; to actualize professional knowledge, abilities, and skills taking into account the possibilities of ICT; to form abilities and skills of planning ICT resources that are necessary for carrying out professional tasks; to develop communicative abilities and skills of collective work; to acquaint with modern methods of scientific and research and project activities in a professional area. ***Functions*** of informatization at vocational schools are the following: instrumental, informing, compensatory, motivational, individualizing, adaptive, integrative, control and diagnostic, designing, prognostic, and administrative ones. The tasks and functions of informatization are interconnected and directed at forming ICT competence as an obligatory component of a specialist's professional training.

The basic notions of informative component of professional activity are computer literacy, ICT competence and information culture. Computer literacy is defined as mastering a certain amount of intellectual and practical knowledge and skills necessary for the successful use of computer technology in a variety of activities. A specialist's ICT competence is a personality's integrative professional quality, which represents a person's capacity for determination of informative needs, search for the information and effective work with it, as well as, with computers and telecommunication technologies in professional activity and everyday life. ICT competence foresee an ability of a person to orient in the informative space, to use information data from modern informative and communication technologies in accordance with the needs of labor-market to perform professional duties effectively. For students of vocational schools ICT competence means formed abilities and skills to use ICT for learning (Ashworth and Saxton 1991; Cuban 2001). A personality's information culture is an integrity of informative world outlook, value orientations system, knowledge, abilities and skills which provide purposeful and effective independent activity aimed at satisfying own and professional needs in informative products.

Informatization of education is directed at the development of the intellectual potential of the nation, the improvement of the forms and content of the educational process, the implementation of ICT and computer-based learning methods. To increase the productivity and effectiveness of professional training, it is necessary to determine the ways of purposeful formation of the informational and educational environment, which allows to use the functions of ICT to the limits, contributes to the students' independence, the intensification of the acquisition of theoretical material and the development of practical skills in the field of professional activity. Unsolicited, unsystematic use of ICT in vocational training will not produce the desired result.

2 Methodology of research

2.1 General background

The research covered all the students studying at construction vocational schools in Ukraine (i.e. the population of the study). The experimental research was carried out on the basis of a number of construction vocational schools in different regions of Ukraine (Ivano-Frankivsk, Lviv, Rivne, and Ternopil regions) during the 2015–16 and 2016–17 academic years. This research was focused on the analysis and experimental verification of the effectiveness of the developed system of vocational education informatization (on the example of construction vocational schools). More specifically, the experiment was aimed at fulfilling the following objectives:

1) To examine and analyze the state of VET informatization.
2) To determine the degree of influence of informatization of education on the quality of future workers' professional-theoretical and professional-practical training.
3) To check whether there are statistically significant differences in the ICT competence of students enrolled in the author's method and in the traditional training.

2.2 Sample

The research target group consisted of more than 800 graduate students of technical vocational schools, 80 teachers of Informatics and professionally oriented subjects, and 17 specialists of Training and Methodological centers of VET. To carry on the research, a random students' sample of technical vocational schools was used.

The participant sample was calculated by the formula:

$$n = \frac{t_{0^2} \cdot \sigma^2 \cdot N}{t_{0^2}\sigma^2 + \varepsilon_{\bar{x}}^2 \cdot N},$$

where: t_0 – critical deviation from the average rating score (according to the tables of values, equal to 2.0, with a probability level of .95); σ – standard deviation (calculated according to the data of the previous sampling experiment); ε_x – marginal error (taken equal to .05); N – total sample (60,249 people – all students of 178 vocational schools according to the Ministry of Education and Science of Ukraine, operating according to the industrial direction "construction". Sample distribution by variables chosen in total was 402 students of experimental groups and 397 students of control groups. Therefore, the research sample is presentable and reliable.

2.3 Instrument and procedures

The methodology of the experiment was developed, grouped under three core dimensions:

1) The level of informatization of experimental and control educational institutions according to the qualimetric approach.

2) The quality of construction workers' training, namely, the completeness and strength of students' mastery of professional knowledge and skills.
3) The level of graduates' ICT competence.

First of all, for the complex measurement of the informatization of the educational process in the vocational schools of a technical (namely, construction) profile, the developed factor-criterion quali-metric model (Lytvyn 2011) was used. The main factors of the informatization of the educational institution were the pedagogical conditions determined in the research, detailed by 33 indicators. The value of these indicators was adjudicated with the help of an expert group. In order to assess the level of informatization of a particular vocational school, real indicators were substituted into the developed table, their sum was calculated, and the degree of compliance to an ideal state was determined.

The quality of workers-builders' training was determined by a comprehensive comparison of the educational success of control and experimental groups of students. The control measurements were carried out in the final lessons in order to determine the achieved level of theoretical knowledge (20 test tasks) and practical skills (5 tasks) of future builders and its compliance with the state standards of vocational education. The effectiveness of ICT was determined by the formula:

$$E_{ICT} = \frac{\Sigma_e - \Sigma_k}{\Sigma_k},$$

where: E_{ICT} – the effectiveness of ICT training, Σ_e – the sum of marks (points) received by the students of the experimental groups on the results of learning using ICT; Σ_k – sum of marks (points) received by students of control groups.

The level of ICT competence of future builders was studied at the time of graduation. For this purpose, a set of IC criteria was used, which allow to determine the formation of various aspects of a specialist's readiness to use ICT in professional activities with the help of the expert method. For each criterion, indicators were chosen, the generalized values of which corresponded to the high, average, low or insufficient level of specialists' ICT competence. The consistency of the experts' opinions was verified by calculating the correlation connection of the results determined by them.

Overall, this instrument met all quality criteria. The experts' evaluations showed that items were correct and appropriate.

2.4 Data analysis

The analysis of the collected data was performed using the packet STATISTICA 10.0, carrying out analyses with a level of $p < .05$. Thus, the Pearson's r was used to detect the degree of correspondence of the scale of the data of informatization at technical vocational schools, as well as to verify the unanimity of experts' opinions regarding indicators of graduates' ICT competence. Besides, a Students' t-test (comparing the means of two independent samples) was conducted in order to demonstrate the presence or absence of statistically significant differences between the training of students who studied under the experimental model and methods, and students who studied without them. The comparison of the level of academic success was carried out

according to the quality parameters (completeness, thoroughness, awareness, etc.) of both theoretical and practical professional knowledge. If the calculated *p value* is .05, the difference is statistically significant.

3 Results of research

3.1 The ways of ICT application in professional training

Modern industrial production is characterized by a dynamic upgrade of the equipment and materials, an increase in the quality of work, an acceleration of the products design, an increase of their reliability and durability, and the energy efficiency of works. It is impossible to achieve it without paying due attention to innovations in production technologies, as well as without introducing new professions, changes in the content of professional activities and qualifications of employees. Pedagogical technologies based on information systems and focused on the development of professional competence may solve the contradiction between the level of professional training of labor personnel and the requirements of employers to its quality The development and implementation of ICT at all the stages of the educational process, in particular, during educational and production training, contributes to the implementation of the main strategic goals, principles and objectives of the development of technical education.

The information society requires workers adapted to the rapidly changing reality, capable of perceiving life, orienting in it, understanding problem situations and finding rational ways to solve them. ICT competence which is based on awareness of the role of information in the society, knowledge of the laws of the information environment and understanding of its place in it and manifests itself in solving various professional and other tasks using information technologies and tools, is one of the key competences of a modern specialist.

The objects of professional activity of qualified workers today are connected with information and communication processes and systems, and ICT become the means of work. The ICT competence is necessary for workers while working with production papers, operating the newest technique, etc. The on-line tutorials of architectural and technical (industrial) faculties of higher educational institutions are aimed indeed at studying the computer programs of 3D design and CAD/CADD (*computer-aided design and drafting*). It allows the future engineers to learn how to work with information (including traced) with the purpose of the planning, preparation of documents, constructions, development of engineering networks and systems, as well as production process management. Modern building industry needs integral planning of a technical object, when a change of some of its parameters leads to an automatic change of the other ones, up to the drafts, specifications and schedule of works. Such an approach is called information modeling of production that is a concept of the integral planning of a technical object with the help of ICT, when a change of some of its parameters leads to an automatic change of the other ones up to the drafts, specifications and schedule of works (Kymmell 2008). In our opinion, graduates from profile vocational schools must be told about the possibilities of information modeling. The

training of specialists in the technical field already involves the study of the basics of integrated design tools (technologies of CAD/CAM/CAE/PDM and CALS).

Skilled workers must know about basic possibilities and methods of using a computer in the industry, the basis of a computer design, and the possibility of using ICT in industrial work management. They also must know about the features and be able to choose special computer programs; to use technologies of the automated construction planning, and to know the methods of using a computer in organizing their work. Components of ICT competence of technical workers are the following: world outlook, user, algorithmic, and professionally directed ones (Hurevych 2004). Criteria of these component formation are motivational; cognitive; activity; operation; and creative one's life.

Informatization of the educational process concerns all its participants (students, teachers, educational managers, administration) and all the components (visual aids, textbooks, manuals, means of evaluation and control of the success of training, processes for the search, exchange and processing of information, preparation and use of teaching materials, solution of educational and applied tasks, laboratory workshops, etc.). Today, ICT have become a leading technical tool in traditional methods. Justification of rational directions of using ICT in the educational process is considered one of the most important pedagogical problems (Plomp 2003).

The conducted research of technical vocational schools allowed us to define four interdependent ***ways of ICT application*** (Lytvyn 2011):

- *Informatization of organizational and administrative activity at an educational institution:* automation system of managing an institution and network of vocational schools; organization of circulation of documents and financial reporting; creation of the students' and teachers' base data; planning of educational process taking into account the specifics of training for technical professions; development of informative and methodical support of an educational establishment of a technical type; organization of internal banks of data and systems of scientific and technical information; creation and permanent update of a web site; complex pedagogical testing and psycho-diagnostics of students; monitoring of quality of learning and employment of graduates.
- *Informatization of educational process:* introduction of "Information Technologies" subject into the process of workers' training; informatization of traditional forms of teaching and learning of different subjects; inclusion of themes related to the formation of abilities and skills in the area of ICT into the process of workers' training; usage of assessment software, automation of educational activity correction; computer design of different phenomena and processes, including industrial ones; intellectual means and educational environments.
- *Informatization of educational-production process:* visualization and design of industrial technological processes and production situations; development of professional abilities and skills with the help of imitation programs, trainers and simulators of a technical equipment; operation of laboratory equipment, as well as real units and sets with the help of PC; computerized control of professional and practical abilities and skills; fulfillment of project work by the specialized software.
- *Informatization of out-of-class activity:* students' and teachers' self-education and self-training with the help of ICT aimed at acquainting them with the achievements of industry; aesthetic development by means of ICT; application of developing

computer games; use of ICT in future workers' club work; organization of students' intellectual leisure time; etc.

ICT can be used in all the training cycles at all the stages of the learning process, but their effectiveness depends directly on the specific tasks of studying and the overall goal of future workers' training consistent with the general objectives and standards of education (Markauskaitė 2003). Telecommunication technologies penetrate all the areas of informatization, creating new opportunities for students and pedagogical staff in VET, occupying a significant place in the professional training of workers. The future belongs to multimedia applications of a single structure and method of use, each of which will contain the necessary amount of information on a specific subject, forming a system of multimedia professional education of a particular profile. The study of the directions of informatization of education as an innovation process shows that ICT by themselves does not affect the scope and depth of pedagogical innovations that are carried out with their help. The main role belongs to pedagogical staff (Dusick 1998; Sinko and Lehtinen 1999; Research Report 2000), who, while performing the purpose-setting function, adapt ICT to achieve the goals of professional training.

Informatization, as one of the main spheres of pedagogical innovations, introduces modern technical and scientific culture and tools from other branches of human activity into professional education (automated production and design, the latest methods of scientific research, informational service, etc.). Informatization changes the understanding of what the working places of a teacher and students, the ways of constructing the information environment, educational space, and the joint work of participants in the educational process should be like. In the process of informatization an effective system of managed development (upgrade) of educational institutions and educational process is formed (Wong and Li 2006). A full-scale transition to ICT, a rational combination of new technology with traditional learning is a complex pedagogical task that requires solving a complex of psychological, pedagogical, teaching, organizational, technical and other problems.

Educational process informatization at vocational schools is interpreted as the integral phenomenon, system of interconnected organizational, educational and methodical, technological, educational-production and administrative transformations, directed at satisfying informative, calculable, educational-designing and communicative needs of future workers, as well as at forming new culture of pedagogical activity. The informatization system includes students' informative training for professional activity under the conditions of informatization of industrial production and use of ICT in future workers' training.

Today informatization of education is considered as a process of creating a developed information educational environment. In pedagogical and psychological publications there are different variants of this category: "an information communication environment", "an information educational environment", "a computer oriented educational environment" (Bykov 2008). Often researchers do not distinguish between an "educational environment" concept, which refers, mainly, to educational establishment, and a considerably wider concept of "an information educational space" or "Infosphere". The purpose of forming of such a space is to provide certain educational needs and didactic aims which influence on the informative resource of an educational institution, its staff and structural features. Investigating informatization of vocational

and technical education, "an ICT-saturated educational environment" term was used, as it stresses the meaningfulness of using informative and communication technologies while studying subjects of different cycles, first of all, of professional and theoretical one, at vocational schools.

As the analysis shows, informatization of education, does not limit to the replacement of pedagogical technologies by analogical ones which are carried out with the use of ICT. Changing a range of forms and methods of educational work used at vocational schools in support of an ICT-saturated educational environment is one of the important features of the process of education informatization. An ICT-saturated educational environment is a complex of hardware, software, data bases which realize informative processes and proper didactic materials, methods, educational communication, as well as, connection and effective functioning of organizational structures of educational establishments. Such an environment is aimed at exposing, revealing and developing a person's abilities and potential possibilities; forming the conditions for self-education; providing assessment software into the educational process; compensating possible negative results of students' working with ICT. An ICT-saturated educational environment at an educational establishment can be a part of a regional informative and educational space of VET.

3.2 The system of vocational schools informatization

The informatization system reflects the structural and functional interaction of the directions of the use of ICT in the workers' professional training, the general and specific principles, and methodical aspects of information training, a set of criteria and indicators of the formation of a specialist's ICT competence.

For informatization of specialists' training at vocational schools, it is necessary to define, provide and realize certain ***pedagogical conditions*** which allow to manage the educational process effectively, to organize the educational process in accordance with the tasks, applying selected forms, methods, and techniques of ICT. The conditions of educational process informatization at technical vocational schools are the following (Lytvyn 2011):

- *Readiness of pedagogical staff for introducing ICT and complex informatization of educational process:* formed informative culture of teachers and the experience of informative activity; awareness of the necessity of introducing ICT into an educational process; ability to prevent possible risks and failings, inherent to ICT; knowledge of didactics principles, pedagogical theories and approaches; update of didactic, informative and special professional knowledge by means of ICT.
- *Continuous systematic informative training of future workers:* construction of the contents and structure of an educational process in accordance with the components of ICT competence; formation of future workers' informative abilities and communicative skills; students' free access of to the PC and sources of information; formation of students' motivation to use ICT and to intensive informative activity; effective management of cognitive activity using ICT; stimulation of future workers' creative activity.
- *Creation and permanent perfection of methodical and technical base of education informatization:* update of technopolis, networks organization with connection to

regional and global telecommunications; update of modern software, including specialized one; installation of computer trainers and simulators of industrial equipment; creation of an electronic library and informative databases of a technical type; installation of informative terminals; search for software, adaptation to the requirements of educational process, elaboration of own programs of computer-supported collaborative learning.

- *Integral scientifically grounded use of the complex of ICT application directions within the educational process:* coordinated introduction of ICT into different cycles; computer-integrated study of ICT in the process of training; combination of traditional and innovative methods and technologies of education; development of methods of organizing the educational process on the basis of ICT; modeling of processes of a industrial production, and diploma papers writing with the help of ICT.
- *Effective management of professional training informatization:* appointment of a leader and people responsible for the directions of ICT application; elaboration of the concept and program of informatization of an establishment; installation of specialized software for educational process control; assessment of ICT usage efficiency; monitoring of information component of workers' professional competence; collaboration with the network of technical establishments, as well as, with foreign partners in relation to introducing ICT into professional training.

Pedagogical conditions of informatization allow to effectively manage teaching and learning, to carry out educational process in accordance with its tasks, using selected forms and methods of ICT, a set of principles of informatization (conceptual and technological ones).

The process of informatization must be based on the complex of didactic principles, personality and activity approaches, programmable, module and problem education. In addition, a crucial factor is an experience of working with computer hardware and pedagogical workers' qualification. The use of ICT in the educational process, beyond doubt, needs developing vocational schools' infrastructure: to put computer hardware, facilities of network support, information terminals, educational and methodical techniques, and ICT technical support into operation, as well as to develop a strategy of equipping educational establishments with necessary teaching software. ICT must be used in all the cycles of training. The administration of vocational schools must elaborate a long-term program of informatization aimed at putting automation system of educational process management into operation. It enables to improve management effectiveness, productivity of workers' training due to providing a strong feed-back into the educational system. It also develops possibilities operatively to bring in the necessary corrections into the contents, methods and forms of vocational education, and allows to optimize the decision of complex problems of the methodical and technical provision of informatization while workers' professional training.

In continuously changing conditions teachers have to design and make the reality of new educational programs that take into account the last scientific achievements, are systematically self-perfected, constantly actualize the knowledge, renew methods, organizational forms and facilities of the work, and prepare students to the vital functions, the essence and problems of which are yet unable to define exactly (Cradler and Bridgforth 1996; Martin et al. 2002).

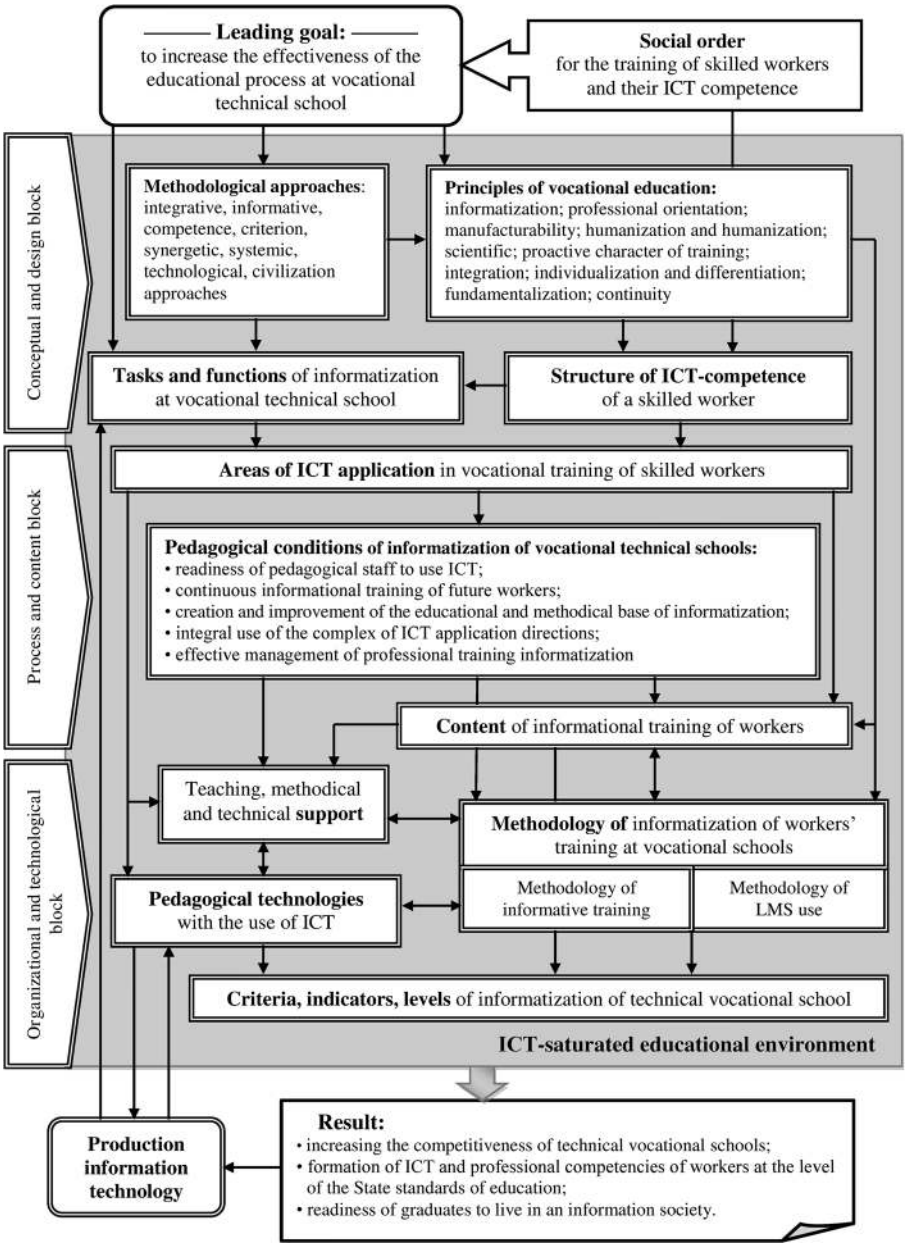

Fig. 1 The model of informatization of technical vocational schools

The theoretical and predictive model of the informatization of the educational process at technical vocational school (Fig. 1) is made on the basis of the general scientific methodology taking into account external and internal factors influencing the process of informatization. The choice of the optimal composition of the model was carried out by expert way, which allowed us to determine the objects and interrelations of the pedagogical system, that

significantly affect the qualitative characteristics, to form requirements to its components, taking into account the latest achievements of science, progressive psychological and pedagogical concepts.

According to the principle of integrity, the introduction of ICT into the technological subsystem of an educational institution causes radical changes in all the subsystems: didactic, organizational, methodical, managerial, productive ones, etc. It results in the use of integrative, informative, synergistic, and other approaches to the modeling of professional training.

The integrity of the model is provided by interconnected conceptual and design, process and content and organizational and technological blocks, which coordinate all the elements of the ICT-saturated educational environment of the educational institution. The *conceptual and design block* represents the source methodological and psychological and pedagogical positions of the process of informatization. The composition of the *process and content block* determines the peculiarities of the activity of educational institutions in the conditions of informatization and the structure of the ICT competence of the skilled worker. The *organizational and technological block* of the model reflects the material and technical and teaching and methodical base the informatization of the technical vocational school.

The implementation of the model involves the optimization of the content and structure of information training, the choice of appropriate ICT, the development of methodological support of the educational process, the coordination of efforts of pedagogical staff. An important element of the informatization model of the educational process at the technical vocational school is the *pedagogical technologies* with the use of ICT, through which integration of information and professional training is carried out.

The developed model of informatization of the educational process at the technical vocational school allows to identify the components of the informatization system, to identify the mechanisms of their interconnections and interactions, to holistically predict the process of specialists' training to use ICT in the educational and professional activities. The use of the informatization model at the vocational school helps to make the educational process more individual, to reduce irrational time expenditures, to minimize the non-functioning activity of teachers and students; it provides interactivity of training, and reliable feedback in pedagogical interaction.

As the basis of planning and organizing all the measures necessary for informatization process realization, the Conception of informatization of specialists' training at technical vocational schools was developed aiming at a complex solution of the problems connected with normative and legal, educational and methodical, organizational and financial provision of informatization at vocational schools (Lytvyn 2011). The *conceptual principles* of education informatization are the principles of priority, system, planning, phasing, standardization, directed development, complexity, project activity, culture conformity. Technological principles of informatization of vocational schools include the focus on the modern telecommunication systems, the maximum use of Internet resources, the use of standard solutions for the organization of hardware and software complexes at the local and regional levels.

For qualitative training of skilled workers, it is necessary to develop modern educational computer complexes, computer-oriented means to conduct laboratory and practical workshops, interactive multimedia pedagogical software tools, computer simulators, automated library systems, banks of up-to-date technical and production information, etc. It is important to create a global computer network of education and science, to develop a system of individual continuous learning based on automated training courses and programs, to develop an information and analytical system for managing vocational education as part of a nationwide information and analytical system of education management. The realization of the suggested conception takes place through the Educational and Methodical Centers of VET by means of planning and observance of "Flow sheet of informatization" of every education institutions.

3.3 Scientific and methodical provision of VET informatization

The scientific and methodical provision of informatization of VET was also planned and approbated; it includes a complex of organizational and methodical aspects. Informatization of vocational education affects all the components of the methods of future specialists' training, and the developed experimental scientific and methodical support contains two main parts: the methods of information training and the methods of the use of pedagogical software at the vocational school.

The tasks of the methods of information training are effective formation of ICT competence of future workers, taking into account the specifics of their further professional activity. The methods involves *the professionally directed teaching and learning of informatics at vocational schools* – the development of future specialists' thinking necessary for solving professional problems with the help of a computer, the ability to use ICT to obtain and process information, practical skills to perceive and use professional information, etc. The methods of *the development of general professional and professionally oriented informative abilities* is the widespread use of ICT in all the training cycles, which enables to develop students' ICT competence comprehensively. *The combination of traditional and innovative forms and methods of organizing educational process on the basis of ICT* is effective. The effectiveness of teaching is facilitated by the inclusion of ICT into innovative pedagogical technologies, the combination of network databases, various pedagogical software tools and automated training systems with traditional textbooks, teaching aids, reference books etc. ICT application actualizes *problem- and project-oriented methods of training workers using ICT.* In the process of problem learning, students develop skills of searching, obtaining information from different sources independently, and structuring knowledge. The design technology using ICT was used mainly while writing the diploma papers. Gaining experience of CAD using, future specialists will gain the skills of analyzing, processing and using professional information. *The workers' professional training by means of the Internet* provides for the comprehensive use of network technologies: search engines, information portals, teleconferences, postal mail, etc. (Coutinho and Alves 2010). Distributed resources allow professionals to access remote databases, information reference systems, libraries.

The *development and introduction of learning management system (LMS) for technical professions* – (in Ukrainian terminology – pedagogical software or e-leaning resources) promotes the increasing of the efficiency of professional training at technical vocational schools considerably. The advantages of LMS are the following: the use of graphic arts, video and audio accompaniment, the support of feed-back, the permanent test control, the searchability and navigation, compactness, and circulating simplicity. They must be functionally comfortable, evident, and interactive; they also must correspond to methodical rules, employers' demands, and foresee a possibility of bringing in additions and changes. LMS creation is facilitated by the specialized software (CourseBuilder and OnViz, Dazzler and Dazzler Deluxe, eLeaning of Suite, HyperStudio, LERSUS, Moodle, Quest and Designers Edge, Seminar, ToolBook II Assistant and ToolBook II Instructor) and programs for editing media (AutoRun Pro Enterprise, Authorware, Dreamweaver, NeoBook Professional, et.al.). For effective informatization of technical vocational schools it was offered to form electronic educational methodical complexes, which include various learning management systems and give the students and teachers necessary informative materials and educational functions. The content of the complex components is varied depending on the necessities of a subject and a type of workers' training.

The methods of *the computer oriented diagnostics of professional training quality* provides for the implementation of all the types of control at vocational school with the help of specially developed computer programs (in the form of LMS or individual), which allow to increase the objectivity, efficiency and timeliness of checking the results of training. The use of ICT to diagnose academic achievements, including professional skills through the management of virtual equipment, helps to create a single information base of all the results of each student's control, which ensures the use of this information for correcting and managing the workers' training. The *preparation of teachers and masters of production studies to use ICT at vocational schools* aims at developing informative culture of pedagogical staff, i.e. a system, multidimensional concept which includes a style of thinking and a system of values of an informative society; and provides the performance of professional activity in the informative educational environment and is the sign of professionalism, as well. The introduction of ICT enables teachers to update the content of teaching, to improve teaching methods, to increase interest and general motivation of students, to implement individualization of training, to provide access to information banks, to objectively perform the control and assessment of knowledge, practical skills and abilities of students, etc. Thereby, the continuous work is necessary to increase the information culture, professional development and self-improvement of the teaching staff of the vocational school. Another problem to solve is to realize step-by-step and continuous informative training of workers, to use ICT in general educational, general professional, professional and theoretical subjects and production studies, fixing it in the State standards of concrete professions. It was considered expedient to create and introduce innovative educational-production and pedagogical technologies on the basis of ICT in accordance with the needs of labor-market and features of different regions, to provide establishments of VET with the newest professionally applied teaching software.

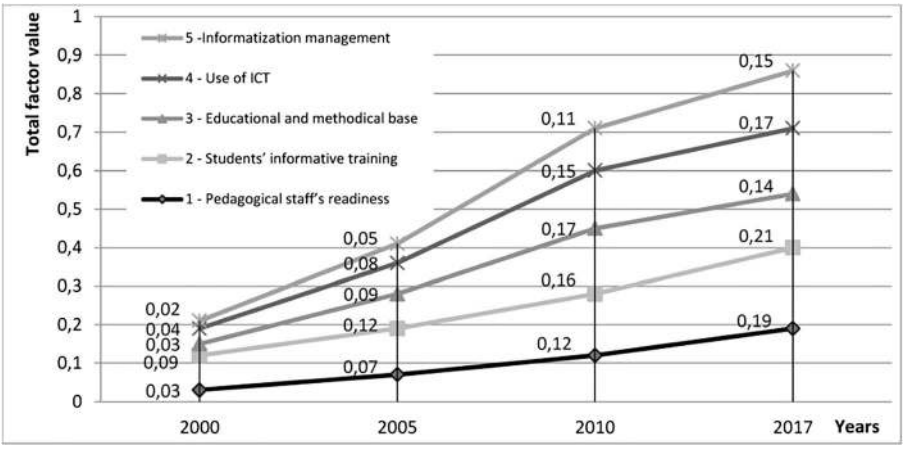

Fig. 2 The level of informatization of experimental vocational schools of construction type

3.4 Experimental verification of the effectiveness of vocational schools informatization

The substantial increase of graduates' professional qualification level and ICT competence as a result of complex informatization of professional training process at vocational schools is experimentally proved. Vocational schools of the construction type in different regions of Ukraine were selected for the experiment (Lytvyn 2011).

In order to comprehensively measure the efficiency of informatization, the factor-criteria qualimetry of educational institutions was used on the basis of the pedagogical conditions of informatization that were substantiated (Fig. 2).

As it can be seen in Fig. 2, the relative increase in the level of informatization of the educational process at the vocational schools of the construction type was most influenced by the increasing readiness of the teaching staff to use ICT in their activities, as well as the use of a combination of areas of ICT application. The comparison of the levels of informatization of experimental and control educational institutions testifies to the effectiveness of the implementation of the informatization of the educational process in the technical vocational school. In almost identical outcomes, the total estimate of informatization (total value of factors) of experimental vocational schools at the end of 2017 was .86 on average, in control ones it was only .72. The correlation between the data of experimental and control educational institutions was verified using the Pearson correlation coefficient.

As a result of the introduction of LMS into the training of construction workers, the ratio of the state of ICT use in training cycles has changed dramatically. In the experimental vocational schools, the information technology is most commonly used while teaching subjects of vocational and theoretical training (58%). There was a significant increase of the percentage of ICT use in the process of vocational training (24%).

The study of the influence of VET informatization on the level of assimilation of professional knowledge, skills and abilities was carried out with a sample that accurately presented the general population and constituted, according to the calculations, 402 students in the experimental group and 404 in the control groups. The comparison of the level of success was carried out according to quality parameters (completeness,

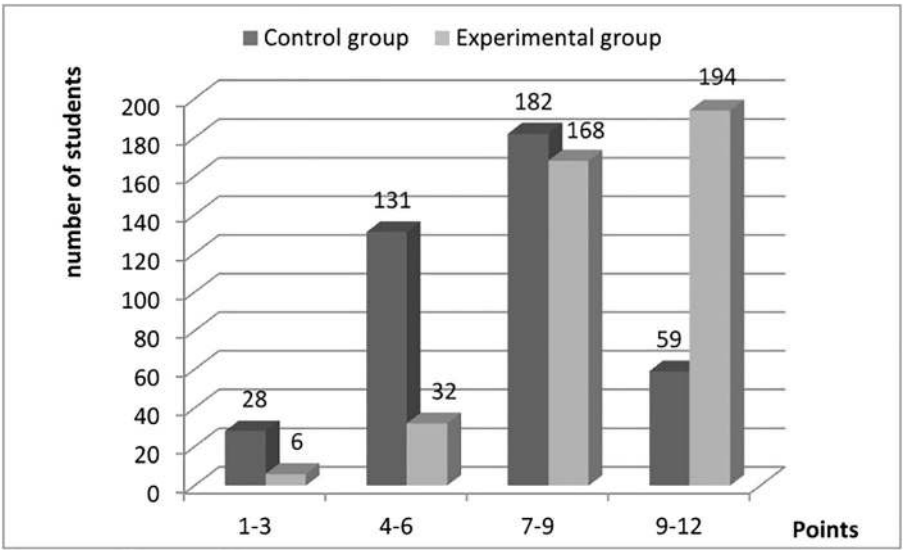

Fig. 3 Distribution of evaluations of professionally oriented knowledge and skills of the construction vocational schools' graduates

thoroughness, awareness, etc.), in theoretical and practical professionally oriented knowledge. Based on the data obtained in control sections, the graphs of empirical distribution functions (cumulative functions), as well as frequency distribution histograms, give grounds to assert that the higher and more predictable level of theoretical and practical training of students is observed in experimental groups. The strength of the professional knowledge and skills obtained in the vocational school was also checked. The results of the control section of the theoretical and practical knowledge and skills that were conducted with students (graduates) of the construction vocational schools at the end of training, are given in Fig. 3, it is evident that the distribution of the values of professionally oriented knowledge and skills of vocational schools graduates who were trained in experimental groups according to the developed methods is higher. Marks according to the 12-point system based on the results of professionally oriented tasks, and, consequently, the strength of knowledge and skills, the formation of theoretical and practical components of professional competence, readiness for the professional activity of graduates of the construction vocational schools who studied according to this methods (average score of 8.97) are much better than of graduates of control groups, where ICT was used unsystematically and fragmentary (the average score is 7.0). The calculation of the t-criterion for comparing the mathematical expectations of the studied samples showed that the level of preparation of students in experimental groups differs from the level of students in control groups with a statistical significance greater than .95.

According to the results of the research, the effectiveness of ICT in theoretical training of construction workers is .29, in practical training it is .15, and according to the results of measuring the strength of professionally oriented knowledge and skills it is .28. As the average efficiency indicator $E_{ict} = .24$, the expected increase in the quality of vocational training is 24%.

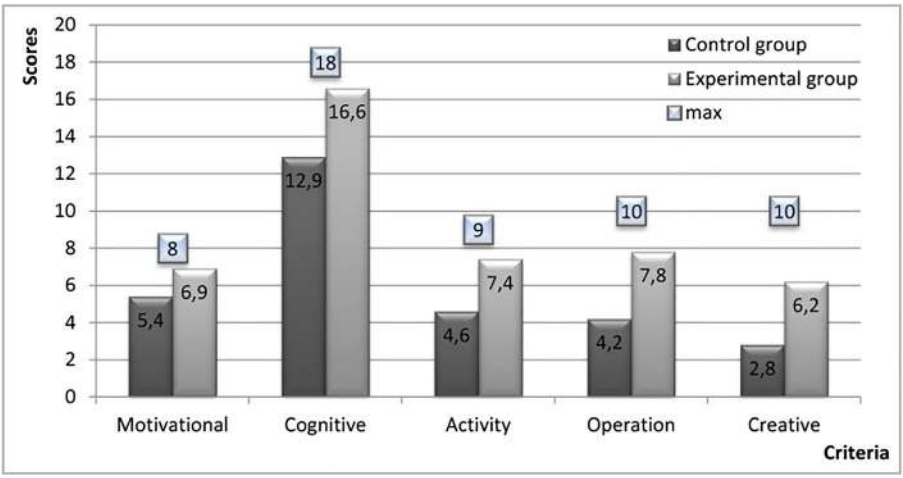

Fig. 4 Average values of the criteria of ICT competence of graduates of the construction vocational schools

The significance of the formation of the ICT competency of graduates of the construction vocational schools according to various criteria is shown in Fig. 4.

It can be seen from the diagram that the ICT competence of the construction workers who were trained by the experimental methods is substantially higher according to all the criteria. The overall indicator of experimental groups is an average of 45.2, and in control groups it is 29.9 points. The graduates of experimental groups are on average at the beginning of the high level, while in control groups they are on the verge of low and middle level of competence. The generalized data on the study of the ICT competence formation of graduates of the construction vocational schools, according to all the criteria, are given in Table 1:

The obtained results testify to the absence in experimental groups, unlike in control ones, the graduates with insufficient level of ICT competence, as well as a small number of future builders with a low level of IC. Thus, in the process of the experiment there were system changes in the educational process, the level of knowledge, abilities and skills and ICT competence of the graduates of the vocational school were raised. All the experimental data are summarized and statistically processed, which ensures their reliability and validity.

Table 1 Results of ICT competence formation of construction vocational school graduates

№	Levels of formation	Ratio of levels			
		Experimental groups		Control groups	
1.	Insufficient	0	.0%	16	4.0%
2.	Low	25	6.2%	39	9.8%
3.	Average	236	58.7%	277	69.8%
4.	High	141	35.1%	65	16.3%
Total students:		402	100.0%	397	100.0%

The posttest showed a significant improvement of the quality of skilled workers' training as a result of integrated informatization of the educational process at the vocational school.

4 Discussion

Based on the research findings this article will contribute to the current discourse of informatization of future specialists' training at vocational schools. Extrapolated on the sphere of education, informative processes (cognitive, communication, and social ones) are its system factor, an important constituent of a new, personality oriented paradigm of education. From this perspective, a scientific ground, planning and introduction of pedagogical technologies and informative resources which would provide the purposeful use of ICTs in future specialists' training, are on great demand.

This research allowed to clarify the tasks of informatization that are the following: generalization and deepening of future workers' theoretical knowledge of the main concepts and methods of informatics as a scientific discipline; training and mastering of the basic principles of informatics; development of algorithmic style and culture of thinking of students; mastering of general informatization means, forming skills and abilities of work on a PC, mastering of methods of work with ICT; studying and mastering the methods and means of using modern ICT in accordance with the needs of future professional activities; updating of professional knowledge and skills taking into account possibilities of ICT; formation of skills to plan ICT resources necessary for professional tasks; development of communicative abilities, skills of collective work; acquaintance with modern methods of research and design activities in the professional field. These findings correlate with those reported by Pečiuliauskienė and Barkauskaitė (2007), who pointed out that the educational institutions are increasingly obliged to use the potential of ICTs providing knowledge and skills for the students.

From this point of view, the functions of informatization of vocational schools are determined by the basic functions of ICT in skilled workers' training, including: instrumental, visual, informative, compensatory, motivational, individual, adaptive, integrative, control and diagnostic, modeling, predictive, management ones. The tasks and functions of VET informatization are interconnected and aimed at the development of ICT competence as a compulsory part of training, a key qualification in the information society.

The aim was to analyze the state of informatization of VET. The results obtained indicate that despite the significant achievements in this field and the development of the problem in general (Anderson 1996; Collis 1996; Cuban 2001; Fuchs and Woessmann 2005; Papert 1997 et al.), the possibilities to optimize skilled workers' training on the basis of ICT have not been sufficiently studied, there has not been a comprehensive analysis and classification of the corresponding teaching software and other electronic teaching aids, there is no clear methods for assessing the quality of information resources and technologies used in VET. The modern state of the informative provision of vocational and technical education does not meet, to full extend, the expectations of users of educational services and the requirements of social partners. These findings are consistent with the results of the scientific research by Becker and Ravitz (2001) et al. It demands the scientific reorientation of aims of

informative training in VET, the grounded update of its contents, the clear determination of the structure and organization of education by means of ICT, and the complex of measures to improve informatization of all the process of skilled workers' professional training at vocational schools.

Taking into account the structure of skilled workers' ICT competence (Ashworth and Saxton 1991; Cuban 2001; Troter and Ellison 2001), the informatization at technical vocational schools is expedient to examine according to four areas: in the organizational and management activity (e.g., Law et al. 1999); in the educational process (Tella 1995); in the educational-production process; and in out-of-class activities. In particular these are educational multimedia systems; business intelligence databases; computer design of production situations and professional actions; programs of knowledge and abilities control and self-control; use of ICT to write diploma papers; computer educational-trainings complexes as well. Thus, the task of every vocational school is a complex development of all these areas.

This research contributed to a deeper understanding of the pedagogical conditions of informatization of the educational process at technical vocational schools. As such, these conditions are a complex of social-pedagogical and didactic factors, i.e.: pedagogical workers' readiness to introduce ICT and complex informatization of educational process; continuous systematic informative training of future workers; creation and permanent perfection of methodical and technical base of informatization; integral scientifically grounded use of a complex of ways of ICT application within the educational process; effective management of professional training informatization.

Another notable finding is that the implementation of the model of informatization of the educational process in the technical vocational school provides for the design and implementation of a comprehensive method of informatization of the future workers' training, aimed at intensifying all the stages of vocational training. Scientific and methodical provision of informatization of workers' training consists of two basic parts: methods of informative training and methods of LMS application at vocational schools. The key aspects of the method are the following: the professionally oriented teaching and learning of informatics at vocational schools; the development of general professional and professionally oriented informative abilities; the combination of traditional and innovative forms and methods of organizing educational process on the basis of ICT (Cotton 1992; Liao 1998; Reed 1996; et al.); the problem- and project-oriented methods of workers' training with ICT application; the workers' professional training by means of the Internet; the development and introduction of teaching software for industrial professions; the computer oriented diagnostics of professional training quality; the methods of preparation of teachers (Pečiuliauskienė and Barkauskaitė 2007; Pegalajar 2018) and masters of production studies to use ICT at technical vocational schools. Thus, informatization is directed at students' effective stimulation and motivation, increase of structured of educational contents, provision of complex visualization of professional phenomena, design of difficult professional objects, and increase of efficiency of the training stage of professional preparation.

To summarize the results of the research, the use of ICT enables to prepare qualified workers for the information society needs: to develop their ability to work with

information, to reflect on new ideas, to develop communicative abilities, individual and team work skills, design skills, abilities to make optimal decisions, to work with virtual objects, to carry out the role of researcher, designer, etc.

Simultaneously, there are a number of difficulties associated with the psychological and pedagogical and organizational principles of the use of ICT in the learning process, as ICT dramatically change the information and method provision of the educational process. It refers to teaching technologies that have provided a methodological innovation, facilitating learning, increasing students' motivation, integrating technology into the teaching process (Ghaleb 2014) as well as improving the access to resources, information etc. (Domingo and Marquès 2011; Lucena 2016). In our opinion, a multifaceted problem of designing a strategy for producing and introducing new learning environments suitable for constructive studying needs to be solved (Coughlin 1999; Dexter et al. 2000; Jonassen 1996; Knierzinger et al. 2002; Schacter 1999), which would allow to use all the benefits that enhance the quality of the educational process and to avoid the losses and risks inherent in abrupt changes in the teaching methods.

5 Conclusions

Overall, the study of the state of VET informatization showed that, despite significant achievements in this field and the development of the problem in a whole, the possibilities of optimizing the training of skilled construction workers based on ICT was not sufficiently studied, i.e. there is no comprehensive analysis and classification of appropriate pedagogical software and other electronic teaching aids; there is no clear methodology for assessing the quality of information resources and technologies used in vocational schools or no methodological recommendations for their effective use.

The approbation and the results of this research highlight the fact that the substantiated and experimentally verified model of informatization of the educational process at technical vocational school provides the interaction of all the elements of informatization. It accurately reflects its main properties and allows predicting the results of the process of VET informatization. The model is aimed at the creation, maintenance and development of ICT-saturated educational environment on the basis of the computer-oriented and telecommunication resources. This environment is favorable to the development of the processes of informative and educational co-operations between pedagogical staff, students and ICT facilities, and the formation of students' cognitive activity, as well. The ICT-saturated educational environment, where ICT and pedagogical software are an integral part of the organization and functioning of the educational process, is an element of the information and education space of the regional VET system.

A substantial improvement in the ICT competence of graduates was experimentally proven as a result of the complex informatization of the training process at vocational schools. Due to the fact that, according to our methodology, the proportion of ICT use in professional-theoretical teaching and

professional-practical training significantly increases, and, simultaneously, the quality of professional training of future construction workers also meaningfully enhances.

To summarize, the conception of informatization of specialists' training at technical vocational schools realizes the ideology of a balanced, steady development of separate educational institutions and the VET system on the whole. The conception is aimed at the system use of the newest technologies, taking into account the real possibilities of the resource provision of vocational education informatization, the development of electronic educational and methodical complexes, the update and approbation of the contents of specialists' informative training and methods of ICT application while training workers. This enables to solve complex issues related to the normative-legal, educational-methodical, personnel, organizational and financial support of vocational schools informatization. The implementation of the proposed conception is possible due to the coordination the educational authorities, training and methodological centers as well as VET methodological associations of qualification training groups.

Regarding research implications, further elaborations should be devoted to the improvement of vocational education in Ukraine on the basis of ICT, including the creation and introduction of computer-based trainings systems, planning of distance and blended-type of vocational training, development of means of the electronic support and accompaniment. Special attention should be paid to teaching professionally oriented subjects with the use of ICT, researches on students' age and psychological features while introducing ICT, realization conditions and efficiency criteria of informatization on the different levels of education and for various subjects. In this connection the problems of pedagogical workers' readiness to use ICT in different aspects of educational activity, methods of intelligent tutoring system and methods of educational and cognitive activity management in the system of VET should be investigated.

References

Anderson, R. E. (1996). The United States context of computers in education. In T. Plomp, R. E. Anderson, & G. Kontogiannopoulou–Polydorides (Eds.), *Cross national policies and practices on computers in education* (pp. 445–468). Dordrecht: Kluwer Academic Publishers.

Anderson, J. (Ed.), van Weert, T. (Ed.), & Duchâteau, C. (2002). Information and communication technology in education: A curriculum for schools and programme of teacher development. Paris: UNESCO.

Andresen, B. B., & van den Brink, K. (2002). Multimedia in education. In *Specialised training course*. Moscow: UNESCO Institute for Information Technologies in Education.

Ashworth, P., & Saxton, J. J. (1991). On competence. *Journal of Further and Higher Education, 2*(14), 3–25.

Becker, H. J., & Ravitz, J. L. (2001). *Computer use by teachers: Are Cuban's predictions correct?* Retrieved from https://pdfs.semanticscholar.org/b6ca/78ee22675d8d99e6c7a6224a032dcd10adf0.pdf. Accessed 6 July 2018.

Bykov, V. Y. (2008). *Models of organizational systems of open education*. Kyiv: Atika.

Christmann, E., Badgett, J., & Lucking, R. (1997). Progressive comparison of computer-assisted instruction on the academic achievement of secondary students. *Journal of Research on Computing in Education, 29*(4), 325–337.

Collis, B. (1996). Computers in education. In T. Plomp & A. D. Ely (Eds.), *International encyclopedia of educational technology* (pp. 402–408) 2nd ed. Pergamon: Emerald Group.

Cotton, K. (1992). *Computer-assisted instruction. School improvement research series. 1991–1992.* Close-up #10. USA, northwest regional educational laboratory. Retrieved from https://educationnorthwest.org/sites/default/files/Computer-AssistedInstruction.pdf. Accessed 23 Mar 2019.

Coughlin, E. (1999). Professional competencies for the digital age classroom. *Learning & Leading with Technology, 27*(3), 22–27.

Coutinho, C. P., & Alves, M. (2010). Educação e sociedade da aprendizagem: Um olhar sobre o potencial educativo da internet [education in the learning society: An overview over the educational potential of the internet]. *Revista de Formación e Innovación Educativa Universitaria, 3*(4), 206–225.

Cradler, J., & Bridgforth, E. (1996). *Recent research on effect of technology on teaching and learning*. Policy brief. San Francisco, CA, WestEd regional educational Laboratory. Retrieved from http://www.oten.info/conferences/jukes/research.pdf. Accessed 23 Feb 2019.

Cuban, L. (2001). *Oversold and underused: Computers in the classroom*. Cambridge: Harvard University Press, Cambridge, MA. Retrieved from https://moodle.fct.unl.pt/pluginfile.php/72068/mod_resource/content/0/Cuban_2001_Oversold_and_underused_Computers_in_the_classroom.pdf. Accessed 15 Jan 2019.

Dexter, S. L., Anderson, R. E., & Becer, H. J. (2000). Teachers'views of computers as catalysts for changes in their teaching pratice. *Journal of Reasearch on Computing in Education, 3*(31), 221–239.

Domingo, M., & Marquès, P. (2011). Aulas 2.0 y uso de las TIC en la práctica docente [classroom 2.0 experiences and building on the use of ICT in teaching]. *Comunicar, 37*, 169–175. https://doi.org/10.3916/C37-2011-03-09.

Dusick, D. M. (1998). What social cognitive factors influence faculty members' use of computers for teaching? A literature review. *Journal of Research on Computing in Education, 31*(2), 123–137.

Fuchs, T., & Woessmann, L. (2005). *Computers and student learning: Bivariate and multivariate evidence on the availability and use of computers at home and at school.* Retrieved from https://www.ifo.de/DocDL/IfoWorkingPaper-8.pdf. Accessed 26 Jan 2019.

Ghaleb, A. (2014). Assistive technology in special education and the universal design for learning. *The Turkish online Journal of Educational Technology, 13*(2), 18–23.

Hurevych, R. S. (2004). Information culture is an important part of the person's general culture. *Modern Information Technologies and Innovative Methods of Training in Specialists' Training: Methodology, Theory, Experience, Problems, 6*(1), 42–47.

International Society for Technology in Education (2000). ISTE National Educational Technology Standards (NETS) and Performance Indicators for Teachers. Retrieved from https://id.iste.org/docs/pdfs/nets_for_teachers_2000.pdf. Accessed 11 Oct 2018.

Jonassen, D. H. (1996). *Computers in the classroom: Mindtools for critical thinking*. New Jersey: Prentice Hall Inc., New Jersey. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.485.7583&rep=rep1&type=pdf. Accessed 19 Oct 2018.

Knierzinger, A., Rosvik, S., & Schmidt, E. (2002). *Elementary ICT curriculum for teacher training*. Moscow: UNESCO Institute for information Technologies in Education.

Kymmell, W. (2008). *Building information modeling: Planning and managing construction projects with 4D CAD and simulations*. New York: McGraw-Hill.

Law, N., Yuen, H. K., Ki, W. W., Li, S. C., & Lee, Y. (1999). *Second international information technology in education study.* Hong Kong SAR Report, CITE, HKU, Hong Kong.

Lehtinen, E., Hakkarainen, K., Lipponen, L., Rahikainen, M., & Muukkonen, H. (1998). *Computer supported collaborative learning: A review.* CL-Net. A Report for European Commission Retrieved from https://www.academia.edu/350350/Lehtinen_E._Hakkarainen_K._Lipponen_L._Rahikainen_M._and_Muukkonen_H._1999_._Computer-Supported_Collaborative_Learning_A_review. Accessed 8 Jan 2019.

Li, S. C., Kong, S. C., Lee, F. L., & Henri, J. (2006). Capacity building for lifelong learning: A study of practitioners' perceptions on information literacy framework. *Informatics in Education, 5*(2), 219–231.

Liao, Y.-K. C. (1998). Effects of hypermedia versus traditional instruction on students' achievement: A meta-analysis. *Journal of Research on Computing in Education, 30*(4), 341–359.

Livingstone, S. (2012). Critical reflections on the benefits of ICT in education. *Oxford Review of Education, 38*(1), 9–24. https://doi.org/10.1080/03054985.2011.577938.

Lucena, I. V. (2016). La aplicación de las TIC y la evaluación por competencias en el Grado en derecho [application of ICT and evaluation for competences in the degree in Law]. *International Journal of Educational Research and Innovation, 5*, 42–54.
Lytvyn, A. V. (2011). *Informatization of vocational schools of construction type*. Lviv: Manuscript Co.
Markauskaitė, L. (2003). Critical review of research findings on information technology in education. *Informatics in Education, 2*(1), 65–78.
Martin, W., Gersick, A., Nudell, H., & Culp, K. M. (2002). An evaluation of Intel teach to the future. *Year Two Final Report*. September 2002. Center for Children and Technology, New York. Retrieved from https://www.academia.edu/27425031/An_evaluation_of_Intel_Teach_to_the_Future_Year_two_final_report. Accessed 12 Feb 2019.
McCoy, L. P. (1996). Computer-based mathematics learning. *Journal of Research on Computing in Education, 28*(4), 438–460.
OECD. (2001). *Education policy analysis*. Paris: OECD.
Papert, S. (1997). Why school reform is impossible. *The Journal of the Learning Sciences, 6*(4), 417–427.
Pečiuliauskienė, P., & Barkauskaitė, M. (2007). Would-be teachers' competence in applying ICT: Exposition and preconditions for development. *Informatics in Education, 6*(2), 397–410.
Pegalajar, M. C. (2018). Information and communication technologies and inclusive teaching: Perceptions and attitudes of future early childhood and primary education teachers. *Problems of education in the 21st century, 76*(3), 380–392.
Pelekh, Y. V. (2009). *The valuable-meaningful content of future teachers' professional training*. Rivne: Tetis.
Plomp, T. (2003). *Cross-national information and communication technology policy and practices in education*. Greenwich, Conn: Information Age Pub.
Reed, W. M. (1996). Accessing the importance of computer-based writing instruction. *Journal of Research on Computing in Education, 28*(4), 418–437.
Research Report on Effectiveness of Technology in Schools: Executive Summary (2000). Software and information industry association, USA. Retrieved from http://orion2020.org/archivo/docencia/06%20riete2000.pdf. Accessed 10 Dec 2018.
Schacter, J. (1999). *The impact of education technology on student achievement: What the most current research has to say*. Retrieved from https://files.eric.ed.gov/fulltext/ED430537.pdf. Accessed 20 Jan 2019.
Shapiro, J. J., & Hughes, S. (1996). Information literacy as a liberal art. *Educom Review, 31*, 2 Retrieved from https://teaching.uncc.edu/sites/teaching.uncc.edu/files/media/articlebooks/InformationLiteracy.pdf. Accessed 19 Oct 2018.
Sinko, M., & Lehtinen, A. (1999). *The challenges of ICT in finish education*. Finland: Atena.
Tella, S. (1995). *Virtual school in a networking learning environment*. Helsinki: University of Helsinki.
Troter, A., & Ellison, L. (2001). Understanding competence and competency. In B. Davies & L. Ellison (Eds.), *School leadership for the 21st century* (pp. 36–53). London: Routledge Falmer.
Wong, E. M. L., & Li, S. C. (2006). Is ICT a lever for educational change? A study of impact of ICT implementation on teaching and learning in Hong Kong. *Informatics in Education, 5*(2), 317–336.

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