Applying Information and Communication Technologies as A Scope of Teaching Activities and Visualization Techniques for Scientific Research

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Abstract
The article focuses on the areas of education activities in using techniques for teaching and learning with information and communication technologies (ICTs), researching and analyzing the available ICTs, gearing the technologies to the specific psychological and pedagogical conditions, independently building and modeling ICTs, enlarging and developing their use in the learning environment. The visualization of scientific research has been determined to be part of the educational support for building students' ICT competence during teaching and learning and is essential to the methodology culture. There have been specified main tasks for pedagogy technologies (PTs) to develop the skills of adaptability to the global digital space in students, their effective database operation and using the data bases as necessary elements for learning and as part of professional training for research. We provided rationalization for implementing the latest ICTs into the Ukrainian universities' curricula, as well as creating modern methods for using the technologies in the learning / teaching process and scientific activities.

Keywords:
information and communication technologies, pedagogy technology, database, digital space, infological models, interactivity.

1. Introduction

A fast-moving information approach implementation in education leads to developing information and educational environments wherein the information and communication technologies are carried into effect. Studying issues that relate the ICTs application is an up-to-date and very relevant area in pedagogy. At the same time, the entire professional activity of the punditry essentially depends on the efficiency and positive response of science communications. The current-day computing telecommunications and vast digital-related scientometric databases provide unlimited communication between subscribers and fully meet the requirements of scientists.

The methodology of pedagogy and the methodology of research activities are closely connected with the methodology of education, which implements the degree of theoretical knowledge acquired at the current stage of social, cultural, and scientific development. In other words, the methodology of education focuses on the specific actions to transform an object conforming to that ideal model, and, therefore, that awareness of the object, which are covered by the philosophy of education.

Arguably, the prospective specialist's methodology culture comprises a didactic and teaching culture and it contains the subject of serious academic inquiry, didactic and procedure development, as well as teaching and guiding abilities implemented in professional activities.

To develop the above-mentioned abilities, one should get knowledge applicable to teaching and learning and using ICTs, performing reproductive activities in education (or in a specific area of learning / teaching and research) and applying ICTs, performing creative activities in teaching and learning and applying ICTs, leveraging the best practices of emotional and values-based attitudes to teaching and learning through ICTs.

The purpose of this paper is to present arguments for implementing the latest ICTs into the Ukrainian universities'

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curricula, as well as creating modern methods for using the technologies in the learning / teaching process and scientific activities.

2. Theoretical Consideration

As part of the dynamic modern education, the methodological activity of an expert in education grows increasingly complex, high in content and knowledge-consumptive. The ratio of functions changes therein: the information component takes a back seat, giving way to the functions of design, construction, organization, communication, etc.

The close relationship between ICT methods application in teaching and learning, on the one hand, and research activities as a traditional concept which is endowed with a superstructural essence, on the other hand, has determined the following nominal understanding of the given concept: methods for using (or applying) technologies in teaching and learning are the science dealing with the patterns of choosing pedagogical technologies, in particular ICTs, and their means to achieve learning goals and objectives based on the specific content of the academic subject in different psychological and pedagogical situations.

If this definition is specified in accordance with its goals and objectives, then the methods for using (or applying) ICTs in the educational process are considered to be a science of: patterns that regulate the choice of ICTs or their components (in particular, tools) under specified conditions (situations); activities for designing, modeling, choosing and adapting ICTs to certain psychological and pedagogical features, conditions, to a specific subject matter area, etc. (this is the "knowledge component" projection into the space of goals, specific psychological and pedagogical conditions and features defined by the subject matter area); the implementation of technology in the educational process to achieve the goals of learning in a given subject content in certain psychological and pedagogical situations.

Being among the world's largest supporters of ICT projects in education, the U.S. Agency for International Development (USAID) follows such key principles when implementing ICTs in education systems as: 1. Using ICT to achieve education and development goals. It means that a well-designed technology solution can be used to disseminate resources, connect students to information, enhance teachers' practices and students' performance in all subject areas, improve school management and support data-driven policymaking. 2. Using ICT to enhance student knowledge and skills. It indicates that if education is designed to be relevant to work and important to a society, success in school should be accompanied by the development of a complete range of skills—including literacy, numeracy, information literacy and independent-learning skills that contribute to achievement in later life. ICT should be used to help students build these skills. 3. Using ICT to support data-driven decision making. Regular and reliable data are considered to be underlying to planning and policy, financial management, management of school facilities, decisions about the personnel (including teachers) and support for student learning. 4. Exploring technology alternatives to find appropriate solutions. It focuses on the program designers' consideration of alternative ways of meeting proposed educational objectives, including broadcast or other technologies, low-cost/low-power computers, and mobile telephones. 5. Focusing on teacher development, training and ongoing support. In-service teacher professional development is seen as frequently among the most important and complex components in an education-technology project. Teachers are essential to student learning outcomes [1].

Designing organizational forms in teaching and learning, as didactic components when developing ICT teaching methods, requires taking many factors into consideration, in particular: ICT teaching techniques, psychophysiological characteristics and student quality, the availability of certain teaching aids, a teacher's ICT literacy skills, etc. Notably, building technological tools for designing educational activities is fraught with difficulties due to the variety of pedagogical approaches to specifying organizational forms used in teaching.

The mainstream view in the academic circles is that one of the main organizational forms used in teaching is a lecture, i.e., "an educational talk to an audience, especially one of students in a university" [2]. A. W. Bates considers this teaching form to be "as effective as other methods for transmitting information", but in his opinion, "most lectures are not as effective as discussion for promoting thought; lectures are generally ineffective for changing attitudes or values or for inspiring interest in a subject; lectures are relatively ineffective for teaching behavioural skills" [3, p. 90]. The other teaching forms, stressed by Bates, are seminars and tutorials. To his mind, a "seminar is a group meeting (either face-to-face or online) where a number of students participate at least as actively as the teacher, although the teacher may be responsible for the design of the group experience, such as choosing topics and assigning tasks to individual students" [4, p. 96], and "a tutorial is either a one-on-one session between a teacher and a student, or a very small group (three or four) of students and an instructor, where the learners are at least as active in discussion and presentation of ideas as the teacher" [3, p. 96].

Varying the combination of teaching forms and communication options is noted to result in the different types of the same teaching form, for example, lecture-information, (lecture-visualization, binary lecture, lecture-conference, lecture-discussion, etc.) [4].

The given examples demonstrate the efficacy of combining the classification parameters of teaching and learning, which illustrate discovering new organizational forms of education. At the same time, the other classification parameters of educational process can be considered, in particular: the nature of the transmitted data; a combination of educational, developmental, and pedagogic tasks (the shift of emphasis in targeting); the way of grouping students; the features of the object of activity, etc.

Thus, the didactic design of the methodology for using ICTs in the educational process is based on patterns that standardize the choice of ICTs or their components under certain conditions; on efforts to design, project or adapt ICTs to certain psychological and pedagogical representative conditions and a specific subject area. Implementing the technologies in education to reach learning outcomes in a particular content area makes it possible to do the following: describing teaching and learning through ICTs; investigating and analyzing the available ICTs; adapting ICTs to specific psychological and pedagogical conditions; building and designing ICTs by oneself modifying and developing the practices.

As a result, the given construction can be accepted as a didactic framework for investigating pedagogical reality.

To determine a teacher's knowledge about the ICT options relating to didactics, the various methodological and pedagogical approaches to evaluating, grading and bringing teachers' computer literacy and information competence into correlation should be pointed out.

In this aspect, two fundamental approaches can be highlighted. The approaches let us formulate the essence of an epistemological aspect, including a teacher's ability to design a methodology for using ICTs.

The first one was proposed by Maryland Technology Literacy Consortium (MTLC) and it concerned teachers' basic, functional, and systems literacy rates. In the MTLC members' opinion, the basic level comprises foundational computer literacy skills, the intermediate level includes computer literacy and competency beyond the foundational level, and the proficient one covers computer literacy and competency beyond the intermediate level applied in educational and work settings [5].

According to the MTLC approach, technology literacy "is the ability of an individual, working independently and with others, to responsibly, appropriately, and effectively use technology tools to access, manage, integrate, evaluate, create, and communicate information" [5]. Accordingly, there have been presented the following technology literacy standards for students: 1) Technology Systems: developing foundations in the understanding and uses of technology systems; 2) Digital Citizenship: demonstrating an understanding of the history of technology and its impact on society, and practice ethical, legal, and responsible use of technology to assure safety; 3) Technology for Learning and Collaboration: using a variety of technologies for learning and collaboration, increasing productivity; 4) Technology for Communication and Expression: using technology to communicate information and express ideas using various media formats; 5) Technology for Information Use and Management: using technology to locate, evaluate, gather, and organize information and data; 6) Technology for Problem-Solving and Decision-Making: demonstrating ability to use technology and develop strategies to solve problems and make informed decisions [5].

The second approach concerning the levels of ICT integration in innovative pedagogy among teacher educators was proposed by Avidov-Ungar, O., & Iluz, I. E. in their "Levels of ICT integration among teacher educators in a teacher education academic college" [6]. Examining the perspective of teacher educators and academic officials in an academic teacher education program regarding the integration of ICT in the teacher education program, the authors point out three different levels of ICT integration which could be discerned from their findings: basic, focused, and creative. According to the scientists, the basic level "suggests the use of simple and basic technologies (e.g., presentations or uploading the syllabus to the course site) and to a large extent technological dependence, which necessitates constant accompaniment and support" [6]; at the focused level, "teacher educators use ICT in their teaching in a focused manner, to meet their ongoing immediate needs, as they apply the use of ICT to discrete instances and events, entailing short-term usage" [6]; the creative level is marked by "cooperation, creativity, and the production of innovative pedagogy in the lessons delivered by the teacher educators" [6]. The scientists took special care to the role of the personal and organizational factors that influence ICT levels. Thus, from this consideration, the authors conclude that "it can assist decision makers in the field of professional development in constructing ways to lead teacher educators from the basic level to the creative level of implementation" [6].

At the same time, the ICT development in Ukrainian science has become the subject of special attention and research [7, 8, 9,]. In recent decades, the role of ICTs has steadily grown in science. This also holds true for their impact on research findings.

The advancement of science under IT penetration is fraught with the intensification of both research processes and the distribution of research findings. Therefore, for modern scientists and researchers, the most important task is a prompt and wide-ranging access to the constantly increasing volume of scientific knowledge. Under these circumstances, to assess the possibilities of using various and available digital scientific resources, as well as to develop effective methods for their use are necessary.

The sociology of science regards the professional work of scientists in its totality. In the age of social and economic transformations, special attention is paid to those factors, which are novel for science and have an impact on the scientific community functioning. We consider ICT one of the factors. Therefore, clarifying the real impact of ICTs on scientific research is highlighted as the priority research areas of pedagogical activity in higher school. In this regard, the role of visualizing scientific knowledge in teaching and learning should be considered separately. By visualization, we mean a way of transforming information into a visually perceptible form: a diagram, a graph, a base map, a drawing, a logical sequence diagram, a table, an ontology-based image, etc. The contours of the present science and education show that visualization has come into use to display originally non-visual information (temperature, inflation, crime wave, migration, corruption, etc.).

The development of computer technology has expanded the scope and the scale of visualization by a long way. The main goal of visualization is to create a tangible construct. In our opinion, the true function of visualization is just to express the essence in an easy-to-interpret form. This specific function makes visualization an essential component for both academic work and vocational training. Ample evidence exists that students formally master theoretical skills. This stems from the fact that students, while interpreting signs, do not represent their function, do not know their meaning. According to D. Hilbert, German mathematician and one of the most influential mathematicians of the 19th and early 20th centuries, an abstract theory can be neither true nor false. It acquires these qualities and becomes significant only when its interpretation is found [10].

D. Hilbert considered visualization a necessary component for developing science and education. In his preface to “Geometry and the Imagination”, which was co-written with S. Cohn-Vossen, he stated: “In mathematics, as in any scientific research, we find two tendencies present. On the one hand, the tendency toward abstraction seeks to crystallize the logical relations inherent in the maze of material that is being studied, and to correlate the material in a systematic and orderly manner. On the other hand, the tendency toward intuitive understanding fosters a more immediate grasp of the objects one studies, a live rapport with them, so to speak, which stresses the concrete meaning of their relations” [10, p. 1].

Scientific knowledge visualization is important for at least two reasons: a) it helps to understand the essence of scientific and theoretical knowledge, which is always relevant to education; b) its results, forming a mediator between theory and practice, can suggest ways of materializing abstract knowledge [11].

Due to the development of information technology and the growth of computer systems capabilities, many world researchers have opened new prospects that were previously considered inaccessible. Modern information and communication technologies make it possible to revive static data, make them convenient for analysis and research, and present information in a new context.

Information visualization has been reflected in a user environment, moving data processing to a deeper level. Presentation graphics technologies are undergoing a period of rapid development now. There can be distinguished three key areas among them: data visualization; infographics; knowledge representation.

In keeping with this approach, interactivity should be considered one of the main tools for a high-quality computer information visualization. Information-logical models are inherently interactive, and each element of the model is available for user interaction.

When hovering over each model object, the user receives an extended writing of the event or term represented by the object. Thus, it becomes feasible both to develop behavior patterns in a user, which habituate to a predictable interaction with the model, and to control his attention by highlighting the most significant terms and/or events within the model. Information visualization is a core task of information-logical models. This makes the technology a powerful data analysis tool. The information-logical models not only visualize information and simplify its perception, but significantly reduce the time required for data binding, the automation of content selections and information exchange as well, that is beneficial to the quality of front office services and back-office process optimization. Among the most significant opportunities offered by the information-logical models for data portals and knowledge bases, are the following: data binding, data completeness, and information distribution.

Data binding is “the process that couples two data sources together and synchronizes them. With data binding, a change to an element in a data set automatically updates in the bound data set” [12].

Data completeness "refers to the degree to which all data in a data set is available. A measure of data completeness is the percentage of missing data entries" [13].

Being included into five independent subprocesses "information acquisition, information distribution, information interpretation, information integration, and organizational memory" [14], information distribution "refers to the processes through which individuals, groups, or different units of the organization share data and information among themselves" [14]. The information-logical models, supplemented with a properly configured application program interface, allow one to automate information distribution. The peculiarity of this application lies in the connectivity of the distributed information: the destination database is not limited by the transmitted information-logical model, and it can provide users with the related content.

Enhancing scientific activities by ICTs requires developing students' strong skills in working with databases, as they provide safe and immediate data access.

A Database Management Software or (DBMS) is integral to the educational process as it is "used for storing, manipulating, and managing data in a database environment" [15]. In Naeem Tehreem's opinion, it "enables users to design a personalized database to meet their analytics and reporting needs" and "supports creating, implementing, and maintaining an organization-wide data management system" [15]. An efficient DBMS tool, as Naeem Tehreem puts it, should include the following features: data normalization (it mitigates this risk and minimizes the chance of destructive anomalies appearing); user-defined rules and constraints (a DBMS allows users to define validation and integrity rules and conditions to ensure data satisfies the semantics); security controls (they protect the integrity of a database and the data and records residing in it); data backup (a backup protects the database against data loss); data structuring (a DBMS must allow users to organize information in a database in a clear hierarchical structure. It means all objects, records, and tables can be arranged systematically, like a catalog, so the records can easily be accessed and retrieved) [15].

At the same time, Meet S. Patel [16], digital marketing executive, places emphasis on such benefits of using student database management system as: managing all information pertaining to students' attendance, assignments, academic reports, curriculum details, project details, exam details, grades, achievements, medical history, address, accounts, and much more; streamlining communication, i. e. it facilitates smooth interaction between teachers and students by allowing them to collaborate beyond the four walls of the classroom; enabling the interaction to take place over the online application where teachers can respond to students' queries in real-time; maintaining the registration process, admission approval, documents uploading, test and interview schedules, and much more, thus, reducing workloads to a great extent; minimizing paperwork (it helps one manage students' personal records effortlessly. It keeps the digital track of student data, thus reducing paperwork.); storing all student and school-related data on a cloud-based server to secure the files; leveraging biometric tools to help teachers maintain quick records of students' attendance [16].

Besides the important tools for teaching and learning listed above, special attention should be given to scientometric databases, as students get key data from the references. These are bibliographic and abstract references containing tools for cited reference searching. The following types of digital scientific reference sources can be distinguished: library electronic catalogues; digital repositories of scientific information (widely used due to Open Science, which was initiated by Open Archives and Open Access. They can be divided into the following main categories: institutional repositories, subject/discipline specific repositories, and data repositories [17]); the Directory of Open Access Repositories (OpenDOAR) and the Registry of Open Access Repositories (ROAR); electronic academic periodicals; electronic library indices; abstract databases (Web of Science, Scopus); scientific social communities, etc.

3. Conclusions.

Modern information computer technologies make it possible to implement global trends in education and get on the global information space. Using computer technologies allows students to enhance their self-directed learning, their learning and scientific motivation; it gives quite new opportunities for creativity, for their gaining various professional skills.

The methods of applying information and communication technologies in teaching/learning should be considered as a necessary condition in professional training. The computer visualization of teaching information has wielded considerable influence over mastering a course content and its understanding.Thus, the ICT-based education focal areas include 1) implementing educational environment at an individual educational institution level; 2) system and rapid ICTs integration in education; 3) building and developing national educational standards.

The data resulting from the study can serve as grounds for mainstreaming new ICTs in the curricula of Ukrainian universities, as well as creating modern methods for using the ICTs in teaching and learning.

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