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TECHNOLOGICAL COMPONENT OF ICT COMPETENCY AND APPROACHES TO DETERMINING ITS STRUCTURE

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Abstract

Changes in the modern world have led to the emergence of the term ICT competency, the technological component of which is the subject of our research in this article. An integrative definition of ICT competency, various classifications of its structural components, the rationale for the identification and necessity to study the technological component of ICT competency are given in the introduction. The methods applied are a classification, extraction of characteristic features of objects, methods for constructing tabular, tree-like and multidimensional models. The article shows the need for the technological component of ICT competency. In the above tree structure or list, each technological competency is understood as a set of knowledge, the ability to apply this knowledge in practice and attitudes. The leaves of the tree model represent narrower sets of competencies, while the intermediate nodes of the tree represent broader sets of competencies. Various approaches to constructing a tree structure of the technological component of ICT competency and problems arising in connection with the use of tree models are shown. Based on the conducted research, multidimensional and object-oriented approaches to determining the structure of the technological component of ICT competency are proposed.

Keywords: Components of competency, competency structures, competence, ICT competency, technology, technological component

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1. Introduction

Scientific and technological progress, the third and fourth industrial revolutions (Perez, 2010), and the processes of digitalization and computerization (Kling, 1991), affecting all spheres of society, have led to the need for widespread use of information and communication technologies and the emergence of the term ICT competency in education and its comprehensive consideration (Holloway & Valentine, 2001). The change in the educational paradigm ranging from the approach of knowledge and skills to competence and competency also demonstrates the relevance of this publication in a broad context (Dobryakova, 2018). The COVID-19 pandemic has led to the need for the most widespread use of information and communication technologies in the education, work and leisure of billions of people around the world in the history of mankind (Horgan et al., 2020).

2. Problem Statement

The semantic core of competence is the terms “ability”, “aptitude”, “capability”, “competence”, “effectiveness” and “skill” (Weinert, 1999). F. E. Weinert defines competence as a “specialized system of abilities, proficiencies, or individual dispositions to learn something successfully, to do something successfully, or to reach a specific goal” (Weinert, 1999). Accordingly, ICT competency is a competency that reflects the capabilities, skills and individual ability to effectively use information and communication technologies in activities. The term ICT competency is interpreted differently by different authors, but the above definition is a generalization of various definitions of ICT competency (Evstigneev, 2011; Gluhova & Bazhanova, 2013; Lapchik, 2007). A review of works in the field of research on ICT competency showed that some authors understand information and communication technologies exclusively or predominantly as modern communication technologies, including modern Internet technologies. But it should be noted that ICT is “anything that handles and communicates information electronically including hardware and software” (and in the Russian version of the document: anything that acquires, processes, stores and transmits information electronically, which corresponds to the locally used definition of computer science as the science of the processes of acquiring, processing, transmitting and storing information).

Currently, there is no unified approach to defining the structure of ICT competency and its substructures. This article substantiates the need for the technological component of ICT competency and shows approaches to determining its structure.

3. Research Questions

In the structure of ICT competency, authors of various approaches to classification usually identify several components. UNESCO divides teachers’ ICT competency into six aspects by activity: understanding the role of ICT in education, curriculum and assessment, teaching practices, application of digital skills, organization and management of the educational process, professional development. Also, this model distinguishes three levels of a teacher’s development in ICT in relation to the category of knowledge: knowledge acquisition, knowledge deepening, knowledge creation. At the intersection of

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these aspects and levels, the authors of the model identified individual competencies, which show their multidimensional nature: in the UNESCO model, competencies are presented in the form of a two-dimensional matrix, and competency itself is considered as the possession of competencies. The next ICT competency model based on levels is the ICT competency framework presented and used in Nigeria (Kamba, 2011). The authors of the model identify 5 levels of ICT mastery: ICT Awareness, ICT Literacy, ICT Application, ICT Infusion in Curriculum, ICT Transformation. S.V. Trishina identifies five components of ICT competency: cognitive, value-motivational, technical and technological, communicative, reflective (Trishina, 2005). V.V. Kotenko and S.L. Surmenko distinguish four components: value-motivational, cognitive, activity, pedagogical reflection (Evstigneev, 2011). M.N. Evstigneev identifies five components of ICT competency: cognitive, operational, axiological, communicative, reflexive (Evstigneev, 2011). F. B. Kilicheva identifies three components of ICT competency: motivational, cognitive, technological (Kilicheva, 2020). Therefore, in the Russian approach to the structure of ICT competency, the psychological approach usually prevails through consideration of the properties and characteristics of personal and professional qualities (Kilicheva, 2020).

The study aims to answer the following research questions: Is it justified to single out the technological component of ICT competency? How is it possible to use trees to describe the structure of competency components? What other methods of describing the competency structure are applicable?

4. Purpose of the Study

The authors of the article consider it necessary to have a technological component of ICT competency in the structure of ICT competency for the following reasons. Firstly, it is modern technologies that underlie information and communication technologies and, as a consequence, information and communication competency. Hence, the causal interdependence of technology and competency and the causal relationship “technology → ICT competency” are the methodological basis for including the technological component in the existing structure of ICT competency. Secondly, the existing and considered options for the structure of ICT competency are based not only on the internal properties of the individual, which is characterized by one or another level of competency and competencies, but are also explicitly or implicitly based on the technological component, its interiorization, training and experience in using technologically new tools. An example of such classification is (Evstigneev, 2011), where the technological component of ICT competency is implicitly presented in the rows of the table describing other components: for example, such components of the technological component as web resources, Internet communications, Web 2.0 are presented. This implies the possibility of adding a technological component as an additional dimension when considering the structure of ICT competency. Thirdly, information and communication technologies in their development had first technological and only then social and communication aspects, which makes it necessary to consider the technological component of ICT competency as one of the basic and fundamental ones. Fourthly, highlighting the technological component of ICT competency once again focuses attention on digital skills and abilities that are useful in the modern and future world, as well as their internal structure.

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The purpose of the study is to demonstrate the identification of the technological component of ICT competency and its structure. Further, in the article, approaches to determining the structure of the technological component of ICT competency are presented.

5. Research Methods

To analyze the technological component of ICT competency and its inner components, methods of a classification, analysis and identification of characteristic features of objects, methods of constructing lists, tabular and tree models from graph theory and multidimensional models are used. Each vertex of the presented trees represents a set of competencies, which, in turn, are understood as a set of knowledge, skills and attitudes.

6. Findings

The multidimensional nature of ICT competency, shown in the sections no. 1-3 and structure of UNESCO ICT Competency Framework on the one hand, can be expanded by introducing additional classification features and dimensions; on the other hand, it can be extrapolated to individual components of ICT competency, in particular, the technological component. At the same time, significant classification features in the structure of a technological component may be features that reflect and influence ICT competency to a significant extent. Depending on the classification attribute, the following components of the technological component of ICT competency can be identified, and the structure of this component itself can be shown in the form of a tree.

6.1. Structure based on computer science

The structure of the technological component of ICT competency can be based on the structure of the corresponding subject and scientific field, which is computer science. The given structure (Figure 01) of the technological component is based on the tabular structure of the computer science subject area, presented at the II International UNESCO Congress “Education and Informatics” (Khenner, 2008). The structure presented in (Khenner, 2008) distinguishes theoretical computer science, means of informatization, information technology, communication technology, social information science, which have their own internal structure. The presented tabular (Khenner, 2008) or tree model (Figure 01) has its own problems, reflecting the difficulties of the classification. For example, in the presented model of the technological component system, computer networks belong to both the field of technical means of information and communication technologies, and text processing is simultaneously included in the information technologies field and universal program means of informatization. The inclusion of the same technology in several branches of a tree classification at once shows the impossibility of constructing such tree structure in its pure form.

In this regard, an interesting opportunity to study the structure and construction of competency models is the use of neural networks (Loktev et al., 2022) and modern research in the field of user interface and data representation.

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The vertices of the presented tree such as “Theoretical”, “Measure of Information”, “Information Models”, “Theory of Algorithms” correspond not only to sections of computer science, but also to groups of competencies.

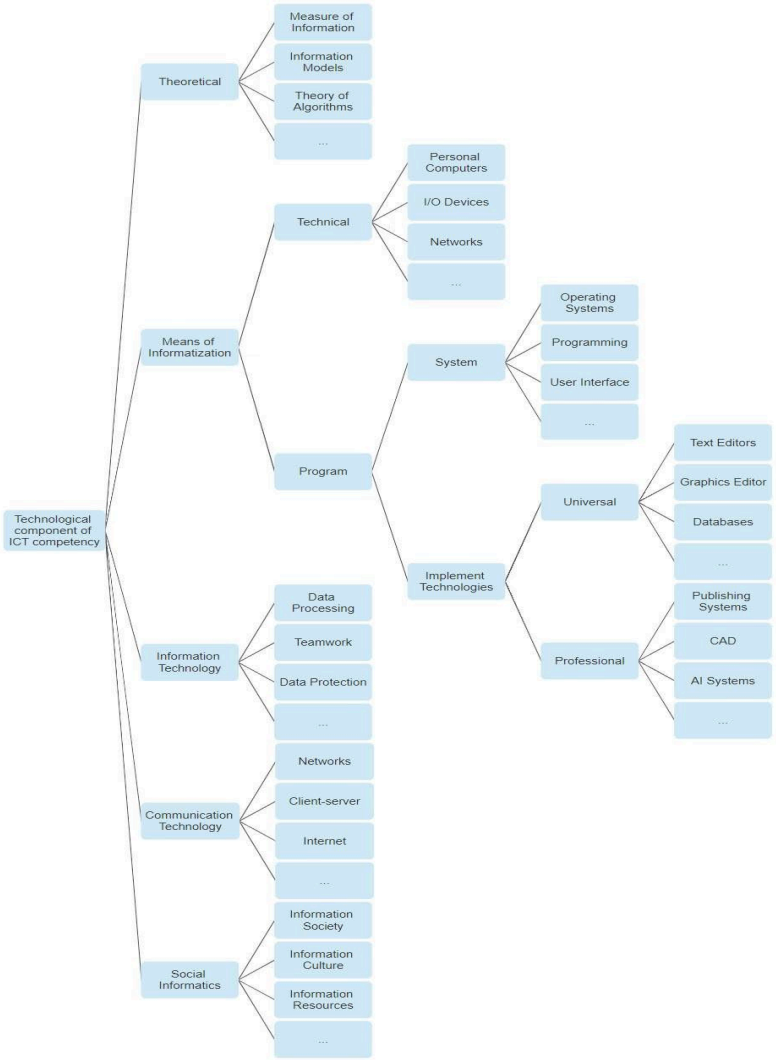

Figure 1. Tree structure of the technological component of ICT competency, based on the computer science structure

6.2. Ware-based

In the ware-based structure of the technological component of ICT competency, hardware and software are taken as the main components of the first level of technological components. The problem of using a tree structure of competencies in ICT also manifests itself: for example, microprocessor systems or PLDs can be studied and applied from a hardware point of view when directly developing a device and from a software point of view when programming it.

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6.3. Vendor-based

An interesting way to identify the structure of ICT competency can be the use of various professional certifications in the field of ICT, since the very idea of competence and competency in education appeared due to changes in the labour market. The modern version of the popular and mass certification ECDL/ICDL consists of five programs, each of which consists of separate modules combined into groups:

- ICDL Workforce modules
  i. Essential Skills (Application Essentials, Computer and Online Essentials, Computer Essentials, Online Essentials)
  ii. Office Applications (Documents, Spreadsheets, Presentation, Teamwork)
  iii. Good Practice (Cyber Security, Online Collaboration, Data Protection, Remote Work)
- ICDL Professional modules
  i. Creative (Advanced Presentation, Advanced Documents, Web Editing, 2D Design, 3D Design, Image Editing)
  ii. Entrepreneurial (Digital Marketing, Project Planning, E-Commerce)
  iii. Computational (Management Spreadsheets, Financial Spreadsheets, Data Analytics, Coding Principles, Using Databases, Advanced Databases)
  iv. ICDL for Teachers (ICT in Education)
- ICDL Insight Modules
  i. Cloud Computing
  ii. Internet of Things
  iii. Blockchain
  iv. Artificial Intelligence
  v. Big Data
- ICDL Digital Student modules
- ICDL Digital Citizen modules
  i. ICDL Digital Citizen
  ii. ICDL Digital Citizen Plus
  iii. ICDL Digital Tablets

7. Conclusion

The article shows the need for the technological component of ICT competency. In the above tree structure or list, each technological competency is understood as a set of knowledge, the ability to apply this knowledge in practice and attitudes. The leaves of the tree model represent narrower sets of competencies, while the intermediate nodes of the tree represent broader sets of competencies. Although sections 6.1–6.3 show examples of multi-level tree structures of the technological component of ICT competency, several important conclusions can be drawn from the examples presented:

i. Tree models of the structure of the technological component of ICT competency are possible, and for each case of tree classification it is necessary to select a classification attribute.

ii. Tree structure models or list models are not ideal, since with this method of grouping objects, the same object (in this case, a competency or set of competencies) can be assigned to different branches of the tree or list elements. In this context, generic and species sets may overlap.

iii. Classification features can be the names of object properties that can be set for each competency when presented in an object-oriented environment. The hardware/software, online/offline, theoretical/applied properties can be specified as Boolean values (yes/no), while other properties, such as the purpose of the software (text/spreadsheet/video/audio/browsers) can be represented in object-oriented model by enumeration values.

iv. The model of the technological component of ICT competencies can be presented as a multidimensional structure, expanding the two-dimensional tabular model of UNESCO ICT Competency Framework. Each competency can correspond to a specific cell of this multidimensional structure.

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