# Mobile ICT for Teaching Informatics of Future Bachelors of Professional Education

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Abstract: The paper considers the problem of using mobile information and communication technologies as a tool of teaching Computer Sciences to future bachelors in Professional Education. Based on the analysis of the scientific literature, the problem of applying information and communication technologies to teaching Computer Sciences and training future bachelor's in Professional Education is theoretically analysed. The content, criteria and levels of information and communication competences of future bachelor's in Professional Education are defined. The model of applying mobile information and communication technologies to training future bachelors in Professional Education is theoretically substantiated and developed. Methods of using mobile ICT as a training tool for teaching Computer Sciences to future bachelors in Professional Education are developed and their effectiveness experimentally verified. The structure and content of information and communication competences of future bachelor's in Professional Education are improved. Methodical foundations of teaching Computer Sciences to future bachelor's in Professional Education are elaborated.

## 1 INTRODUCTION

The Concept for implementing the state policy in Professional Education and training "Modern Professional (Professional) Education and Training" for the period up to 2027 (Cabinet of Ministers of Ukraine, 2019) notes that nowadays qualifications of workers, including graduates of Professional Educational and training institutions, do not meet current and future socio-economic needs. The problem is supposed to be solved by creating a system of quality assurance of Professional Education, which includes informatization of Professional Education, development of pedagogical software tools, and access to global information resources as well as improvement of the system of training, retraining, and professional development of teachers.

In Ukraine, the decline in the state order for workforce training, coupled with significant variation in the volume across different sectors of the economy, necessitates the training of bachelor's in Professional Education – future teachers at colleges and Professional Education institutions who can quickly adapt to meet the labour market's demand for qualified workers, considering international practices. This requires the development of information and communication technologies (ICT) competences of future bachelor's in Professional Education, for in-service training.

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## 2 LITERATURE REVIEW

National and international researchers have been studying various aspects of this issue: the creation and use of ICT tools (Sultana and Brown, 2017; Tan et al., 2019; Bingimlas, 2009; Heo, 2016; Matteucci et al., 2013), the use of ICT in training bachelors in Professional Education (Singh and T. S., 2014; Lytvyn et al., 2020; Humeniuk, 2018; Tytova, 2018; Loftus and Kinsella, 2021; Sell and Rüütmann, 2015; Tsidylo et al., 2019), training of future bachelors in Professional Education (Bakum and Tkachuk, 2014; Köhler et al., 2013; Kersten, 2018; Diachok et al., 2020; Ravi, 2022), formation of components of ICT competences and teaching Computer Sciences (Hevko et al., 2021; Oleksiuk and Oleksiuk, 2022; Seidametova et al., 2022; Spirin et al., 2018; Shepiliev et al., 2020; Shyshkina, 2013; Vakaliuk, 2015; Yatsko, 2014).

Improving the structure of teachers' training and retraining is a priority task for development of continuous teacher-training education, aimed at implementation of acmeological and axiological principles in teachers' training, formation of motivation and creation of conditions for their training and self-development in the course of professional activity, comprehensive modernization of the content, forms, and methods of education and training technologies in accordance with the requirements of the information civil multicultural society.

Ensuring the principles of continuous teacher-training education development, including integration of national educational traditions and global best practices, flexibility in responding to social changes and prognostication, innovativeness, etc. requires modernization of Computer Sciences training for future bachelor's in Professional Education, based on the use of mobile ICT tools, which provide the opportunity to meet educational needs of the learning target anytime and anywhere.

## 3 THEORETICAL PRINCIPLES OF TEACHING COMPUTER SCIENCES TO FUTURE BACHELORS IN PROFESSIONAL EDUCATION

After analysing the current state of training bachelors in Professional Education, the problem of forming their information and communication competences, the structure and content of ICT training of bachelors in Professional Education in Computer Sciences are determined.

In Ukraine, bachelor's in Professional Education major in Specialty 015 Professional Education. The training content is harmonized with the international IGIP standard, specified by area of expertise and expressed in terms of competences (International Society for Engineering Pedagogy, 2023).

The conducted analysis of standards for training bachelor's in Professional Education reveals the need to modernize components of the national standard of higher education for bachelor training. The result analysis of the expert survey made it possible to single out 18 general professional competences of bachelors in Professional Education:

1) the ability to apply the system of knowledge about communication patterns and methods of managing an individual and a group in the training process;
2) the ability to control and correct the educational process;
3) the ability to perform work at the appropriate qualification level (by profession);
4) the ability to master new types of equipment and innovative technologies (by profession);
5) the ability to adapt, adjust and use modern training technologies, automated learning systems, and electronic learning tools in professional and educational activities;
6) the ability to use modern methods of theoretical education in general professional subjects, general technical subjects and specific subjects (disciplines), as well as industrial training in the selected field;
7) the ability to improve the training process by searching for optimal methods, forms, and tools of teaching, using modern training and information technologies;
8) the ability to organize one's own work in a reasonable manner, and to possess general labour skills and abilities;
9) the ability to analyse the results and process of one's own work, setting and implementing tasks in the field of professional self-improvement, establishing the compliance of one's professional activity with changing requirements;
10) the ability to predict the results of professional and training activities;
11) the ability to form professional knowledge, skills and abilities of those who study, to ensure their professional, social and personal development;

12) understanding the essence and social significance of one's profession, the main problems in a specific field of one's activity;
13) the ability to acquire new knowledge using modern technology;
14) the ability to maintain and control labour and production discipline;
15) the ability to conduct psychological and pedagogical diagnosis, analyse its results and apply them to managing individual training activities;
16) the ability to work with regulatory, technical and reference literature;
17) the ability to prepare documents (work schedules, instructions, plans, applications, business letters, etc.), and reports (by area of expertise) according to established formats;
18) the ability to create a training complex, develop its main components and adapt them to the actual situation of the institution.

The analysis of international (UNESCO, 2018) and foreign standards (Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland, 2019; Gérard, 2006) and the results of an expert survey enables determining 13 specific professional (information and communication) competences of bachelors in Professional Education (digital technologies). The compentences are formed when studying Computer Sciences according to the following content blocks: theoretical foundations of Computer Sciences, architecture of modern computer technology, basics of algorithmization and programming, computer system software, computer technologies in professional activities of bachelors in Professional Education.

# 4 MODELLING AND DESIGN OF MOBILE ICT APPLICATION TO TEACHING COMPUTER SCIENCES TO FUTURE BACHELORS IN PROFESSIONAL EDUCATION

The content of information and communication competences of future bachelors in Professional Education is determined when designing a tool for monitoring the formation of competences and diagnosing the level of their maturity, i.e. the competence matrices. In the matrices, the rows correspond to specific criteria (cognitive, operational-technological, and value-motivational), the columns correspond to the levels (low, medium, and high), and the cells to the maturity indicators of each competence. Assessment of the maturity level of information and communication competences of future bachelors in Professional Education is proposed at 6 levels – initial, minimum basic, basic, high, advanced, and research (according to Spirin et al. (Spirin et al., 2018)).

According to the hypothesis, mobile ICTs, applied to teaching Computer Sciences, which, following Rashevska and Tkachuk (Rashevska and Tkachuk, 2015) are defined as a set of mobile hardware and software tools and a system of methods and forms of using such tools in teaching Computer Sciences for receiving, storing, processing and reproducing audio, video, text, graphic and multimedia data in the context of operational communication with global and local electronic educational resources, will contribute to improving the maturity level of information and communication competences of future bachelors in Professional Education (Tkachuk et al., 2020b).

The developed structural and functional model of mobile ICT application as a tool of teaching Computer Sciences to future bachelors in Professional Education (figure 1) (Tkachuk et al., 2018) is based on competence-based, personality-centred and systematic methodological approaches, built on the principles of Professional Education, general didactic principles, Computer Sciences teaching principles and mobile learning principles, taking into account current conditions and trends in mobile ICT development.

The model consists of four blocks:

1) the purpose-oriented block, which identifies the factors of change in training bachelors in Professional Education that led to the design of the information and communication competence system of future bachelors' training in Professional Education and the corresponding goal – its formation in the process of studying Computer Sciences with mobile technologies;
2) the content-technological block, which defines the content blocks of Computer Sciences, mobile ICT tools, forms of organization and methods of teaching them;
3) the diagnostics block, which defines general and special tools of monitoring and diagnosing the process of competence development; and
4) the result block, which defines the predicted result of the model implementation – increasing the level of maturity of information and communication competences of future bachelors in Professional Education (digital technologies). All blocks of the model are interconnected both directly and through their components.

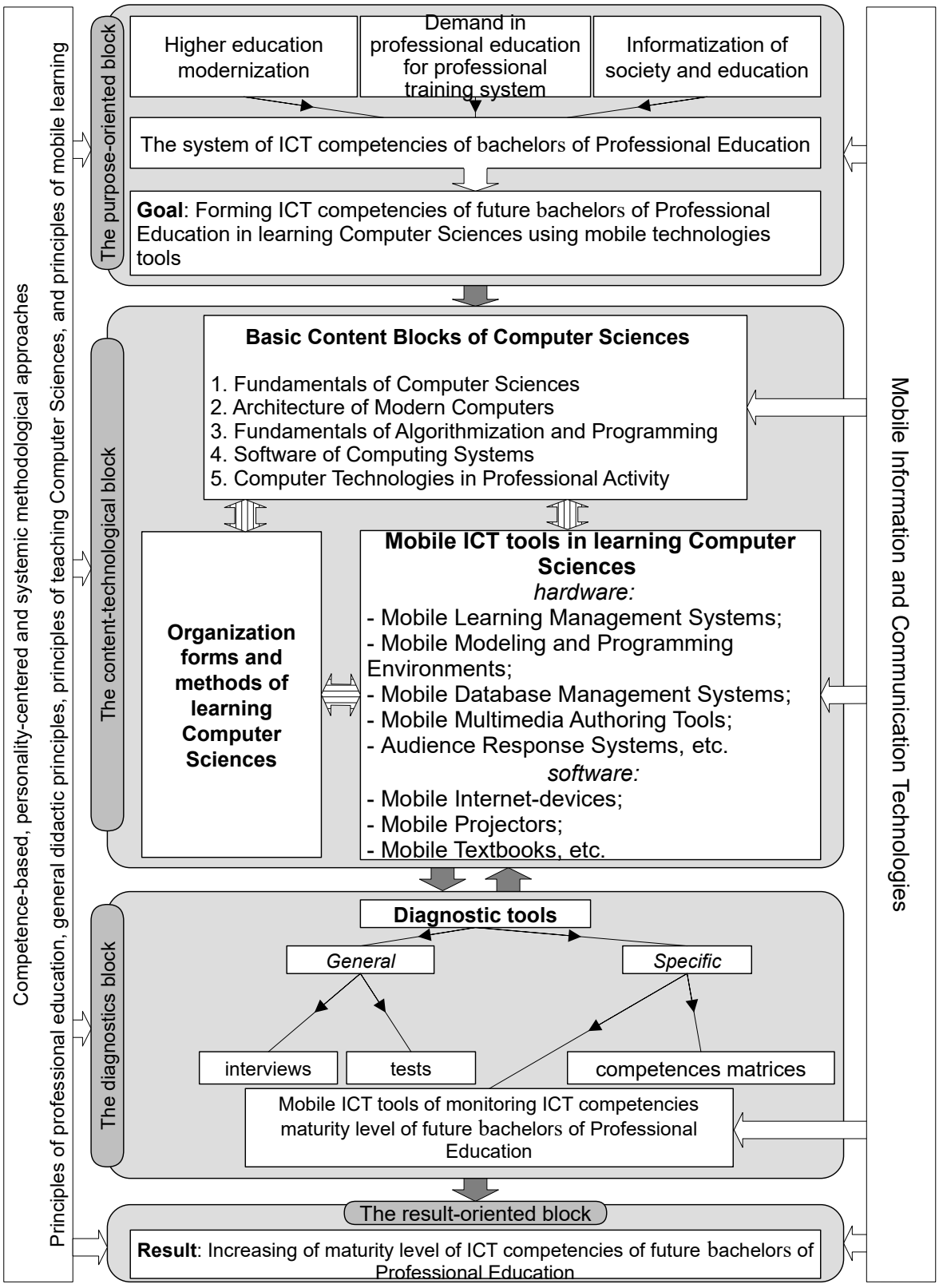


Figure 1: Model of mobile ICT application in teaching Computer Sciences to future bachelors in Professional Education (Tkachuk et al., 2018).

# 5 METHODOLOGICAL BASIS OF MOBILE ICT APPLICATION IN TEACHING COMPUTER SCIENCES TO FUTURE BACHELORS IN PROFESSIONAL EDUCATION

In the course of the research, we have developed a structure of methods for mobile ICT application in teaching Computer Sciences to future bachelors in Professional Education. There are determined goals and the content of teaching Computer Sciences to future bachelors in Professional Education and relevant mobile ICT tools for teaching Computer Sciences to future bachelors of Professional Education are selected. The main components of methods for mobile ICT application as a tool for teaching Computer Sciences to future bachelors in Professional Education are described.

Based on the results of the expert survey, the feasibility of teaching Computer Sciences by using the following mobile ICT tools is determined (table 1):

- Mobile Learning Management Systems – adaptive, accessible, and mobile e-learning resources that support educational and administrative tasks, assign participant roles in the training process, assess students' learning outcomes, contribute to collaboration between students and teachers, facilitate various types and methods of presenting educational materials, etc;
- Mobile Modeling and Programming Environments – software packages adapted to different operating systems and mobile devices that combine the basic tools needed to write and debug software;
- Mobile Database Management Systems – software for creating and managing databases which allows users and programmers to design, create, retrieve, update, and manage data through client access to the server side provided by a mobile software interface and/or mobile Internet devices;
- Mobile Multimedia Authoring Tools – mobile software that develops electronic training resources based on multimedia principles, spatial proximity, temporal contiguity, coherence, modality, redundancy, personalization, interactivity, signaling, and consideration of individual differences;
- Audience Response Systems – mobile software for measuring students' learning outcomes through automatizing current and final control processes based on the latest testing tools and comprehensively enhancing the learning process.

It is revealed that:

- Mobile Audience Response Systems and Mobile Learning Support Systems are universal tools for teaching Computer Sciences;
- Mobile Multimedia Authoring Tools are highly feasible for all Computer Sciences, except for low-level and system programming and system software, which also allows for their universal classification;
- Mobile Modeling And Programming Environments are the leading tools of teaching theoretical foundations of Computer Sciences and the basics of algorithmization and programming (with the exception of visual programming and low-level and system programming);
- Mobile Database Management Systems are the basic teaching tools only for database programming.

Methodology of using mobile ICT as a tool of teaching Computer Sciences to future bachelors in Professional Education is defined as a theoretically grounded set of methods, ways, techniques and forms of using mobile ICTs:

- methods of using mobile audience response systems (Plickers);
- methods of using mobile learning support systems (Moodle and Intune for Education);
- methods of using mobile multimedia authoring tools (augmented reality multimedia authoring tools);
- methods of using mobile modelling and programming environments in Machine Learning training (Pydroid and Jupyter Notebook environments);
- methods of using mobile database management systems in teaching relational DBMSs (the Google Cloud SQL server and mobile clients).

# 6 ORGANIZATION, CONDUCT AND RESULTS OF EXPERIMENTAL WORK

In the course of the research, experimental work was carried out to design a system of information and communication competences. At the confirmation stage of the pedagogical experiment, 57 students were included in the control and experimental groups. Pearson's $\chi^2$ criterion was used to find

Table 1: Assessment of feasibility of mobile ICT application to teaching Computer Sciences to future bachelors in Professional Education (Tkachuk et al., 2020a).

| Content block | Group of Informatics subjects | Mobile ICT tools | | | | | Average efficiency estimate for subject **group** |
|---|---|---|---|---|---|---|---|
| | | mobile learning management systems | mobile modelling and programming environments | mobile database management systems | mobile multimedia authoring tools | mobile audience response systems | |
| Theoretical principles of Informatics | Discrete Programming, Operations Research, Computer Logic, Theory of Automatic Control | 4.09 | 4.36 | 3.27 | 4.18 | 4.45 | **4.07** |
| | Computer Cryptology | 4.00 | 4.00 | 3.36 | 4.00 | 4.18 | **3.91** |
| Architecture of modern computing machines | Architecture of Computer Systems and Networks, Microprocessor Systems | 4.09 | 3.55 | 3.00 | 4.09 | 4.27 | **3.80** |
| Basics of algorithmization and programming | Basics of Algorithmization and Elements of Programming | 4.27 | 4.45 | 3.27 | 4.36 | 4.36 | **4.15** |
| | Visual Programming | 4.09 | 3.91 | 2.73 | 4.36 | 4.18 | **3.85** |
| | Low-Level and Systems Programming | 4.00 | 3.91 | 3.00 | 3.91 | 4.09 | **3.78** |
| | High-Level Programming Language | 4.09 | 4.45 | 3.55 | 4.27 | 4.18 | **4.11** |
| | Web Programming | 4.27 | 4.36 | 3.55 | 4.18 | 4.36 | **4.15** |
| | Software Design Technologies | 4.09 | 4.45 | 3.64 | 4.18 | 4.27 | **4.13** |
| | Database Programming | 4.09 | 4.27 | 4.82 | 4.09 | 4.27 | **4.31** |
| Software of computing systems | Project Management | 4.09 | 2.82 | 2.82 | 4.09 | 4.27 | **3.62** |
| | Application Software | 4.36 | 2.91 | 3.09 | 4.27 | 4.45 | **3.82** |
| | Systems Software | 4.09 | 3.45 | 3.18 | 3.91 | 4.27 | **3.78** |
| | Basics of Information Security | 4.09 | 3.00 | 3.09 | 4.00 | 4.27 | **3.69** |
| | Computer Design and Multimedia | 4.18 | 3.64 | 2.64 | 4.73 | 4.36 | **3.91** |
| | Engineering and Computer Graphics | 4.09 | 3.00 | 2.55 | 4.91 | 4.55 | **3.82** |
| | Computer Aided Design | 4.18 | 3.45 | 3.09 | 4.18 | 4.36 | **3.85** |
| Computer technologies in professional activity of professionals in engineering pedagogy | Automation Systems for Document Management | 4.27 | 3.36 | 3.45 | 4.09 | 4.36 | **3.91** |
| | Computer Pedagogical Technologies, Computer Ergonomics | 4.36 | 2.91 | 2.91 | 4.64 | 4.82 | **3.93** |
| Average efficiency estimate of the tool | | **4.15** | **3.70** | **3.21** | **4.23** | **4.33** | |

out whether there are statistically significant differences between the obtained distribution of the levels of information and communication competences of students in the control and experimental groups. The calculated empirical value of the criterion $T_{emp} = 1.556 < T_{crit}(0.05) = 7.815$ provided the basis for concluding that there are no statistically significant differences in the control and experimental groups.

After the completion of the formative stage of the pedagogical experiment, which included the systematic teaching of Computer Sciences through mo-

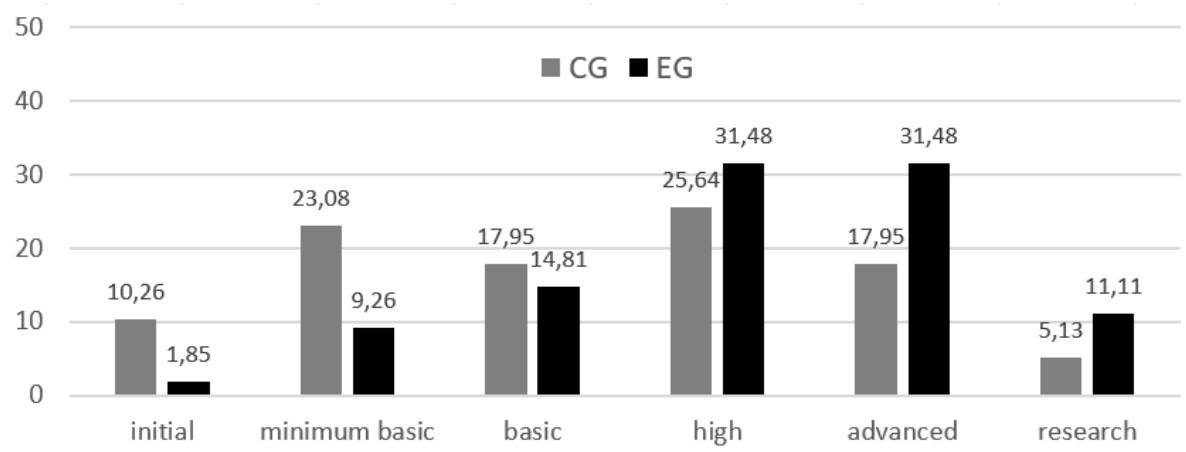


Figure 2: Distribution of students of the control (CG) and experimental (EG) groups by levels of information and communication competences after the formative stage of the pedagogical experiment.

bile ICT application according to the developed methods, the diagnostics of the maturity level of information and communication competences of future Professional Education bachelors was repeated (figure 2). The results processed with Pearson's $\chi^2$ criterion reveal that $T_{emp} = 8.38$ is greater than the critical $T_{crit}(0.05) = 7.815$ at the 0.05 level of statistical significance and less than the critical $T_{crit}(0.01) = 11.345$ at the 0.01 level of statistical significance. This provides a basis for concluding that when the formative stage of the pedagogical experiment is completed, there is a statistically significant difference between the experimental and control groups at the 0.05 significance level.

The results show that after the formative stage of the educational experiment, the percentage of students with initial, minimum basic, and basic levels of competence decreased (8.40 %, 13.82 %, and 3.13 %, respectively), while the percentage of students with high, advanced, and research levels increased (5.84 %, 13.53 %, and 5.98 %, respectively). Thus, it can be assumed that an increase in the number of students with high information and communication competences is due to the transition from lower level groups, i.e., the effect of the increase in the level of information and communication competences of future bachelors in Professional Education in Computer Sciences. To verify this assumption, the $\phi^*$ criterion, i.e. Fisher's angle transformation, was applied. The calculated criterion value $\phi^* = 2.51$ is higher than the limits at the levels of statistical significance 0.05 ($\phi^*_{crit}(0.05) = 1.64$) and 0.01 ($\phi^*_{crit}(0.01) = 2.31$). This gives grounds to assert the existence of the effect of increasing the maturity level of information and communication competences of future bachelors in Professional Education (Digital Technologies) in the experimental group at the formative stage of the pedagogical experiment at the level of significance of 0.01.

Based on the fact that the experimental group applied the developed methods of using mobile ICTs as a tool of teaching Computer Sciences to future bachelors in Professional Education, we can conclude that this was a factor of increasing the maturity level of their information and communication competences, and, therefore, the research hypothesis is proven.

# 7 CONCLUSIONS

1. Bachelors in Professional Education are trained in accordance with the international IGIP standard, and in Ukraine, they major in Specialty 015 Professional Education. Its component is Computer Sciences training, which is carried out in the following content blocks of Computer Sciences: 1) theoretical foundations of Computer Sciences; 2) architecture of modern computer technology; 3) basics of algorithmization and programming; 4) computer system software; 5) computer technologies in professional activity of bachelors in Professional Education.
2. Students majoring in Speciality 015.39 Professional Education (Digital Technologies) and teachers of Computer Sciences have a high level of technological readiness, an average level of psychological readiness and a low level of methodological readiness to use mobile ICTs in training, which necessitates the development of appropriate research principles. Based on the results of the expert survey, basic and auxiliary mobile ICT training tools are identified for each of

the content blocks of Computer Sciences.

3. The result of teaching Computer Sciences to future bachelors in Professional Education majoring in Digital Technologies is the maturity level of their information and communication competences. The content of information and communication competences is determined when designing a tool for monitoring the formation of competences and diagnosing the level of their maturity through competence matrices. A comprehensive methodology for assessing the maturity level of information and communication competences of future bachelors in Professional Education (digital technologies) is developed.
4. The developed model of using mobile ICTs as a tool of teaching Computer Sciences to future bachelors in Professional Education is based on competence-based, personality-oriented and systematic methodological approaches, built on the principles of Professional Education, general didactic principles, principles of teaching Computer Sciences and mobile learning principles, taking into account current conditions and trends in mobile ICT development.
5. Methodology of using mobile ICTs as a tool of teaching Computer Sciences to future bachelors in Professional Education is defined as a theoretically grounded set of methods, ways, techniques and forms of mobile ICT application to teaching Computer Sciences to future bachelors in Professional Education. The components of the methodology are partial methods of using Mobile Audience Response Systems, Mobile Learning Support Systems, Mobile Multimedia Authoring Tools, Mobile Modelling And Programming Environments, and Mobile Database Management Systems.
6. The analysis of the results of the experimental work allows asserting that the experimental group at the formative stage of the pedagogical experiment has the effect of increasing the maturity level of ICT competences of future bachelors in Professional Education. Based on the fact that the experimental group used the developed methods, we can conclude that this was a factor in increasing the maturity level of ICT competences.

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