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THE INFLUENCE OF INTERDISCIPLINARY INTEGRATION OF INFORMATION TECHNOLOGIES ON THE EFFECTIVENESS OF IT TRAINING OF FUTURE TEACHERS

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ABSTRACT

The problem of finding ways to integrate information technologies in education, as well as identifying new ways of their implementation, is relevant in the light of the emergence of new disciplines driven by the development of science and technology. The purpose of the study is to practically confirm the effectiveness of the proposed approaches to the selection of information technologies in the training of future teachers in the field of computer science within the framework of two successive courses, which are often taught separately. The integration of technologies and teaching aids can significantly increase the effectiveness of training students in these areas. The educational research was carried out by forming a control (64 people) and experimental (65 people) groups of first-, second-, and third-year students of teacher's university. In the experimental group, the ICT ("Information and Communication Technologies") and DTE ("Digital Technologies in Education") courses were conducted using the same software, selected following the specifics of teaching both disciplines. Assessment of student's knowledge was carried out using the mathematical statistics and specially developed tests. The proposed approaches to conducting classes based on the interdisciplinary integration of IT and preliminary selection of the necessary integrated teaching aids contribute to the personal development of future teachers and diversity of IT sphere. Interdisciplinary integration of information technologies needs comprehensive and balanced multidisciplinary training and integration in the classroom presents a significant challenge. In course of this study were given suggestions and methods for modern educators for coping with the increasing dividing of IT from other disciplines. The positive influence of the interdisciplinary integration on the effectiveness of training students in the interdependent areas of informatics and computing has been confirmed. Forming the correct attitude to digital resources as a teaching medium is a significant factor in the effectiveness of professional training of teachers.

Keywords: *Digital technologies, Educational technologies, Quality of education, Educational resources, Digital competence.*

1. INTRODUCTION

Almost all ongoing reforms in the system of higher vocational education, one way or another, contribute to the improvement of information support of the training of future teachers. In this regard, the problem of updating such training, development and selection of the most suitable teaching aids, corresponding to the scientific development of society and improved teaching technologies, is urgent [1]. Requirements for the content of higher vocational education suggest that a future teacher requires not only knowledge and skills, but also the ability for continuous personal development, applying the concept of lifelong learning. This is determined, among other things, by the need to respond quickly to constantly emerging changes in professional activities. In this regard, a significant problem is the search for approaches and means for improving educational materials aimed at effective training of future computer science teachers.

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The task of modern education is to form the personality of the future teacher in accordance with the priorities of the development of the information society, ready for successful pedagogical activity, updating professional knowledge, ready for professional and personal growth.

There is a large number of theoretical and practical studies devoted to the specifics and prospects of informatisation of education. Informatisation entails an increase in the clarity and rate of learning, the development of the qualities necessary for professional activity of students in the context of the global informatisation of society. In this regard, a special role is played by disciplines related to computer science, such as the "Information and Communication Technologies" (ICT), which are included in the curricula of most pedagogical universities. The purpose of teaching such disciplines is to familiarise students with the essence, composition, and prospects for the development of current digital technologies. This includes approaches to operating ICT tools at the user level, and methods of ensuring information security. To date, relatively traditional goals and objectives of ICT training have already been formed. A great contribution to the development of the theory and methodology of teaching the corresponding training courses was made by the studies of L.L. Bosova, S.G. Grigorieva, V.V. Grinshkun, A.P. Ershova, A.A. Kuznetsova, M.P. Lapchik, I.V. Levchenko and others [2-8].

No less important for future teachers are courses that introduce them to the aspects of learning with the use of digital technologies, when information resources act as teaching aids. In particular, at the Abai Kazakh National Pedagogical University (Abai KazNPU), the course "Digital Technologies in Education" (DTE) has been introduced into the curriculum to train all students in the field of professional education using the latest technologies. The DTE course is aimed at mastering the most significant aspects of the implementation of educational activities in the context of using digital technologies. Moreover, the development and use of new information resources is of great importance today, due to the discussed trends in the digital transformation of university education. Comparison of the content of both courses shows that they do not overlap and can complement each other. Therewith, the content of these disciplines is invariant, in no way related to the educational programme of teachers and educational psychologists [9]. The development of modern scientific knowledge, which leads to the emergence of new branches of learning, must be carried out taking into account the factor of interdisciplinarity. From the standpoint of the formation of core information competencies of future teachers, it becomes logical to rely on all types of interdisciplinary integration. It provides a purposeful strengthening of interdisciplinary ties while maintaining the theoretical and practical integrity of academic courses. Interdisciplinary ties expand the educational space, create a virtual educational laboratory, where students, repeatedly applying knowledge of each discipline in new conditions, develop the ability to apply knowledge in professional activity [10]. Interdisciplinary connections contribute to the integration of subject areas in the training system due to the assimilation of unrelated knowledge by students in the study of a large number of academic disciplines.

Many scientists have studied an interdisciplinary approach to teaching different courses, one of the effective examples of which is the use of interdisciplinary integration of information technologies used as an object and means of training students. Study has revealed the positive impact of such a pedagogical approach on the formation of students' core digital competence [11-13]. For example, P.V. Nikitin considered the methodological features of the organisation of individual training for computer science teachers, based on two factors – pedagogical approaches: interdisciplinary integration and internal differentiation, using modern information technologies. The introduction of such a methodology in the training of future teachers has a positive effect not only on the quality of education, but also on the research activity of students [14]. With the advent of new information technologies, such as artificial intelligence, the Internet, virtual reality, blockchain, smart classroom, BYOD, robotics, etc., educators and researchers are studying the impact of integrating these technologies into the university curriculum. In his work, M.P. Lapchik describes an innovative approach based on the introduction of an integrated information education environment "school – teacher's university". Such an environment reinforces social partnership of teacher's universities, educational organisations, virtual methodological associations of teachers [5]. Professional training of teachers is based on the introduction of innovative activities in the educational process with the aim of organising creative information interaction of students and teachers in the process of mastering e-learning technologies.

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Various modern digital technologies can be used uniformly for teaching computer science. The practices of educational institutions gradually include the use of mobile tools and systems. BYOD technology is promising, but its success depends on the readiness of all participants in the educational process: teachers, parents, students to use personal mobile devices for educational purposes. In addition, the teacher is required to have a high level of training in the field of information technology, knowledge of the technical characteristics of various mobile devices, computer software, and network services [15]. Given the challenges and opportunities described, further study is necessary to address several relevant issues. First of all, it is important to continue the study of the pedagogical approach based on the interdisciplinary integration of information technologies in the context of the competence-based approach in the training of future teachers [10]. In addition, the relationship between the issue of forming high-quality content of information resources and the low readiness of educators to teach with their help requires further consideration [7]. Of particular interest is the impact of interdisciplinary integration of IT, as means of training future teachers in the field of computer science.

2. MATHERIALS AND METHODS

Within the framework of this study, an attempt was made to improve the methodological systems of conducting ICT and DTE courses on the basis of interdisciplinary integration of IT and subsequent assessment of the influence of such an approach on the effectiveness of teacher training. Training systems for ICT and DTE courses have acquired the possibility of joint systemic and uniform application of the same information technologies, taking into account the use of software as an additional factor in linking these courses. As part of this activity, technologies and tools were used for:

– formation of additional interdisciplinary links of both courses and the acquisition of the possibility of parallel or sequential study of individual sections and topics;

– conscious application of the required information technologies in the study of disciplines with regard to the emerging needs in the use of IT;

– creation of effective uniquely designed digital educational resources (DER), both by teachers and students;

– use in the classroom of the appropriate necessary software that affects the learning;

– development of communication and other skills in students in the process of creating tests, reports, projects in the field of informatics and informatisation of education using various electronic resources collected in a set for teaching both relevant disciplines.

Despite the fact that ICT and DTE courses are consistent with the need to comply with the requirements of continuation (the DTE course is studied by students after the ICT course and can be taught by different teachers), the content of these subjects identified topics within the framework of which it is advisable to integrate the applied information technology tools. On the basis of this application, interdisciplinary connections can be formed by implementing, for example, crosscutting interdisciplinary projects. In the KazNPU, ICT course is studied for one semester in the first or second year, depending on the curriculum.

The DTE course also lasts for one semester and is studied in the third year. As part of the study, students were asked to complete projects using a set of open educational resources (OER) with ready-made templates. In particular, the open online collection of educational resources Merlot (merlot.org) was chosen as a key integrating factor for the study. The choice in favour of the specified collection was made by the following arguments:

– collection contains different types of materials (virtual laboratories, ready-made environments for the independent design of electronic resources, online courses for a detailed study of certain topics, syllabuses, etc.) in different fields of science. They can be simultaneously used as objects and means of teaching computer science;

– electronic resources contained in the collection are of high quality, since they were developed at major universities (Harvard University, Massachusetts Institute of Technology, and others);

– resources are grouped by the knowledge level: from beginner to advanced. This division is very important when drawing up tasks for students of humanities and natural sciences, as well as separately for students of IT specialties both in computer science and in the informatisation of education;

– most of the resources in collections are open source and published in English. This is also important considering that the ICT course is taught

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in English. The uniform use of such resources would help to improve the language proficiency of students in the field of informatisation of education.

The content of ICT course includes topics such as: "Computer architecture", "Operating systems", "Databases", "Internet technologies", "Cloud technologies", "Mobile technologies", etc. Therewith, students are relatively familiar with the resources for studying the basics of the course due to the presence of computer science in the school curriculum. There are a large number of relevant teaching materials. At the same time, special attention was paid to the use of new information technologies in the professional activities of teachers, since it is a key for digital competence of future teachers. The Merlot collection contains teaching materials on most of the subjects taught. In this regard, the corresponding video lectures, virtual laboratories (simulators), user instructions can be outlined. Such teaching aids were used in the study to visualise information. For example, the video resource "How to organise online communities" was used during a lecture on the topic "Internet technologies". As a result, students became familiar with one of the areas of application of Web-technologies. A whole section is devoted to mobile learning in Merlot. An example of recommended tasks for students focused on using this section is the "Selecting one of the mobile applications for learning". In the ICT course, the Merlot collection was mainly used as an introductory material and a teaching tool.

As part of the DTE course, future teachers get acquainted with the didactic and other foundations of software development, creating their own electronic educational resources during training. According to the national standard, bachelors who completed the DTE course must not only be able to use ready-made electronic learning resources, but also be able to create them themselves. One of the interdisciplinary tasks within the framework of this study is the creation of a mobile educational application using ready-made constructors from the Merlot collection. Students were asked to choose the topic of the created resource by their own specialties and profiles. To complete the assignment correctly, students need knowledge of mobile and cloud technologies, hypertext, algorithmisation and other aspects, obtained during the previous ICT course. Assignments of this type are more focused on the independent study of relevant topics by students, while teachers act as consultants.

Figure 1 shows an example of the simplest electronic educational resource on the topic "Colouring animals", developed by a third-year student of the specialty "Pedagogy and methodology of primary education". Figure 2 shows The App Inventor that was used to develop a two-dimensional graphical mobile application.

Figure 1. An example of an electronic learning resource developed by a student within the framework of integrated training in informatics and informatisation of education

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Figure 1. An Example Of An App Inventor Window With Application Developed By A Student Within The Framework Of Integrated Training In Informatics And Informatisation Of Education

As part of the study, the most complete and effective educational resources created by students were included in the university collection for subsequent use in the educational process as objects and teaching aids for ICT, DTE and many other subjects. When performing the described interdisciplinary tasks, the attention of students was paid to:

– independence shown in the study of the topic;

– the importance of educational and creative activities for a person;

– creativity in the use of information technology;

– distinctness in the choice of information technologies and the level of their use in solving problems.

The introduction of this collection in the training aimed to provide teachers with the possibility of flexible response to deviations from the assigned parameters in the process of forming knowledge and skills for the entire period of learning both disciplines. This approach can also be used to assess students' performance. Along with the Merlot collection, electronic learning resources from other collections were integrated within the framework of teaching these disciplines. Electronic resources, such as BilimLand, iMektep, "Moscow Electronic School", "Mobile Electronic Education" and some others were created in Kazakhstan and Russia [16]. The format of the paper does not allow to describe the experience of their use in detail, which, in general, was similar to the experience of using resources of the Merlot collection.

The study of the impact of interdisciplinary integration of information technologies on the effectiveness of training future teachers in the field of informatics and informatisation of education was carried out in the first half-year of the 2018-2019 academic year and the first half-year of the 2019-2020 academic year. Students of Abai KazNPU took part in the educational experiment. The experimental group included first-year students majoring in "Kazakh language and literature" and "Pedagogy and methodology of primary education" (total 65 people). The control group consisted of 64 people –

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students majoring in "Philology" and "Two foreign languages". Mathematical statistics was applied to process the results of the experimental part of the study.

3. RESULTS

Students in the control group (CG) were taught ICT and DTE courses in a traditional manner. Various information technologies and tools were used, and their application was not based on the proposed approach to the interdisciplinary integration of objects and teaching aids. The students in the experimental group (EG) participated in the above-mentioned projects for the development of digital educational resources with a uniform and systematic use of described approaches and technologies. As part of the experiment, teaching materials from various sections of the ICT and DTE courses were used. The conducted interviews and questionnaires showed a high interest of students in the formation of ICT competence based on the interdisciplinary integration of IT. The need of students for obtaining practical knowledge and skills, as close as possible to future pedagogical activity, was noted. The criteria for the effectiveness of training future computer science teachers, necessary for the experiment, were identified based on the analysis of the content of State Compulsory Educational Standards in the teaching specialties. The following factors were identified and used:

– a significant increase in the average share of theoretical knowledge assimilation by students;

– a significant increase in the ability to solve professionally oriented tasks;

– a significant increase in the formedness of digital competencies.

The formedness of theoretical knowledge was assessed by computer testing, which was repeatedly carried out in the experimental and control groups. The average value of this indicator was determined for each group. The control over the formedness of practical skills and abilities was carried out using interdisciplinary tasks and was assessed by teachers. The methods for studying the levels of assimilation proposed by V.P. Bespalko [17] were used to assess these performance indicators. It contains four levels of assimilation.

Level I – "prompted" reproductive activity, recognition of objects, processes, properties during the repeated perception of previously assimilated information.

Level II – reproduction of previously assimilated information and the ability to solve typical problems.

Level III – productive actions for the application of the information received in the process of independent activity.

Level IV – the possibility of creative application of the information received through the independent construction of personal activity. At this level, the subject demonstrates the ability to carry out research and inventive activity.

At the beginning of the experiment, students' knowledge was analysed at the first two levels of assimilation. Notably, there were no significant differences in the assimilation of educational material at these levels between the students of both groups. To measure the assimilation at the end of the experiment, an analysis of III and IV levels of assimilation was conducted. The students participating in the experiment were offered tasks of four levels of complexity. Such an approach provides relatively objective idea about the level of knowledge and allows applying a scale for to assess the quantitative characteristics of the learning process. The criteria for scoring corresponded to the level of assimilation and were determined on a twelve-point scale in accordance with the table of points (Table 1).

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TABLE 1: Scale For Determining The Results Of The Implementation Of Assignments By Students Of The Control And Experimental Groups

Level of assimilation	Score	Percentage of tasks completed correctly
I	0	<50%
	1	50-70%
	2	70-90%
	3	>90%
II	0	<50%
	4	50-70%
	5	70-90%
	6	>90%
III	0	<50%
	7	50-70%
	8	70-90%
	9	>90%
IV	0	<50%
	10	50-70%
	11	70-90%
	12	>90%

The final score was determined by calculating the average score within each level, based on the criterion (Eq. 1):

$$K=a/n \quad (1)$$

where: a – the sum of the points scored, n – the total number of tasks, and the comparison of the average score with the limits for this level. The limits for each level were (respectively): level I – 1, level II – 4, level III – 7, level IV – 10. If the average score received by the student was below the possible minimum value for this level, it was considered that the student has not mastered the training material at this level. The final score was determined by the average score of the highest level successfully passed by the student.

Mastering the level IV was more successful in the experimental group (85% of students reached the level IV). In the control group, only 55% of the trainees reached this level. The reliability of the performance criteria growth was assessed using the Page's trend test. The final values of the experimental and control groups were compared using the parametric Student's t-test. The total percentage of material assimilation, the degree of development of practical skills and competencies was compared according to V.P. Bespalko in the model of complete assimilation with 70% [17]. Selected test results for five topics are presented in Table 2.

TABLE 2. The coefficient of assimilation of educational material on five topics in the control and experimental groups

Group	Topic					Average share
	1	2	3	4	5	
Control	0.59	0.71	0.67	0.76	0.68	0.68
Experimental	0.63	0.74	0.86	0.91	0.88	0.80

The analysis of the results obtained suggest that the assimilation of educational material in the EG is, on average, 12% higher than in the CG. For the EG, a significant increase was noted (Lemp. =922, at Lcr. =918), at the same time, for the CG, the growth was absent (Lemp. =835, at Lcr. =918). According to the Student's test at the end point, there is also a significant difference between the average shares of the experimental and control groups (temp.=1.83, tcr. =1.67). Thus, the data obtained indicate above-limit value of the indicator reflecting the degree of assimilation of theoretical knowledge among the students in the experimental group.

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No. of topic	The average level of formedness of the ability to solve tasks, %
1 (ICT)	66
2 (ICT)	69
3 (DTE)	71
4 (DTE)	75
5 (DTE)	82

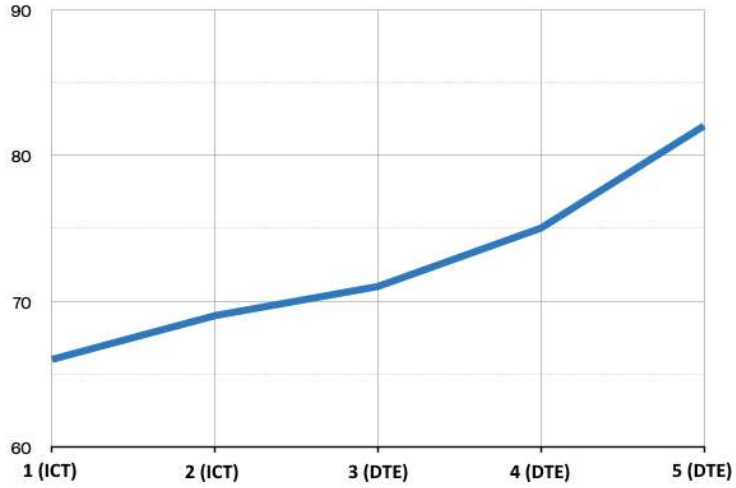

Figure 2. The average level of formedness of the ability to solve professionally oriented tasks among future teachers

Figure 2 shows the average percentage of the formedness of the ability to solve professionally oriented tasks for students in the experimental group. Comparison of the data showed the reliability of the growth of the level of the formedness of the ability to solve such tasks (Lemp. =960, at Lcr. =918). The experimental data show that at the final stage, the average level of the ability to solve professionally oriented tasks for future teachers exceeds the critical limit of 70% (according to the method of V.P. Bespalko).

4. DISCUSSION

To track the progress of the development of students' digital competencies, the project method was used [18; 19]. In the analysis of crosscutting professional projects, expert assessments, questionnaires, and analysis of project defence were used [20]. In the course of the study, the students several projects, for the preparation of which, within the framework of the ICT and DTE courses, a joint provision of information technology was carried out. As a result of this part of the experiment, a significant increase in digital competencies in future teachers has been revealed.

The issue of training pedagogical personnel in the field of informatics and informatisation of education was addressed in the works of E.Y. Bidaibekov, S.G. Grigoriev, V.V. Grinshkun, M.P. Lapchik, N.S. Prokopova, S.R. Sharmukhambet, G.A. Fedorova [2-8] and others. The authors describe and substantiate the ways of improving the system of teacher training in the field of computer science.

Works by of mentioned authors are a good basis for research in the development of methods for teaching computer scientists, but most of them are outdated now and require updating [21; 22]. The indisputable advantage of the authors' work in this context is the relevance of the information. Due to past research, updated methods and processes have been applied to obtain the most accurate and analysed results. The analysis of the methodologies of past research has allowed to improve and apply completely new processes for more effective training of future specialists [23]. The literature cited is dominated by outdated theoretical information, which meant that the authors' study required a detailed description of practical applications to justify the chosen methods. For the current study, the authors were able to achieve their goals and analyse the result to show their correctness. Thanks to mathematical analysis, it was proved that the results of the experimental group are 12% higher than the standard one. Thus, it can be argued that the practical value of this study is higher than that of previous works. The authors were able to develop a methodology based on past research and apply it in real-life conditions, with positive results. However, it was not possible to apply the entire methodology due to its large number, and the realities of modern time which in turn means that the variability of subsequent studies can be achieved by choosing alternative methods and analysing a different methodology for constructing alternative processes. This research has several ways to improve it. The number of students in groups can be significantly larger and alternative methods can be applied in the development of a methodology, which makes it

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possible to predict the great scientific value of both this work and subsequent research.

5. CONCLUSIONS

The findings indicate that the use of an approach based on the interdisciplinary integration of information technologies has a positive effect on teaching in the field of computer science. This is due to the fact that interdisciplinary integration contributes to the formation of an integral system of ideas about computer technologies as a means of teaching ICT and DTE. This system is significant for the development of the professional qualities of a modern teacher.

It has been proven that the organisation of training courses on the basis of interdisciplinary integration of IT allows creating flexible, personality-oriented educational programmes. Some of which could be publicly used in the future. This method makes way for huge number of fresh ideas. It stimulates students to independently acquire knowledge and participate in activities that turn a student from a subject of the educational process into a co-author who takes part in planning. The experience of using such methods to enhance interdisciplinary integration in education confirms their positive impact on the effectiveness of training future computer science teachers and on IT sphere as a whole.

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