УДК 378.14

Mironova L. I.[1]
[1] Ural Federal University, Yekaterinburg, Russia
e-mail: [1] mirmila@mail.ru

IMPLEMENTATION OF INTERDISCIPLINARY APPROACH IN THE PROCESS OF HIGHER EDUCATION DIGITAL TRANSFORMATION

Abstract. The article deals with the problem of information and methodological support of the educational process in universities in the context of the digital transformation of higher education. An analysis of scientific publications on the topic of the article showed that this process can be activated by applying an interdisciplinary approach. It can be implemented by creating interdepartmental research teams at universities, the main participants of which will be future IT specialists and their leaders from among the leading teachers of IT departments. As part of the activities of these teams, digital educational resources will be developed by order of university departments and other departments of the university. At the same time, IT developers of educational resources will increase their skills in the field of creating various kinds of software. As a result of the activities of such teams, the digital educational environment of the university will be replenished with up-to-date digital educational resources and their methodological support.

Keywords: interdisciplinary approach, digital educational environment, digital educational resources, interdepartmental research team, educational and methodological support.

Миронова Л. И.[1]
[1] Уральский федеральный университет, Екатеринбург, Россия
e-mail: [1] mirmila@mail.ru

ВНЕДРЕНИЕ МЕЖДИСЦИПЛИНАРНОГО ПОДХОДА В ПРОЦЕССЕ ЦИФРОВОЙ ТРАНСФОРМАЦИИ ВЫСШЕГО ОБРАЗОВАНИЯ

Аннотация. В статье рассматривается проблема информационно-методического обеспечения образовательного процесса в вузах в контексте цифровой трансформации высшего образования. Анализ научных публикаций по теме статьи показал, что активизировать этот процесс можно, применив междисциплинарный подход. Он может быть реализован путем создания межкафедральных научных коллективов в университетах, основными участниками которых станут будущие IT-специалисты и их руководители из числа ведущих преподавателей IT-кафедр. В рамках деятельности этих коллективов будут разрабатываться цифровые образовательные ресурсы по заказу университетских кафедр и других подразделений вуза. При этом ИТ-разработчики образовательных ресурсов будут наращивать свое мастерство в области создания разного рода программного обеспечения. В результате деятельности таких команд цифровая образовательная среда университета будет пополняться актуальными цифровыми образовательными ресурсами и их методическим обеспечением.

Ключевые слова: междисциплинарный подход, цифровая образовательная среда, цифровые образовательные ресурсы, межкафедральный научный коллектив, учебно-методическое обеспечение.

Introduction

The development of informatization of education is characterized by the active and systematic use of digital technologies at all levels of the education system.

According to the results of research conducted at the Institute for the Development of Education of the Russian Academy of Education within the framework of the scientific school of Robert I. V., the digital transformation of education is understood as the result of significant systemic changes that have occurred and are occurring in the field of education (both positive and negative), in connection with the active and systematic use of digital technologies and the implementation in educational practice of the results of the achievements of scientific and technological progress of the modern information society of mass global communication [1].

In the context of the development and functioning of the digital educational environment of a modern university, the process of creating digital educational resources, information and methodological support of the educational process, information interaction, both between the subjects of the educational process and with interactive digital resources, are most actively undergoing digital transformation. The development of informatization of education is characterized by the active and systematic use of digital technologies at all levels of the education system.

In the context of the development and functioning of the digital educational environment of a modern university, the process of creating digital educational resources, information and methodological support of the educational process, information interaction, both between the subjects of the educational process and with interactive digital resources, are most actively undergoing digital transformation.

The relevance of the topic of the article is determined by the insufficient development of scientific and methodological foundations in the development and use of digital educational resources focused on information and methodological support of the educational process in universities in the context of digital transformation of higher education.

The purpose of the article is to develop theoretical provisions in the field of creating digital educational resources based on interdisciplinary design.

To achieve the goal, it is necessary to analyze the concept of "interdisciplinarity", substantiate and formulate the goals of interdisciplinary design, as well as

organizational and technological issues in the development of digital educational resources.

Object of study: the process of university training in the context of the digital transformation of higher education.

Subject of research: implementation of an interdisciplinary approach in the development of information and methodological support of the educational process (IMS EP) of a university in the context of digital transformation of higher education.

Literature review

Since the IMS EP is developed, as a rule, for two or more subject areas, it is advisable to use the project approach, which was considered in the studies of Gromyko Yu. V. [2], Kilpatrick W. H. [3], Dewey J. [4], Polat E. S. [5] and others in the context of interdisciplinarity (Franks D. et al. [18], Margalef Garcia L. et al. [6], Rabb R. et al. [7]), which initiates “the development of close interaction between representatives different disciplines (including natural sciences: physics, chemistry, biology, etc.) and IT-specialists” [8].

Researchers, students and teachers involved in the problem of establishing a connection and integration of two or more academic disciplines, professions or technologies with their methods and perspectives, pursue a common goal. Problems that seem complex or large-scale to researchers belonging to the same discipline are usually solved using interdisciplinary approaches. In the educational field, the adjective "interdisciplinary" is used when researchers from two or more disciplines combine their approaches and transform them so that they become acceptable for solving certain problems.

According to the research of Bortnik B. I., Stozhko N. Yu. [9, 10], Gendjova A., Yordanova V. [11], Grebenyuk I. [12], Konga S. K. [13], Mironova L. I. [8, 14], Naumenko M. [15], Sampson D. G. [16], Chu H. S. [17], etc.), an interdisciplinary project includes specialists from different disciplines and professions who are involved in the process of joint work as parties interested in solving a common problem. According to J. Berger, an interdisciplinary group may consist of persons trained in

different fields of knowledge, with concepts and concepts, methods, material and terminology characteristic of each. These individuals are united to work together on a problem in conditions of constant communication between participants representing different disciplines [18].

Based on the research of a number of scientists (Margaret Garcia L. and Pareya Roblin N. [19], Nikitina S. [16], Haywood J. [20] and others), as well as based on the understanding that the process of education in higher education relies on the basic principles of consistency and integration, in the context of the digital transformation of education, it was concluded that the implementation of an interdisciplinary approach provides new opportunities in the field of organizing and improving efficiency, in particular, engineering education [21].

A number of works (Alshara O. K. and Ibrahim M. [22], Rabb R. [7] and others) describe the experience of joint training of students of different professional orientations. It is expedient to solve complex social, engineering and other problems is the formation of interdisciplinary teams of students (Da Figueredo [23 16], Carpenter S. L. [24], Piuno P. A. E. [25], Pooley S. P. [26], Stetter R. [27], Shea K. [28], etc.). The result of such activity of students in interdisciplinary practical and research activities is described in the works of Haiter A. [29], Mac Goldrick N. B. [6], Rahala I. [30], Richter D. M. [31], Tana J. K. [32], Franks D. [33] and others).

The issues of developing interdisciplinary projects in vocational education are also considered in many domestic studies (Bortnik B. I. and Stozhko N. Yu. [9], Gendjova A. [11], Grebenyuk I. [12], Kong S. K. [13], Mironova L. I. [14], Naumenko M. [15], Stozhko N. Yu. [10], etc.).

With any approach to solving the problem of interdisciplinarity, the project approach is relevant, which in its essence is of an oversubject nature and is considered by methodologists within the framework of activity and personality-oriented areas of education [34].

At the same time, the computational methods used in various subject areas require the use of modern software. This contributes to the development of close

cooperation between specialists in various disciplines (including natural sciences: physics, chemistry, biology) and specialists in the information field.

One of the forms of implementation of interdisciplinary cooperation is interdisciplinary design (Project Based Learning (PBL)). Barack M. and Dori Y. J. described the experience of integrating PBL in an IT environment when implementing this technology in three undergraduate chemistry courses [35]. Students in the experimental group developed IT-based individual projects, while their peers in the control group developed traditional chemistry projects. Comparison of learning outcomes convincingly demonstrated the high efficiency of the applied technology.

Dekhan S. and Tsoi M. Ya. [36] presented a peculiar model of interdisciplinary interaction between students based on "business relations": students of the information direction of study were "hired" by chemistry students to develop software for designing mobile applications for the organic chemistry course in order to study the course more effectively.

The given brief review testifies to the relevance, relevance and significance of various strategies and technologies of interdisciplinary design.

Method

In the course of the study, a theoretical analysis and generalization of the provisions of pedagogical science on the problems of professional training of students were carried out; studied and analyzed the experience of teaching various university disciplines on the basis of information and communication technologies (ICT); the analysis of the State Educational Standards and the Federal State Educational Standards of Higher Education in the IT direction of training future programmers, curricula and teaching materials for the preparation of bachelors and masters in the field of programming was carried out.

Results and discussion

The analysis of scientific publications on the topic of the article suggests that one of the ways to solve the problem of digital transformation of higher education is the development of interdisciplinary projects by future IT specialists.

The subject-professional training of students – future IT specialists is implemented on the basis of blocks of basic and major disciplines, the content of which changes extremely dynamically due to the rapid development of the scientific and technological foundations of informatics as a scientific field. Informatics, being an interdisciplinary scientific direction and performing an integrative function in the system of sciences, is reflected in the system of higher education. The sharply increased role of digital technologies should find a response in pedagogical research to improve the subject training of specialists for various areas of the economy, including in combination with project-based learning. At the same time, educational projects can be not only research, but also reflect the patterns of technological processes in the subject area, i.e., have the features of professional projects, which is typical for engineering, construction, architecture, economics and other specialties.

In modern universities, students are trained for various sectors of the economy, which, in the context of the digital transformation of higher education, requires the development of a distributed educational resource (educational and methodological materials in electronic presentation formats, information and communication subject environments, information and reference systems, knowledge control systems, the implementation of simulation models in subject areas, software and hardware for organizing the educational process, databases of subject areas, etc.). At the same time, the qualifications of teachers who provide training in these specialties have a different focus. In addition, the software that is freely available does not always meet the requirements of the educational process.

According to the Federal State Educational Standard of Higher Education (FSES HE), the objects of their professional activity for future IT specialists are mathematical and algorithmic models, programs, software systems and complexes, as well as methods for their design and implementation in interdisciplinary areas [21, 34].

Basic professional training of IT specialists is traditionally a combination of programming (Computer Science) and engineering (Computer Engineering) approaches to education. Such a symbiosis of two areas of training allows students to form simultaneously with the skills of assessing, selecting, organizing and processing

information a creative approach to creating new methods of information processing and informatization tools. At the same time, their basic professional training forms their potential, which allows them to solve problems related to the development of services that provide educational and any other university processes under the guidance of teachers and methodologists of departments where future programmers study.

Thus, the basic training of future IT specialists allows them to integrate professional competencies in the field of software development, regulated by the FSES HE, into the interdisciplinary design of digital educational resources in the process of digital transformation of education. This approach will allow future IT specialists to solve problems related to the development of digital educational resources (DER) to support the educational process of the university, which include:

- content and educational and methodological support presented in electronic format;
- automated means of monitoring learning outcomes;
- means of forming knowledge and skills in specific subject areas.

Then, under the interdisciplinary design (IDD) of digital educational resources (DER), we mean the activities of future IT specialists, including the following sequence of actions:

- development of an algorithm that implements the content component of the DER content;
- development of an algorithm that implements the technological component of the DER interface;
- development of the DER application program code;
- debugging the DER code;
- experimental use of DER in the educational process;
- adjustment of the DER based on the results of trial use;
- the use of DER in the educational process of the university;
- development of methodological documentation for DER users;
- development of methodological documentation for conducting a training seminar for potential users of the developed DER;

– registration of the results of interdisciplinary design (presentation at a scientific student conference, publication of a scientific article, obtaining a certificate of state registration of a computer program, preparing a report for presentation at a scientific conference, participation in a competition, a creative report, etc.) [34].

The purpose of interdisciplinary design as part of the educational and methodological process of training future IT specialists simultaneously with the propaedeutics of the preparation of final qualification works is the formation of their professional competencies in the development of modern digital educational resources and services in the course of the digital transformation of education in order to create a digital educational environment of the university, in during which future programmers develop design skills and experience in assessing the quality of software products for pedagogical purposes.

The implementation of this approach will allow more intensive creation and expansion of the digital educational environment, providing its participants with up-to-date educational resources and services.

Organizational and methodological management of the DER development process within the framework of the IDD should be carried out by teachers of the graduating department, where future IT specialists are trained, and teachers and methodologists from the departments of the university, for which the DER is being developed within the framework of the interdepartmental scientific team (IDST), which includes students who wish to take part in the development of the DER.

In the course of joint work within the framework of the IDST, the students-developers of the DER develop competence in the development and use of the DER, by which we mean the following set:

– knowledge in the field of: theoretical foundations for the development of DER based on interdisciplinary design; the use of algorithmic structures in data processing; basic theoretical provisions in the field of design for the application of teaching methods; requirements for the pedagogical and ergonomic quality of the DER (supervised by the teacher of the executing department and the leading subject teacher of the customer department);

- skills in the field: application of modern programming technologies; implementation of the stages of interdisciplinary design in the development of DER; development of the DER scenario; development of the technological components of the content and interface of the DER (supervised by the teacher of the executing department); determining the compliance of the developed DER with pedagogical, technological and pedagogical-ergonomic requirements for organizing the educational process (supervised by the leading subject teacher of the customer department or a representative of the customer unit);
- experience in the field of: determining the pedagogical goal of using the DER in the learning process; development of a training scenario (supervised by a leading subject teacher of the customer department or a representative of the customer unit); content design (supervised by a teacher of the executing department, a leading subject teacher of the customer's department or a representative of the customer's department); development of application programs for the implementation of the content and technological components of the content and interface of the DER in accordance with the terms of reference from the customer unit (supervised by the teacher of the executing department or a representative of the customer unit).

Conclusion

The implementation of the interdisciplinary approach proposed in the article is a factor in the successful organization of independent work of students at the university, which allows you to form the cognitive activity of future IT specialists and is aimed at their professional self-improvement. At the same time, the result of interdisciplinary design, carried out within the framework of the work of interdepartmental research teams, will be relevant digital educational resources to ensure the educational process of the university, the development of its digital educational environment, which should ensure interaction with educational resources in all areas of student training carried out at the departments of the university. This mutually beneficial activity is aimed at improving the quality of learning outcomes by intensifying the educational process,

enhancing the cognitive activity of students, increasing their efficiency and motivation for learning.

The task of mastering digital technologies for the digital economy of Russia is interdisciplinary in nature, which requires a clear understanding of educational tasks in the field of digitalization associated with the need to form the competence of specialists in the development and implementation of digital transformation projects in any applied field, which directly depends on the level of training of graduates of modern universities. One of the directions for activating the process of digital transformation of higher education can be the implementation of the interdisciplinary cooperation of the departments of modern universities proposed in the article.

References

1. Robert, I. V. (2020). Aksiologicheskiy podkhod k prognozu razvitiya obrazovaniya v usloviyakh tsifrovoy paradigmy [An axiological approach to the forecast of the development of education in the context of the digital paradigm] Podufalov, N. D. (Ed.*) Innovatsionnyye protsessy v professional'nom i vysshem obrazovanii* [*Innovative processes in professional and higher education*]. Ekon-Inform Publishing House. (In Russian)
2. Gromyko, Yu. V., Davydova, V. V. (2000). Ponyatiye i proyekt v teorii razvivayushchego obrazovaniya [Concept and project in the theory of developing education] *Izvestiya RAO.* 2, 36–43. (In Russian)
3. Kilpatrick, W. H. (1925). *Metod proyektov. Primeneniye tselevoy ustanovki v pedagogicheskom protsesse* [*Project method. Application of target setting in pedagogical process*]. Brockhaus-Efron. (In Russian)
4. Bim-Bad, B.M. (Ed.). (2003). *Pedagogicheskiy entsiklopedicheskiy slovar'* [*Pedagogical Encyclopedic Dictionary*]. Bol'shaya Rossiyskaya entsiklopediya (In Russian)
5. Polat, E. S. (Ed.). (2000). *Novyye pedagogicheskiye i informatsionnyye tekhnologii v sisteme obrazovaniya* [*New pedagogical and information technologies in the education system*]. Academia. (In Russian)
6. Mc Goldrick, N. B., Marzec, B., Scully, P. N., Draper, S. M. (2013) Implementing a multidisciplinary program for developing learning, communication, and team-working skills in second-year undergraduate chemistry students. *Journal of Chemical Education*. (90) 3, 338–344.
7. Rabb R., Rogers J., Chang D. (2008). Course development in interdisciplinary controls and mechatronics // *Frontiers in Education Conference, Saratoga Springs, USA*. pp. T3F11–T3F15. https://doi.org/10.1109/FIE.2008.4720525.
8. Mironova, L. I., Stozhko, N. Yu., Bortnik, B. I., Chernysheva, A. V., Podshivalova, E. A. (2015) Interdisciplinary project based learning: technology for improving student cognition. *Research in Learning Technology*. (23), 1–13. https://doi.org/10.3402/rlt.v23.27577.
9. Bortnik, B. I., Stozhko, N. Y. (2013) Proyektirovaniye innovatsionnogo protsessa yestestvennonauchnoy podgotovki v ekonomicheskom vuze [Designing Innovative Process for Teaching Natural Sciences in Economic Universities]. *Izvestiya Ural'skogo gosudarstvennogo ekonomicheskogo universiteta* [*Review of the Ural State University of Economics*]. (49) 5, 113–118. (In Russian)

10. Stozhko, N. Y., Tchernysheva, A. V., Mironova, L. I. (2014) Computer assisted learning system for studying analytical chemistry. *Chemistry: Bulgarian Journal of Science Education.* (23) 4, 607–613.
11. Gendjova, A., Yordanova, B. (2009) Project-Based Learning in Science at the American College of Sofia. *Chemistry*. (18). 4, 255–267.
12. Hrebenyk, L. I., Primova, L. A., Berest, O. B. (2014). Ispol'zovaniye komp'yuternogo modelirovaniya laboratornykh rabot na prakticheskikh zanyatiyakh po biologicheskoy khimii [Using of computer simulations of laboratory work for practical classes on biological chemistry]. *Informatsionnyye tekhnologii i sredstva obucheniya* [*Information technology and learning tools*]. 40(2), 42-49. (In Russian)
13. Kong, S. C., Chan, T.-W., Griffin, P., Hoppe, U., Huang, R., Kinshuk, Looi C. K., Milrad, M., Norris, C., Nussbaum, M., Sharples, M., So, W. M. W., Soloway, E. & Yu, S. (2014) E-learning in School Education in the Coming 10 Years for developing 21st Century Skills: Critical Research Issues and Policy Implications *Educational Technology & Society*. 17(1), 70–78.
14. Mironova, L. I., Stozhko, N. Yu., Chernysheva, A. V. (2014) Computer Assisted Learning System for Studying Analytical Chemistry. *Chemistry: Bulgarian Journal of Science Education*. 23 (4), 606–613.
15. Naumenko, M. (2013) Internet-resursy i povysheniye kachestva shkol'nogo khimicheskogo obrazovaniya [Internet resources and improving the quality of school chemical education]. *Informatsionnyye tekhnologii i sredstva obucheniya* [*Information technology and learning tools*]. (34)2, 56–63. (In Russian)
16. Nikitina, S. (2006) Three strategies for interdisciplinary teaching: Contextualizing, conceptualizing, and problem-centring *Journal of Curriculum Studies*. (38) 3, 251–271.
17. Chu, H.-C., Hwang, G.-J., Tsai C.-C. (2010) A knowledge engineering approach to developing mind tools for context-aware ubiquitous learning. *Computers and Education*. (54) 1, 289–297.
18. Berger, G. (1972). Opinions and Facts. In.: Interdisciplinary. *Problems of Teaching and Research in Universities, OECD Publication Center*, 23–26.
19. Margalef García, L., Pareja Roblin, N. (2008) Innovation, research and professional development in higher education: Learning from our own experience. *Teaching and Teacher Education*. (24) 1, 104–116.
20. Heywood J. (2005). *Engineering Education: Research and Development in Curriculum and Instruction*. John Wiley and Sons. https://doi.org/10.1002/0471744697
21. Mironova, L. I. (2021). *Informatsionnoye obespecheniye vuzovskoy podgotovki v usloviyakh mezhdistsiplinarnogo proyektirovaniya i menedzhmenta kachestva* [*Information support for university training in the context of interdisciplinary design and quality management*]. UMC UPI Publishing House. (In Russian)
22. Alshara, O. K., Ibrahim M. (2007). Business integration using the Interdisciplinary Project Based Learning model (IPBL). *Symposium on Human Interface*, Beijing, China,.821–833.
23. Da C. Figueiredo, R. M., De Sales, A. B., Ribeiro, L. M., Laranjeira L. A., Rocha, A. (2010). Teaching software quality in an interdisciplinary course of engineering. *Quality of Information and Communications Technology, Porto, Portugal*. 144-149.
24. Carpenter, S. L., Delugach, H. S., Etzkorn, L. H., Farrington, P. A., Fortune, J. L., Utley, D. R., Virani, S. S. (2007) A knowledge modeling approach to evaluating student essays in engineering courses. // *Journal of Engineering Education*. (90) 3, 227–239.
25. Piunno, P. A. E., Boyd, C., Barzda, V., Gradinaru, C. C., Krull, U. J., Stefanovic, S., Stewart, B. (2014) The advanced interdisciplinary research laboratory: A student team approach to the fourth-year research thesis project experience. *Journal of Chemical Education*. (91) 5, 655–661.

26. Pooley, S. P., Mendelsohn, J. A., Milner-Gulland, E. J. (2014) Hunting down the chimera of multiple disciplines in conservation science. *Conservation Biology*. 28, 22–32.
27. Stetter, R., Paczynski, A., Voos, H., Bäuerle, P. (2006) Teaching "coupling competence" by means of interdisciplinary projects. *9th International Design Conference, DESIGN*. Dubrovnik, Croatia, pp. 1267–1274.
28. Shea, K., Engelhard, M., Helms, B., Merz, M. (2008) Teaching an integrated new product development seminar on cognitive products. *10th International Design Conference, DESIGN*. Dubrovnik, Croatia. pp. 1401-1408.
29. Hayter, A. J. (2012). *Probability and Statistics for Engineers and Scientist* (2nd ed.). Cengage Learning.
30. Rahal, I. (2008) Undergraduate research experiences in data mining. *39th ACM Technical Symposium on Computer Science Education, SIGCSE*. Portland, OR, United States, pp. 461-465.
31. Richter, D.M., Paretti, M.C. (2009) Identifying barriers to and outcomes of interdisciplinarity in the engineering classroom. *European Journal of Engineering Education*. (34) 1, 29-45.
32. Tan, J. K., Fleming, W. J., Connor, C. G., Wilson, C. (2006) Development of an interdisciplinary design curriculum: preparing the students for final year major design projects, *DS 38: Proceedings of E and DPE 2006, the 8th International Conference on Engineering and Product Design Education*, 7-8 September 2006, Salzburg, Austria, pp. 33-38.
33. Franks, D., Dale, P., Hindmarsh, R., Fellows, C., Buckridge, M., Cybinski, P. (2007) Interdisciplinary foundations: Reflecting on interdisciplinarity and three decades of teaching and research. *Studies in Higher Education*. (32) 2, 167–185.
34. Mironova, L. I. (2016) Metodika otsenki urovnya sformirovannosti kompetentnosti studentov v oblasti razrabotki elektronnykh obrazovatel'nykh resursov [Methodology for assessing the level of formation of students' competence in the field of development of electronic educational resources]. *Obrazovatel'nyye tekhnologii i obshchestvo* [*Educational technologies and society*]. (19) 3, 544–560. (In Russian)
35. Barak, M., Dori, Y. J. (2005) Enhancing undergraduate students' chemistry understanding through project-based learning in an IT environment. *Science Education*. (89) 1, 117–139.
36. Dekhane, S., Tsoi, M. Y. (2010). Work in progress – Inter-disciplinary collaboration for a meaningful experience in a software development course. *Frontiers in Education Conference, Arlington, USA*, S1D1–S1D2.