Project-based learning in training IT-personnel for the digital economy

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Abstract. The purpose of the study is to modernize IT personnel training to enhance the development of the digital economy by means of project-based learning methods. The objectives of the study are to harmonize the educational process with the needs of production and to develop appropriate educational and methodological support. The experience for the preparation of IT-bachelors at Lobachevsky State University of Nizhny Novgorod is analyzed on the example of the Sergach sugar factory modernization. The analysis of the experience gained at Lobachevsky State University of Nizhny Novgorod in applying the project approach shows the high potential of project-based training methods for IT specialists to work in the digital economy. In order for the project approach to become an effective means of training personnel to work in line with modern standards, it is necessary that the topics of projects be closely related to the actual problems facing real manufacturers. Therefore, a stable interaction between education and industry must be established. Project-based training methods using the above principles were introduced into the educational process of preparing bachelors in the area "Fundamental Informatics and Information Technology" at Lobachevsky State University of Nizhny Novgorod.

1 Introduction

Currently, digital computer technologies are becoming a significant factor in ensuring the competitiveness of production [1-3]. Nowadays information technologies in the manufacturing sector are most often used to generate reporting indicators based on accounting and statistical data. However, the so-called "end-to-end" technologies have the greatest impact on the development of the economy [4]. These include big data processing technologies, neural and quantum technologies, artificial intelligence, industrial Internet, robotics and sensors, wireless communication technologies, virtual and augmented reality technologies. Ensuring the current level of economic efficiency dictates the need to introduce end-to-end technologies in various sectors of the economy. These technologies are used not only in traditional science-intensive industries, such as nuclear energy or astronautics, but also in agriculture, textile, food and processing industries [5-8]. As an example, it can be noted that the large-scale reconstruction of the Sergach Sugar Plant in

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the Nizhny Novgorod Region, currently underway by decree of the Government of the Russian Federation, provides not only for the modernization of equipment, but also for the optimization of management based on the introduction of artificial intelligence technologies and machine learning, and intelligent data processing. The importance of digital computer technologies for the development of the economy was reflected in the creating of a targeted large-scale state program "Digital Economy of the Russian Federation" at the federal level which was designed to promote the introduction of digital technologies in Russian production since 2018.

An integral component for the transition to a digital economy is the training of qualified personnel capable of servicing and developing new technologies in a modernized industrial production [9]. The existing personnel potential is no longer able to fully respond to the challenges of our time. In this regard, within the framework of the state program for the digitalization of the economy of the Russian Federation, the federal project "Personnel for the Digital Economy" is envisaged. The purpose of this project is to ensure the development of educational, scientific and methodological practices for training specialists in the field of information and end-to-end technologies. The education system is designed to train specialists who meet the needs of the modern information society, in particular, who are able to take an active part in the development of the digital economy. At the previous stage of the development of society, the needs of the economy were fully satisfied by ensuring the "computer literacy" of the population, i.e. mastering basic computer skills. The current level of economic development requires education to form new competencies that meet the needs of the digital society. The central place among such competencies is occupied by the competencies of "digital culture", which involve the ability to work with information "end-to-end" technologies [10-11]. The system of such competencies involves not only the development of the mathematical foundation and modern information technology tools, but also the ability to competently apply them in real economic conditions to improve the efficiency of industrial production.

An economy based on knowledge and technology requires education to modernize basic educational programs, supplementing them with "end-to-end technologies" and intellectual technical means [9]. This problem is generally solved by adding components to educational programs and curricula devoted to getting to know "end-to-end" technologies [10]. However, such a cosmetic improvement is not capable of globally changing the situation. The introduction of an introductory discipline into the curriculum or the addition of new review sections to the program of existing disciplines is not able to solve the existing problems. New challenges require the improvement of forms of education, a significant modernization of educational technologies. In particular, the use of computer learning tools, various forms of e-learning is of great importance [11-15].

The above mentioned problems are also relevant for the training of IT specialists. IT professionals form the core of the workforce designed to make the transition to a digital economy. At present, the task has been set to increase the number of graduates in the field of information technology at the state level in Russia. However, the quantitative growth of IT graduates cannot solve various problems of economic development.

The tasks of training personnel for the digital economy have a particular specificity for IT areas of study. The development of information technologies is included in the curriculum [10-11]. However, graduates of these programs are often focused exclusively on work in IT corporations, and the needs of a wide range of manufacturing industries are ignored. The traditional curriculum assumes a relatively autonomous acquisition of mathematical knowledge and the formation of computer skills. At the same time, the development of information technologies is carried out in isolation from the practical needs of industrial production. The issues of updating and supporting existing information support in a particular enterprise and the problems of implementing intellectual developments are often ignored. Students do not learn how to respond to consumer needs. The issues of economic efficiency assessment and risk assessment remain outside the attention of students. In this regard, the modernization of the educational process, aimed at ensuring the close integration of education, science and economics, is of great importance [16].

The project-based approach to teaching is one of the most promising one among the existing means of modernizing educational programs [17, 18]. The project approach is considered to be the most important as a result of the research devoted to finding ways to improve the education of bachelors of information technology [19]. However, one should note here that the project-based approach is just a form of learning. The project approach can be used in the development of a variety of skills, including for traditional mathematical education. But real manufacturers most often need not a formally optimal mathematical solution, but a solution that takes into account the most diverse features of the production process. Consequently, students should be oriented not to the correct application of standard mathematical methods and their software implementation, but to the formation of recommendations for the manufacturer to improve the production situation and the creation of appropriate calculation and control tools.

Thus, in order for the project approach to become an effective means of integrating education and the economy, it must contain appropriate content; a focus on a particular consumer must be expressed [17]. The objectives of the project should reflect the production needs, take into account the conditions and constraints of a particular production. This requires the development of appropriate educational and methodological support.

The purpose of the study is to modernize IT personnel training to enhance the development of the digital economy by means of project-based learning methods. The objectives of the study are to harmonize the educational process with the needs of production and to develop appropriate educational and methodological support. The experience for the preparation of IT-bachelors at Lobachevsky State University of Nizhny Novgorod is analyzed on the example of the Sergach sugar factory modernization.

2 Materials and methods

The project-based approach in teaching is considered as the main method of improving the educational process [19]. It makes possible to put students in conditions close to the real production process. It should be noted that at the moment it is the project form that is the main one for organizing labor in IT corporations. The use of the project method allows students to activate the independent work of students, motivates them to study the theoretical foundations, and allows them to show their own initiative, develop teamwork skills, the ability to plan, allocate resources to achieve the goal, and the ability to present the results.

As part of the application of the project approach, the methodology of teaching in small groups is used. For each project, small groups of students of 3-5 people are formed, with the help of which the project problem is collectively solved. At the same time, interaction between students is ensured, teamwork competencies are formed, which are essential in modern production.

When organizing design work, a methodology is used that involves the successive passage of several stages. Although the stages of project work are quite traditional, however, here their essential feature is the focus of each stage on the formation, deepening or development of one or another competence of digital culture. The first stage is preparatory. At this stage, students are selected to complete the project, get acquainted with the subject and goals of the project, formulate the problem mathematically, detail the plan and schedule, distribute responsibilities between project participants, and organize interaction between them. Students evaluate the expected amount and types of work and decide who does what part and how it fits in with the overall goal. To coordinate the interaction, students choose a coordinator. Social networks can be used to ensure operational interaction. This stage is associated with the formation of students' competencies in the use of digital technologies for communication, cooperation and professional interaction, the ability to plan and evaluate a resource, including a human one.

The second stage involves studying the theoretical foundations for solving the problem posed. At this stage, students study the proposed literature and compile a review of sources, study the mathematical foundations for the project. It should be noted that mathematical knowledge is the foundation for the competencies of digital culture. When implementing a project, the improvement of mathematical qualifications is not a manifestation of abstract interest, but is dictated by the need to solve an applied problem, thereby increasing the motivation for an in-depth study of mathematical methods. When considering mathematical models of production, an inextricable link between mathematics and real economic issues is demonstrated. At this stage, competencies related to the search and use of digital resources are developed.

The third stage is the development of software tools when students become familiar with existing standard software and learn how to create software tools to support the solution of a design problem. At this stage, the main acquaintance with the digital and "end-to-end" technologies necessary to achieve the goal of the project is carried out.

The fourth stage is the solution of the research problem. To effectively solve the design problem in a particular production environment, it is necessary to establish interaction with manufacturers, use existing data on real technological processes. Here, an in-depth development of digital and "end-to-end" technologies is carried out, the ability to use them in the conditions of a particular enterprise is formed, taking into account real restrictions and risks.

The final stage is the preparation of the report and the final defense of the project. This is where competencies for using digital tools to present results are developed.

Substantially, for the implementation of design work, mathematical methods used in economics were used. These include the method of mathematical modeling and optimization methods.

The central place in the ongoing projects was occupied by computer tools for solving the assigned applied problems, in particular, methods of intelligent data processing. In addition, computer learning tools, in particular distance learning systems, are used to support the implementation of projects.

Only the project that is carried out on the basis of the requests of a particular enterprise can be effective for training personnel in the digital economy. In 2022, bachelors from the Nizhny Novgorod State University carried out a project for the Sergach sugar factory.

The Sergach Sugar Plant began operation in 1967 and it is the northernmost sugar plant in Russia. The production capacity of the plant allows processing up to three thousand tons of raw materials per day. Beet processing per season is 330 thousand tons. Sergach sugar factory belongs to the city-forming enterprises of Sergach. At the end of 2015, the owner of the plant decided to terminate the business in the Nizhny Novgorod region, and the plant was on the verge of bankruptcy. This could have had a negative impact on the employment situation in the city of Sergach. In May 2016, the plant was taken over by Vesna, a Nizhny Novgorod agricultural firm specializing in the production of sugar, the cultivation of sugar beets and legumes. Currently, by order of the Government of the Russian Federation, a large-scale reconstruction and modernization of the plant is being carried out. At the same time, in order to ensure competitiveness, it was impossible to confine ourselves only to updating equipment. It was necessary to introduce new technologies for control and production management. It should be noted that the introduction of new monitoring and control systems imposes new requirements on the service personnel and creates the need to improve their skills. Modernization of technology also requires the involvement of qualified personnel trained in information technology, able to work in the new conditions of the digital economy. It should be noted that Vesna has a total of 1,000 employees, and efforts are being made to attract new young specialists. Lobachevsky State University of Nizhny Novgorod takes an active part in the modernization program, in particular, works to optimize management based on modern information technologies, artificial intelligence and machine learning. The university is also able to train personnel to maintain and improve new technologies.

3 Results

In order to modernize the training of the bachelors at Lobachevsky State University of Nizhny Novgorod in the direction of "Fundamental Informatics and Information Technology" (FIIT), a series of educational and research projects were organized in the interests of the Sergach sugar factory. The organization of projects included the creation of appropriate educational and methodological support, which includes the formulation of the goals and objectives of the educational project, correlation with the competencies being formed, coordination with the structure of the curriculum, definition of the plan and schedule, creation of electronic learning resources to support project work.

The goal of each project was to solve the actual problem of the enterprise, identified in interaction with consumers. When implementing the project, a complex engineering solution of the task was required. In order to form digital competencies, the project task included a mandatory requirement for the practical use of information and "end-to-end" technologies in solving the problems posed. The implementation of the project is not limited to the correct mathematical solution of a formalized problem and the creation of appropriate calculation software. It provides for a comprehensive assessment of the solution obtained, taking into account possible risks, issues of sustainable development, and the socio-economic effect. The report on the results of the research was to contain conclusions and practical recommendations for manufacturers.

Since the current curriculum for FIIT bachelors does not provide for the implementation of the project as a separate component, the projects were carried out within the framework of existing academic disciplines, consistent with their programs and prescribed learning outcomes.

The first project was aimed at evaluating the efficiency of sugar production. This project was carried out within the framework of the discipline of choice "Mathematical modeling of selection processes" [20]. The assessment of the competitiveness of enterprises and goods based on machine learning methods – ranking and regression is one of the sections of the program of this discipline. Thus, the implementation of the project is successfully consistent with the material being studied and provides an opportunity to apply the acquired knowledge in practice.

When managing production processes, there is a need to build a model with a high predictive potential for assessing the effectiveness of technological processes and for optimizing them. There are many models of varying degrees of detail for various stages of sugar production [21-23]. Both models are used that reflect in detail the features of the ongoing physical and chemical processes, as well as models that describe the production process in an enlarged way by means of a sequence of transfer functions. Simplified linear models of sugar production based on balance equations for substances and energy are widely used. Accordingly, there is a wide variety of calculation formulas. At the same time, different models have different predictive capabilities. Some of them make it possible to predict the course of the technological process quite well from the input data, while others only make it possible to calculate some characteristics of the completed process from the results obtained. The adequacy of calculation formulas often depends on the conditions under which they are applied. In order for the constructed model to be of practical value for a particular enterprise, it is necessary to identify the coefficients of the model, calibrate its parameters based on the analysis of data from this enterprise. In this case, methods of intellectual data processing, methods of regression analysis are used. It seems promising to use machine learning methods to predict both intermediate parameters of the technological process and the output of finished products. In reality, you have to work with incomplete and somewhat noisy data.

The aim of the project was to build a sucrose balance model that meets the production conditions of the Sergach sugar plant, which has predictive capabilities for assessing the yield of sugar according to the characteristics of raw materials and assessing production efficiency. The model reflects the main stages of sugar production – diffusion extraction of juice from beets, purification of diffusion juice by defecosaturation, evaporation and crystallization. The chemical composition of raw materials and sugar-containing solutions at different stages of production is taken into account. The input data of the model are indicators of the composition of raw materials (sugar beet): digestion (sugar content), the amount of potassium, sodium, alpha-amine nitrogen, invert substances, dry substances. Table 1 shows a sample of data on the initial composition of raw materials processed at the Sergach sugar factory.

Table 1. An example of the composition of raw materials

Sugar content, %	Dry matter, %	Potassium content, mol/100 g	Sodium content, mol/100 g	Content of alpha-amine nitrogen, mol/100 g
18.93	25.9	5.23	0.82	2.72

The main parameters of the model to be identified are the efficiency of raw material purification in the diffusion process, the efficiency of juice purification in the process of defecosaturation, the molasses-forming coefficient, the crystallization coefficient, etc. The losses of sucrose in the pulp, during filtration, due to decomposition into invert sugars, in molasses, conservation coefficient of potassium and sodium after cleaning, etc.

During the implementation of the project at the stage of studying the theoretical foundations, students get acquainted with the methods of mathematical modeling, studied the existing models of sugar production [21, 22]. Particular attention is paid to machine learning methods and their role in the calibration of model parameters. Introductory lectures with an overview of issues related to the implementation of the project are used to support the passage of this stage. Orientation lectures are held at the expense of lecture hours allotted for the discipline. Since it is impossible to consider all the issues in detail within the framework of the lectures, a synchronous electronically controlled course in the MOODLE environment on the discipline "Mathematical modeling of selection processes", presented in the e-learning system of the university (http://elearning.unn.ru/), is used. Its components are a course of lectures, teaching aids and a system of electronic testing of students in order to assimilate the studied material and check their independent work. The course also contains materials for self-study. As a result of passing this stage, students choose the structure of the mathematical model, the methods used to configure its parameters and determine which metrics can be applied to evaluate the effectiveness of the future solution.

At the stage software tools development, students get acquainted with existing machine learning packages, particularly, with software tools for regression analysis. The practical acquaintance ends with the application of computer tools to the processing of real plant data. Here it is necessary to establish coordination with the customer, to ensure the transfer of the necessary data. Figure 1 shows sample data that was received from the Sergach sugar factory, namely, a graph of the amount of sugar received during the 2021 season for each production shift. It can be seen from the above graph that the production indicators are characterized by significant noise, which imposes additional difficulties both on data processing and on determining the model parameters. To solve the problem of data noise, the averaging method was used. In particular, the yield of sugar was considered not in shifts, but for every 12 shifts. Figure 2 shows the output of sugar on a cumulative basis for 12 shifts. As you can see, this approach allows you to significantly smooth the data. From this graph, it can be seen that the increase in output is carried out almost linearly, this allows you to successfully calibrate the model parameters. As a result of passing the stage of mastering the software, students carry out the initial calibration of the model parameters.

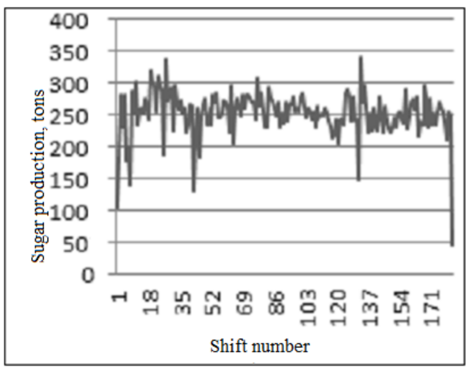

Fig. 1. The amount of sugar produced by production shifts during the 2021 season

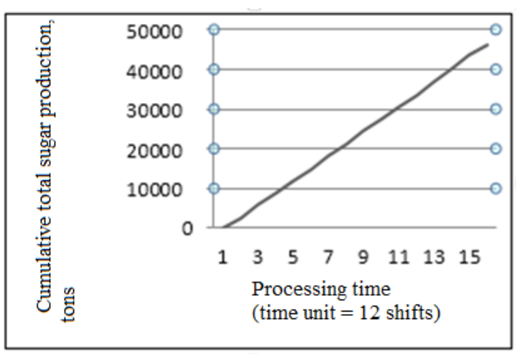

Fig. 2. The amount of sugar produced on a cumulative basis for each 12 shifts.

At the next stage, the resulting model is evaluated and the parameters are refined. If required, refinement and detailing is carried out. This stage essentially uses the opinion of the customer regarding the achieved result. Here, the model is tested to assess the efficiency of the enterprise, its testing and monitoring. The result of the study is a model, the parameters of which are adjusted taking into account the data of a real enterprise. In particular, using the data for the first half of October 2021 (October 1 – October 19), we can conclude that the production factor was 0.89%, which is consistent with the forecast made by the constructed model. This model can be further used to optimize technological processes at different stages of sugar production.

Particularly, this model is being used for a second study and research project on optimizing the beet processing schedule. The raw material for sugar production is sugar beets, which are harvested during the ripening period and then stored in pile fields to ensure the uninterrupted operation of the plant during the season. The output of sugar from the mass unit of the raw material is calculated according to the constructed model based on the chemical composition of the raw material. At the same time, the content of sucrose in raw materials is essential. The chemical composition of raw materials depends on the variety of beets, on the conditions of its cultivation and storage. When beets are stored in heap fields during the processing season, their production value decreases, which is not the same for different batches of beets.

The implementation of the optimal processing strategy can potentially significantly increase the yield of the final product. Thus, the solution of this optimization problem is of considerable interest to a particular consumer. The task of constructing an optimal product processing schedule takes place not only in sugar production, but also in a number of other branches of the food and processing industry [24-28]. With the help of simple mathematical transformations, it can be reduced to the classical assignment problem. There are efficient algorithms for solving such a problem. However, the use of such algorithms in the conditions of sugar production faces significant difficulties. The fact is that the coefficients of degradation of raw materials during storage are determined by previously unknown weather conditions. In this case, the problem posed takes the form of an assignment problem under uncertainty, for which there are also mathematical solutions. But the solution algorithms that are built on the basis of such techniques are not trivial and in practice can create additional difficulties for manufacturers.

A real manufacturer does not need sophisticated mathematical algorithms that are difficult to implement in practice, but simple and reliable solutions that, although they do not provide the absolute maximum output, deviate from it by a negligible amount under the conditions of a particular production. Thus, the original abstract optimization problem turns into the problem of finding a quasi-optimal solution. Two simplest heuristic algorithms are considered as quasi-optimal: the "greedy" algorithm, in which the batch of beets that gives the highest sugar yield is processed every day, and the "thrifty" algorithm, when the batch of raw materials that gives the lowest sugar yield is processed every day.

The task of the second project is to evaluate different algorithms in terms of their effectiveness in a particular plant, evaluate the possible losses of quasi-optimal algorithms compared to the absolute optimum, and formulate recommendations for manufacturers regarding the strategy for processing raw materials.

The second project was carried out within the framework of the academic discipline "Computational Methods". During the implementation of this project, at the stage of studying the theoretical foundations, students get acquainted with the main stages and problems in the production of sugar, mathematical models of sugar production, study discrete optimization problems and assignment problems, algorithms for solving them – the simplex method, the Hungarian algorithm, etc. Students gain an understanding of discrete optimization problems under uncertainty, learn to analyze the available methods for solving them, evaluate their advantages and disadvantages from the point of view of a particular production. At the stage of mastering software tools, students get acquainted with existing discrete optimization packages, adapt existing software to solve the task of the project.

At the stage of solving a research problem, data from a specific production are used, which is ensured by interaction with manufacturers. A sample of such data is presented in Table 2, which shows the values of the initial sugar content, measured in September 2021, for 15 batches of beets.

Table 2. Initial sugar content of sugar beet batches

Batch number	1	2	3	4	5	6	7	8
Sugar content	17.8	18.333	16.6	17.73	17.16	17.65	17.83	18.06

Batch number	9	10	11	12	13	14	15
Sugar content	18.0	18.2	17.53	17.93	17.43	17.86	18.45

As part of a project to optimize the processing schedule, students evaluated the losses of heuristic algorithms compared to an absolutely optimal solution.

On the basis of the studies carried out using real data obtained as a result of long-term measurements at the Sergach sugar factory, it was shown that the best processing plan can give up to 15% more product yield than the worst one. This means that the transition to the optimal processing strategy can give a tangible economic effect. In most cases, the "greedy" algorithm is quasi-optimal and loses no more than 4% of the product yield to the absolutely optimal one. This indicates the prospects of using the "greedy" algorithm in practice. Figure 3 shows the calculated yield of sugar during the season using different processing algorithms.

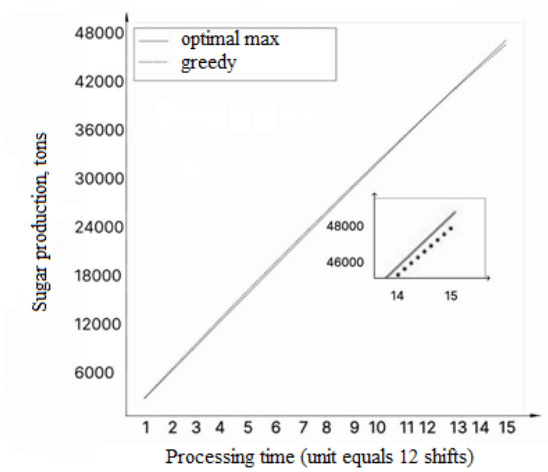

Fig. 3. Dependence of sugar yield on time using different processing algorithms.

4 Conclusion

The analysis of the experience gained at Lobachevsky State University of Nizhny Novgorod in applying the project-based approach shows the high potential of project-based training methods for IT specialists to work in the digital economy. At the same time, the effectiveness of project-based learning is not ensured automatically. In order for the project approach to become an effective means of training personnel to work in line with modern standards, it is necessary that the topics of projects be closely related to the actual problems facing real manufacturers. Therefore, a stable interaction between education and industry must be established. Moreover, the effectiveness of project-based learning depends on the competent development of educational and methodological support, which includes the formulation of the goals and objectives of the educational project, correlation with the competencies being formed, coordination with the structure of the curriculum, definition of the plan and schedule, creation of electronic learning resources to support project work. The implementation of the project involves a comprehensive engineering solution to the problem.

Project-based training methods using the above principles were introduced into the educational process of preparing bachelors in the field of "Fundamental Informatics and Information Technology" at Lobachevsky State University of Nizhny Novgorod.

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References

1. J. Arias-Pérez, J. Velez-Ocampo, J. Cepeda-Cardona, J. Knowl. Manag. **25(5)**, 1319-1335 (2021)
2. L. Li, F. Ye, Y. Zhan, et al., J. Bus Res. **149**, 54-64 (2021)
3. J. Zhang, Y. Lyu, Y. Li, Y. Geng, Envir. Impact Assess. Rev. **96**, 106821 (2022)
4. L.V. Zaikina, Rus. Econ. Bul. **4(6)**, 100-108 (2021)
5. L. Shen, X. Zhang, H. Liu, Manag. Decis. Econ. **43(6)**, 2038-2054 (2021)
6. M.M. Chavez, W. Sarache, Y. Costa, J. Soto, J Clean. Prod. **276(18)**, 123305 (2020)
7. C. A. Armin, R. Emad, Mod. Concep. Dev. Agr. **5(4)**, 556-560 (2020)
8. M. Varas, F. Basso, S. Maturana, D. Osorio, R. Pezoa, Comp. Ind. Eng. **145**, 106497 (2020)
9. S.V. Rastorguev, Y.S. Tjan, Pub. Opin. Monit.: Econ. Soc. Changes, **153(5)**, 136-161 (2019)
10. O.A. Kuzenkov, I.V. Zakharova, Mod. Inf. Techn. IT Edu. **17(2)**, 379-391 (2021)
11. A.P. Snegurenko, et al., Integr. Edu. **23(1)**, 8-22 (2019)
12. O.I. Vaganova, J.M. Tsarapkina, M.R. Zheltukhina, E.G. Knyazeva, J.S. Krasilnikova, Rev. Amaz. Inv. **10(47)**, 27-34 (2021)
13. W. Holmes, M. Bialik, C. Fadel, Artificial Intelligence In Education Promises and Implications for Teaching and Learning (The Center for Curriculum Redesign. Boston, 2019)
14. W.S. Leung, F.F. Blauw, An Augmented Reality Approach to Delivering a Connected Digital Forensics Training Experience, in K. Kim, H.Y. Kim (eds.) Information Science and Applications. Lecture Notes in Electrical Engineering, **621** (Springer, Singapore, 2020)
15. L. Robb, J. Morphew, J. Kang, M. Junokas, Mind, Brain, Edu. **13(1)**, 53-61 (2019)
16. A.N. Rajkov, et al., Dig. Econ. **3(19)**, 45-51 (2022)
17. D.V. Balandin, et al., Educational and Research Project "Optimization of the Sugar Beet Processing Schedule", in V. Voevodin, S. Sobolev, M. Yakobovsky, R. Shagaliev (eds.) Supercomputing. Lecture Notes in Computer Science **13708**, 409-422 (2022)
18. S.N. Strebulyaev, D.A. Sirotkina, Mod. Inf. Techn. Edu. **17(2)**, 392-403 (2021)
19. I.S. Soldatenko, et al., *Modernization of math-related courses in engineering education in Russia based on best practices in European and Russian universities*, in Proc. 44th

Annual Conference of the European Society for Engineering Education – Engineering Education on Top of the World: Industry-University Cooperation, 131
20. O.A. Kuzenkov, G.V. Kuzenkova, T.P. Kiseleva, Edu. Techn. Soc. **21(1)** 435-448 (2018)
21. S.V. Kharchenko, Econ.: Yest., Today, Tomor. **10(2-1)**, 407-419 (2020)
22. V.I. Tuzhilkin, et al., Univ. News. Food Techn. **2-3**, 117-121 (2018)
23. R. Junqueira, R. Morabito, Int. J. Prod. Econ. **231(1)**, 150-160 (2019)
24. T.-D. Nguyen, et al., AgriEng. **3**, 519-541 (2021)
25. T. Taskiner, B. Bilgen, Logistics **5(3)**, 52 (2021)
26. J. Li, et al., Inf. Proces. Agr. **7(1)**, 83-92 (2020)