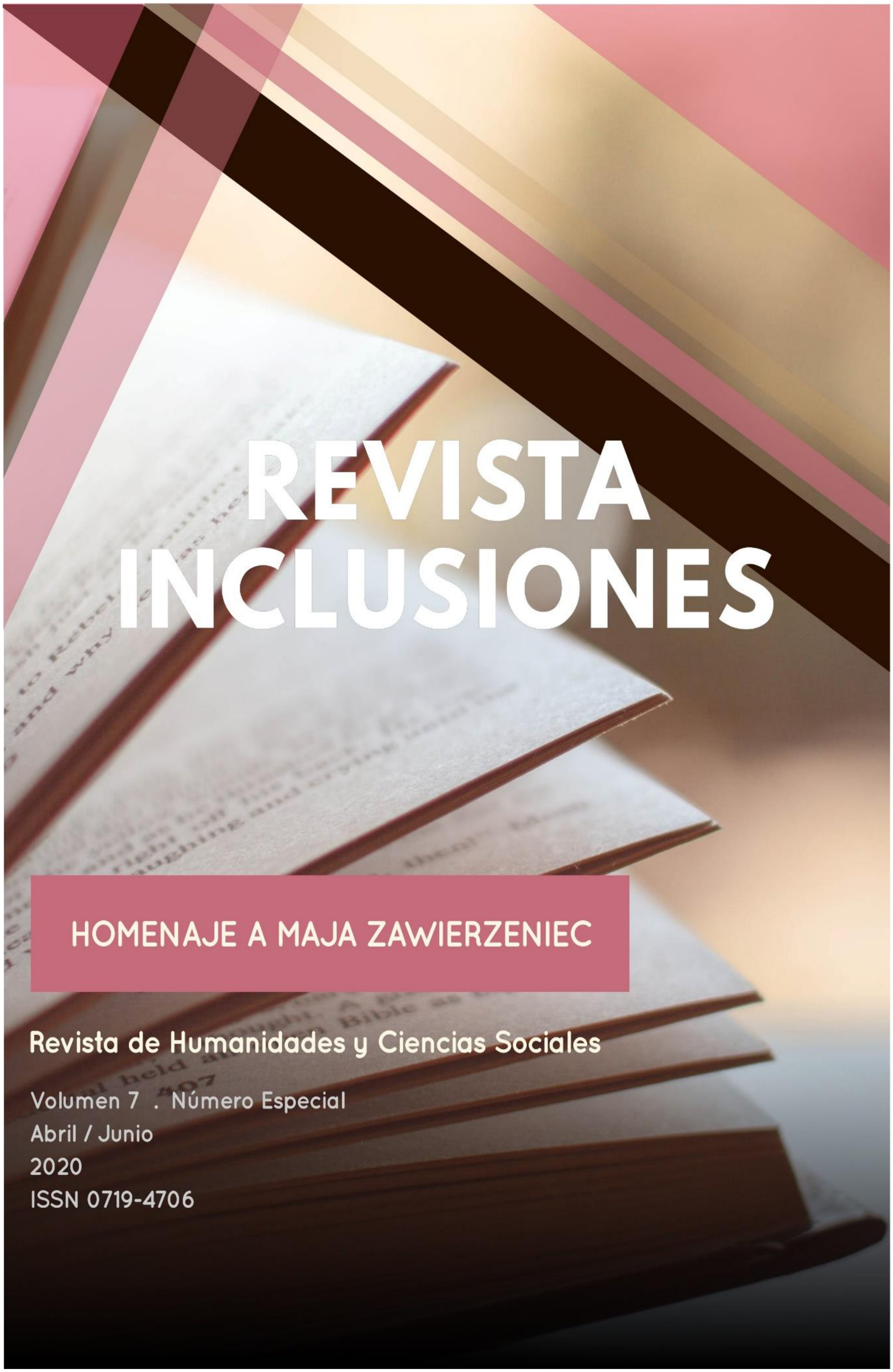

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SOFTWARE EDUCATIONAL RESOURCES AS A MEANS OF STUDYING ECONOMIC AND MATHEMATICAL DISCIPLINES AT UNIVERSITY

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Abstract

The mathematization of economic sciences, which is observed today, in some cases poses the problem not only of new content but also of a completely new structure, which requires specific means of studying economic and mathematical disciplines for its solution. The article presents an analysis of studies on various aspects of the use of software educational resources as a means of studying economic and mathematical disciplines at university. Based on the results of a pedagogical experiment, the effectiveness of using software educational resources (for example, Mathcad) in the process of training future economists in the study of economic and mathematical disciplines has been verified. It is concluded that the introduction of software educational resources to the educational process improves the training of future economists and affects the methodology of teaching economic and mathematical disciplines at all levels.

Keywords

Software educational resources – Economic and mathematical disciplines – Mathcad system

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Introduction

Employers have set serious requirements for an economics specialist today, providing for cooperation with a creative person who can easily adapt to modern market conditions. In this regard, the higher school has a task to prepare specialists who can make decisions independently, be able to track the emergence of new information necessary for their self-development and assess their need for new knowledge and skills, as well as take a critical approach to their self-education and constantly improve. One of the tools that can help educators solve this issue is the introduction of software educational resources (SER) in the educational process. The use of SER in the fundamental training of future specialists in economic universities requires the development and implementation of changes in the teaching methods of all disciplines[1].

This is due to the fact that the educator is no longer the only source of knowledge for the student. Today, the student is provided with many opportunities for self-education since the necessary materials can be found on the Internet. The memory and reproduction inherent in traditional learning are no longer relevant today. New requirements arise for students: the ability to compare, analyze, evaluate, predict, and plan.

The introduction and dissemination of educational technologies that use SER in the educational process contribute to improving the quality of higher education[2]. Educational technologies are in the process of development, becoming more convenient to use and rapidly filtering through all disciplines, as more and more educators recognize the need to train specialists who are familiar with the purpose and possibilities of using SER for professional activities.

Changes in the methodology for training future economists should affect both fundamental and special disciplines. The use of SER in learning enhances the role of active learning methods. An important place in the fundamental education of economic universities is occupied by mathematical training. This is due to the important interdisciplinary function of mathematics, including in the economic sphere. It is impossible to mechanically transfer a program in mathematics, for example, from engineering specialties to economic ones. Therefore, both universal methods of studying higher mathematics, probability theory, mathematical statistics, as well as ways of thinking and activity that develop opportunities, and individual ones, dictated by the specialties, which, in combination with information richness, should be present in the continuous applied mathematical education of an economist[3].

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[1] V. D. Sekerin; M. N. Dudin; A. E. Gorokhova; A. V. Kondrashova y E. S. Blinkova, “Mathematical Modeling of the analysis of medical services at the "prevention" stage through quality indicators”, Quality Access to Success, num 20 Vol: 173 (2019): 9-11 y N. A. Zavalko; V. O. Kozhina; E. V. Yudina; O. N. Beketova y A. V. Lavrenova, “Innovative Approaches to Business Modeling at an Enterprise”, Revista Inclusiones, num 7 (2020): 84-92.

[2] N. V. Gryzunova; V. I. Pyatanova; V. V. Manuylenko y K. V. Ordov, “Models of credit limit-setting for companies as means of encouraging competitiveness”, Entrepreneurship and Sustainability, Vol: 7 num 1 (2019):615-625 y M. N. Dudin; S. P. Posohov; A. A. Filina y Y. I. Migachev, “The Triple Helix Model in the Russian Economy: the Quality Evaluation of New Institutionalization”, Revista Inclusiones, Vol: 6 (2019): 234-243.

[3] N. A. Burmistrova, “Matematicheskaya kompetentnost budushchikh bakalavrov napravleniya "Ekonomika”, Vysshee obrazovanie segodnya, num 8 (2011):18-22.

Consequently, the system of higher economic education is faced with the need, on the one hand, to fulfill the social order for training specialists who would meet the innovative model of development of the Russian economy and, on the other, to meet their personal needs in obtaining a quality education and specialized training. Both tasks involve the ability of specialists to consciously and rationally use modern SER[4].

However, despite the fact that a significant number of educational institutions have access to computer networks, the lack of completed methods and technologies and established stereotypes often inhibit innovative development, making it impossible to perceive and implement new ideas.

Scientists consider issues related to the use of SER in teaching mathematical disciplines in various aspects. Thus, the issues of development and implementation of free pedagogical software products in the educational process, in particular, web-based computer mathematics systems (CMS)[5], mobile mathematics teaching technologies[6], and dynamic mathematics programs[7], which are used during problem-solving, are relevant.

Methods of studying the effectiveness of the use of SER in the educational process and psychological and pedagogical requirements for the introduction of computer-oriented systems in the process of training students in order to improve the effectiveness of teaching mathematics are considered[8].

Individual developments relate to the use of software packages (CMS) when teaching mathematical courses in higher educational institutions[9]. For example, the use of the MATHEMATICA mathematical package for solving applied problems by economist students is discussed in[10], symbolic calculations in the Maple system in[11], and the educational website www.exponenta.ru contains guidelines for using MATLAB, Mathematica, Mathcad, Maple, Statistica, and other packages. The experience of using

[4] I. A. Baigusheva, “Matematicheskaya podgotovka kak komponent formirovaniya professionalnoi kompetentnosti ekonomista”, Prepodavatel XXI vek, num 3 (2013): 63-71.
[5] J. Engelbrecht y A. Harding, “Teaching undergraduate mathematics on the Internet. Part 1: Technologies and taxonomy”, Educational Studies in Mathematics, Vol: 58 num 2 (2005): 235–252.
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[7] L. R. Wiest, “The Role of Computers in Mathematics Teaching and Learning, Computers in the Schools: Interdisciplinary”, Journal of Practice, Theory, and Applied Research, Vol: 17 num 1-2 (2001): 41-55.
[8] L. Yu. Nizamieva, “Professionalno-orientirovannaya matematicheskaya podgotovka v ekonomicheskom vuze”, Vestnik KTU, num 10 (2010): 242 – 245 y P. Drijvers, “Digital technology in mathematics education: why it works (or doesn’t)”, PNA, Vol: 8 num 1 (2013): 1-20.
[9] P. P. Melnikov, Kompyuternye tekhnologii v ekonomike: uchebnoe posobie (Moscú: Knorus, 2009); V. P. Dyakonov Entsiklopediya kompyuternoi algebry (Moscow: DMK-Press, 2009) y R. Pierce y K. Stacey, “Mapping pedagogical opportunities provided by mathematics analysis software”. International Journal of Computers for Mathematical Learning, Vol: 15 num 1 (2010): 1–20.
[10] A. A. Khakimova, “Distantsionnoe obuchenie matematike s ispolzovaniem kompyuternoi matematicheskoi sistemy MATHEMATICA pri podgotovke spetsialistov ekonomicheskogo profilya, Obrazovanie”, Nauka. Nauchnye kadry, num 4 (2011): 233-237.
[11] V. Z. Aladev; V. K. Boiko y E. A. Rovba, Programmirovanie i razrabotka prilozhenii v Maple: monografiya (Tallinn: Mezhd. akad. Noosfery, 2007) y V. P. Dyakonov. MAPLE 9 v matematike, fizike i obrazovanii (Moscow: Izdatelstvo "Solon-Press", 2004).

the Mathcad system deserves attention when solving various classes of problems from applied mathematics[12].

The analysis of the content of scientific papers showed that the problem of deep and systematic implementation of SER in the process of mathematical training of economists remains relevant. First of all, it concerns the development of integral and complete methods.

It is possible to get closer to overcoming the indicated contradictions with the solution of the problem of increasing the training effectiveness and intensifying educational activities due to the introduction of SER in the process of mathematical preparation, which should be carried out in conjunction with the development of appropriate methodological support.

The purpose of the article is to substantiate certain didactic features of the technology of using SER in the mathematical training of the future economist.

Research hypothesis: the introduction of SER to the educational process improves the training of future economists and affects the methodology of teaching economic and mathematical disciplines at all its levels.

Based on the results of the study, it can be concluded that the goal set in the study was achieved.

Methods

The following methods were used during the study:

- theoretical: analysis of scientific literature devoted to the theoretical aspects of the use of SER as a means of studying economic and mathematical disciplines at university;

- empirical: a pedagogical experiment to test the effectiveness of training conditions for future economists in the study of economic and mathematical disciplines with the help of SER;

- mathematical statistics (λ-Kolmogorov-Smirnov criterion) – for processing the results of the experiment and evaluating the effectiveness of the mathematical training process.

We chose Mathcad as an SER in the process of mathematical training of economists since it is a simple and, at the same time, a powerful universal environment for solving problems from various fields of finance and economics, mathematics and statistics, organization of production and management. Mathcad allows performing a wide range of symbolic transformations, including operations of mathematical analysis, linear and vector algebra, probability theory, and mathematical statistics. The Mathcad system has developed two- and three-dimensional graphics for visualizing mathematical objects. The

[12] G. Ch. Shushkevich y S. V. Shushkevich, Kompyuternye tekhnologii v matematike. Sistema MathCAD 14 (Minsk: Izd-vo Grevtsova, 2010) y V. F. Ochkov, Mathcad 14 dlya studentov, inzhenerov i konstruktorov (SPb.: BHV-Peterburg, 2007).

possibility of using various numerical methods, combining symbolic, graphical, and numerical calculations, makes this system an extremely powerful and convenient tool for mathematical calculations[13].

A comparison of students' distributions by the level of competence formation for using the SER was made to test the effectiveness of the training conditions for future economists in the study of economic and mathematical disciplines using the SER.

Control and experimental groups were formed as follows:

- the control group (CG) included students of economic and mathematical specialties who studied according to the traditional training model;

- the experimental group (EG) included students of economic and mathematical specialties who studied according to the training model using MS Excel.

As a rule, there are three levels of competence formation: low, sufficient, and high. In the study, we considered the process of formation of economic and mathematical competence as a transition between these levels: low → sufficient → high.

Low level is characterized by a negative or indifferent attitude to the process of studying economic and mathematical disciplines, superficial and non-systematic knowledge, presence of separate disparate skills, and weak motivation to study economic and mathematical disciplines. Sufficient level involves identifying an interest in the process of studying economic and mathematical disciplines, ordered and structured knowledge, sufficient skills, manifestation of the ability to cooperate and use of funds to organize joint work on the project, as well as the ability to self-study. High level is characterized by a positive attitude to the process of studying economic and mathematical disciplines, stable and deep knowledge, creative approach, ability to solve non-standard problems, fight personal corner, cooperate, use tools for organizing joint work, and self-study.

Diagnostics of the economic and mathematical competence levels formation was performed using the indicators from Table 1.

No.	Component	Characteristic	Component weight (p_i)
1	Epistemological (knowledge)	knowledge level of economic and mathematical disciplines and opportunities for their use	0.4
2	Praxeological (activity)	explanation of the purpose and functions of economic and mathematical disciplines, description of action algorithms, ability to design, describe, check, and analyze results	0.3
3	Axiological (value-semantic)	interest in the processes of studying economic and mathematical disciplines,	0.2

[13] T. G. Korotkova; S. A. Bushumov; S. Y. Ksandopulo y N. V. Solonnikova, "Studying the Efficiency of Treatment Model Mixtures of Petroleum Products with the Modified Sorbent Made of Ash-and-Slag During Dynamic Sorption", JEE, Vol: 20 num 11 (2019). Available at: http://www.jeeng.net/Studying-the-Efficiency-of-Treatment-Model-Mixtures-of-Petroleum-Products-with-the,113582,0,2.html

		motivation for their development	
4	Social and behavioral	ability to collaborate in the learning process and to use collaborative tools	0.1

Table 1
Assessment of the economic and mathematical competence formation and the weight of components in the general competence

Each component of economic and mathematical competence was evaluated on a three-point scale (from 0 to 2), which corresponded to a low, sufficient, and high level of the corresponding component formation. Indicators of component formation were diagnosed using methods of pedagogical observation, in the process of knowledge control and project defense. The weight of each component in the overall formation of economic and mathematical competence was determined based on the method of expert assessments. Thus, the numerical value of the formation level of economic and mathematical competence was determined using the following formula:

$$B = k \sum S_i p_i$$

where S_i is the assessment of the competence component;

p_i is the component weight;

$k = 50$ is the multiplier.

The multiplier k before the sum was chosen so that the resulting numerical value of the level of competence formation was an integer. Thus, according to expert estimates of the weight of all components of competence in computer modeling, the value of b can be in the range from 0 to 100. The obtained numerical values were distributed according to the levels of economic and mathematical competence formation as follows: 0-39 points – low, 40-74 points – sufficient, and 75-100 points – high.

Results

The results of the forming experiment in CG and EG are shown in Table 2.

Number of points	Level	CG		EG	
		students	%	students	%
1-34	low	0	0.00	0	0.00
35-39		4	11.76	1	1.92
40-67	sufficient	12	35.29	5	9.62
68-74		8	23.53	13	25.00
75-81	high	6	17.65	16	30.77
82-89		4	11.76	13	25.00
90-100		0	0.00	4	7.69

Table 2
Comparative distribution of students by the formation level of economic and mathematical competence in CG and EG

It is possible to use the Kolmogorov-Smirnov λ-test since the task was to identify differences in the distribution of a particular feature when comparing two empirical distributions.

This criterion is nonparametric and is applied under the following conditions: selections are random and independent; categories are ordered in ascending or descending order.

Since both of these conditions were met in the samples we received, we can apply this criterion to estimate the deviation of the distribution in EG from the distribution in CG:

F(x) is an unknown probability distribution function of the formation level of economic and mathematical competence of future economists in the CG;

G(x) is an unknown probability distribution function of the formation level of economic and mathematical competence of future economists in the EG.

Null hypothesis H_0: F(x) = G(x)

Alternative hypothesis H_1: F (x) ≠ G(x)

When hypothesis H_0: F(x) = G(x) is correct, the deviation

$D = \sup |G(x) - F(x)|$

is small and when the H_0 hypothesis is not correct, this deviation is large. The results of processing experimental data are shown in Table 3, which indicates that D = 0.355.

Level	Points	Absolute frequency		Cumulative frequency		Relative cumulative frequency		D
		CG	EG	CG	EG	CG	EG	
low	1-39	4	1	4	1	0.118	0.019	0.098
sufficient	40-67	12	5	16	6	0.471	0.115	***0.355***
	68-74	8	13	24	19	0.706	0.365	0.340
high	75-81	6	16	30	35	0.882	0.673	0.209
	82-100	4	17	34	52	1.000	1.000	0.000

Table 3
Calculation of the Kolmogorov-Smirnov criterion

Limit values $\varepsilon_{0,05;\,34}$ = 0,2480, $\varepsilon_{0,05;\,52}$ = 0,1921.

Hence D > $\varepsilon_{\alpha;n}$ (0.355>0.2480 and 0.355>0.1921), that is, according to the Kolmogorov-Smirnov λ-criterion, the null hypothesis H_0 F(x) = G(x) is rejected and the alternative hypothesis H_1 is accepted: F(x) ≠ G(x).

This means that there was a difference in the distribution of the level of economic and mathematical competence of students who studied under the traditional system of professional training and using the Mathcad system. Thus, students who studied at the EG had higher scores that characterize the formation level of economic and mathematical competence.

Given that students were taught using the Mathcad system in EG, we can assume that this is what made it possible to achieve better results. Thus, we can talk about the experimental confirmation of the proposed hypothesis.

Discussion

The Mathcad system is endowed with certain didactic features, namely: the possibility of deep insight into the essence of the studied objects and phenomena; illustrative positions, if necessary, in the dynamics; information saturation; the variety of visual techniques, their expressiveness, emotional saturation; lack of time and space boundaries.

Using the Mathcad system in conjunction with modern multimedia design tools allows improving the quality of traditional presentations during various types of lectures. Not only two-dimensional and three-dimensional graphics, combinations of text, statistical and dynamic graphic objects, but also animations can be used as presentation fragments.

In addition, the use of Mathcad in procedural terms makes it possible to use various forms and methods of teaching, which activate the cognitive activity of students. This technology allows using independent, problematic, practical, research, and creative work. Tasks involve both group and individual activities, in and out of the classroom.

Using the Mathcad system, there are opportunities to introduce computer modeling to the educational process.

In general, the analysis of research on the use of SER in higher mathematics education has shown that today, the level of SER use by educators in Russian universities is quite high, but does not have a systematic approach. The widespread use of SER by educators and students is limited due to the lack of skills to use it, motivation, and interest in using SER to facilitate their work. Although, in our opinion, the use of SER by educators of higher mathematics in economic universities will help to improve the level of professional training of students and the teaching and learning process, creating a generation of economists who are competitive in the labor market.

The use of SER in the learning process provides educators of higher mathematics with the opportunity to diversify lectures and practical classes, conduct demonstrations of educational materials, organize independent work of students, and increase their activity and motivation. Also, the use of different technologies allows educators to save time and activate the attention of students during classroom sessions.

The use of SER in the mathematical background of future economists is accompanied by managerial, educational, and advisory functions, considering educational, organizational, and didactic requirements that affect the outcome of the learning process. Therefore, the functions of applying SER in the mathematical training of future economists are divided into management, training, and advisory.

The educational function of applying SER in the process of teaching higher mathematics to economics students is to provide all available SER to ensure a high level of assimilation of knowledge, skills, and abilities in the discipline.

We highlight the following conditions for effective use of SER in teaching higher mathematics to students of economic specialties:

- using available Internet resources for educators and future economists in the course of mathematical training to support mathematical activities;

- providing open access to educational materials by means of Internet resources with the help of training support systems;

- ensuring the continuity of the learning process through the direct use of SER in the classroom and extracurricular activities.

Thus, the use of SER in teaching higher mathematics provides an opportunity to regulate the educational activities of students and develop their educational interests. Introducing SER to the learning process and providing students of economic specialties and educators with the necessary methodological recommendations for the use of SER in mathematical training create conditions for improving the quality of training of future economists.

When applying SER in the mathematical training of future economists, it is necessary to consider the professional orientation of the proposed SER application. Educational materials of Internet resources should be systematically updated in accordance with the training program and specialty of students.

SER tools in the mathematical training of future economists should be used for the following purposes:

- using SER tools to support students' mathematical activities;

- supporting the educator’s feedback with students through SER;

- systematic updating of educational materials of Internet resources following the program.

It should be noted that most universities around the world are currently integrating virtual learning environments (VLE) to their higher education programs. These Web tools can be used to develop traditional and alternative forms of learning and provide an opportunity to make instruction available to students limited in time or place. This, in turn, is seen as a potential and effective means to address the growing demand for higher education. Such Internet and multimedia learning platforms now provide, for example, students with convenient access to all or part of the learning materials they need, take tests, access to a set of homework assignments, participate in various individual and collaborative learning activities, ask questions to educators or a general group of students, and solve learning problems[14].

[14] D. A. Kartezhnikov, Vizualnaya uchebnaya sreda kak uslovie razvitiya matematicheskoi kompetentnosti studentov ekonomicheskikh spetsialnostei [Visual learning environment as a condition for the development of mathematical competence of students of economic specialties]: author's abstract, candidate of pedagogical sciences (Ekaterinburg, 2007).

An important role in the organization of the educational process, in our opinion, is played by CMS and Web-CMS, expert pedagogical systems, simulators, and testing systems.

It is advisable to use CMS when performing complex calculations of an intermediate nature, the solution of which takes a large amount of time. The existence of a large number of available mathematical packages allows the educator to choose a convenient, accessible, and understandable resource, considering the advantages and disadvantages of this SER[15].

Expert pedagogical systems are specialized computer programs for processing and structuring amorphous (incomplete, uncertain, unreliable, complex, confusing, contradictory) data and forming conclusions in industries where such data is circulated and used, including in the economy, tax affairs, politics, law, etc. The development of expert systems is aimed at using computers for data processing in those branches of science and technology where traditional modeling methods are of little use. The basis of expert systems is the knowledge base about the subject area, which is accumulated during the construction and operation of the expert system[16].

It is advisable to use the eXpertise2Go expert system shell, which is a freely distributed Web-based software tool, in the process of studying higher mathematics. The specified expert system shell provides the ability to generate a knowledge base in the e2gRuleEngine format using the e2grulewriter solution table creation and validation tool[17].

There is a large number of tools for creating and conducting online testing, a lot of educational expert systems and simulators have been developed, the use of which can help students to prepare qualitatively for the test work in economic and mathematical disciplines.

Passing online thematic testing, students have the opportunity to systematize the acquired knowledge on the topic, highlight the main material of the topic, discover the issues that cause complications, carry out self-control, and pass a test at a convenient time.

In addition to using the personal websites, emails, search engines, educational portals, and blogs, we believe it will be useful to implement the Piazza platform in the learning process to support extracurricular learning communication[18].

Using the Piazza platform provides educators and students with the opportunity to continue working outside the classroom by supporting interactive communication with students. By posting a question on Piazza, students can get an answer from both the

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[15] G. Gadanidis; K. Sedig y H. N. Liang, "Designing online mathematical investigation", Journal of Computers in Mathematics and Science Teaching, Vol: 23 num 3 (2004): 275–298.
[16] Y. Chen; C. Y. Hsu; L. Liu y S. Yang, "Constructing a nutrition diagnosis expert system", Expert System with Application, Vol: 39 num 2 (2012): 2132–2156.
[17] Y. Duan; J. S. Edwards y M. X. Xu, "Web-based expert systems: benefits and challenges", Information & Management, num 42 (2005): 799–811.
[18] N. Vivekananthamoorthy y V. D. Subramanian, "Driving Success in e-Learning Portals: Piazza, a Multi-Faculty Collaborative Model" International Journal of Web-Based Learning and Teaching Technologies, Vol: 14 num 2 (2019): 31-49.

educator and their classmates. By simulating a real discussion in the audience, the use of Piazza helps to increase the activity of students in learning and saves time for the educator and students since all problems are solved collectively and quickly.

The achievement of a qualitatively new level in training of specialists with higher education is impossible without ensuring the development of higher education based on new progressive concepts, introduction of modern pedagogical and information technologies and methodological developments, overcoming obsolete learning technologies.

Conclusions

The use of SER in the study of economic and mathematical disciplines contributes to the quality and timely presentation of educational materials and information about the learning process. The use of various online resources of educational networks increases the rating of a university, which can play a significant role for applicants when choosing a place of study.

The use of SER tools (including online) in the mathematical training of future economists will help to deepen the understanding of the material on the fundamentals of economics and enhance educational activities, providing: the learning process – with the properties of mobility, continuity, and adaptability, educators – with new opportunities for combining forms of organization and teaching methods, and students – with free access to educational materials, mobile learning support, and variability of the learning process.

The use of SER in the mathematical training of future economists allows preparing a specialist in the economics who masters SER, has a professional orientation, and is capable of continuous training to improve themself as a specialist.

The pedagogical experiment confirmed the hypothesis that the introduction of SER to the educational process improves the training of future economists and affects the methodology of teaching economic and mathematical disciplines at all its levels: at the level of learning objectives (there is a learning objective of economic and mathematical disciplines as models of economic processes); at the level of training content (conditions are created for the fundamentalization of training, the strengthening of intersubject communications, and the integration of various teaching technologies); at the level of teaching methods; at the level of training tools, training support systems, and Web 2.0 tools; at the level of forms of training organization (conditions are created for the implementation of combined training, training in small groups, pair and group programming, in particular in Web environments).

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