The usage of digital technologies in the university training of future bachelors (having been based on the data of mathematical subjects)

Oksana M. Hlushak[1[0000-0001-9849-1140]], Svetlana O. Semenyaka[1[0000-0001-5083-1433]], Volodymyr V. Proshkin[1[0000-0002-9785-0612]], Stanislav V. Sapozhnykov[2[0000-0001-6674-7631]] and Oksana S. Lytvyn[1[0000-0002-5118-1003]]

[1] Borys Grinchenko Kyiv University, 18/2 Bulvarno-Kudriavska Str., Kyiv, 04053, Ukraine
o.hlushak@kubg.edu.ua, s.semeniaka@kubg.edu.ua,
v.proshkin@kubg.edu.ua, o.lytvyn@kubg.edu.ua
[2] Alfred Nobel University, 18 Sicheslavska Naberezhna Str., Dnipro, 49000, Ukraine
sapozhnikov70@meta.ua

Abstract. This article demonstrates that mathematics in the system of higher education has outgrown the status of the general education subject and should become an integral part of the professional training of future bachelors, including economists, on the basis of intersubject connection with special subjects. Such aspects as the importance of improving the scientific and methodological support of mathematical training of students by means of digital technologies are revealed. It is specified that in order to implement the task of qualified training of students learning econometrics and economic and mathematical modeling, it is necessary to use digital technologies in two directions: for the organization of electronic educational space and in the process of solving applied problems at the junction of the branches of economics and mathematics. The advantages of using e-learning courses in the educational process are presented (such as providing individualization of the educational process in accordance with the needs, characteristics and capabilities of students; improving the quality and efficiency of the educational process; ensuring systematic monitoring of the educational quality). The unified structures of "Econometrics", "Economic and mathematical modeling" based on the Moodle platform are the following ones. The article presents the results of the pedagogical experiment on the attitude of students to the use of e-learning course (ELC) in the educational process of Borys Grinchenko Kyiv University and Alfred Nobel University (Dnipro city). We found that the following metrics need improvement: availability of time-appropriate mathematical materials; individual approach in training; students' self-expression and the development of their creativity in the e-learning process. The following opportunities are brought to light the possibilities of digital technologies for the construction and research of econometric models (based on the problem of dependence of the level of the Ukrainian population employment). Various stages of building and testing of the econometric model are characterized: identification of variables, specification of the model, parameterization and verification of the statistical significance of the obtained results.

Keywords: digital technologies, e-learning course, economic and mathematical modelling, econometrics, university training, future bachelor.

1 Introduction

In the conditions of modern development of the economy of Ukraine, special attention is paid to solving complex theoretical and applied problems that quantitatively and qualitatively describe the relationship between different economic objects [10]. It demands the development and study of new areas of economic theory and related scientific disciplines. First of all, there is a need for the development and implementation of innovative teaching methods, the usage of which would make it possible to form for future bachelors new economic thinking and understanding of the essence of economic processes or phenomena, to obtain appropriate know-how of regulation and management of these processes at any level of complexity, to predict their development [23]. In this regard, the formation and development of competencies associated with the ability to optimally combine the possibilities of logical analysis with knowledge not only of the laws of mathematics and economics, but also the basics of mathematical modeling become important.

Mathematical modeling with the maximum usage of its potential makes it possible to identify and solve professional problems of different nature: to define clearly the purpose of the research, to find quickly possible ways to achieve it, to develop appropriate models of economic objects or phenomena and on the basis of these models to create effective algorithms and programs for optimal solutions to current problems [19]. Obviously, mathematics in the system of higher education has outgrown the status of the general educational subject and should become an integral part of the professional training, on the basis of intersubject connections with special subjects [14]. In this regard, it becomes actual to resolve the contradictions between the needs of highly qualified specialists who effectively use mathematical tools in their professional activities, and the lack of scientific and methodological support for mathematical training of students, in particular by means of digital technologies.

In Ukraine, the development of educational informatization takes place in accordance with national and European programs ("Digital agenda of Ukraine – 2020" [18], containing priority areas, initiatives, projects of digitalization of Ukraine until 2020, the thesis of the updated recommendations of the European Parliament and the EU Council for lifelong learning [7], etc.). Various aspects of educational informatization in the context of mathematical training of students have become the subject of research for a number of scientists. Thus, Natalya V. Rashevska [11; 20] investigated mobile information and communicational technologies of higher mathematics teaching. Kateryna I. Slovak [21; 22] developed a methodology for the use of mobile mathematical environments in the process of higher mathematics teaching for students of economic specialties. Oksana I. Tyutyunnik [15] described the usage of computer math systems in the process of linear programming teaching. Mariia A. Kyslova [12; 13] presented the development of mobile educational environment of higher mathematics, Mariia M. Astafieva, Dmytro M. Bodnenko and Volodymyr V. Proshkin [2; 1] found out the possibilities of the educational environment for the

formation of critical thinking of students in the process of mathematics learning. Oksana M. Hlushak, Volodymyr V. Proshkin and Oksana S. Lytvyn [9] revealed the possibilities of e-learning course (ELC) on "Analytical geometry" in the process of professional training of students. In these works, the theoretical and methodological foundations of the usage of electronic educational environment in the process of professional training of bachelors are revealed, the tendencies of the development of mathematical educational informatization are indicated. The studies on the use of ICT in the process of economic and mathematical modeling learning are of particular interest. So, Dana Országhová [16] investigated the e-learning approach in mathematical training of future economists. Dimitros Asteriou, Stephen G. Hall [4, pp. 29–91] and Roberto Pedace [17, pp. 59–134] reviewed the classical linear regression model.

In the above mentioned works the features of formation of qualitative modern cloud-oriented educational environment in the context of mathematical subjects learning are presented. In addition, the experience of using e-learning courses is interesting for our research. Thus Charlotte Brooke, Pamela McKinney and Angie Donoghue [5] claim that students who take e-learning courses on the distance learning platform use their own time allocated for training more efficiently. Similar ideas are found in the works of other scientists (Jana Burgerova, Martina Adamkovičova [6], Paul Drijvers, Carolyn Kieran, Maria-Alessandra Mariotti, Janet Ainley, Mette Andresen, Yip Cheung Chan, Thierry Dana-Picard, Ghislaine Gueudet, Ivy Kidron, Allen Leung, Michael Meagher [8] etc.). At the same time, the analysis of scientific researches testifies the limitation of investigation methodical questions of learning econometric modeling in combination with ICT.

2 The objective of research

The purpose of the article is to highlight the areas of the use of digital technologies in the university training of future bachelors (having been based on the data of mathematical subjects).

3 Research methodology

The usage of appropriate methods such as scientific literature analysis with the aim of establishing the state of readiness of the studying problem, the definition of categorical and conceptual apparatus of the research; synthesis, generalization, systematization of theoretical justification of the use of digital technologies in the educational process at the university and empirical ones: diagnostic (interview, content analysis, testing), statistical (Fisher and Student criteria) to test the statistical significance of mathematical model promoted to achieve the purpose of the research.

The research was carried out within the framework of the project "Partnership for mathematics learning and teaching at the university" (PLATINUM) of the EU Erasmus + KA203 – Strategic partnership for higher education, 2018-1-NO01-KA203-038887 and the complex scientific theme of the department of computer science and

mathematics of Borys Grinchenko Kyiv University “Theoretical and practical aspects of the use of mathematical methods and information technologies in education and science”, SR No. 0116U004625. The experimental base of the research is Borys Grinchenko Kyiv University and Alfred Nobel University (Dnipro city).

4 Results and discussion

We believe that in order to implement the task of high-quality training of students studying economic and mathematical modeling in “Econometrics”, “Economic and mathematical modeling” subjects, it is necessary to introduce digital technologies in two directions: for the organization of educational space and in the process of solving applied problems at the junction of the branches of economics and mathematics branches.

The background for the organization of educational space is the availability of the necessary material and technical base (computers, software, communication channels) and informational educational environment, the effectiveness and basis of which are digital technologies. We believe that the informational and educational environment can be organized through the activities of the teacher with the use of an e-learning course of the subjects that are aimed at teaching economic and mathematical modeling, on the basis of the distance learning platform. The Moodle distance learning platform has been introduced into the educational process at the Borys Grinchenko Kyiv University. Therefore, electronic courses of “Econometrics”, “Economic and mathematical modeling” subjects are presented on the basis of this platform.

Let us present the advantages of ELC using in the educational process.

Firstly, it is providing the individualization of the educational process in accordance with the needs, characteristics and capabilities of students. The basis for the implementation of this ELC characteristic is clearly structured nature, so that the placement and sequence of teaching materials corresponds to the logic of the mathematical subject studying. For example, the ELC can be presented in the form of a chain: a description of the ELC indicating the educational and professional program; general information of the academic subject (working curriculum, syllabus, assessment criteria, sources, glossary, announcements, information about the author); teaching materials for each module: theoretical material, practical (laboratory, seminar) works, tasks for individual work of students, modular control, accompanied by video materials and hyperlinks that allow students to increase the amount of information. Besides, ELC provides information for the final assessment (advancement questions, self-assessment test, final test) and contains a list of references and addresses of Internet sources for the implementation of independent students’ work.

Indeed, the structure of ELC allows students to choose a convenient time and rate of assimilation of mathematical material, based on their own rhythm of life, individual characteristics and abilities. This helps in the best way to realize an individual educational trajectory consistent with the following principles: education is for everyone and is lifelong.

Secondly, it is improving the quality and efficiency of the educational process. This characteristic is directly correlated with the quality of teaching materials, allowing to form the mathematical competence of students [3]. The advantage of ELC is the following one: its content can be constantly updated in accordance with the development of mathematical science, the latest methods of the educational process. As a rule, the ELC consists of two types of electronic resources:

- resources designed to present the content of educational material (lecture notes, multimedia presentations of courses, audio and video materials, guidelines, etc.);
- resources that provide the consolidation of the studying material, the formation of skills, acquisition of competencies, self-assessment and evaluation of educational achievements of students (tasks, questionnaires, testing, forums, including using of Web 2.0).

The ability to receive advice, recommendations and explanations through digital interaction, for example, in forums, also contributes to the quality of students' education.

It should also be noted that the quality of the ELC is also related to the fact that these resources are created and reviewed by a number of teachers whose mathematical competence meets the immediate requirements of the time.

Thirdly, it is ensuring systematic monitoring of the education quality. In order to implement this characteristic, a clear schedule of the curriculum for implementation by students has been submitted on the ELC website. There are also opportunities for interactive communication between teachers and students, as well as students among themselves. ELC contains a system of monitoring and evaluation of all types of educational activities of students. Thus, for the self-test, the testing is submitted. Assessment of tasks is carried out automatically that excludes subjective assessment from the teacher.

According to the above mentioned, electronic educational courses of "Econometrics", "Economic and mathematical modeling" subjects have the unified structure (Fig. 1): general information on the subject (curriculum of the subject, plan, assessment criteria, printed sources and Internet resources, glossary); thematic modules, which include information about the main topics of the module the theoretical material in the form of a structured lecture material submitted by means of the lesson, multimedia presentations of lectures, audio, video learning materials and tests (training and advancement); laboratory work, which reflect the content of the work, list of individual tasks and methodical recommendations about performance of work; tasks for individual work with the guidelines of the performing task, a list of individual tasks and their assessment criteria; tasks for module test, which provides individual tasks and criteria of assessment of the work performed.

Each of these ELC blocks contributes to the implementation of individual tasks. Thus, the theoretical material is built in such a way that a student who missed classes could easily master the training material, and a student who was in the audience at the lesson could systematize the material obtained at the lesson, test himself for understanding and perception of the topic with the help of tests, which had been built

into the lectures. If students have questions, they have the opportunity to ask them on the forum discussion on the topic of each content module.

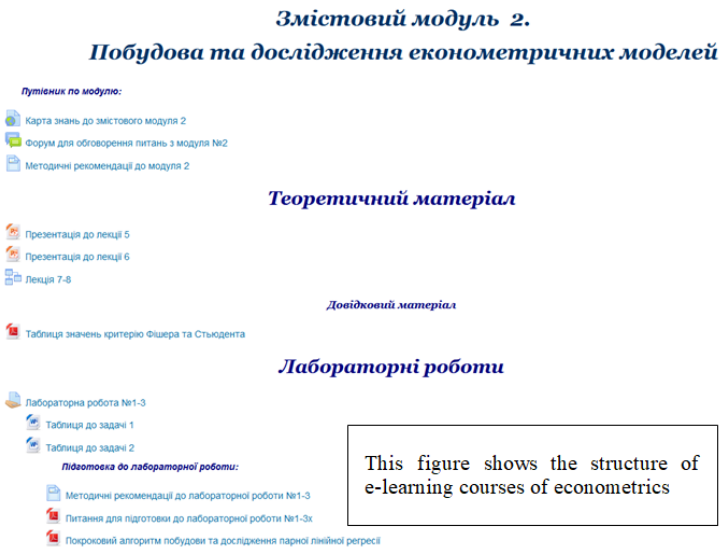


Fig. 1. ELC structure of "Econometrics"

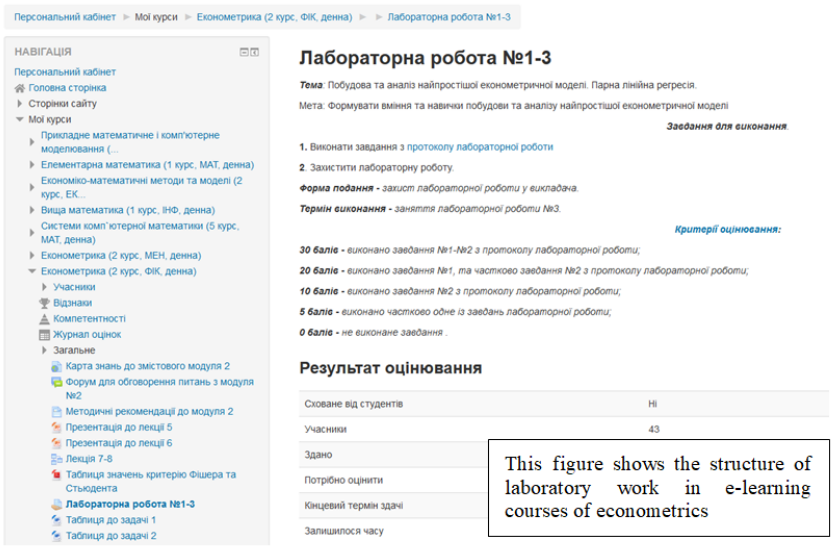
ELC laboratory works are presented in the form of web pages with a common structure: theme, purpose, tasks, form of result presentation, deadlines and assessment criteria (Fig. 2). Educational and methodological materials recommended to read are presented under the laboratory work: these are guidelines for tasks, questions for laboratory work, preparation step-by-step algorithms for tasks, examples of construction and research of models. In addition, the block of laboratory works contains instructional videos for performing tasks according to protocol of the laboratory work.

For self-test is planned the block of the task for individual work of students which provides individual tasks for each student, methodical recommendations to their performance and advancement questions.

At the end of the study of each module, a modular test work is offered for students of economic and mathematical specialties. The form of module tests for each content module is different: a complex test that involves answers to 40 questions of different types: multivariate, alternative, with a short answer, numerical, questions to establish compliance, or the construction and research of economic and mathematical models for an individual set of input data.

In our opinion, such a methodological approach to supply educational material with the use of digital technology for building electronic educational environment will promote student's motivation for the subject learning, implementation of a systematic approach to mastering academic content and implementation of the principles of personality-oriented approach. Therefore, due to the use of this ELC in the educational

process of studying “Econometrics”, “Economic and mathematical modeling” subjects, the teacher will be able to organize individual, group and frontal form of student work.



This figure shows the structure of laboratory work in e-learning courses of econometrics

Fig. 2. Example of the structure of laboratory work

To find out the real attitude of students to the use of ELC in economic and mathematical modeling, we conducted a pedagogical experiment during 2018-2019. The basis of the experiment was Borys Grinchenko Kyiv University and Alfred Nobel University (Dnipro city). In total, 125 students of “Finance, banking and insurance”, “Management”, “Economics”, “Accounting and taxation” specialties took part in the research. Respondents were asked 10 questions about the usefulness of the ELC with economic and mathematical modeling with the following answers: “Yes”, “rather Yes than No”, “rather No than Yes”, “No”. In the research, we were interested only in “Yes” answer, which we considered as a clear indicator of readiness for the effective use of ELC in the educational process.

As a result of the survey, the following results were obtained (see table 1).

According to the results of the research, students generally express a positive attitude to the use of ELC with economic and mathematical modeling in the educational process. Special noticeable dynamics in the evaluation of the following indicators: is constant communication with the teacher (+7.2%), ability to study mathematics conveniently (+5.5%), favorable conditions for learning (+3.4%). The following indicators need to be improved: availability of educational mathematical materials that meet the requirements of the time; individual approach in teaching; self-expression of students and development of their creativity in the e-learning process.

The second direction of the introduction of digital technologies in the process of economic and mathematical modeling teaching of future bachelors is the demonstration of ICT as a tool for the construction and research of econometric models. Let’s consider

more detailed influence of the following factors on the example of the problem of dependence of the level of employment of the population of Ukraine:

1. share of employees with higher education in % to the list number;
2. labor productivity growth rate;
3. growth rate of the average wage;
4. capital investment index;
5. export-import coverage ratio.

Table 1. Attitude of students to the use of ELC in economic and mathematical modelling

Questions	Answer: "Yes"	
	At the beginning of the experiment	**At the end of the experiment**
1. ELC provides opportunities to conveniently study mathematics (at any time, in a convenient place and pace)	16.3	21.8
2. The use of ELC improves the results of teaching mathematical subjects	12.2	14.2
3. ELC helps students to keep in touch with the teacher (on-line or off-line)	8.0	15.2
4. ELC is available educational mathematical materials that meet the requirements of the time	12.6	12.5
5. ELC provides an individual approach in the educational process	8.2	10.5
6. ELC of mathematical subjects effectively contributes to the formation of mathematical competence	12.3	12.7
7. ELC enriches the educational process with the most advanced digital technologies	8.0	8.9
8. ELC provides students with equal opportunities to study mathematical subjects	16.1	18.9
9. ELC does not limit self-expression of students and contributes to the development of their creativity	8.3	8.7
10. ELC creates favorable conditions for studying (ELC allows students to feel comfortable when checking knowledge; eliminates subjective attitude on the part of teachers)	8.9	12.3

The statistics for the task are taken from the official website of the State Statistics Service of Ukraine [24]. The problem will be solved with the help of general-purpose application software MS Excel.

The first stage for constructing and researching of an econometric model is the identification of variables. According to the results of identification we get:

Y – level of employment of the population of Ukraine;
X_1 – share of employees with higher education in Ukraine;
X_2 – growth rate of labor productivity in Ukraine;
X_3 – growth rate of average wages in Ukraine;
X_4 – index of capital investments in Ukraine;
X_5 – export-import coverage ratio in Ukraine.

The specification of the model is the second stage of construction, it provides the choice of the form of f communication between the factor and the resultant variable. We will carry out the construction of the correlation field depending on the level of employment of the population from each of the factors using a scatter chart in MS Excel (Fig. 3). To determine the best type of relationship between the factor and the result, we will use the trend line. Using the trend line format dialog box, we will display the coefficient of determination and the equations of the model on the chart (Fig. 4). Comparing the determination coefficients for each type of corresponding dependencies R^2, we can conclude that the most optimal were the dependencies for which the value R^2 takes the maximum value of possible ones. As a result, on the basis of the above research, it was established the existence of a linear relationship between the relevant factors of the econometric model.

Hence, the theoretical multiple regression equation will take the form

$$Y = a_0 + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + u, \quad (1)$$

where u – probabilistic component that is not directly determined from the equation.

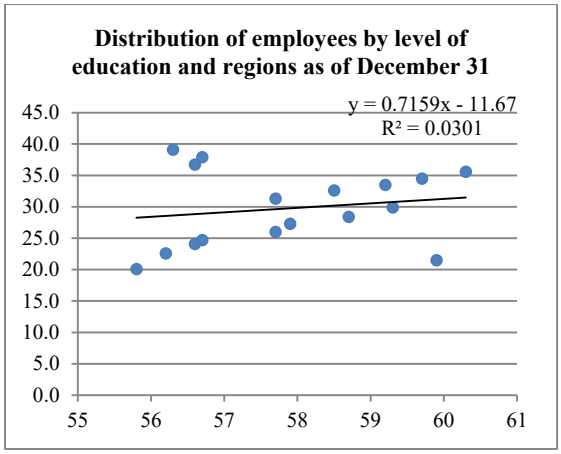


Fig. 3. Scatter chart

The next stage of the model construction is the parameterization stage: finding of parameter estimate $\hat{a}_i$ $(i = \overline{0,5})$ and constructing of the corresponding regression equation. This step can be implemented in MS Excel in several ways. The first method is purely mathematical, and consists in determination of the estimates of parameters using the least squares method using numerical calculations. To do this, we write down the vector-column of observations of the dependent (productive) variable Y and the matrix of observations of independent (factor) variables X_i and we apply to calculate estimates of regression coefficients by the formula

$$\hat{A} = (X^T X)^{-1} X^T Y, \quad (2)$$

where $\widehat{A}$ - the vector is a column of estimates of the equation coefficients, X^T – the transposed matrix to the matrix X, $(X^TX)^{-1}$ – inverse matrix to the product of two X^TX. To implement this method, students will be able to multiply matrices, find transposed and inverse matrices in MS Excel using the mathematical functions MMULT, TRANSPOSE, MINVERSE.

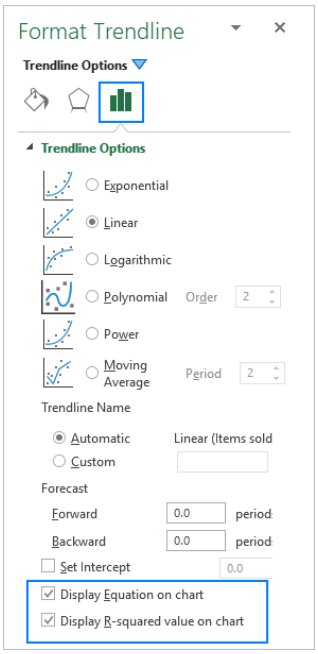


Fig. 4. The parameters of the trend line

The second method of finding parameter estimates is implemented through "Analysis package" add-in and "Regression" tool. After entering a range containing a set of statistics of the dependent variable (employment rate of the population of Ukraine) – Y and X_i a set of observations of independent (factor) variables MS Excel displays the results, which reflect the estimates of the coefficients (Fig. 5).

The third way to find parameter estimates is to use LINEST statistical function, which after entering the known values Y, X_i, constant and statistics, displays the result as a table of 5 rows and 6 columns by pressing the combination of Ctrl+Shift+Enter (table 2).

Table 2. The result of applying of LINEST statistical function

-0.8864	0.0157	-0.0017	0.00002	0.5061	45.7234
1.0676	0.0231	0.0020	0.0002	0.3097	8.0111
0.2517	1.5171	#N/A	#N/A	#N/A	#N/A
0.7401	11.0000	#N/A	#N/A	#N/A	#N/A
8.5174	25.3179	#N/A	#N/A	#N/A	#N/A

SUMMARY OUTPUT

Regression Statastics	
Multiple R	0,501728543
R Square	0,25173153
Adjusted R Square	-0,088390501
Standard Error	1,517111003
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	8,517410372	1,703482074	0,740121213	0,609206985
Residual	11	25,31788375	2,301625795		
Total	16	33,83529412			

	Coefficients	*Standard Error*	*t- Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95%*	*Upper 95%*
Intercept	45,72338655	8,011134005	5,70747993	0,000136673	28,09099949	63,35577361	28,09099949	63,35577361
X Variable 1	0,506111339	0,309699046	1,634203741	0,130483068	-0,175531665	1,187754343	-0,175531665	1,187754343
X Variable 2	-2,25217E-05	0,00023614	-0,095374478	0,92573268	-0,000542263	0,000497219	-0,000542263	0,000497219
X Variable 3	-0,001661698	0,002012612	-0,825642346	0,426551123	-0,006091427	0,002768032	-0,006091427	0,002768032
X Variable 4	0,015661933	0,023063952	0,679065462	0,511131637	-0,035101482	0,066425348	-0,035101482	0,066425348
X Variable 5	-0,886383793	1,067607512	-0,830252488	0,424049221	-3,236172083	1,463404498	-3,236172083	1,463404498

Fig. 5. Finding of parameter estimates using "Regression" tool of "Analysis package" add-in

The first row of the table shows the value of parameter estimates. Thus, the resulting multiple regression equation will take the form:

$$\hat{Y} = 45.723 + 0.506X_1 - 0.00002X_2 - 0.002X_3 - 0.016X_4 + 0.886X_5. \qquad (3)$$

Note that the last two methods of finding parameter estimates, in our opinion, is advisable to use only after familiarizing of students with the first method, which demonstrates the step-by-step application of the mathematical apparatus for finding parameter estimates.

The next stage is the research of the model – check for adequacy, which involves finding the average value of the relative errors of approximation A_i, which are measured as a percentage and determined by the formula:

$$A_i = \left|\frac{u_i}{y_i}\right| \cdot 100\%. \qquad (4)$$

Hence,

$$\bar{A} = \frac{1}{n} \cdot \sum A_i. \qquad (5)$$

Students are offered to make these calculations in the table 3 and finding the coefficient of determination by formula.

Table 3. Table for registration of calculations

Y	X_1	X_2	X_3	X_4	X_5	$\hat{Y}$	u	u^2	$\frac{u_i}{y_i}$	Y^2

So, having carried out calculations we will receive

$$\bar{A} \approx 1.7\%, \quad R^2 = 0.888207527 \approx 0.89.$$

We can say that the model is adequate, since the average value of the relative approximation errors is in the range of 8-10%. The coefficient of determination tends to 1, and the closer R^2 to 1, the more significant is the relationship between these variables, that is, the change in the resulting variable is largely due to the change in the factor variable and only a small part of the changes – other factors.

The last stage of the research of the model is the check of statistical significance. To check the statistical significance of the results, we offer students two criteria: Fisher criterion (F-criterion) and Student criterion (t-criterion).

Checking the statistical significance, we put forward two hypotheses – the null hypothesis H_0: $R^2 = 0$ and the alternative one to it H_1: $R^2 \neq 0$. Next, we calculate the experimental value according to the formulas of each criteria, find the tabular values of each of the criteria for a certain number of degrees of freedom and compare the experimental values. Make appropriate conclusions: if the experimental value exceeds the table one, the null hypothesis is rejected.

Students should note that the tabular values for F-criterion) and t-criterion shall be found using the statistical functions FINV and TINV.

According to the described calculations we find $F_1 = 17.479$ and $F_0 = 3.204$. Since $F_1 > F_0$, the null hypothesis is rejected, so the model is statistically significant.

Similar results are obtained by the t-criterion. Thus, $t_1 = 9.349$ and $t_0 = 2.593$. Since $t_1 > t_0$, the null hypothesis is rejected, so the model is statistically significant.

5 Conclusions

1. As a result of the analysis of scientific sources it is established that mathematical modelling with the maximum use of its potential makes it possible to identify and solve professional problems of different nature: to define clearly the purpose of the research, to quickly find possible ways to achieve it, to develop appropriate models of economic objects or phenomena and on the basis of these models to create effective algorithms and programs for optimal solutions to current issues. It is noted that in order to implement the task of obtaining high-quality training of future bachelors on study of build and research of economic and mathematical modelling within “Econometrics”, “Economic and mathematical modelling” subjects it is to introduce digital technologies in two directions: for the organization of educational space and in the process of solving applied problems at the junction of economic sectors and mathematics.
2. It is established that for the organization of educational space it is advisable to use e-learning courses of “Econometrics”, “Economic and mathematical modelling” subjects, which is a complex of teaching materials created for individual and group learning using digital technologies for teaching mathematical modelling to students. Based on the indicated possibilities of application of the electronic learning course, as well as its didactic functions, the structure of the electronic learning course of “Econometrics”, “Economic and mathematical modelling” subjects on the basis of Moodle platform is developed and described.

3. The results of a pedagogical experiment regarding the study of attitude of students to the use of electronic learning courses are presented. It is established that students in general positively evaluate the use of ELC in the educational process. At the same time, the following indicators need to be improved: availability of educational mathematical materials that meet the requirements of the time; individual approach in teaching; self-expression of students and development of their creativity in the e-learning process.
4. Features of application of MS Excel on an example of a problem of dependence of employment level of the population of Ukraine on influence of the chosen factors are considered. Various stages of building and study of the econometric model are characterized, they are following ones: identification of variables, specification of the model, parameterization and verification of the statistical significance of the obtained results.

We see the prospect of further scientific inquiry in the research of implementing an interactive approach using electronic learning courses.

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References

1. Astafieva M., Bodnenko, D., Proshkin, V.: Cloud-oriented Training Technologies as a Means of Forming the XXI Century Skills of Future Mathematics Teachers. CEUR Workshop Proceedings **2387**, 507–512 (2019)
2. Astafieva, M.M., Bodnenko, D.M., Proshkin, V.V.: Using computer oriented geometry means in the process of critical thinking formation of future mathematics teachers. Information Technologies and Learning Tools **71**(3), 102–121 (2019). doi:10.33407/itlt.v71i3.2449
3. Astafieva, M.M., Zhyltsov, O.B., Proshkin, V.V., Lytvyn, O.S.: E-learning as a mean of forming students' mathematical competence in a research-oriented educational process. In: Kiv, A.E., Shyshkina, M.P. (eds.) Proceedings of the 7th Workshop on Cloud Technologies in Education (CTE 2019), Kryvyi Rih, Ukraine, December 20, 2019, CEUR-WS.org, online (2020, in press)
4. Asteriou, D., Hall, S.G.: Applied Econometrics, 2nd edn. Macmillan, New York (2011)
5. Brooke, C., McKinney, P., Donoghue, A.: Provision of Distance Learner Support Services at U.K. Universities: Identification of Best Practice and Institutional Case Study. Library Trends **61**(3), 613–635 (2013). doi:10.1353/lib.2013.0003
6. Burgerová, J., Adamkovičová, M.: Vybrané aspekty komunikačnej dimenzie e-learningu (Selected aspects of communication dimension in e-learning). University in Prešov, Prešov (2014)

7. Council Recommendation of 22 May 2018 on Key Competences for Lifelong Learning. Official Journal of the European Union (2018). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604%2801%29 (2018). Accessed 28 Nov 2019
8. Drijvers, P., Kieran, C., Mariotti, M.A., Ainley, J., Andresen, M., Chan, Y.C., Dana-Picard, T., Gueudet, G., Kidron, I., Leung, A., Meagher, M.: Integrating Technology into Mathematics Education: Theoretical Perspectives. In: Hoyles, C., Lagrange, J.-B. (eds.) Mathematics Education and Technology – Rethinking the Terrain, pp. 89–132. Springer, Boston (2009). doi:10.1007/978-1-4419-0146-0_7
9. Hlushak, O.M., Proshkin, V.V., Lytvyn, O.S.: Using the e-learning course "Analytic Geometry" in the process of training students majoring in Computer Science and Information Technology. In: Kiv, A.E., Soloviev, V.N. (eds.) Proceedings of the 6th Workshop on Cloud Technologies in Education (CTE 2018), Kryvyi Rih, Ukraine, December 21, 2018. CEUR Workshop Proceedings **2433**, 472–485. http://ceur-ws.org/Vol-2433/paper32.pdf (2019). Accessed 10 Sep 2019
10. Kiv, A., Semerikov, S., Soloviev, V., Kibalnyk, L., Danylchuk, H., Matviychuk, A.: Experimental Economics and Machine Learning for Prediction of Emergent Economy Dynamics. In: Kiv, A., Semerikov, S., Soloviev, V., Kibalnyk, L., Danylchuk, H., Matviychuk, A. (eds.) Experimental Economics and Machine Learning for Prediction of Emergent Economy Dynamics, Proceedings of the Selected Papers of the 8th International Conference on Monitoring, Modeling & Management of Emergent Economy (M3E2 2019), Odessa, Ukraine, May 22-24, 2019. CEUR Workshop Proceedings **2422**, 1–4. http://ceur-ws.org/Vol-2422/paper00.pdf (2019). Accessed 1 Aug 2019
11. Kiyanovska, N., Rashevska, N.: Using LMS for supporting training mathematics in higher education. Metallurgical and Mining Industry **7**(9), 593–598 (2015)
12. Kyslova, M.A., Semerikov, S.O., Slovak, K.I.: Development of mobile learning environment as a problem of the theory and methods of use of information and communication technologies in education. Information Technologies and Learning Tools **42**(4), 1–19 (2014). doi:10.33407/itlt.v42i4.1104
13. Kyslova, M.A., Slovak, K.I.: Method of using mobile learning environments in teaching mathematics of future electromechanical engineer. Information Technologies and Learning Tools **51**(1), 77–94 (2016). doi:10.33407/itlt.v51i1.1360
14. Modlo, Ye.O., Semerikov, S.O., Bondarevskyi, S.L., Tolmachev, S.T., Markova, O.M., Nechypurenko, P.P.: Methods of using mobile Internet devices in the formation of the general scientific component of bachelor in electromechanics competency in modeling of technical objects. In: Kiv, A.E., Shyshkina, M.P. (eds.) Proceedings of the 2nd International Workshop on Augmented Reality in Education (AREdu 2019), Kryvyi Rih, Ukraine, March 22, 2019. CEUR Workshop Proceedings **2547**, 217–240. http://ceur-ws.org/Vol-2547/paper16.pdf (2020). Accessed 10 Feb 2020
15. Mykhalevych, V.M., Tyutyunnik, O.I.: Design of educational problems on linear programming using systems of computer mathematics. Information Technologies and Learning Tools **38**(6), 123–137 (2013). doi:10.33407/itlt.v38i6.896
16. Országhová, D.: The Application of Computational Tools of IT in Mathematical Tasks. In: Smyrnova-Trybulska, E. (ed.) Effective Development of Teachers' Skills in the Area of ICT, pp. 438–448. Studio-Noa for University of Silesia, Katowice-Cieszyn (2017)
17. Pedace, R.: Econometrics for Dummies. Wiley, Hoboken (2013)
18. Proekt Tsyfrova adzhenda Ukrainy – 2020 ("Tsyfrovyi poriadok dennyi"–2020). Kontseptualni zasady (versiia 1.0). Pershocherhovi sfery, initsiatyvy, proekty "tsyfrovizatsii" Ukrainy do 2020 roku (Digital Agenda of Ukraine Project - 2020 ("Digital

Agenda" - 2020). Conceptual principles (version 1.0). Priority areas, initiatives, projects of "digitalization" of Ukraine until 2020). http://ucci.org.ua/uploads/files/58e78ee3c3922.pdf (2016). Accessed 28 Nov 2019

19. Pursky, O., Dubovyk, T., Gamova, I., Buchatska, I.: Computation Algorithm for Integral Indicator of Socio-Economic Development. In: Ermolayev, V., Mallet, F., Yakovyna, V., Kharchenko, V., Kobets, V., Korniłowicz, A., Kravtsov, H., Nikitchenko, M., Semerikov, S., Spivakovsky, A. (eds.) Proceedings of the 15th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer (ICTERI, 2019), Kherson, Ukraine, June 12-15 2019, vol. II: Workshops. CEUR Workshop Proceedings **2393**, 919–934. http://ceur-ws.org/Vol-2393/paper_267.pdf (2019). Accessed 30 Jun 2019
20. Rashevska, N., Tkachuk, V.: Using LMS for supporting training mathematics in higher education. Metallurgical and Mining Industry **7**(9), 593–598 (2015)
21. Semerikov, S.O., Slovak, K.I.: Theory and method using mobile mathematical media in the process of mathematical education higher mathematics students of economic specialties. Information Technologies and Learning Tools **21**(1) (2011). doi:10.33407/itlt.v21i1.413
22. Slovak, K.I.: Methodology of separate components formation of mobile mathematical environment "Higher mathematics". Information Technologies and Learning Tools **30**(4) (2012). doi:10.33407/itlt.v30i4.687
23. Soloviev, V.N., Moiseenko, N.V., Tarasova, O.Yu: Modeling of Cognitive Process Using Complexity Theory Methods. In: Ermolayev, V., Mallet, F., Yakovyna, V., Kharchenko, V., Kobets, V., Korniłowicz, A., Kravtsov, H., Nikitchenko, M., Semerikov, S., Spivakovsky, A. (eds.) Proceedings of the 15th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer (ICTERI, 2019), Kherson, Ukraine, June 12-15 2019, vol. II: Workshops. CEUR Workshop Proceedings **2393**, 905–918. http://ceur-ws.org/Vol-2393/paper_356.pdf (2019). Accessed 30 Jun 2019
24. State Statistics Service of Ukraine. http://www.ukrstat.gov.ua (2019). Accessed 28 Nov 2019