Multi-disciplinary educational information environment

L N Borisoglebskaya¹, A A Fedotov¹, O V Pilipenko¹, S M Sergeev² and O Ja Kravets³

¹ Orel State University, Engineering centre of digital environment technologies for integrated security: telecommunications, communications and energy efficiency, 95, Komsomolskaya st., Orel, 302026, Russian Federation
² Peter the Great St. Petersburg Polytechnic University, 29, Polytechnicheskaya st., Saint-Petersburg, 199000, Russian Federation
³ Voronezh State Technical University, 14, Moskov ave., Voronezh, 394026, Russian Federation

E-mail: sergeev2@yandex.ru

Abstract. The past spring semester under COVID-19 conditions forced all educational institutions to find ways to make a quick transition to online education technology. At the same time, there have been numerous positive outcomes to this way of working with students. On the other hand, most of the educational methods proved unready for such a swift change of the teaching paradigm. The problem of spreading successfully recommended techniques for building an educational information environment is currently relevant. The current work presents the results of such a development with the application of a cluster of convergent technologies. The problem of introducing modern information-communication technology as a systematic component of forming a new educational model has been repositioned. Distance education technologies are considered by the authors to be an integral part of the educational space and a factor which accentuates the attention of future specialists when choosing areas of education. The pattern of applying cloud technology for building an expert system is examined. A combination of various disciplines for achieving an application convenient for educational activities is demonstrated, where students located in different areas can simultaneously in one task master the roles of expert, manager, programmer, and at the same time use the mathematical apparatus for economic analysis. The focus of the material allows the method to be used when forming software for pedagogical activities.

1. Introduction
The process of penetration of information technology into the educational environment reflects the global shifts taking place both in equipping modern people with means of communication and in the way of obtaining knowledge. As feedback, there is a need to change not only the structure of curricula, but also a large-scale combination of disciplines. In this case, the emphasis of student requirements is shifted precisely to the competencies [1] associated with the possession of the ever-expanding capabilities of computers [2] for solving professional problems [3] in various disciplines and areas of study. The education market in modern conditions is developing under the influence of new technological and organizational factors [4]. On the one hand, interest in university curricula is quite high; on the other hand, requirements for their content and effectiveness are growing. This factor is a
consequence of digitalization [5] and growing competition. Not so long ago, universities focused on obtaining knowledge in the subject area. At the same time, the skills of cross-system [6] knowledge, the unification of disciplines were given the role of the optional. Today, such a scheme is not effective. The key question is what skills need to be developed to make a career and how to transform university programs. When preparing only in basic subjects, you can get a qualified specialist, but you can’t think that they will become managers. It is necessary to teach the student the ability to calculate the project, to know how to sell it and how to determine the effectiveness of the project. It is necessary to develop managerial education at the junction of different academic disciplines. If today the concept of a convergent technology cluster or NBIC most often sounds [7], then the interests of specific students are nevertheless directly related to the development of the current material using modern solutions, both from the field of subjects studied and the presentation methods. Choosing the direction of study, the student wants to get those competencies that will further shape his competitive advantages [8] in the labor market. The catalyst for these processes was primarily the penetration of high-speed Internet networks not only in large centers of Russia, but also the coverage of most of the country. In addition, we note the active development of wireless access to Internet resources, including LTE networks [9], and the necessary level of saturation with various means of computer technology, including for building networks. All this, together with the availability of specialized software packages, the training of a sufficient number of specialists in computer technology, served as the basis for the convergence [10] of disciplines.

2. Formulation of the problem
The success of training, the formation of knowledge bases, information resources [11], multimedia educational programs depends on the ability of teachers to combine the capabilities of modern computer technologies [12], such as cloud services, office applications, cross-platform solutions and electronic training materials, within of single academic discipline. Such an approach will accelerate the creation of a branched, sustainable educational infrastructure, and not only within the framework of one educational institution. The process of replication of innovative knowledge will be greatly simplified, the modern level of educational services will become more accessible. The development driver is information and communication technology as the most developed. In the educational process, it is this technology that most often provides tools for the development of others. It is necessary to be able to widely use the possibility of computer simulation of various processes [13]. Consider a specific example of multidisciplinary convergence [14] in education. The formation of systemic thinking skills among managers should include possession of not only the fundamentals of economic calculations. You need to know well and, most importantly, learn to practically apply the methods of choosing the best management decisions [15]. At the same time, experience in using expert systems [16], compilation of mathematical models, and statistical calculations is needed. All this must be able to produce in the operating environment of cloud computer information technology.

3. The task
Offered for sale equipment. The specific name is not of particular importance, since a universal method [17] is proposed that is acceptable in various segments of economic activity. In any case, when determining the trade margin for expensive products of complex equipment, it is important to take into account many factors. In addition to overhead costs, a significant amount is the probable loss that the vendor will incur in case of complaints. These values, as well as possible losses associated with the loss of image, should participate in the formation of the trade margin. Another important circumstance is the presence of competition. Economic calculations [19] must be carried out simultaneously for all samples.

4. The main formalisms
Complex-E is for sale of the European brand and, similar in terms of options, complex-A from Southeast Asia. The first of them has a high purchase value, while, accordingly, the seller is forced to
make a minimum margin [20]. The other has a low producer price and you can earn a lot more by selling. However, if complex-E is highly reliable, then with the operation of other, cheaper equipment, various problems arise with a high degree of probability [21]. It is necessary to calculate the margin component, determined by the possible costs of eliminating defects, reclamations and loss of reputation. To solve it is necessary to use methods of probability theory. The length of the analysis is determined by the warranty period for the equipment. The expert’s work is based on repair statistics for the main models and manufacturers, which is well known and formally represents a knowledge base. To find a solution and issue recommendations, the manager needs to use mathematical modeling [22]. We introduce the following notation: \( N \) – The length of the warranty period; \( \vec{S} \) - state probability vector; \( P \) — a matrix of transition probabilities; \( R \) - matrix of remunerations. The elements of the vector \( \vec{S} \) will be the probabilities of the equipment being in one of three states: fully operational; minor repairs or adjustments required; the equipment is defective, the defect is serious, a return of equipment to the supplier is required. Accordingly, the vector will be three-dimensional [23] and is written as: \( \vec{S} = (s_1, s_2, s_3) \), moreover \( s_1 + s_2 + s_3 = 1 \), that is, the probabilities \( s_i \) for \( i = 1,...,3 \) constitute a complete group of events. The matrix \( P \) is composed of the probabilities of changes in the state of the equipment [24]. The values are summarized in table 1.

| No | current status                      | fully operational | minor repairs or adjustments required | serious defect |
|----|------------------------------------|-------------------|---------------------------------------|----------------|
| 1  | fully operational                  | 0.95              | 0.03                                  | 0.02           |
| 2  | minor repairs or adjustments required | 0.86              | 0.11                                  | 0.03           |
| 3  | serious defect                     | 0                 | 0                                     | 1              |

5. Calculation and mathematical model

The stochastic matrix on the right corresponding to table 1 has the form:

\[
P = \begin{pmatrix}
p_{11} & p_{12} & p_{13} \\
p_{21} & p_{22} & p_{23} \\
p_{31} & p_{32} & p_{33}
\end{pmatrix} = \begin{pmatrix}
0.95 & 0.03 & 0.02 \\
0.86 & 0.11 & 0.03 \\
0 & 0 & 1
\end{pmatrix}
\quad \text{and} \quad \sum_{j=1}^{3} p_{ij} = 1 \quad \text{for} \quad i = 1,...,3.
\]

We apply the theory of Markov processes for calculations. It should be noted that state 3 is an absorbing state. [25]. \( R \) - a matrix containing the values of profit or loss (interest). For example, minor repairs incur expenses for setting up or replacing any part; in the event of a breakdown, these are transportation costs and image losses. The items \( R \) are cash amounts. For this case, we have the following [26] matrix:

\[
R = \begin{pmatrix}
r_{11} & r_{12} & r_{13} \\
r_{21} & r_{22} & r_{23} \\
r_{31} & r_{32} & r_{33}
\end{pmatrix} = \begin{pmatrix}
20 & 17 & -18 \\
12 & 5 & -22 \\
0 & 0 & -45
\end{pmatrix}.
\]

The total remuneration, through \( n \) transitions from the initial period to the \( n \) -th is equal to: \( \overline{V}(n) = (v_1(n), v_2(n), v_3(n)) \). Elements of the vector \( \overline{V}(n) \) are equal to the total reward for each of the possible initial states. In this case, \( v_i(n) \) – the remuneration is subject to the condition of the complex during the sale. The expected remuneration for the \( n \) periods [27] will be: \( r_{ij} + v_j(n-1) \), while the expected remuneration for a known current state \( i \) is equal to:
$v_i(n) = \sum_{j=1}^{3} p_{ij} \left[ r_{ij} + v_j(n-1) \right] = \sum_{j=1}^{3} p_{ij} r_{ij} + \sum_{j=1}^{3} p_{ij} v_j(n-1)$.

Having compiled such an expression for $i=1,...,3$, we obtain the elements of the vector $\bar{V}(n)$. Given that $\bar{V}(n-1) = (v_1(n-1), v_2(n-1), v_3(n-1))$, then the system of equations for $i=1,...,3$, can be written in the vector form: $\bar{V}(n) = \bar{Q} + \bar{P} \cdot \bar{V}(n-1)$, where $\bar{Q}$ is the vector whose elements are $q_i = \sum_{j=1}^{3} p_{ij} r_{ij}$ for $i=1,...,3$. Thus, a recurrence calculation formula is obtained. It is clear that $q_i$ is the $i$-th diagonal element of the matrix $\bar{P} \cdot \bar{R}^T$, where $\bar{R}^T$ is the transposed matrix $\bar{R}$. Having performed the calculations according to the formula, we will get a number of results: If the equipment of the complex is delivered in good condition, then the first element of the vector $\bar{V}(n)$ equal to $v_i(n)$ will give us the minimum value, from the condition of risk compensation, margins. The latter $v_i(n)$ characterizes the maximum discount for the sale [28-30] of substandard copies of equipment.

As a result of calculation for, we obtain the following values: $\bar{V}(1) = (19.5, 10.2, -45)$, $\bar{V}(2) = (36.7, 26.45, -90)$, $\bar{V}(3) = (53.05, 42.02, -135)$, ..., $\bar{V}(12) = (146.64, 130.06, -540)$. The data for economic calculation are summarized in table 2.

| No. | Model     | Purchase price | Overhead costs | Market share |
|-----|-----------|----------------|----------------|--------------|
| 1   | Complex-E | 11200          | 740            | 7%           |
| 2   | Complex-A | 5200           | 560            | 21%          |

Since the equipment is sold in good condition, the minimum margin component that compensates for the risks arising from the reliability of agricultural equipment is 146.64 thousand USD. Of course, the full margin also includes overhead. Putting both components together, we get the minimum margin. Having done the above calculations for the types of complexes planned for sale, it is possible, based on the available funds and purchase statistics, to determine the volumes for each type of equipment.

6. Conclusions
The example looked at of applying cloud technologies for constructing an expert system shows that a combination of various disciplines can result in an application convenient for educational activities and for conducting distance lessons. At the same time, students located in different areas can simultaneously in one task master the roles of expert, manager and programmer while using the mathematical apparatus for achieving an economically sound solution. This type of approach is valuable due to the fact that there is no need to specially combine various types of courses when preparing the presented material, since it harmoniously combines expert systems, knowledge bases, information-communication technologies in education, and courses of mathematics, statistics, management and economy. All this in combination with the cross-platform nature of the services, as well as the invariance to technical tools, opens up wide possibilities for multi-disciplinary convergence. In the coming years, a sustainable educational environment will be formed based on cloud technology.

References
[1] Kalinina O, Kapustina I, Barykin S, Balchik E and Sedyakina A 2019 Development of a combined approach of innovative and traditional scenarios of the company’s strategy Proceedings of the 33rd International Business Information Management Association
Conference 9410-19

[2] Barykin S, Gazul S, Kiyaev V, Kalinina O and Yadykin V 2020 Forming Ontologies and Dynamically Configurable Infrastructures at the Stage of Transition to Digital Economy Based on Logistics Advances in Intelligent Systems and Computing 1116 844-52

[3] Borisoglebskaya L N, Provotorov V V, Sergeev S M and Kosinov E S 2019 Mathematical aspects of optimal control transference processes in spatial networks IOP Conf. Ser.: Mater. Sci. Eng. 537 042025

[4] Volkova A S and Provotorov V V 2014 Generalized solutions and generalized eigenfunctions of boundary-value problems on a geometric graph Russian Mathematics 58(3) 1-13

[5] Sergeev S and Kirillova T 2019 Information support for trade with the use of a conversion funnel IOP Conf. Ser.: Mater. Sci. Eng. 666 012064

[6] Krasnyuk I A, Kobeleva A A, Mikhailushkin P V, Terskaya G A and Chuvakhina L G 2018 Economic interests focusing as a basis of the formation of investment policy Espacios 39(28) 518-31

[7] Krasnov S, Sergeev S, Titov A and Zотова Y 2019 Modelling of digital communication surfaces for products and services promotion IOP Conf. Series: Materials Science and Engineering 497 012032

[8] Zabko A P, Provotorov V V and Balaban O R 2019 Stabilization of weak solutions of parabolic systems with distributed parameters on the graph Vestnik of Saint Petersurg University. Applied mathematics. Computer science. Control processes 15(2) 187-98

[9] Pilipenko O V, Provotorova E N, Sergeev S M and Rodionov O V 2019 Automation engineering of adaptive industrial warehouse J. Phys.: Conf. Ser. 1399 044045

[10] Krasnyuk I A, Bakharev V V and Medvedeva Yu Yu 2017 Sector specific features of innovative development in the Russian economy SHS Web of Conferences 35 01052

[11] Zhabko A P, Nurtazina K B and Provotorov V V 2019 About one approach to solving the inverse problem for parabolic equation Vestnik of Saint Petersurg University. Applied mathematics. Computer science. Control processes 15(3) 322-35

[12] Krasnov S, Zотова E, Sergeev S, Krasnov A and Draganov M 2019 Stochastic algorithms in multimodal 3PL segment for the digital environment IOP Conf. Ser.: Mater. Sci. Eng. 618 012069

[13] Provotorov V V 2008 Eigenfunctions of the Sturm-Liouville problem on star graph Sbornik: Mathematics 199(10) 1523-45

[14] Krasnyuk I A, Bakharev V V, Kozlova N A and Mirzoeva D D 2018 Staffing in the sphere of trade: the main issues and prospects of solution Proceedings of 2017 IEEE 6th Forum Strategic Partnership of Universities and Enterprises of Hi-Tech Branches (Science. Education. Innovations), SPUE 6 48-50

[15] Kalinina O, Alekseeva L, Varlamova D, Barykin S and Kapustina I 2019 Logistic approach to intellectual property E3S Web of Conferences 110 02103

[16] Aleksandrov A, Zhabko A and Hu G-D 2014 Delay-independent stability conditions for some classes of nonlinear systems IEEE Transactions on Automatic Control 59(8) 2209-14

[17] Kosnikov S N, Khaiibullina I V, Ignatskaya M A, Bakharev V V and Pinchuk V N 2017 Characteristic of economic indicators of reproduction of fixed capital International Journal of Applied Business and Economic Research 15(13) 243-53

[18] Podvalny S L, Provotorov V V and Podvalny E S 2017 The controllability of parabolic systems with delay and distributed parameters on the graph Procedia Computer Science 12th. International Symposium Intelligent Systems 2017 324-30

[19] Kapustina I V, Kirillova T V, Ilyina O V, Razhavin O A and Smelov P A 2017 Features of Economic Costs of Trading Enterprise: Theory and Practice International Journal of Applied Business and Economic Research 15(11) 1-10

[20] Krasnyuk I, Kirillova T, Bakharev V and Lyamin B 2019 Life cycle management in network retail enterprise based on introduction of innovations IOP Conf. Ser.: Mater. Sci. Eng.
[21] Grishchenko O V, Kireev V S, Dubrova L I, Yanenko M B and Vakulenko R Y 2016 Organization, planning and control of marketing logistics International Journal of Economics and Financial Issues 6(8) 166-72

[22] Borisoglebskaya L N, Provotorova E N and Sergeev S M 2019 Promotion based on digital interaction algorithm IOP Conf. Ser.: Mater. Sci. Eng. 537 042032.

[23] Borisoglebskaya L N, Provotorova E N, Sergeev S M and Khudyakov A P 2019 Automated storage and retrieval system for Industry 4.0 concept IOP Conf. Ser.: Mater. Sci. Eng. 537 032036

[24] Provotorov V V and Provotorova E N 2017 Optimal control of the linearized Navier-Stokes system in a netlike domain Vestnik of Saint Petersburg University. Applied mathematics. Computer science. Control processes 13(4) 428-41

[25] Artemov M A, Baranovskii E S, Zhabko A P and Provotorov V V 2019 On a 3D model of non-isothermal flows in a pipeline network Journal of Physics. Conference Series 1203 012094

[26] Krasyuk I, Medvedeva Y, Baharev V and Chargaziya G 2019 Evolution of strategies of retail and technological systems under broad digitalization conditions IOP Conference Series: Materials Science and Engineering 1234 012124

[27] Kalinina O, Kapustina I, Burova A, Firsova S, Barykin S and Sedyakina A 2019 Financial logistics theory as innovative approach to management Proceedings of the 33rd International Business Information Management Association Conference 4695-702

[28] Kravets O Ja and Oleinikova S A 2014 Multiagent technology for the application of a distributing function for load balancing in multiserver systems Automation and Remote Control 75(5) 977-82

[29] Lvovich Ya E, Tishukov B N, Preobrazhenskiy A P, Pitolin A V and Kravets O Ja 2019 Complex-Structured Objects Optimization During Modeling on the Population Algorithms Adaptation Basis International Journal on Information Technologies and Security 3(11) 41-50

[30] Nedyalkov I, Stefanov A and Georgiev G 2019 Studying and Characterization of the Data Flows in an IP-Based Network International Journal on Information Technologies and Security 1(11) 3-12