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# DIGITAL MODERNIZATION OF THE REGION'S EDUCATIONAL MARKET AND ITS INFLUENCE ON QUALITY OF EDUCATION

***Abstract:*** *The purpose of the paper is to study the experience of increase of quality of education as a result of digital modernization of the educational market in modern Russia's regions based on technologies of Industry 4.0 with the help of reorganization of regional universities and to develop recommendations for optimizing the practice of managing this process in modern Russia in the interests of the fullest implementation of the potential of mentioned problem. The research is performed by the example of the regions of the Volga Federal District of the Russian Federation. The authors perform analysis of the achieved results of increase of quality of education as a result of digital modernization of the educational market in regions of the Volga Federal District of the Russian Federation based on technologies of Industry 4.0 with the help of reorganization of regional universities and perform modeling of scenarios of increase of quality of education in this regions based on technologies of Industry 4.0 through reorganization of universities and develop recommendations for practical implementation of the most optimal scenario. This envisages the increase of quality of education in mentioned regions based on technologies of Industry 4.0 through reorganization of universities. The methods of horizontal, scenario, and regression analysis are used. It is substantiated that as of now (2019) Russia has not achieved significant results in the sphere of increase of quality of education during digital modernization of universities based on technologies of Industry 4.0 in the process reorganization (formation of regional flagship universities). The authors also try to solve the different aspects of this problem.*

***Key words:*** *Reorganization of universities; Modernization of the educational market in region; Technologies of Industry 4.0; Quality management; Quality of education.*

## 1. Introduction

Digital modernization of the educational market in the regions on the basis of technologies of Industry 4.0 in the process of reorganization of regional universities is proclaimed as the key tool of realization of the Decree of the Government of the Russian Federation (2019b) dated November 17,

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2008, No. 1662-r "Regarding the concept of long-term socio-economic development of the Russian Federation until 2020: development of education". However, neither this concept nor the concept of development of education of the Russian Federation until 2020 gives clear answers to the three key issues that appears during their practical implementation.

The first issue is connected to uncertainty as to which breakthrough digital technologies, which are created and developed within Industry 4.0, are already adapted to the needs and specifics of activities of universities and could be adapted in the near future. The federal program "Digital economy of the Russian Federation", adopted by the Decree of the Government of the Russian Federation (2019a) on July 28, 2017, No. 1632-r provides a generalized list of nine end-to-end digital technologies, which are developed within this program.

The specialized investment scientific and technological platform "The second industrialization of Russia" (2019) included the presentation of a tree (expanded detailed list) of breakthrough digital technologies that are developed in modern Russia. According to this list, the sphere of education and training of personnel has only "car simulators, medical simulators, ship and helicopter simulators, and the training complex for ship crews". These technologies are very narrow and cannot be used for complex authomatization of business processes by the modern Russian universities (e.g., humanitarian or economic universities).

The second issue is what advantages could and should be provided by digital modernization of the educational market in the region on the basis of technologies of Industry 4.0. The existing normative and legal documents have only general statements on increase of effectiveness of the work of universities and acceleration of socio-economic development of regions without specific indicators, which does not allow for quantitative measuring and evaluation of the essence and effectiveness of the performed modernization.

The third issue is what risks accompany the process of digital modernization the educational market in the region on the basis of technologies of Industry 4.0. Obviously, innovational activities in the process of modernization will inevitably lead to emergence of new risks. Absence of the list of these risks and their potential negative consequences for universities, the regional educational market, the regional economy, and all interested parties and the probability of risks and recommendations for risk management causes distrust of the modern Russian universities to the process of digital modernization, as well as their justified opportunism.

Absence of solution to these issues complicates the process of digital modernization of the market of education in the Russian regions on the basis of technologies of Industry 4.0 in the process of reorganization of regional universities. Based on this, we offer a hypothesis that as of now (early 2019) Russia does not have significant results in this sphere due to imperfection of management, despite the intensity of the processes of reorganization in the sphere of education that are aimed at formation of regional flagship universities (growth points of the regional educational market and sources of digital personnel and breakthrough digital technologies for the regional economy).

In view of the fact that the most important strategic (social and meso-economic) priority of modernization of universities is increasing the quality of higher education, the sense of the offered hypothesis consists in the absence of substantial changes in quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0, as a result of reorganization of universities in regions of Russia.

The purpose of the research is to study the experience of increasing the quality of education as a result of digital modernization of the educational market in modern Russia's regions based on technologies of Industry 4.0 with the help of reorganization of regional universities and to develop recommendations for optimizing the practice of managing this process in modern Russia in the interests of the fullest implementation of the potential of increase of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0.

The research is performed by the example of regions of the Volga Federal District of the Russian Federation. The following scientific and practical tasks are solved:

- analysis of the achieved results of increase of quality of education as a result of digital modernization of the educational market in regions of the Volga Federal District of the Russian Federation based on technologies of Industry 4.0 with the help of reorganization of regional universities (determining the influence of reorganization of universities on quality of education from the positions of transition to Industry 4.0);
- modeling of scenarios of increase of quality of education in regions of the Volga Federal District of the Russian Federation based on technologies of Industry 4.0 through reorganization of universities;
- developing recommendations for practical implementation of the most optimal scenario that envisages increase of quality of education in the regions of the Volga Federal District of the Russian Federation based on technologies of Industry 4.0 through reorganization of universities.

## 2. Literature review

The issues of reorganization of universities are studied sufficiently in the modern scientific literature. Diniz-Filho et al. (2016) write that the government program of reorganization of universities in Brazil became a driver of increase of academic efficiency (number of registered patents, publications and their citations, etc.). Hogan (2012) thinks that universities of the UK require reorganization for increasing their effectiveness. Kim (2018) performs an analysis of effective strategies of reaction to the policy of reorganization of a university and substantiates that the strategy of supporting reorganization is the most effective one.

The issues of digital modernization of the market of education in a region based on technologies of Industry 4.0 have also been elaborated in detail. Popkova (2017) shows that in modern Russia the process of institutionalization of digital education has just begun – which slows down the modernization of the educational market in regions based on technologies of Industry 4.0. Popkova (2019) shows that the knowledge economy creates favorable conditions for modernization of the market of education in the region based on technologies of Industry 4.0. Popkova and Sergi (2019) write of the systemic influence of modernization of education on formation of Industry 4.0 in economy (shown by the example of Russia). Sozinova (2019) determines the causal connections of transition to Industry 4.0 and, in particular, the related preconditions for digital modernization of the market of higher education.

Sukhodolov et al. (2018) developed a model of the modern information economy, which core is digital education that is based on the technologies of Industry 4.0. The processes of reorganization and marketing activities in these processes are studied in Sozinova (2018a) and Sozinova (2018 b). The author offers a marketing concept of managing the

reorganization of entrepreneurial structures (including universities) with the usage of new information technologies and substantiates the expedience of applying IT in solving the marketing tasks of modern companies (including universities) and shows that reorganization could stimulate application of these technologies (without any guarantee of high effectiveness).

The quality of higher education and, in particular, digital education in the conditions of Industry 4.0, as an economic category, is studied in the existing scientific literature. Hu et al. (2019) perform a qualitative content analysis of the reports of self-assessment of Chinese universities and determine the factors that influence the quality of transnational higher education in China. Khoi et al. (2019) prove the connection between quality of educational services, reputation of university, and consumer behavior (choice of university) in Vietnam. Ashraf (2019) substantiates the influence of labor conditions and preservation of lecturers on quality of education in private universities of Bangladesh.

Vnoučková et al. (2019) write that the entrepreneurial approach to quality management is preferable in the system of higher education (shown by the example of private universities of the Czech Republic). Mwiya et al. (2019) shows that there are differences in the methods of teaching in the ideas of quality of universities' educational services (shown by the example of Zambia). Hur (2018) substantiates the perspectives of increasing the quality of university education based on two-dimensional model of quality of Kano. Mgaiwa (2018) determined a paradox – financing of state-funded higher education in Tanzania does not always lead to increase of quality of education, and could even lead to its decrease in certain cases.

Thus, the results of the performed overview of the existing publications on the selected topic showed that there are a lot of works devoted to its key aspects. However, there are gaps in the existing knowledge.

One of the gaps is that the connection between reorganization of universities and modernization of the educational market in the region based on technologies of Industry 4.0 is not sufficiently studied by the modern economic science. Another gap is poor elaboration of the influence of reorganization of universities on quality of education in a region from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0. That's why in this paper we try to fill these gaps.

## 3. Materials and method

The logic of verification of hypothesis H consists in determining the consequences of reorganization of universities in regions of the Volga Federal District of the Russian Federation for quality of the provided higher educational services from the positions of the level of their digitization and activity of application. The method of horizontal analysis is used for studying the dynamics of the values of the indicators of digital modernization in federal flagship universities of the Volga Federal District of the Russian Federation in 2017-2018. The analysis envisages determining the absolute growth of the values of the indicators in 2018 as compared to 2017 and relative growth (in per cent).

- The logic of the performed scientific experiment consists in the idea that in order to confirm the offered hypothesis we have to determine insignificant (less than 10% in relative expression) growth of the values of the studied indicators. In the opposite case the hypothesis will be disproved.
- The source of the initial statistical data for the horizontal analysis is the information and analytical materials on the results of monitoring of effectiveness of activities of educational organizations of higher education,

which were prepared by the Ministry of Education and Science of the Russian Federation (2019a).

- The only indicators connected to digital modernization of the educational market in the region on the basis of technologies of Industry 4.0 are as follows:
    - quantity of PC's per student;
    - share of the cost of machines and equipment (not older than 5 years) in the total cost of machines and equipment.

That's why the research is performed on the basis of these indicators for obtaining the objective results. At the same time, two indicators are not enough for building a full picture of the change of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0. Thus, we use additional qualitative estimate indicators, which are assigned the values on the basis of the sociological survey of undergraduates of reorganized universities. The indicators are as follows:

- RE: indicator of accessibility of remote education;
- EE: indicator of accessibility of digital educational materials;
- DE: indicator of activity of application of digital technologies in the educational process;
- IE: indicator of activity of application of breakthrough technologies Industry 4.0 in the educational process;
- E4.0: generalized indicator of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0.

The following form was developed for the survey (Table 1).

**Table 1.** Form for a survey and assigning the values to the indicators that characterize the quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0

| Indicator (not given during the survey) | Question for determining the value of the indicator | Answer (value of the indicator) |
|---|---|---|
| RE | What is the level of accessibility of remote education (online education, remote interaction with lecturers)? | points 1-10 (the higher the better) |
| EE | What is the level of accessibility of educational materials (online ratings of students, library sources, lecture materials, and digital diplomas)? | points 1-10 (the higher the better) |
| DE | How actively are digital technologies used in the educational process (multimedia presentations, interactive boards)? | points 1-10 (the higher the better) |
| IE | How actively are breakthrough technologies of Industry 4.0 used in the educational process (technologies of virtual and alternate reality, the IoT, AI, etc.)? | points 1-10 (the higher the better) |
| E4.0 | What is quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0? | points 1-10 (the higher the better) |

We also developed a scale for qualitative treatment of the values of the generalized indicator of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0, which is used by undergraduates for assigning values to indicator E4.0 and during processing of the survey's results (Table 2).

**Table 2.** Scale for qualitative treatment of the value of the generalized indicator of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0

| Intervals of values of the indicator E4.0 in points | Qualitative treatment |
|---|---|
| [1-3) | potential of increase of quality of education based on technologies of Industry 4.0 is poorly implemented |
| [3-6) | fragmentary and small-scale digital modernization of education has been performed, which allows only for a slight increase of its quality based on technologies of Industry 4.0 |
| [6-9] | quality of education grew substantially due to its digital modernization based on technologies of Industry 4.0 |
| [9-10] | quality of education is very high, its digital modernization has been successfully performed, and technologies of Industry 4.0 are actively used in the educational process |

Source: developed and compiled by the authors.

As is seen from Table 2, we distinguish four intervals of the values of the generalized indicator of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0 (E4.0). If this indicator acquires value from 1 to 3, this means that potential of increase of quality of education based on technologies of Industry 4.0 has been poorly implemented. If indicator E4.0 is in the interval 3-6, this means that fragmentary and small-scale digital modernization of education has been performed, which allows only for a slight increase of its quality based on technologies of Industry 4.0.

If indicator E4.0 takes values in the interval 6-9, quality of education has grown significantly due to its digital modernization based on technologies of Industry 4.0. If indicator E4.0 is in the interval 9 – 10, quality of education is very high, and digital modernization of has been successfully performed, and technologies of Industry 4.0 are actively used in the educational process. The calculations are performed on the basis of direct averages of the values of the indicators.

For compiling the scenarios of increase of quality of education in regions of the Volga Federal District of the Russian Federation based on technologies of Industry 4.0 through reorganization of universities we use the method of regression analysis. We determine the dependent (build a model of multiple linear regression) generalized indicator of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0 (y) on all other indicators: number of PC's per one student ($x_1$), share of cost of machines and equipment (not older than 5 years) in the total cost of machines and equipment ($x_2$), indicator of accessibility of remote education($x_3$), indicator of accessibility of digital educational materials ($x_4$), indicator of activity of application of digital technologies in the educational process ($x_5$), and indicator of activity of application of breakthrough technologies Industry 4.0 in the educational process ($x_6$).

The determine dependence is shown in the form of regression equation: $y=a+b_1*x_1+b_2*x_2+b_3*x_3+b_4*x_4+b_5*x_5+b_6*x_6$. Also, the correlation coefficient is calculated – multiple R – which shows the share of the change of the dependent variable due to the change of the independent variables. This equation is used during scenario analysis with the simplex method. Its sense consists in determining the values of independent variables at which the target value of the dependent variable is achieved.

The target function is set the regression equation. The following limitations are accepted: target values of independent

variables should not be below their factual values in 2018. Within each scenario, absolute and relative growth of the indicators (variables) as compared to 2018 is determined, as well as the change of the target growth compared to factual growth in 2018 as compared to 2017, for determining the perspectives of practical realization of the scenario.

## 4. Results

### 4.1. The influence of reorganization of universities in regions of the Volga Federal District of the Russian Federation on quality of education from the positions of transition to Industry 4.0

The values of statistical indicators of digital modernization in federal flagship universities of the Volga Federal District of the Russian Federation in 2017-2018 are given in Table 3, and the obtained results of their horizontal analysis – in Table 4.

It is showm that for the federal flagship universities of the Volga Federal District of the Russian Federation in 2017-2018 on average, growth of the quantity of PC's per student was almost zero, and growth of the share of the cost of machines and equipment (not older than 5 years) in the total cost of machines and equipment was negative (-1.92 pcs; 1.06%). This confirms the offered hypothesis and shows the absence of visible results of the increase of quality of education based on digital modernization in the process of formation of regional flagship universities in modern Russia.

The obtained values of the indicators that characterize quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0 in federal flagship universities of the Volga Federal District of the Russian Federation in 2017-2018 are given in Table 5, and the obtained results of their horizontal analysis – in Table 6. 1,000 students were surveyed in each university, with the total number of respondents equaling 8,000. The survey was performed in 2017 and then repeatedly in 2018.

**Table 3.** Dynamics of the values of the indicators of digital modernization in the federal flagship universities of the Volga Federal District of the Russian Federation in 2017-2018.

| Regional flagship university | Quantity of PC's per student, pcs | | Share of the cost of machines and equipment (not older than 5 years) in the total cost of machines and equipment, % | |
|---|---|---|---|---|
| | 2017 | 2018 | 2017 | 2018 |
| Ufa State Oil Technical University | 0.49 | 0.50 | 42.57 | 45.19 |
| Vyatka State University | 0.32 | 0.33 | 37.12 | 19.90 |
| Mari State University | 0.34 | 0.33 | 67.52 | 68.85 |
| Nizhny Novgorod State Technica University | 0.33 | 0.35 | 19.24 | 36.12 |
| Samara State Technical University | 0.32 | 0.34 | 34.38 | 36.93 |
| Tolyatti State University | 0.30 | 0.28 | 25.68 | 17.35 |
| Saratov State Technical University | 0.45 | 0.46 | 52.78 | 49.89 |
| Ulyanovsk State University | 0.30 | 0.27 | 37.64 | 27.31 |

Source: compiled by the authors based on (Ministry of Education and Science of the Russian Federation. 2019).

**Table 4.** Horizontal analysis of the indicators of digital modernization in the federal flagship universities of the Volga Federal District of the Russian Federation in 2017-2018.

| Regional flagship university | Growth of the quantity of PC's per student | | Growth of the share of the cost of machines and equipment (not older than 5 years) in the total cost of machines and equipment | |
|---|---|---|---|---|
| | Absolute (2018-2017) | Relative (2018*100/2017-100), % | Absolute (2018-2017) | Relative (2018*100/2017-100), % |
| Ufa State Oil Technical University | 0.01 | 2.04 | 2.62 | 6.15 |
| Vyatka State University | 0.01 | 3.13 | -17.22 | -46.39 |
| Mari State University | -0.01 | -2.94 | 1.33 | 1.97 |
| Nizhny Novgorod State Technical University | 0.02 | 6.06 | 16.88 | 87.73 |
| Samara State Technical University | 0.02 | 6.25 | 2.55 | 7.42 |
| Tolyatti State University | -0.02 | -6.67 | -8.33 | -32.44 |
| Saratov State Technical University | 0.01 | 2.22 | -2.89 | -5.48 |
| Ulyanovsk State University | -0.03 | -10.00 | -10.33 | -27.44 |
| **On average** | **0.00** | **0.01** | **-1.92** | **-1.06** |

Source: calculated and compiled by the authors.

**Table 5.** Dynamics of values of the indicators digital modernization of в federal flagship universities of the Volga Federal District of the Russian Federation in 2017-2018.

| Regional flagship university | RE | | EE | | DE | | IE | | E4.0 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
| Ufa State Oil Technical University | 4.37 | 4.70 | 9.02 | 9.31 | 6.23 | 6.72 | 2.68 | 3.45 | 3.16 | 4.00 |
| Vyatka State university | 4.86 | 5.21 | 9.40 | 9.80 | 7.85 | 8.38 | 2.46 | 2.90 | 4.90 | 5.73 |
| Mari El State University | 3.61 | 3.99 | 9.83 | 9.92 | 8.01 | 8.59 | 2.89 | 3.31 | 4.67 | 5.25 |
| Nizhny Novgorod State Technical University | 5.19 | 5.36 | 9.97 | 10.56 | 6.86 | 7.28 | 2.57 | 3.11 | 4.59 | 4.99 |
| Samara State Technical University | 3.31 | 3.88 | 9.08 | 9.42 | 8.99 | 9.22 | 2.35 | 2.82 | 4.57 | 4.79 |
| Tolyatti State University | 5.15 | 5.62 | 9.68 | 9.94 | 7.34 | 7.60 | 1.46 | 1.92 | 3.43 | 3.59 |
| Saratov State Technical University | 4.71 | 4.86 | 9.35 | 10.08 | 6.30 | 7.07 | 1.87 | 2.17 | 4.99 | 5.57 |
| Ulyanovsk State University | 3.77 | 4.56 | 9.90 | 9.97 | 7.73 | 8.45 | 2.62 | 3.34 | 5.25 | 5.89 |
| On average | 4.37 | 4.77 | 9.53 | 9.88 | 7.41 | 7.91 | 2.36 | 2.88 | 4.45 | 4.98 |

Source: compiled by the authors based on (Ministry of Education and Science of The Russian Federation. 2019).

**Table 6.** Dynamics of values of the indicators of digital modernization of federal flagship universities of the Volga Federal District of the Russian Federation in 2017-2018.

| Regional flagship universi | Growth RE | | Growth EE | | Growth DE | | Growth IE | | Growth E4.0 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | abs. | rel. ($x_3$ | abs. | rel. ($x_4$ | abs. | rel. ($x_5$ | abs. | rel. (x | abs. | rel. (y) |
| Ufa State Oil Technical University | 0.33 | 7.55 | 0.29 | 3.22 | 0.49 | 7.87 | 0.77 | 28.7 | 0.84 | 26.58 |
| Vyatka State University | 0.35 | 7.20 | 0.40 | 4.26 | 0.53 | 6.75 | 0.44 | 17.8 | 0.83 | 16.94 |
| Mari El State University | 0.38 | 10.53 | 0.09 | 0.92 | 0.58 | 7.24 | 0.42 | 14.5 | 0.58 | 12.42 |
| Nizhny Novgorod State Technical University | 0.17 | 3.28 | 0.59 | 5.92 | 0.42 | 6.12 | 0.54 | 21.0 | 0.40 | 8.71 |
| Samara State Technical University | 0.57 | 17.22 | 0.34 | 3.74 | 0.23 | 2.56 | 0.47 | 20.0 | 0.22 | 4.81 |
| Tolyatti State University | 0.47 | 9.13 | 0.26 | 2.69 | 0.26 | 3.54 | 0.46 | 31.5 | 0.16 | 4.66 |
| Saratov State Technical University | 0.15 | 3.18 | 0.73 | 7.81 | 0.77 | 12.22 | 0.30 | 16.0 | 0.58 | 11.62 |
| Ulyanovsk State Universit | 0.79 | 20.95 | 0.07 | 0.71 | 0.72 | 9.31 | 0.72 | 27.4 | 0.64 | 12.19 |
| **On average** | 0.40 | 9.88 | 0.35 | 3.66 | 0.50 | 6.95 | 0.52 | 22.1 | 0.53 | 12.24 |

Source: compiled by the authors based on (Ministry of Education and Science of The Russian Federation. 2019).

According to the data of Table 6, growth of the indictor of accessibility of remote education (RE) in 2018, as compared to 2017, constituted 0.40 points (9.88%); growth of the indicator of accessibility of digital educational materials (EE) constituted 0.35 points (3.66%). Growth of the indicator of activity of application of digital technologies (DE) in the educational process constituted 0.50 points (6.95%); growth of the indicator of activity of application of breakthrough technologies Industry 4.0 (IE) in the educational process constituted 0.525 points (22.15%). Growth of the generalized indicator of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0 (E4.0) constituted 0.53 points (12.24%). As relative growth of all studied indicators does not exceed 15%, hypothesis H is proved.

### 4.2. Scenarios of increase of quality of education in regions of the Volga Federal District of the Russian Federation based on technologies of Industry 4.0 through reorganization of universities

As a result of the regression analysis, we obtained the following equation of multiple linear regression: $y=-27.44+10.76*x_1-0.02x_2-0.25*x_3+2.14*x_4+1.05*x_5+0.39*x_6$. Multiple R constituted 0.7943. Therefore, the change of the dependent variable by 79.43% is explained by the change of the independent variables in the regression equation. The obtained equation is the target function. Also, the following limitations are set: $x_1 \geq 0.36$, $x_2 \geq 37.69$, $x_3 \geq 4.77$, $x_4 \geq 9.95$, $x_5 \geq 7.95$, $x_6 \geq 2.89$.

The 2018 average value of the generalized indicator of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0 (E4.0) – 4.98 points – is in the interval 3-6 and shows that universities of the regions of the Volga Federal District have performed fragmentary and small-scale digital modernization of education, which allows for a slight increase of its quality based on technologies of Industry 4.0. Thus, we determined three scenarios of increase of quality of education in regions of the Volga Federal District of the Russian Federation based on technologies of Industry 4.0 through reorganization of universities:

- scenario of moderate digital modernization of education, at which the generalized indicator of

quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0 (E4.0) reaches the maximum value in the current interval (5.99 points);

- scenario of accelerated digital modernization of education, at which the generalized indicator of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0 (E4.0) is in the middle of the following interval ([6-9]), constituting 7.5 points;
- scenario of transition of education to Industry 4.0, at which the generalized indicator of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0 (E4.0) is in the middle of the last (the most preferable) interval ([9-10]), constituting 9.5 points.

Quantitative characteristics of the compiled scenarios are shown in Tables 7-9.

**Table 7.** Quantitative characteristics of the scenario of moderate digital modernization of education

| Variable | Target value of the variable | Value in 2018 | Absolute growth (2018-2017), pcs./%/points | Relative growth (2018*100/2017-100), % ($x_1$) | Growth in 2018, % | Change of growth, times |
|---|---|---|---|---|---|---|
| x1 | 0.45 | 0.36 | 0.09 | 25.10 | 0.01 | 2230.71 |
| x2 | 37.69 | 37.69 | 0.00 | 0.00 | -1.06 | 0.00 |
| x3 | 4.77 | 4.77 | 0.00 | 0.00 | 9.88 | 0.00 |
| x4 | 9.89 | 9.88 | 0.02 | 0.18 | 3.66 | 0.05 |
| x5 | 7.92 | 7.91 | 0.01 | 0.11 | 6.95 | 0.02 |
| x6 | 2.88 | 2.88 | 0.00 | 0.00 | 22.15 | 0.00 |
| y | 5.99 | 4.98 | 1.01 | 20.37 | 12.24 | 1.66 |

Source: calculated and compiled by the authors.

As is shown in Table 7, for increasing the value of the generalized indicator of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0 (y) up to 5.99 (by 1.01 points – i.e., by 20.37% as compared to 2018), the following growth of independent variables should be achieved:

- nnumber of PC's per one student should be increased by 0.09 pcs. (by 25.10%) and should constitute 0.45 pcs.;
- share of the cost of machines and equipment (not older than 5 years) in the total cost of machines and equipment has to remain unchanged and constitute 37.49%;
- iindicator of accessibility of remote education has to remain unchanged and constitute 4.77 points;
- indicator of accessibility of digital educational materials should be increased by 0.02 points (by 0.18%) and constitute 9.89 points;
- indicator of activity of application of digital technologies in the educational process should be increased by 0.01 points (by 0.11%) and constitute 7.92 points;
- indicator of activity of application of breakthrough technologies of Industry 4.0 in the educational process has to remain unchanged and constitute 2.88 points.

Thus, the main changes for implementing the studied scenario should take place regarding the number of PC's per one student. Its relative growth should be increased in 2,230 times as compared to growth in 2018 (as compared to 2017).

**Table 8.** Quantitative characteristics of the scenario of accelerated digital modernization of education

| Variable | Target value of the variable | Value in 2018 | Absolute growth (2018-2017), pcs/%/points | Relative growth (2018*100/2017-100), % (x1) | Growth in 2018, % | Change of growth, times |
|---|---|---|---|---|---|---|
| x1 | 0.58 | 0.36 | 0.22 | 62.48 | 0.01 | 5553.38 |
| x2 | 37.69 | 37.69 | 0.00 | 0.00 | -1.06 | 0.00 |
| x3 | 4.77 | 4.77 | 0.00 | 0.00 | 9.88 | 0.00 |
| x4 | 9.92 | 9.88 | 0.04 | 0.45 | 3.66 | 0.12 |
| x5 | 7.94 | 7.91 | 0.02 | 0.28 | 6.95 | 0.04 |
| x6 | 2.89 | 2.88 | 0.01 | 0.34 | 22.15 | 0.01 |
| y | 7.50 | 4.98 | 2.52 | 50.72 | 12.24 | 4.14 |

Source: calculated and compiled by the authors

As is shown in Table 8, for increasing the value of the generalized indicator of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0 (y) up to 7.50 (by 2.52 points – i.e., by 50.72%, as compared to 2018), the following growth independent variables should be achieved:

- nnumber of PC's per one student should be increased by 0.22 pcs. (by 62.48%) and should constitute 0.58 pcs.;
- share of the cost of machines and equipment (not older than 5 years) in the total cost of machines and equipment has to remain unchanged and constitute 37.69%;
- indicator of accessibility of remote education has to remain unchanged and constitute 4,77 points;
- indicator of accessibility of digital educational materials should be increased by 0.04 points (by 0.45%) and constitute 9.92 points;
- indicator of activity of application of digital technologies in the educational process should be increased by 0.02 points (by 0.28%) and should constitute 7.94;
- indicator of activity of application of breakthrough technologies Industry 4.0 in the educational process should be increased by 0.01 points (by 0.34%) and constitute 2.89 points.

Thus, the main changes for implementation of the studied scenario should take place regarding the number of PC's per one student. Its relative growth should be increased by 5,553 times as compared to growth in 2018 (as compared to 2017).

As is shown in Table 9, for increasing the value of the generalized indicator of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0 (y) up to 9.50 (by 4.52 – i.e., by 90.91% as compared to 2018), the following growth of independent variables should be reached:

- number of PC's per one student should be increased by 0.40 pcs. (by 111.99%) and should constitute 0.76 pcs.;
- share of the cost of machines and equipment (not older than 5 years) in the total cost of machines and equipment has to remain unchanged and constitute 37.69%;

- indicator of accessibility of remote education has to remain unchanged and constitute 4.77 points;
- indicator of accessibility of digital educational materials should be increased by 0.08 points (by 0.81%) and constitute 9.95 points;
- indicator of activity of application of digital technologies in the educational process should be increased by 0.04 points (by 0.50%) and constitute 7.95 points;
- indicator of activity of application of breakthrough technologies Industry 4.0 in the educational process should be increased by 0.01 point (by 0.34%) and constitute 2,89 points.

Thus, the main changes for implementing the studied scenario should take place regarding the number of PC's per one student. Its relative growth should be increased by 9,954 times as compared to growth in 2018 (as compared to 2017).

Thus, among the studied scenarios the largest perspectives of practical implementation are peculiar for the scenario of moderate digital modernization of education. This is due to the fact that all three scenarios envisage multiple increase of the growth of the number of PC's per one student. It is obvious that in the mid-term this increase will be difficult to achieve – due to absence of the investment resources with the university, the state, and venture investors in the sphere of digital education. That's why the scenario that envisages the lowest increase of growth of this indicator with a vivid advantage for quality of education is the most optimal.

**Table 9.** Quantitative characteristics of the scenario of education's transition to Industry 4.0.

| Variable | Target value of the variable | Value in 2018 | Absolute growth (2018-2017), pcs./%/points | Relative growth (2018*100/2017-100), % (x1) | Growth in 2018, % | Change of growth, times |
|---|---|---|---|---|---|---|
| x1 | 0.76 | 0.36 | 0.40 | 111.99 | 0.01 | 9954.28 |
| x2 | 37.69 | 37.69 | 0.00 | 0.00 | -1.06 | 0.00 |
| x3 | 4.77 | 4.77 | 0.00 | 0.00 | 9.88 | 0.00 |
| x4 | 9.95 | 9.88 | 0.08 | 0.81 | 3.66 | 0.22 |
| x5 | 7.95 | 7.91 | 0.04 | 0.50 | 6.95 | 0.07 |
| x6 | 2.89 | 2.88 | 0.01 | 0.34 | 22.15 | 0.02 |
| y | 9.50 | 4.98 | 4.52 | 90.91 | 12.24 | 7.43 |

Source: calculated and compiled by the authors.

### 4.3. Recommendations for increase of quality of education in regions of the Volga Federal District of the Russian Federation based on technologies of Industry 4.0 through reorganization of universities

We determined three following reasons of emergence of the research problem, which is connected to low increase of quality during digital modernization of the educational market in the region based on technologies of Industry 4.0 in the process of reorganization of universities in modern Russia, which are barriers on the path of the optimal scenario of moderate digital modernization of education:

- absence of a clear plan of increasing the quality of education during the digital modernization in the process of reorganization for each university;
- absence of a precise list of accessible digital technologies and business processes for the reorganized

universities, which could be automatized with the help of these technologies and ensure the increase of quality of education;

- absence of the indicators for measuring the results of modernization for the quality of education from the positions of application of technologies of Industry 4.0.

For systemic elimination of all determined reasons and for successful practical realization of the scenario of moderate digital modernization of education we developed the following algorithm of quality management of education during reorganization of universities in the interests of modernization of the market of education in the region based on technologies of Industry 4.0 (Figure 1).

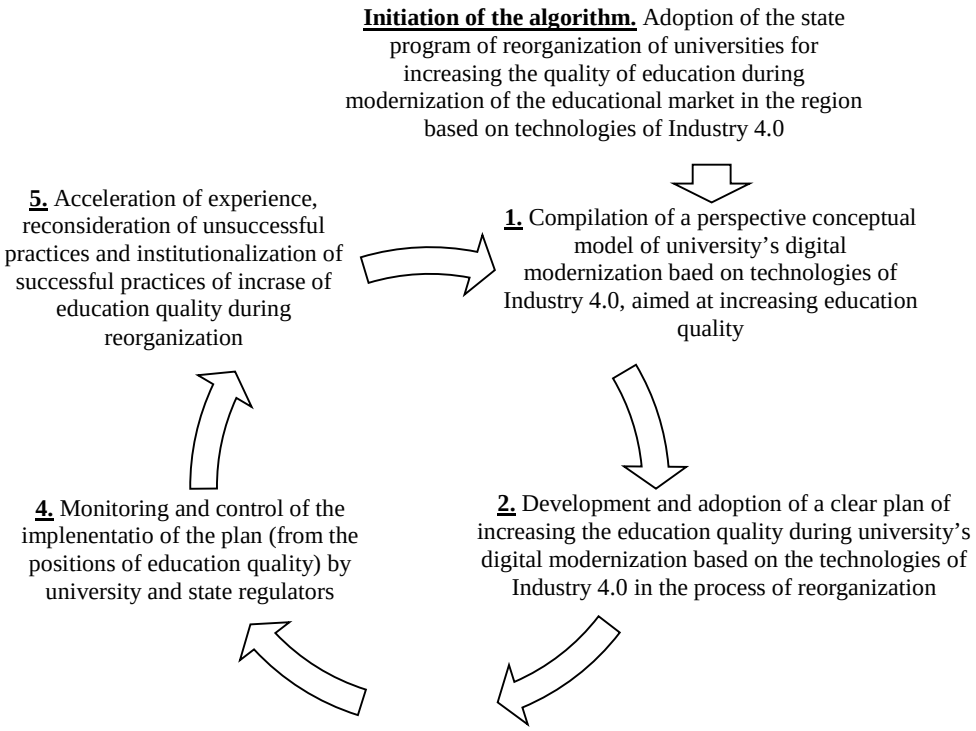


**Figure 1.** The algorithm of quality management of education during reorganization of universities in the interests of modernization of the market of education in a region based on technologies of Industry 4.0.
Source: compiled by the authors.

As is seen from Figure 1, the offered algorithm is cyclic. It initiated due to adoption of the state program of reorganization of universities in the interests of increase of quality of education during modernization of the market of education in the region based on technologies of Industry 4.0. At the first stage of the algorithm, a perspective conceptual model of digital modernization of university is based on technologies of Industry 4.0 is

compiled, which is aimed at increasing the quality of education. At the second stage, a clear plan of increase of quality of education during university's digital modernization based on technologies of Industry 4.0 in the process reorganization is developed and adopted.

At the third stage, the plan is implemented – reorganization and digital modernization of the university based on technologies of Industry 4.0 are conducted, and quality of education is increased. At the fourth stage, monitoring and control of the implementation of the plan (from the positions of quality of education) by the university and state regulators are conducted. The fifth stage envisages acceleration of experience, reconsideration of unsuccessful practices, and institutionalization of successful practices of increase of quality of education during reorganization. Then, return to the first stage takes place, at which the conceptual model is improved. For practical implementation of the offered algorithm in modern Russia, we offer the following recommendations:

- specification (expansion) of the list of indicators of universities' effectiveness by including the indicators of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0 – e.g., the number of implemented breakthrough digital technologies or the share of automatized business processes, etc.;
- adoption of a conceptual model of the work of digital university based on technologies of Industry 4.0 – our vision of this model is presented in Figure 2.

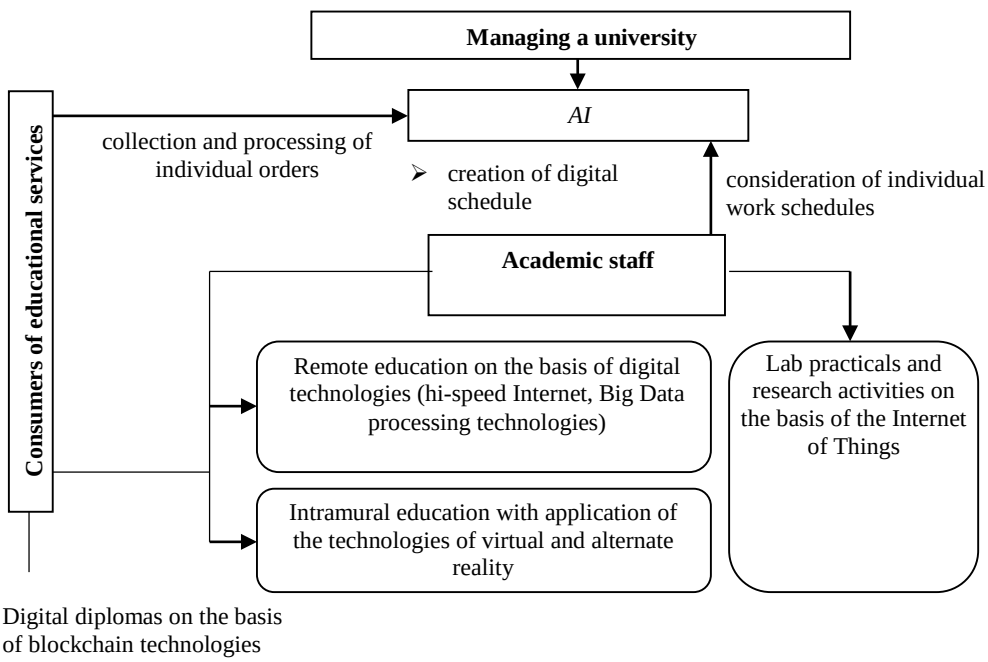


**Figure 2.** A conceptual model of the work of a digital university on the basis of technologies of Industry 4.0.
Source: compiled by the authors.

As is seen from Figure 2, a digital university is managed with the help of AI. Though most of the organizational and managerial functions are performed by humans, AI allows for authomatization of certain tasks within these functions – e.g., solving the optimization task on compilation of a digital schedule on the basis of collection and processing of individual orders from consumers of educational services and in view of individual schedules of lecturers' work. The university's production activities are implemented in three directions:

- intramural education with application of the technologies of virtual and alternate reality;
- remote education on the basis of digital technologies (hi-speed Internet, technologies of Big Data processing);
- lab practical and research activities on the basis of the Internet of Things.

As a result of training, graduates receive digital diplomas on the basis of blockchain technologies. The offered concept could be used as a model during digital modernization of the modern Russian universities on the basis of technologies of Industry 4.0 in the process of reorganization (formation of regional flagship universities).

## 5. Conclusion

As a result of the research, the offered hypothesis has been proved – as of now (2019) Russia has not yet achieved significant results in the sphere of increase of quality of education during digital modernization of universities based on technologies of Industry 4.0 in the process reorganization (formation of regional flagship universities). The current issues related to this problem have been solved in this paper.

In particular, the authors have offered a specific list of breakthrough digital technologies that are created and developed within Industry 4.0, which could and should be adapted to the needs and specifics of the universities' activities in the near future (next 3-5 years): AI, technologies of virtual and alternate reality, hi-speed (industrial) Internet, technologies of Big Data processing, the Internet of Things, and blockchain technologies.

Implementation of these technologies will created the following potential advantages for quality of education, which could and should be ensured by digital modernization of the educational market in the region on the basis of technologies of Industry 4.0: possibility of verification of diplomas' authenticity for employers, possibility of combining the work in different universities for lecturers, and possibility of combining work and study for students. The potential risks that accompany the process of digital modernization of the educational market in the region on the basis of technologies of Industry 4.0 are connected to provision of continuity (accuracy and stability) of the work of digital technologies. Risk management envisages development of the corresponding infrastructural provision in the Russian regions.

Thus, the offered authors' recommendations allow improving the modern Russian practice of managing the process of reorganization of universities (during formation of regional flagship universities) and making them a tool of increase of quality of education from the positions of the level of its digitization and activity of application of the technologies of Industry 4.0.

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