frontiers | Frontiers in Education

TYPE Brief Research Report
PUBLISHED 21 February 2023
DOI 10.3389/feduc.2023.1113922

OPEN ACCESS

EDITED BY
Elena G. Popkova,
Moscow State Institute of International Relations,
Russia

REVIEWED BY
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Serbia
Stuart Perrin,
Xi'an Jiaotong-Liverpool University,
China

*CORRESPONDENCE
Veronika V. Yankovskaya
✉ veronika28-2@mail.ru

SPECIALTY SECTION
This article was submitted to Leadership in Education, a section of the journal Frontiers in Education

RECEIVED 01 December 2022
ACCEPTED 31 January 2023
PUBLISHED 21 February 2023

CITATION
Yankovskaya VV, Suglobov AE, Bykovskaya NV and Mustafin TA (2023) Digital education in the social investment model of Gross Domestic Product growth in the context of Industry 4.0.
Front. Educ. 8:1113922.
doi: 10.3389/feduc.2023.1113922

Digital education in the social investment model of Gross Domestic Product growth in the context of Industry 4.0

Veronika V. Yankovskaya[1]*, Aleksandr E. Suglobov[2], Natalya V. Bykovskaya[3] and Timur A. Mustafin[4]

[1]Department of Political Analysis and Sociopsychological Processes, Plekhanov Russian University of Economics, Moscow, Russia, [2]Department of Audit and Corporate Accounting, Financial University Under the Government of the Russian Federation, Moscow, Russia, [3]Moscow Timiryazev Agricultural Academy, Moscow, Russia, [4]Diplomatic Academy of the Russian Foreign Ministry, Moscow, Russia

The motivation for this research was the desire to disclose the potential for human potential development that is created by Industry 4.0. The goal of this paper is to study the modern international experience and prospects for implementing the social investment model of economic growth under the conditions of Industry 4.0 with the help of the development of digital education. The method of regression analysis is used to model the econometric dependence of human development on digital education in 2019–2021. The paper's contribution to the literature consists in the development of scientific provisions of the concept of the social investment model of economic growth through reconsidering the approach to human potential development with the help of education under the conditions of Industry 4.0. Unlike the existing approach, which implies the foundation on traditional (pre-digital) education, this paper offers a new approach to human potential development under the conditions of Industry 4.0, which is based on digital education. The advantage of the authors' approach is its allowing for the fullest use of new opportunities that open under the conditions of Industry 4.0. The main conclusion of this research is that under the conditions of Industry 4.0, the social investment model of economic growth should be based on digital education. The theoretical significance of the results obtained lies in their allowing reconsidering the role of education in the implementation of the social investment model of economic growth under the conditions of Industry 4.0. It is proved that this role is performed most successfully with the help of digital education. The practical significance of the conclusions is due to the fact that implementation of the authors' recommendations will allow balancing the level of human development in the countries of distinguished categories: countries with the highest Gross Domestic Product (GDP) growth rate; countries with the highest level of human development; countries with the most developed digital education. The social significance of the paper consists in its support for the practical implementation of SDG 4, SDG 8, and SDG 10.

KEYWORDS

digital education, digital personnel, social investment model, Gross Domestic Product (GDP) growth, Industry 4.0

1. Introduction

In the context of the "knowledge economy," the concept of a social investment model of Gross Domestic Product (GDP) growth has gained wide popularity. According to this concept,

GDP growth is based on human development, since human resources are the central factor of production, acting as a source of social (labour), information (knowledge) and intellectual (technology) capital. In the context of Industry 4.0, the social investment model of GDP growth is supported in the national programmes of technological modernization of most countries of the world. This is reflected in the adopted and implemented initiatives for training digital personnel for high-tech sectors of the economy, in which digital education plays a central role (Vinnikova et al., 2021; Zhang, 2021).

There are three central ideas in the social investment model: (1) educate a labour force so that it is ready for new jobs in the knowledge economy; (2) raise employment levels through providing specific support (child-care/kindergartens, etc.); (3) promote a living wage. All these three ideas are supported and developed under the conditions of Industry 4.0. Whilst Industry 4.0 involves the dissemination and active use of disruptive technologies, artificial intelligence (AI) and greater automation, it also created new opportunities for human potential development.

The advantages of transition to Industry 4.0 for human potential development include the creation of new knowledge-intensive, highly efficient and highly paid jobs, as well as additional opportunities for the development of talents and the manifestation of innovative activity by company employees in Industry 4.0. The key role in ensuring these advantages belongs to education. Leading technologies provide opportunities for the formation of digital education, which is treated as the use of digital technologies and automation tools (from the Internet to virtual and augmented reality and robots) in the process of training, development of digital competencies with students (training of digital personnel) and the active development of new—remote—form of education (Lacka et al., 2021; Qureshi et al., 2021; Sayaf et al., 2021; Secundo et al., 2021; Zawacki-Richter, 2021).

Here it is important to take into account the experience of developing countries that demonstrate the fastest rates of GDP growth (Zhang, 2021). For example, Eritrea, which demonstrated one of the highest rates of GDP growth in 2019 (8.7%, the third place in the world), according to the materials of the World Bank (2022), takes 182nd place in the ranking of human development (0.434), according to UNDP (2022), and in the IMD (knowledge) Digital education rating (2020), this country is not represented, which indicates a low level of digital education development.

A bright example of high-tech GDP growth, one of the highest rates of which in 2019 was demonstrated by China (6.1%), is the reliance on Automation (Robotization) within a large-scale failure and a decrease in the importance of human resources and sidelining it in the system of production factors. For example, in terms of Digital/Technological skills in 2020, China ranks the 12th, in terms of Total Public Expenditure on education, 51st, and in terms of Robotization, the 1st (World Robots Distribution) as reported by IMD (2022). This indicates a pronounced predominance of Automation over digital education as a source of GDP growth (Fan et al., 2021).

In this regard, the problem arises of determining whether in the context of Industry 4.0 the social investment model of GDP growth is implemented, and what role digital education plays in it. The above examples show that, under the conditions of Industry 4.0, the social investment model of economic growth becomes more popular and effective, since knowledge-intensive and high-tech economic growth is necessary and is achieved. The quick development of digital education, which became popular around the world during the COVID-19 pandemic, deserves special attention since it could be laid at the basis of the successful realisation of the technocratic model of GDP growth.

The goal of this paper is to study the modern international experience and prospects for implementing the social investment model of economic growth under the conditions of Industry 4.0 with the help of the development of digital education. The paper's originality is due to its reconsidering the role of education in the social investment model of economic growth. We present a new proprietary vision of this role under the conditions of Industry 4.0; in it, the development of human potential is performed not with the help of not traditional education but digital education.

2. Literature review

Digital education as a new form of delivery of educational services is considered in the works of Speight (2017), Popkova and Zmiyak (2019), Batool (2022), Blankson (2022), Fernández-Sánchez et al. (2022), and Suyo-Vega et al. (2022). The place of education, social investment and human development in the system of sources of GDP growth is determined in the works of Goyal and Sergi (2015), Ibrahim (2018), Munir and Arshad (2018), Marquez-Ramos and Mourelle (2019), Reyes and Useche (2019), Uddin and Sarntisart (2019), Anetor (2020), Karambakuwa et al. (2020), and Tahir et al. (2020).

The conducted literature review showed that existing studies and publications do not sufficiently take into account the latest experience and the specifics of GDP growth in the context of Industry 4.0. The social investment model of GDP growth is considered either at the theoretical level of economic science or is based on the experience of past years without taking into account the latest data that appeared in the context of Industry 4.0. Digital education is considered apart from GDP growth and therefore their relationship is poorly understood.

Thus, the uncertainty about the place of digital education in the social investment model of GDP growth in the context of Industry 4.0 is the study gap that this article aims to fill in. That is why an important direction for further research of the social investment model of economic growth is the clarification of the role of education in its implementation. This leads to the following research question (RQ): What role does digital education play in the implementation of the social investment model of economic growth under the conditions of Industry 4.0?

The works of Algraini (2021), Grisolia et al. (2022), Guijarro-Garvi et al. (2022), and Indrawati and Kuncoro (2021) state that the social investment role of economic growth is based on education with the preference for the traditional (pre-digital) practise. This position is proved by the fact that an increase in human potential, which is a source of economic growth, takes place through education (Bloom et al., 2021; Nouira and Saafi, 2022; Wang et al., 2022).

Digital education, which often implies the use of a remote form of training, is criticised in the existing works of Maaravi and Heller (2021), Rodríguez-Abitia et al. (2020), and Saltos-Rivas et al. (2021), because it may reduce the quality of education. Contrary to this, Gunathilaka et al. (2022), Kasımoğlu et al. (2022), and Li et al. (2022) note the important contribution of digital education to the support for the normal functioning of the educational system under the conditions of lockdowns that took place during the COVID-19 pandemic.

This demonstrates the large potential of digital education and is the basis for offering the following hypothesis (H): digital education plays an important role in the implementation of the social investment

model of economic growth under the conditions of Industry 4.0. To search for an answer to the set RQ and to test hypothesis H, we perform the econometric modelling of the relationship between digital education and human potential development and the relationship between human potential development and economic growth.

3. Materials and methodology

The methodological apparatus of the study is based on the method of regression and correlation analysis. To test the developed hypothesis, a sample of countries divided into the three categories, highlighted by the authors of this study, was formed: countries with the highest rate of GDP growth, according to the World Bank (2022) rating, countries with the highest level of human development, according to the UNDP (2022) rating, and countries with the most advanced digital education, according to the IMD (2022) rating. The values of the indicators, required to test the developed hypothesis, for the countries of the sample are collected in Table 1.

We test the hypothesis by finding the regression dependence of human development (z, according to the materials of UNDP, 2022) on digital education (x, indicator "Knowledge" based on the materials of IMD, 2022). The research model has the following form:

$$z = a + b * x. \quad (1)$$

Hypothesis H is deemed proved if the regression coefficient at the factor variable x is positive [$b > 0$ in the model (1)], which will prove a positive contribution of digital education to the development of human potential. The reliability of the econometric model is determined with the help of the correlation coefficient, the F-test and the t-test.

In addition to this, we determine the differences in the contribution of human development (z, according to the UNDP, 2022) to GDP growth (y, according to the World Bank, 2022). It is assumed that this contribution will be different amongst the distinguished categories of countries, which will be a sign of the differences in the social investment model of economic growth. We build regression curves to discover these differences. The logic of the research is clearly shown in Figure 1.

Figure 1 shows that Industry 4.0 has a strong influence and determines GDP growth at present. This forms a close connection between economic growth and human development, and between human development and digital education. In this regard, it becomes necessary to embed digital education into a new model of GDP growth by establishing a direct link between digital education and GDP growth (eliminating the mediation of human development).

4. Results

To test the offered hypothesis using the data from Table 1, we calculated the regression dependence of human development (z, according to the materials of the UNDP, 2022) on digital education (x, indicator "Knowledge" based on the materials of IMD, 2022). This allowed specifying the research model (1) and obtaining the following equation of simple linear regression:

$$z = 0.5582 + 0.0043 * x. \quad (2)$$

The obtained regression equation shows that an increase in the level of the development of digital education by 1 point leads to an increase in the level of human development by 0.0043. The demonstrated regularity is objective since it takes into account the pre-pandemic experience (2019) and the experience of the COVID-19 pandemic (2020–2021) for the entire sample of countries. The reliability of the econometric model (2) is tested in Table 2.

The results from Table 2 show that the level of human development in the countries of the sample is by 79.44% explained by the influence of digital education. Significance F equals $7.3^{*}10^{-11}$, therefore, model (2) conforms to the highest level of significance 0.01 (it is the most accurate, and the model's error is minimal). At the set level of significance, with 45 observations, table F equals 7.2636. Observed $F = 73.5653$—it exceeds table F; therefore, the F-test was passed.

The observed value of t-Stat for the factor variable equals 8.5770. Similarly, it exceeds the table value (2.692 with 44 degrees of freedom). Therefore, the t-test was also passed. The standard error of the regression model is small, equalling 0.0590. The performed tests confirmed the reliability of the econometric model (2) and proved the hypothesis H: the regression coefficient at the factor variable x is positive [$b > 0$ in the model (2)], which is proof of the positive contribution of digital education to the development of human potential.

Based on model (1), we established that maximisation of the level of the development of digital education (100 points) will allow for almost complete realisation of human development potential, due to which it will reach 0.99 (out of maximum possible 1). Due to digital education, the level of human development in the distinguished categories of countries will be balanced, which will make a significant contribution to the reduction of their socio-economic inequality.

In countries with the highest GDP growth rate, the level of human development will grow by 32.35%, which will require an increase in the level of the development of digital education by 94.64%. In countries with the highest level of human development, the level of human development will grow by 3.66%, which will require an increase in the level of digital education development by 34.44%. In countries with the most developed digital education, the level of human development will grow by 5.52%, which will require an increase in the level of digital education development by 19.21%.

In addition to this, based on the data from Table 1, we determined the differences in the contribution of human development (z, according to the UNDP, 2022) to GDP growth (y, according to the World Bank, 2022; Figure 2).

Regression curves (Figure 2) demonstrate that the largest contribution to economic growth is made by human development in countries with the highest level of human development, where an increase in the human development level by 0.1 leads to an acceleration of the GDP growth rate by 16.547%. In countries with the most developed digital education, an increase in the level of human development by 0.1 leads to an acceleration of the GDP growth rate by 3.5444%. In countries with the highest GDP growth rate, an increase in the human development level by 0.1 accelerates the GDP growth rate by 0.0574%. This additionally strengthens the evidence base and scientific arguments in favour of the suggested hypothesis,

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TABLE 1 Statistics of digital education in the social investment model of Gross Domestic Product (GDP) growth in the context of Industry 4.0 in 2019–2021.

Category of countries	Country	GDP growth, annual %	Human development Index	Knowledge (digital competitiveness index), score 1–100
–	–	*y*	*z*	*x*
2019				
Countries with the highest GDP growth rate	China	5.95	0.758	78.067
	Philippines	6.12	0.712	53.539
	Mongolia	5.60	0.735	43.669
	Indonesia	5.02	0.707	48.395
	Russia	2.20	0.824	75.017
Countries with the highest level of human development	Norway	0.75	0.954	80.333
	Switzerland	1.14	0.946	90.850
	Ireland	5.44	0.942	74.805
	Germany	1.06	0.939	83.072
	Australia	2.17	0.944	80.702
Countries with the most developed digital education	USA	2.29	0.920	90.998
	Singapore	1.10	0.935	90.503
	Sweden	1.99	0.937	89.727
	Canada	1.88	0.922	87.849
	Denmark	1.49	0.930	85.987
2020				
Countries with the highest GDP growth rate	China	2.24	0.761	85.105
	Philippines	−9.52	0.718	42.557
	Mongolia	−4.56	0.737	44.127
	Indonesia	−2.07	0.718	41.260
	Russia	−2.66	0.824	67.891
Countries with the highest level of human development	Norway	−0.72	0.957	78.196
	Switzerland	−2.38	0.955	89.770
	Ireland	6.18	0.955	68.812
	Germany	−3.70	0.947	81.028
	Australia	−0.05	0.944	77.848
Countries with the most developed digital education	USA	−2.77	0.926	97.922
	Singapore	−4.14	0.938	92.031
	Sweden	−2.17	0.945	89.199
	Canada	−5.23	0.929	88.825
	Denmark	−1.99	0.940	86.145
2021				
Countries with the highest GDP growth rate	China	8.11	0.768	82.500
	Philippines	5.70	0.699	35.158
	Mongolia	1.64	0.739	36.916
	Indonesia	3.69	0.705	36.578
	Russia	4.75	0.829	65.728

(Continued)

TABLE 1 (Continued)

Category of countries	Country	GDP growth, annual %	Human development Index	Knowledge (digital competitiveness index), score 1–100
Countries with the highest level of human development	Norway	3.88	0.961	73.499
	Switzerland	4.22	0.962	86.929
	Ireland	13.59	0.959	65.790
	Germany	2.63	0.942	75.854
	Australia	2.24	0.951	69.844
Countries with the most developed digital education	USA	5.95	0.921	85.601
	Singapore	7.61	0.939	84.132
	Sweden	5.08	0.947	86.485
	Canada	4.54	0.936	81.795
	Denmark	4.86	0.948	81.415

Compiled by the authors based on materials from IMD (2022), UNDP (2022), and World Bank (2022).

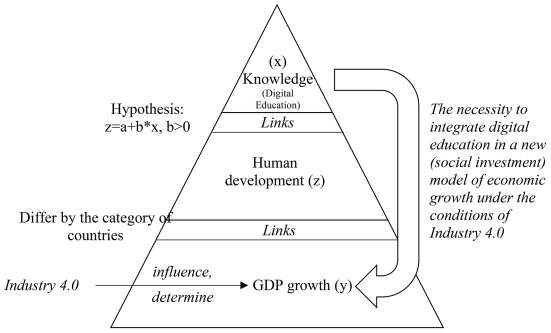

FIGURE 1
The hypothesis and logic of the study. Developed and compiled by the authors.

since it is a sign of the prospects of the social investment model of economic growth that is based on digital education.

5. Discussion

This paper's contribution to the literature consists in the development of the scientific provisions of the concept of the social investment model of economic growth through reconsideration of the approach to human potential development with the help of education under the conditions of Industry 4.0. Unlike the existing approach, which implies the foundation on traditional (pre-digital) education (Algraini, 2021; Indrawati and Kuncoro, 2021; Grisolia et al., 2022; Guijarro-Garvi et al., 2022), we offered a new approach to human potential development under the conditions of Industry 4.0, which is based on digital education.

The advantage of the authors' approach is that it allows for the fullest use of new opportunities that open under the conditions of Industry 4.0. On the one hand (at the input), the leading technologies of Industry 4.0 are used in digital education, which allows raising its effectiveness and ensuring the mass availability of life-long learning. On the other hand (at the output), the digital competencies of broad masses of the population are developed and the training of digital personnel for Industry 4.0 is ensured. Thus, the entire system of education is modernised according to the conditions of Industry 4.0 and makes the most comprehensive contribution to the implementation of the social investment model of economic growth.

6. Conclusion

The developed hypothesis was confirmed. Under the conditions of Industry 4.0, digital education should be put in the basis of the social investment model of economic growth. The theoretical significance of the results obtained consists in their allowing for reconsideration of the role of education in the implementation of the social investment model of economic growth under the conditions of Industry 4.0. It was proved that this role is performed most successfully with the help of digital education.

The practical significance of the conclusions made is that they allow improving the practise of human development through the most comprehensive realisation of the digital education potential. The practical implementation of the authors' recommendations will allow balancing the level of human development in countries of the distinguished categories (countries with the highest GDP growth rate; countries with the highest level of human development; countries with the most developed digital education) at the almost maximum level –0.99.

The social significance of this paper is that it supports the practical implementation of the Sustainable Development Goals (SDGs), which were adopted by the UN. In particular, this paper strengthened the scientific and methodological framework and offered applied recommendations to implement the following SDGs (1) SDG 4 through human development based on digital education; (2) SDG 8 through developing the potential of knowledge-intensive and highly-efficient employment in the social investment model of economic growth under the conditions of Industry 4.0 due to the development of digital education; (3) SDG 10 through revealing the prospects for the reduction of global inequality by levelling the differences and

TABLE 2 Regression dependence of the human development index on knowledge (digital competitiveness index) for the entire sample in 2019–2021.

Regression statistics						
Multiple R	0.7944					
R square	0.6311					
Adjusted R-square	0.6225					
Standard error	0.0590					
Observations	45					
ANOVA and F-test						
	df	SS	MS	*F* observed	*F* table	Significance *F*
Regression	1	0.2564	0.2564	73.5653	7.2636	$7.3*10^{-11}$
Residual	43	0.1499	0.0035	Level of significance: 0.01		
Total	44	0.4063				
Regression coefficients and t-test						
	Coefficients	Standard error	*t*-Stat	*p*-Value	Lower 95%	Upper 95%
Constant	0.5582	0.0383	14.5781	$3*10^{-18}$	0.4810	0.6355
x	0.0043	0.0005	8.5770*	0.0000	0.0033	0.0053

**t*-table at the level of significance of 0.01 at 44 degrees of freedom equals 2.692.
Calculated and compiled by the authors.

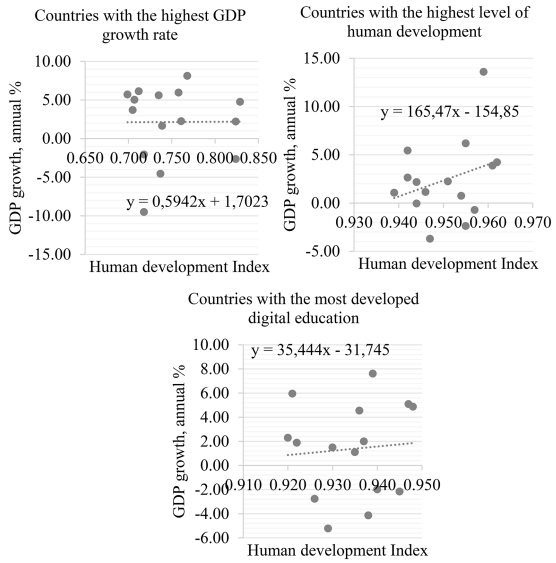

FIGURE 2
Regression curves. Calculated and constructed by the authors.

balancing human development in countries of the world based on digital education.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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