



Digital Transformation of Education for Sustainability of the Caspian Region

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Abstract

In the modern times of the fourth industrial revolution, digital technologies have spread throughout all spheres of life. In the context of rapid technological changes, it is necessary to maintain social sustainability, implying a balance between the development of economic, environmental and social – including educational – spheres. Theoretical analysis of WoS scientific papers published within the period from 2017 to 2021 has identified specific features of the dependence of sustainable development on the digital transformation of education. Analysis of these features in relation to Astrakhan State University allowed to identify areas of digitalization in education that are being actively developed (training and retraining of HR for the digital economy, improving digital literacy of the population, developing competencies that are professionally relevant for the digital economy) and areas of activities that require effort mobilization (upgrading educational technologies, methods, content and learning outcomes, developing a digital learning environment, increasing the digital and ethical competence of teachers, stimulating environmental education). The results obtained are of applied relevance for the training of highly skilled professionals capable of addressing professional tasks with the use of modern digital tools, both for sustainable development of Astrakhan Region and other Caspian bordering regions of Russia, as well as the Caspian countries.

Keywords

Digital Transformation; Sustainable Development; Digitalization of Education; Digitalization of Economy; Ethics of Digitalization; Environmental Digital Education



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Цифровая трансформация образования с целью устойчивого развития Каспийского региона

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Аннотация

В современную эпоху четвертой промышленной революции цифровые технологии проникли во все сферы жизни. В условиях стремительных технологических изменений необходимо сохранить устойчивое развитие общества, предполагающее наличие баланса между развитием экономической, экологической и социальной, в том числе образовательной, сфер. Посредством теоретического анализа научных работ, размещенных в базе данных Web of Science за период с 2017 по 2021 год, были выявлены особенности обусловленности устойчивого развития цифровой трансформацией образования. Анализ этих особенностей применительно к Астраханскому государственному университету позволил определить активно реализующиеся направления деятельности по цифровизации образования (подготовка и переподготовка кадров для цифровой экономики, повышение цифровой грамотности населения, формирование профессионально значимых для цифровой экономики компетенций) и направления деятельности, требующие мобилизации усилий (модернизация образовательных технологий, методов, содержания и результатов обучения, развитие цифровой обучающей среды, повышение цифровой и этической компетентности преподавателей, стимулирование экологического образования). Полученные результаты имеют прикладное значение в подготовке высококвалифицированных специалистов, способных решать профессиональные задачи с использованием современных цифровых средств, как для устойчивого развития Астраханского региона, так и других Прикаспийских регионов России, а также стран Прикаспия.

Ключевые слова

цифровая трансформация; устойчивое развитие; цифровизация образования; цифровизация экономики; этика цифровизации; экологическое цифровое образование



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Introduction

We are living in the times of the digital revolution, the fourth industrial revolution (Industry 4.0) described by extraordinary digital advances, rapid technological changes involving artificial intelligence, robotic engineering, the Internet of Things and quantum computing. We are Society 5.0 (Super Smart Society), characterized by a socioeconomic and cultural development strategy that is based on the use of digital technologies in all spheres of life. These new trends in society bring both new challenges and new opportunities.

Over the years, a lot of countries have been striving to make their development more sustainable at the initiative of the United Nations. Sustainable Development (SD) implies economic growth that does no harm to the environment and contributes to addressing social issues by finding a balance between economic, environmental, educational and social development without detriment to the future generations.

Modern society, businesses and financial structures attach great importance to education. The United Nations has set a 2030 SD Goal that aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. N.C. Burbules, G. Fan, and P. Repp note that now this goal is being achieved through the transformation of education by means of new digital technologies, and mark out aspects of education that lead to a sustainable future and need to be rethought: 1) educational aims and objectives; 2) educational ecologies and learning contexts; 3) learning processes; 4) teaching processes; 5) educational governance and policy (Burbules et al., 2020).

G. Rodríguez-Abitia, S. Martínez-Pérez, M.S. Ramírez-Montoya, and E. López-Caudana mentioned the digital divide in universities as a problem for quality education. The authors stressed the importance of introducing digital technologies into teaching and learning processes and pointed out that carrying out digital transformation and acquiring new skills and knowledge associated with it, indicate the quality of education for SDGs (Rodríguez-Abitia et al., 2020).

Initiatives related to the transformation of education with the use of new digital technologies have also impacted the education system of the Caspian region. Requirements for the training of highly skilled professionals capable of using cutting-edge technologies, addressing professional tasks with the use of modern digital tools, providing new opportunities in achieving high efficiency and economic performance in compliance with the requirements of eco-friendliness have been determined for the system of higher education in Astrakhan Region. The Caspian studies aim to address a number of important tasks for the region, which will allow achieving sustainable development in the economic, environmental and social spheres both in our region and in the Caspian countries:

- ensuring food security through digitalization of agriculture allowing to overcome the technological backwardness of this economic sphere;



- restoring soils destroyed as a result of the anthropogenic impact (erosion, desertification, land degradation) with the use of computer modeling;
- conserving and reproducing the marine environment and bio-resources of the Caspian Sea under the conditions of oil and gas exploration and production by the Caspian countries;
- restoring natural reproduction of fish disrupted by the Volga damming during floods;
- applying information and telecommunication technologies as a means of developing tourism industry in the Caspian bordering regions of Russia;
- developing the International North – South and West – East Transport Corridors corresponding to the modern economy realities, meeting the international standards.

Specialists training aimed to address socioeconomic challenges of the Caspian countries should be carried out with an active use of digital technologies in the learning process. Astrakhan State University (ASU) teaches a large number of students from the Caspian countries. These are both Russian students from Caspian bordering regions of Russia and foreign students from Kazakhstan, Turkmenistan, and Uzbekistan. As for Iran, ASU has established long-term cooperation with this country, aimed for practical training of Farsi proficient specialists.

The paper aims to single out the information in WoS scientific papers published within the period from 2017 to 2021 concerning the peculiarities of the content of digital transformation of education that are significant for social sustainability, and to identify the nature of the ASU activity in digitalization of education.

The study hypothesizes heterogeneous nature of the activity of digital transformation in different areas of digitalization in education in ASU.

Theoretical justification

Results of Scopus Bibliometric Studies for the Period between 1986 and 2019

The issue of digital transformation of education and its connection with SDG implementation has always been relevant and is reflected in the works of many scientists.

Having conducted a bibliometric study of 1,590 Scopus articles for the period between 1986 and 2019, Abad-Segura, M.D. Gonzalez-Zamar, J.C.I.M. Aand, and R.G. Garcia analyzed global research trends in the issue of sustainable management of digital transformation in higher education and found that in those articles, digital transformation in higher education mainly implies sustainable management aimed for adapting to the changes caused by new digital technologies (Abad-Segura et al., 2020)



E. Abad-Segura, M.D. Gonzalez-Zamar, A. Luque-de la Rosa, and M.B.M. Cevallos conducted a bibliometric analysis of 1,977 articles published between 2005 and 2019 and containing issues related to augmented reality (AR) as a sustainable educational virtual technology that adds digital objects to the real, physical world. The authors identified a growing and dynamic interest in university education studies on augmented reality, which, on the one hand, is an important element of digital transformation in university education and, on the other hand, is associated with SDGs. They found that the issue of AR had been mainly investigated in the context of technological resources, computers, simulation, learning, and education (Abad-Segura et al., 2020).

Having applied a bibliometric method for a sample of 1,814 Scopus articles published between 2000 and 2019, M.D. Gonzalez-Zamar, E. Abad-Segura, E. Lopez-Meneses, and J. Gomez-Galan analyzed the studies on the use of information and communication technologies in the context of higher education and revealed a number of regularities. In general, the studies on sustainable ICT management in the context of higher education have been increasing at an exponential rate over the last five years, which indicates the relevance of the issue. This study allows to establish the relationship between science, sustainability and digital technologies in higher education institutions and to ground the process of making decisions on the drivers of this branch of knowledge (González-Zamar et al., 2020).

The content of digital transformation has changed during the COVID-19 pandemic, which influenced sustainable development of the regions.

Health and the COVID-19 Pandemic

Considering the issue of digital determinants of human health, J. Shill, C. Busst, K. Horton, K. Corben, and S. Demaio point out that COVID-19 has been both a great disruptor and a great accelerator of positive progressive actions (Shill et al., 2021).

Defining digital transformation as a trend that brings about changes and promotes sustainable development, A. Kutnjak points out that the COVID-19 pandemic triggered digital transformation in all sectors, requiring rapid adjustments to be made and consideration of the challenges, obstacles and problems encountered (Kutnjak, 2021).

M.J. Sa and S. Serpa point out that the COVID-19 pandemic has had a profound and global impact both on the education system and on sustainability plans in all regions. On the one hand, the COVID-19 pandemic made the educational institutions close and lose the ability to function in a regular way, and became an obstacle to in-class studies, but, on the other hand, it contributed to the sustainable development of new teaching methods, becoming a pivot for the intensive development, adoption and dissemination of digital technologies among students (Sá & Serpa, 2020).



Ethics of Digitalization

P. Fobel and A. Kuzior point out that our coming future is connected with the digital revolution, i.e. the fourth industrial revolution (Industry 4.0), which is a fundamental pivot that deserves ethical evaluation and decisions, timely assessment of potential risks and negative effects of new technologies, and the use of digital data in relation to clients and partners. The authors emphasize that ethical aspects should be considered as an important part of innovative digital approaches; they call for ethical caution and moral prudence, stress the need for focusing on ethical values and contexts, and emphasize how important it is for sustainable development to apply ethical criteria for evaluation of digital technologies (Fobel & Kuzior, 2019).

J. Shill, C. Busst, K. Horton, K. Corben, and S. Demaio also warn that digital transformation needs strict control that would ensure its ethical and fair application and use, corresponding to the region's sustainable development (Shill et al., 2021).

P. Fobel and A. Kuzior stress that in the times of the digital revolution, the education system is undergoing radical changes in personalization, use of digital technology, robotic engineering and artificial intelligence, accompanied by a growing demand for creative people, professionals who understand the human in the new environment, respond ethically and creatively to specific situations and needs, new forms of self-fulfillment and self-development (Fobel & Kuzior, 2019).

Having studied humane attitudes and creativity in the moral development of young people, N.G. Bryukhova and S.V. Agafonova state that it is important for the moral development of young people to evolve a positive connection between humane attitudes as a manifestation of ethics and inventiveness as a manifestation of creative abilities (Bryukhova & Agafonova, 2018).

M.D. Gonzalez-Zamar, E. Abad-Segura, E. Lopez-Meneses, and J. Gomez-Galan state that management of educational digital technologies in the context of higher education sustainability should ensure development of humane attitudes, internalization of ethics and humankind sustainability (González-Zamar et al., 2020).

Environmental Digital Education

Studying educational and globalization components of SD and their factors, O. Borisova, V. Frolova, and L. Artamonova define environmental education as a process of acquiring knowledge about environmental problems, their causes, necessity and possibilities of their solution. Digital transformation is one of the driving forces for the development of environmental education as a component of SD (Borisova et al., 2019).

J.E. Petersen, D.R. Daneri, C. Frantz, and M.R. Shammin advocate that university teachers and students use educational models that highlight their civic participation in the development and management of digital technologies. For the purposes of social sustainability, the authors suggest the introduction and use of digital environmental dashboards in the form of feedback-based digital



signage which can be used to encourage ideas and actions for the environment and community protection (Petersen et al., 2017).

Digital Education for the Economy

Recalling the nationwide support of the digital economy programme in Russia, M.V. Kivarina investigated the specificity of transformation of the economy and education in the context of the economy digitalization. She writes that at the stage of forming a digital society within the process of digitalization of the economy based on new IT technologies, economic education, timely awareness and stimulation of the population and companies for a rapid transition to the digital economy era are relevant. The author points out the introduction of massive open online courses, which are innovative projects for the digital educational environment, as one of the promising areas contributing to the development of the economy in the context of digitalization (Kivarina, 2019).

I.V. Nikulina, O.V. Yudina, L.V. Averina, and S.V. Gorbatov point out that the digital economy is not only about the development of information technology but also about the introduction of brand new business models focused on sustainable development, self-development and self-improvement. Digital literacy is a crucial factor in the development of the digital economy. I.V. Nikulina, O.V. Yudina, L.V. Averina, and S.V. Gorbatov mention the need for reproducing HR that will be ready to apply digital technologies, the leading role of the education system in reproducing the country's HR and the associated need for improving the education system which is to provide the digital economy with competent HR. In order to unlock the full potential of new digital technologies and develop the skills relevant for the labour market among the population, including digital literacy, it is necessary to organize transformation of all forms of life-long education and professional training (Nikulina et al., 2019).

Digital Economy Jobs and Competencies

G. Barbieri, K. Garces, S. Abolghasem, S. Martinez, M.F. Pinto, G. Andrade, F. Castro, and F. Jimenez write that now we are living in Society 5.0 (Super Smart Society), based on the use of digital technologies in all spheres of life. Complex and technology-focused jobs are emerging, and they require appropriate education (Barbieri et al., 2021).

M.V. Kivarina proved that the accelerating development of educational digital networks is connected with the transformation in employment of the new graduates on the digital jobs and the development of teamwork skills for addressing technological, demographic and socioeconomic challenges efficiently (Kivarina, 2019).

I. Hamburg, E. O'Brien, and G. Vladut point out that skills like problem-solving, critical thinking and entrepreneurship allow students to gain sustainable education and adapt to changes in communication through digital technologies. Teamwork skills allow learners to cooperate and use technology on changing and transformed digital jobs (Hamburg et al., 2019).



Empirical Studies in Education

T. Brudermann, R. Aschemann, M. Fuellsack, and A. Posch emphasize that today's education system aimed at student sustainable development is to prepare them for the digital environment in future. The authors examined the student expectations at the University of Graz, Austria, and found that the students recognized high importance of digital competence and work with future-oriented topics (Brudermann et al., 2019).

Having conducted a diagnostic study in some higher education institutions of Mexico and Spain, G. Rodríguez-Abitia, S. Martínez-Perez, M.S. Ramírez-Montoya, and E. López-Caudana analyzed the ways of implementing digital technologies and their application in the educational process in order to ensure sustainable education. Based on direct observations and an in-depth interview, the authors identified the factors that influence the choice and accessibility of digital technologies. It allowed them to identify a regularity indicating that context-specific technological, organizational and pedagogical factors determine the ability of an educational institution to benefit from digital technologies (Rodríguez-Abitia et al., 2020).

S. Baena-Morales, R. Martínez-Roig, and M.J. Hernández-Amoros identified and analyzed peculiarities of self-assessment of the digital competence in Spanish preschool, primary and secondary education teachers in the context of their sustainable use of digital technologies. The authors identified a low level of knowledge and training among the teachers in relation to the impact of digital technologies on the environment and application of preventive measures. The study resulted in a conclusion that the teacher training is both the main problem and the main solution. Therefore, all efforts should be focused on teaching sustainable methods and approaches to teachers with regard to the use of digital technologies in accordance with a holistic approach to sustainability (Baena-Morales et al., 2020).

Recommendations for Digital Transformation of Education

O. Ahel and K. Lingenau point out that digitalization can be the key to improve students' access to sustainable education if information about SDGs is better disseminated, and digital transformation can improve the access to higher education through digital media (Ahel & Lingenau, 2020).

N.L. Gales and R. Gallon focus on the need for developing an intelligent pedagogy for digital transformation, which should include tripartite cooperation between schools, other educational institutions and businesses and can be used to involve students into SDG implementation (Galés & Gallon, 2019).

J.M. De Pablos, M.P. Colas, A.L. Gracia and I. Garcia-Lazaro write about the importance of widespread use of digital platforms in educational studies in higher education in order to make the education system sustainable. The authors suggest that special attention should be paid to the relevance of the use both of technologies like active or adaptive learning and of new technologies like digital learning analytics and digital creative spaces, for educational contexts (De Pablos et al., 2019).



G. Cebrian, R. Palau, and J. Mogas note that sustainable education involves rethinking of the learning environment (physical and virtual) in accordance with the SD principles; it is transformative and refers to the content and learning outcomes, pedagogy and learning environment as such. The authors emphasize that teacher training programmes focused on developing their digital competence are crucial for successful implementation of the digital sustainable transformation of education (Cebrián et al., 2020).

Talking about a crucial need for reforming university education in Colombia and studying a specific case of engineering education, G. Barbieri, K. Garces, S. Abolghasem, S. Martinez, M.F. Pinto, G. Andrade, F. Castro, and F. Jimenez point out that special skills gained by students within student-centred education should be integrated with ethics and sustainable development in an interdisciplinary environment. In order to address social issues in the future, students need to learn about the concept of Society 5.0 and acquire the skills necessary for digital transformation. It will allow them to propose solutions that they will be able to test in terms of specific professional, ethical and sustainability requirements, which will contribute to the country's sustainable development (Barbieri et al., 2021).

N. Aboobaker and K.A. Zakkariya revealed that the digital learning orientation has a significant impact on innovative creative behaviour of the Indian university students in their scientific work through their readiness for change and self-development, and that digital learning is influenced by organizational learning culture through a moderator as a leader (Aboobaker & Ka, 2021).

Discussion

The analysis conducted by the authors revealed the main issues and areas that are studied by scientists in the context of social sustainability through digital transformation of education.

The bibliometric study of a large number of Scopus articles identified and confirmed high activity of various authors in relation to this issue (E. Abad-Segura, M.D. Gonzalez-Zamar, J. C.I.M. Aand, R.G. Garcia (Abad-Segura et al., 2020), E. Abad-Segura, M.D. Gonzalez-Zamar, A. Luque-de la Rosa, M.B.M. Cevallos (Abad-Segura et al., 2020), M.D. Gonzalez-Zamar, E. Abad-Segura, E. Lopez-Menes, J. Gomez-Galan (González-Zamar et al., 2020)), which indicates its relevance and high practical importance. The digital transformation of higher education requires sustainable management, since it entails changes that require adaptation (E. Abad-Segura, M.D. Gonzalez-Zamar, J.C.I.M. Aand, R.G. Garcia (Abad-Segura et al., 2020)), especially social, socio-psychological, psychological, physiological adaptation, etc.

C. Busst, K. Horton, K. Corben, S. Demaio (Shill et al., 2021), A. Kutnjak (Kutnjak, 2021), M.J. Sa, S. Serpa (Sá & Serpa, 2020), and J. Shill mention a positive role of the COVID-19 pandemic which has significantly accelerated digital transformation in all sectors of human activity, including education. The COVID-19 pandemic conditions boosted the development and implementation of new digital learning



methods and technologies, intensified and updated the process of students' adaptation to digital technologies.

Augmented reality (AR) is an important element of digital transformation in university education that increases learning opportunities (E. Abad-Segura, M.D. Gonzalez-Zamar, A. Luque-de la Rosa, M.B.M. Cevallos (Abad-Segura et al., 2020)). Using AR in training requires technical resources (computers, software) and the teachers' mastery of the technical skills to use them, as well as AR inclusion in the training programmes. It requires assessment of the availability of the necessary technical resources and of the training programmes with teachers who have no or little competence.

M.D. Gonzalez-Zamar, E. Abad-Segura, E. Lopez-Meneses, J. Gomez-Galan (González-Zamar et al., 2020), J. Shill, C. Busst, K. Horton, K. Corben, S. Demaio (Shill et al., 2021), P. Fobel, and A. Kuzior (Fobel & Kuzior, 2019) stress that the digital transformation of society is a turning point in getting to a new level of its development. It both opens new opportunities and brings new high risks for humankind. Therefore, it is crucial to exercise high ethical caution and moral prudence in assessing possible risks and potential negative consequences of the introduction and wide application of digital technologies at this stage of sustainable development, to exercise strict control over the compliance of the ongoing transformations with ethical criteria. The potential of Humanities teachers (teaching psychology, philosophy, sociology, pedagogy) of the ASU Faculty of Psychology, Faculty of Social Communications and Faculty of Pedagogical Education, Art, Service and Culture, who are qualified to train teachers of engineering, natural science and other branches, can be used for getting ready to meet this requirement.

O. Borisova, V. Frolova, and L. Artamonova (Borisova et al., 2019), as well as J.E. Petersen, D.R. Daneri, C. Frantz, and M.R. Shammin (Petersen et al., 2017) note that the digital transformation of education generates new technical means that allow to encourage ideas and actions to protect the environment and thereby stimulate the development of environmental education as a component of the community's sustainable development. Environmental digital education as a basis for the regional SD is a burning issue. It concerns the issues of the human's place in digital technologies and their impact on people.

M.V. Kivarina (Kivarina, 2019), I.V. Nikulina, O.V. Yudina, L.V. Averina, and S.V. Gorbatov (Nikulina et al., 2019) believe that in order to intensify the transition to the sustainable digital economy, it is necessary to train and retrain specialists for all economic sectors, who will be proficient in applied IT technologies, to increase digital literacy of the population, using life-long learning opportunities, including massive open online courses. This area of work has been intensified at ASU since 2021 through the introduction of courses like Introduction to Information Technology, Artificial Intelligence Systems, Information Technology and Programming into the bachelor programmes. In the training area of Computer Technologies, ASU has developed 23 advanced training programmes for specialists in various fields which can be implemented both in-class and via distance learning.



Both Russian and foreign authors – M.V. Kivarina (Kivarina, 2019), G. Barbieri, K. Garces, S. Abolghasem, S. Martinez, M.F. Pinto, G. Andrade, F. Castro, and F. Jimenez (Barbieri et al., 2021), I. Hamburg, E. O'Brien, and G. Vladut (Hamburg et al., 2019) – mark out universal competencies that are relevant for professional activities in the context of the economy digitalization and creation of digital jobs – teamwork skills, integrated team problem-solving, critical thinking and entrepreneurship. These competencies are already established by the requirements of the Federal State Educational Standards of Higher Education of Russia and are developed in the training of ASU graduates in higher education programmes.

O. Ahel, K. Lingenau (Ahel & Lingenau, 2020) note that digitalization will improve students' access to education. N. Aboobaker and K.A. Zakkariya found that students' orientation towards digital learning has a positive impact on their creative behaviour in the scientific work (Aboobaker & Ka, 2021).

The digital transformation of education requires further development and introduction of new technologies and teaching methods – intellectual pedagogy (N. L. Gales, R. Gallon (Galés & Gallon, 2019)), digital learning analytics (J. M. De Pablos, M. P. Colas, A. L. Gracia and I. Garcia-Lazaro (De Pablos et al., 2019)), etc.; a review of the learning content and outcomes (G. Cebrian, R. Palau, J. Mogas (Cebrián et al., 2020)); development of a digital creative space (J. M. De Pablos, M. P. Colas, A. L. Gracia, and I. Garcia-Lazaro (De Pablos et al., 2019)) or a learning environment (G. Cebrian, R. Palau, J. Mogas (Cebrián et al., 2020)); development of teachers' digital competence through their training (G. Cebrian, R. Palau, and J. Mogas (Cebrián et al., 2020)); integration of special skills gained by students within student-centred education with ethics and sustainable development in an interdisciplinary environment (G. Barbieri, K. Garces (Barbieri et al., 2021), S. Abolghasem, S. Martinez, M.F. Pinto, G. Andrade, F. Castro, and F. Jimenez (Aboobaker & Ka, 2021)). The above challenges are also relevant for ASU, where some elements are already being transformed, but a lot remains to be done in this area.

References

- Abad-Segura, E., González-Zamar, M.-D., Infante-Moro, J. C., & Ruipérez García, G. (2020). Sustainable Management of Digital Transformation in Higher Education: Global Research Trends. *Sustainability*, 12(5). <https://doi.org/10.3390/su12052107>
- Abad-Segura, E., González-Zamar, M.-D., Luque-de la Rosa, A. L. la, & Morales Cevallos, M. B. (2020). Sustainability of Educational Technologies: An Approach to Augmented Reality Research. *Sustainability*, 12(10). <https://doi.org/10.3390/su12104091>
- Aboobaker, N., & Ka, Z. (2021). Digital learning orientation and innovative behavior in the higher education sector: Effects of organizational learning culture and readiness for change. *International Journal of Educational Management*, 35(5), 1030–1047. <https://doi.org/10.1108/IJEM-09-2019-0345>



- Ahel, O., & Lingenu, K. (2020). Opportunities and Challenges of Digitalization to Improve Access to Education for Sustainable Development in Higher Education. In W. Leal Filho, A. L. Salvia, R. W. Pretorius, L. L. Brandli, E. Manolas, F. Alves, U. Azeiteiro, J. Rogers, C. Shiel, & A. Do Paco (Eds.), *Universities as Living Labs for Sustainable Development* (pp. 341–356). Springer International Publishing. https://doi.org/10.1007/978-3-030-15604-6_21
- Baena-Morales, S., Martínez-Roig, R., & Hernández-Amorós, M. J. (2020). Sustainability and Educational Technology—A Description of the Teaching Self-Concept. *Sustainability*, 12(24). <https://doi.org/10.3390/su122410309>
- Barbieri, G., Garces, K., Abolghasem, S., Martínez, S., Pinto, M. F., Andrade, G., Castro, F., & Jimenez, F. (2021). An Engineering Multidisciplinary Undergraduate Specialty with Emphasis in Society 5.0. *International Journal of Engineering Education*, 37(3), 744–760.
- Borisova, O., Frolova, V., & Artamonova, L. (2019). The Educational and Globalization Components of Sustainable Development, and Their Factors. *E3S Web of Conferences. IV Th International Innovative Mining Symposium*, 105. <https://doi.org/10.1051/e3sconf/201910504047>
- Brudermann, T., Aschemann, R., Füllsack, M., & Posch, A. (2019). Education for Sustainable Development 4.0: Lessons Learned from the University of Graz, Austria. *Sustainability*, 11(8), 2347. <https://doi.org/10.3390/su11082347>
- Bryukhova, N. G., & Agafonova, S. V. (2018). Humaneness and Creativity in the Moral Development of Young People. *Russian Psychological Journal*, 14(1), 39–61. <https://doi.org/10.21702/rpj.2017.1.3> (In Russian)
- Burbules, N. C., Fan, G., & Repp, P. (2020). Five trends of education and technology in a sustainable future. *Geography and Sustainability*, 1(2), 93–97. <https://doi.org/10.1016/j.geosus.2020.05.001>
- Cebrián, G., Palau, R., & Mogas, J. (2020). The Smart Classroom as a Means to the Development of ESD Methodologies. *Sustainability*, 12(7). <https://doi.org/10.3390/su12073010>
- De Pablos, J. M., Colás, M. P., López Gracia, A., & García-Lázaro, I. (2019). Los usos de las plataformas digitales en la enseñanza universitaria. Perspectivas desde la investigación educativa [The uses of digital platforms in university teaching. Perspectives from educational research]. *REDU. Revista de Docencia Universitaria*, 17(1), 59. <https://doi.org/10.4995/redu.2019.11177> (In Spanish).
- Fobel, P., & Kuzior, A. (2019). The Future (Industry 4.0) Is Closer Than We Think. Will It Also Be Ethical? *Proceedings of the International Conference of Computational Methods in Sciences and Engineering 2019 (ICCMSE-2019)*. Proceedings of the International Conference of Computational Methods in Sciences and Engineering 2019 (Iccmse-2019), Rhodes, Greece. <https://doi.org/10.1063/1.5137987>
- Galés, N. L., & Gallon, R. (2019). Integrating Education, Technology, and SDG's: A three-pronged collaboration. *Innovations, Technologies and Research in Education*, 2019, 10–22. <https://doi.org/10.22364/atec.2019.itre.01>
- González-Zamar, M.-D., Abad-Segura, E., López-Meneses, E., & Gómez-Galán, J. (2020). Managing ICT for Sustainable Education: Research Analysis in the Context of Higher Education. *Sustainability*, 12(19). <https://doi.org/10.3390/su12198254>
- Hamburg, I., O'Brien, E., Vladut, G., & -. (2019). Entrepreneurship Business Research Skills. *Proceedings of the International Conference on Business Excellence, 13th International Conference on Business Excellence (ICBE)*, 13(1), 100–111. <https://doi.org/10.2478/picbe-2019-0010>
- Kivarina, M. V. (2019). Transformation Of Science And Education In The Conditions Of Digitalization Of Economy. In V. A. Tifonov (Ed.), *Contemporary Issues of Economic Development of Russia: Chal-*



- lenges and Opportunities, vol 59. *European Proceedings of Social and Behavioural Sciences* (pp. 225–232). <https://doi.org/10.15405/epsbs.2019.04.26>
- Kutnjak, A. (2021). Covid-19 Accelerates Digital Transformation in Industries: Challenges, Issues, Barriers and Problems in Transformation. *IEEE Access*, 9, 79373–79388. <https://doi.org/10.1109/ACCESS.2021.3084801>
- Nikulina, I. V., Yudina, O. V., Averina, L. V., & Gorbatov, S. V. (2019). Transformation of Economic Education Under Conditions of Digital Economy. In V. Mantulenko (Ed.), *GCPMED 2018 – International Scientific Conference Global Challenges and Prospects of the Modern Economic Development* (Vol. 57, pp. 1741–1747). <https://doi.org/10.15405/epsbs.2019.03.176>
- Petersen, J. E., Rosenberg Daneri, D., Frantz, C., & Shammin, M. R. (2017). Environmental Dashboards: Fostering Pro-environmental and Pro-community Thought and Action Through Feedback. In W. Leal Filho, M. Mifsud, C. Shiel, & R. Pretorius (Eds.), *Handbook of Theory and Practice of Sustainable Development in Higher Education* (pp. 149–168). Springer International Publishing. https://doi.org/10.1007/978-3-319-47895-1_10
- Rodríguez-Abitia, G., Martínez-Pérez, S., Ramírez-Montoya, M. S., & Lopez-Caudana, E. (2020). Digital Gap in Universities and Challenges for Quality Education: A Diagnostic Study in Mexico and Spain. *Sustainability*, 12(21), 9069. <https://doi.org/10.3390/su12219069>
- Sá, M. J., & Serpa, S. (2020). The COVID-19 Pandemic as an Opportunity to Foster the Sustainable Development of Teaching in Higher Education. *Sustainability*, 12(20). <https://doi.org/10.3390/su12208525>
- Shill, J., Busst, C., Horton, K., Corben, K., & Demaio, S. (2021). Our Path to Health for All: Australia in 2030. *Medical Journal of Australia*, 214(8 Supplement), 5–6. <https://doi.org/10.5694/mja2.51020>

Список литературы

- Abad-Segura, E., González-Zamar, M.-D., Infante-Moro, J. C., & Ruipérez García, G. (2020). Sustainable Management of Digital Transformation in Higher Education: Global Research Trends. *Sustainability*, 12(5). <https://doi.org/10.3390/su12052107>
- Abad-Segura, E., González-Zamar, M.-D., Luque-de la Rosa, A. L. la, & Morales Cevallos, M. B. (2020). Sustainability of Educational Technologies: An Approach to Augmented Reality Research. *Sustainability*, 12(10). <https://doi.org/10.3390/su12104091>
- Aboobaker, N., & Ka, Z. (2021). Digital learning orientation and innovative behavior in the higher education sector: Effects of organizational learning culture and readiness for change. *International Journal of Educational Management*, 35(5), 1030–1047. <https://doi.org/10.1108/IJEM-09-2019-0345>
- Ahel, O., & Lingenau, K. (2020). Opportunities and Challenges of Digitalization to Improve Access to Education for Sustainable Development in Higher Education. B W. Leal Filho, A. L. Salvia, R. W. Pretorius, L. L. Brandli, E. Manolas, F. Alves, U. Azeiteiro, J. Rogers, C. Shiel, & A. Do Paco (Ред.), *Universities as Living Labs for Sustainable Development* (cc. 341–356). Springer International Publishing. https://doi.org/10.1007/978-3-030-15604-6_21
- Baena-Morales, S., Martinez-Roig, R., & Hernández-Amorós, M. J. (2020). Sustainability and Educational Technology—A Description of the Teaching Self-Concept. *Sustainability*, 12(24). <https://doi.org/10.3390/su122410309>



- Barbieri, G., Garces, K., Abolghasem, S., Martinez, S., Pinto, M. F., Andrade, G., Castro, F., & Jimenez, F. (2021). An Engineering Multidisciplinary Undergraduate Specialty with Emphasis in Society 5.0. *International Journal of Engineering Education*, 37(3), 744–760.
- Borisova, O., Frolova, V., & Artamonova, L. (2019). The Educational and Globalization Components of Sustainable Development, and Their Factors. *E3S Web of Conferences. IV th International Innovative Mining Symposium*, 105. <https://doi.org/10.1051/e3sconf/201910504047>
- Brudermann, T., Aschemann, R., Füllsack, M., & Posch, A. (2019). Education for Sustainable Development 4.0: Lessons Learned from the University of Graz, Austria. *Sustainability*, 11(8), 2347. <https://doi.org/10.3390/su11082347>
- Burbules, N. C., Fan, G., & Repp, P. (2020). Five trends of education and technology in a sustainable future. *Geography and Sustainability*, 1(2), 93–97. <https://doi.org/10.1016/j.geosus.2020.05.001>
- Cebrián, G., Palau, R., & Mogas, J. (2020). The Smart Classroom as a Means to the Development of ESD Methodologies. *Sustainability*, 12(7). <https://doi.org/10.3390/su12073010>
- De Pablos, J. M., Colás, M. P., López Gracia, A., & García-Lázaro, I. (2019). Los usos de las plataformas digitales en la enseñanza universitaria. Perspectivas desde la investigación educativa [The uses of digital platforms in university teaching. Perspectives from educational research]. *REDU. Revista de Docencia Universitaria*, 17(1), 59. <https://doi.org/10.4995/redu.2019.11177> (In Spanish).
- Fobel, P., & Kuzior, A. (2019). The Future (Industry 4.0) Is Closer Than We Think. Will It Also Be Ethical? *Proceedings of the International Conference of Computational Methods in Sciences and Engineering 2019 (ICCMSE-2019)*. Proceedings of the international conference of computational methods in sciences and engineering 2019 (ICCMSE-2019), Rhodes, Greece. <https://doi.org/10.1063/1.5137987>
- Galés, N. L., & Gallon, R. (2019). Integrating Education, Technology, and SDG's: A three-pronged collaboration. *Innovations, Technologies and Research in Education*, 2019, 10–22. <https://doi.org/10.22364/atee.2019.itre.01>
- González-Zamar, M.-D., Abad-Segura, E., López-Meneses, E., & Gómez-Galán, J. (2020). Managing ICT for Sustainable Education: Research Analysis in the Context of Higher Education. *Sustainability*, 12(19). <https://doi.org/10.3390/su12198254>
- Hamburg, I., O'Brien, E., Vladut, G., & -. (2019). Entrepreneurship Business Research Skills. *Proceedings of the International Conference on Business Excellence, 13th International Conference on Business Excellence (ICBE, 13(1), 100–111. <https://doi.org/10.2478/picbe-2019-0010>*
- Kivarina, M. V. (2019). Transformation Of Science And Education In The Conditions Of Digitalization Of Economy. В V. A. Tifonov (Ред.), *Contemporary Issues of Economic Development of Russia: Challenges and Opportunities*, vol 59. *European Proceedings of Social and Behavioural Sciences* (cc. 225–232). <https://doi.org/10.15405/epsbs.2019.04.26>
- Kutnjak, A. (2021). Covid-19 Accelerates Digital Transformation in Industries: Challenges, Issues, Barriers and Problems in Transformation. *IEEE Access*, 9, 79373–79388. <https://doi.org/10.1109/ACCESS.2021.3084801>
- Nikulina, I. V., Yudina, O. V., Averina, L. V., & Gorbatov, S. V. (2019). Transformation of Economic Education Under Conditions of Digital Economy. В V. Mantulenko (Ред.), *GCPMED 2018 – International Scientific Conference Global Challenges and Prospects of the Modern Economic Development* (T. 57, cc. 1741–1747). <https://doi.org/10.15405/epsbs.2019.03.176>
- Petersen, J. E., Rosenberg Daneri, D., Frantz, C., & Shammin, M. R. (2017). Environmental Dashboards: Fostering Pro-environmental and Pro-community Thought and Action Through Feedback. In



- W. Leal Filho, M. Mifsud, C. Shiel, & R. Pretorius (Ред.), *Handbook of Theory and Practice of Sustainable Development in Higher Education* (с. 149–168). Springer International Publishing. https://doi.org/10.1007/978-3-319-47895-1_10
- Rodríguez-Abitia, G., Martínez-Pérez, S., Ramirez-Montoya, M. S., & Lopez-Caudana, E. (2020). Digital Gap in Universities and Challenges for Quality Education: A Diagnostic Study in Mexico and Spain. *Sustainability*, 12(21), 9069. <https://doi.org/10.3390/su12219069>
- Sá, M. J., & Serpa, S. (2020). The COVID-19 Pandemic as an Opportunity to Foster the Sustainable Development of Teaching in Higher Education. *Sustainability*, 12(20). <https://doi.org/10.3390/su12208525>
- Shill, J., Busst, C., Horton, K., Corben, K., & Demaio, S. (2021). Our Path to Health for All: Australia in 2030. *Medical Journal of Australia*, 214(8 Supplement), 5–6. <https://doi.org/10.5694/mja2.51020>
- Брюхова, Н. Г., & Агафонова, С. В. (2018). Человечность и креативность в нравственном развитии молодежи. *Российский психологический журнал*, 14(1), 39–61. <https://doi.org/10.21702/rpj.2017.1.3>