EdTech Landscape in Ukraine: Smart Education Future in Digital Age

Maryna V. Nehrey[1][a], Larysa M. Zomchak[2][b] and Abdel-Badeeh M. Salem[3][c]
[1]*National University of Life and Environmental Sciences of Ukraine, 15 Heroyiv Oborony Str., Kyiv, 03041, Ukraine*
[2]*Ivan Franko National University of Lviv, 1 Universytetska Str., Lviv, 79001, Ukraine*
[3]*Ain Shams University, El-Khalyfa El-Mamoun Str., Abbasia, 11566, Cairo, Egypt*

Keywords: Digital Education, EdTech, Technological Innovation, Startup, Efficiency.

Abstract: The digitalization of education is much slower than in other areas, due to the high cost of digital solutions and their complex functionality. Recently, the situation is changing, and now education can get real benefits from technology with simple software solutions. Analysis of the effectiveness of education has shown that the countries of Europe and Central Asia have significant potential for the development of education. Technologies used in education used in Tutoring, Language learning, MOOC, School Education (K-12), STEM & coding, Robotics, Information platforms, for teachers, LMS (learning management system), IT Education, Upskilling, Tools, and Talent. These technologies provide an opportunity to improve learning processes and increase its efficiency. In 2020, the EdTech startup ecosystem of Ukraine has more than 80 startups that have been used for education. SWOT-analysis indicate that the EdTech startup ecosystem is characterized by more weaknesses and threats than strengths and opportunities. Ukrainian education has significant potential for increasing efficiency and development.

1 INTRODUCTION

The modern world is a world of technology, digitalization, and rapid change. The digitalization of education is much slower than in other areas due to the high cost of digital solutions and their complex functionality. However, COVID-19 and the lockdown caused by it significantly changed the situation in education (Nagaraju et al., 2020; Polhun et al., 2021). The growth rate of education digitalization during the pandemic has only accelerated and education can benefit significantly from technology through simple software solutions. All this contributes to the intensification of cooperation between universities, business, and science. Universities have a need for modern technologies that will promote effective communication between all participants in the educational process. Accordingly, the niche of digital solutions for education and science has grown, to which business responds by offering new products and services. The development scenarios dictated by the pandemic include a further increase in the share of online education in investment, audience reach, and the absolute number of professionals employed in it.

EdTech research and digitization in education have become widespread in recent years. Education innovation in digital era is studied in (Abad-Segura et al., 2020; Hashim, 2018; Haywood, 2018; Salem and Voskoglou, 2020; Yuliati and Lelawati, 2019). Some directions of use of innovative approaches in education are covered in (Abdel-Basset et al., 2019; Babenko et al., 2021; Dimitrov et al., 2019; Hariharasudan and Kot, 2018; Pinchuk et al., 2020; Salem, 2019; Sousa et al., 2019; Syvyi et al., 2020; Tkachuk et al., 2020; Volkova et al., 2019). Discussion on the analysis of the impact of innovations on the educational process is presented in (Kholiavko et al., 2020; Kuzminska et al., 2020; Savchenko et al., 2018; Vlasenko et al., 2021; Zhilenkova et al., 2019).

2 MATERIALS AND METHODS

In recent years, educational services are increasingly in demand. The concept of lifelong learning, which is implemented through personal and corporate education, has become widespread. In particular, companies understand that it is much cheaper to teach new

[a] https://orcid.org/0000-0001-9243-1534
[b] https://orcid.org/0000-0002-4959-3922
[c] https://orcid.org/0000-0003-0268-6539

Nehrey, M., Zomchak, L. and Salem, A.
EdTech Landscape in Ukraine: Smart Education Future in Digital Age.
DOI: 10.5220/0010932500003364
In *Proceedings of the 1st Symposium on Advances in Educational Technology (AET 2020) - Volume 2*, pages 434-443
ISBN: 978-989-758-558-6

employees than to look for a specialist who has new skills and knowledge. However, there are significant differences in the effectiveness of education in different countries. We evaluate the effectiveness of education in different countries using Data Envelopment Analysis (DEA).

According to the concept of Farrell's economic efficiency (Farrell, 1957), each set of resources (market inputs) is characterized by a maximum of production, and the actual values of market products represent the degree of achievement of this maximum. Productions that provide the maximum market output per unit of market introduction, acquire the status of "standard" and form a "productivity limit". The task of the analysis is to compare objects in terms of efficiency of their resource base and determine the distance between the enterprise and the "productivity limit". To do this, the following methods are used:

- parametric – involves the formation of the production function for production standards by methods of mathematical statistics (construction of the stochastic limit of production capacity; adjusted least squares);
- non-parametric – determine the limits of production capacity (maximum profitability in the market) for any combination of resources (Data Envelopment Analysis – DEA).

The data analysis model (DEA) was developed by Michael Farrell in 1957. Farrell (Farrell, 1957) evaluated the effectiveness of one unit of the final product with one input and one output. The advantage of the DEA method is that it allows you to define a remote function for a multi-production system and does not require specification of the type of production function or cost function (which is necessary when using parametric methods).

The criteria of efficiency in the DEA methodology are the achievement of the Pareto optimum (Pareto et al., 2007), which is determined by the maximum possible volume of production at the existing technological level and resource provision. The DEA method allows: to determine the aggregate indicator for each studied object in the framework of the use of market inputs to market issues; take into account environmental factors; not be limited to the functional form of dependence between inputs and outputs; identify priority areas for productivity growth; assess the necessary changes in market input/output indicators, which would bring the object to the limit of efficiency.

The first DEA model was developed by Charnes et al. (Charnes et al., 1978) in 1978. Further development of DEA-models is characterized by two-vector in accordance with the influence of the scale of production.

Formally, this algorithm involves solving the optimization problem:

$$\max e_0 = \frac{\sum_{j=1}^{s} u_j y_{j0}}{\sum_{i=1}^{r} V_i x_{i0}}, \quad (1)$$

$$\frac{\sum_{j=1}^{s} u_j y_{jm}}{\sum_{i=1}^{r} V_i x_{im}}, m \leq 1, n, \quad (2)$$

$$v_1, v_2, \ldots, v_r \geq 0, \quad (3)$$

$$u_1, u_2, \ldots, u_r \geq 0, \quad (4)$$

where e_0 is the efficiency of the researched enterprise; n is the number of studied objects; r is the number of objects included in the comparison range; s is the number of objects that were selected for the latter after comparison; x_{i0} – the value of the i-th market range of the studied object; y_{j0} – the j-th market type of the studied object; x_{im} – the i-th input factor of the m-th object; y_{jm} – the j-th output of the m-th object; v_i is the value of the range of different objects; u_j is a significant number of analyzed objects j.

The target function is aimed at proportionally increasing the market outputs of the studied objects to the limits of efficiency, a variant of this model is called the output-oriented model.

3 RESULTS AND DISCUSSION

3.1 Analysis of Education Efficiency

The evaluation of the effectiveness of education in Europe and Central Asia by the DEA method, where the input – Expenditure on education, output – GDP per capita (figure 1).

The results of the analysis showed that effective education (efficiency coefficient equal 1) in Greece, Italy, Ireland, and Switzerland. Norway, France, Austria, Germany, Finland, the Netherlands, and Iceland are close to the efficiency curve. That is, European countries, in general, have experience in the effective expenditure on education. As for Ukraine, the expenditure on education is extremely inefficient, a similar situation in Georgia, the Russian Federation, and Moldova (ie in the countries of the former USSR).

Employee education is the key to a company's success. That is why companies try to get highly educated employees and maintain their qualifications at

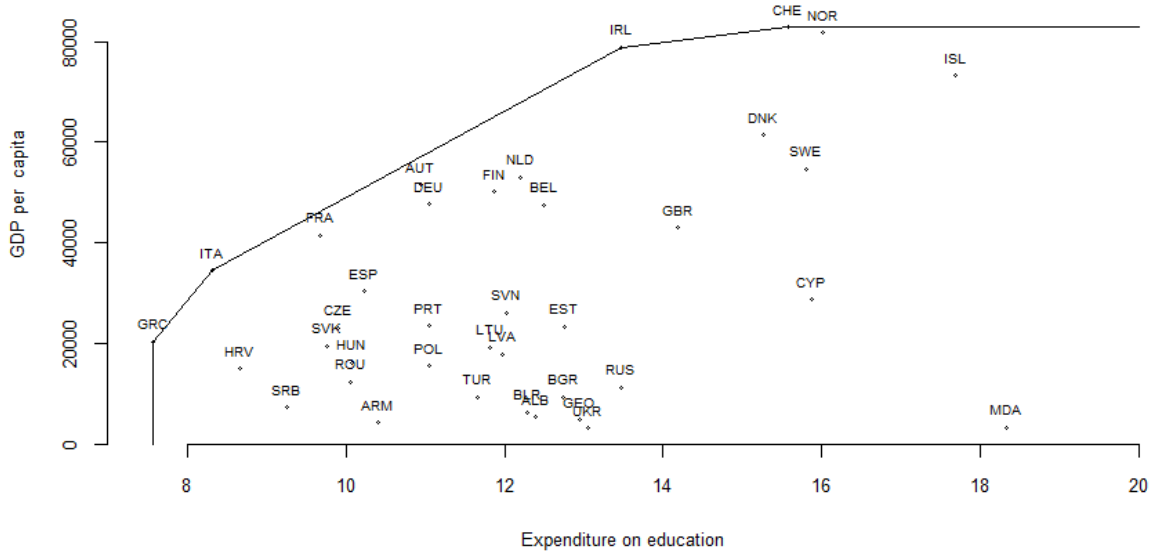

Figure 1: Data Envelopment Analysis of expenditure on education.

a high level. To assess the effectiveness of education in Europe and Central Asia, built a model of DEA, where inputs – GDP per capita, Internet users (per 100 people), Expenditure on education as (% School-age population, output – Labor force with advanced education (% of the total labor force). The simulation results are shown in the table 1.

DEA model analyzing efficiencies by VRS technology and input orientated efficiency. A number of countries with efficiency equal 1 are 21 out of 44, mean efficiency: 0.922.

The results show that efficiency is lower in those countries that incur significant expenditures on education. Conversely, countries with low spending on education have shown high efficiency. For example, Ukraine has an efficiency of 1, Labor force with advanced education – 72.15, GDP per capita - 3095.17, Internet users (per 100 people) – 89.74, Expenditure on education – 13.05, School-age population – 3.9 million. Germany, the efficiency of which is 0.72, has Labor force with advanced education – 73.56, GDP per capita – 47603, Internet users (per 100 people) – 71.13, Expenditure on education – 11.04, School-age population – 2.5 mln.

Analysis of education efficiency in different countries has shown that there is great potential for productivity increases. Therefore, the implementation of innovations in education is promising.

3.2 Investing in Educational Startups

Holon IQ is an international analytical agency founded in 2018 (HolonIQ, 2018). Initially, the company invested in educational startups but switched to market analysis to help more projects. According to the Holon IQ estimates (figure 2), global education venture capital funding in 2020 increased to $16.1 billion, which is more than twice that in 2019. Logically, this is a direct consequence of the COVID-19 pandemic and the quarantine that forced everyone around the world to go online. In the context of expected changes in the structure of the labor market, EdTech tools will continue to be in demand for the acquisition of new skills and retraining of employees. Note that China invests the most in educational programs, for example, US funding is 2 times less than China, and European funding is 10 times less (in total for the last 10 years).

Global EdTech started the last decade with $500m of Venture Capital invested in 2010 and finished 32x higher at $16.1B in 2020, nearly 2x the previous investment record in 2018.

If we talk about the structure of venture financing of educational projects, the largest share falls on corporate education, slightly less on school, and only 16% on higher education (figure 3).

HolonIQ listed the 100 best EdTech companies in Eastern Europe, where 11 projects from Ukraine are included. The rating is based in:

- companies market positions;
- demand and quality of products;
- financial stability;
- attractiveness for investment;
- development progress and dynamics;
- project team.

Table 1: Data Envelopment Analysis of education effectiveness.

Efficiencies range	Number of countries	%	Countries
$0.7 \leq E < 0.8$	5	11.4	Belgium, Denmark, Germany, Netherlands, United Kingdom
$0.8 \leq E < 0.9$	10	22.7	Austria, Czech Republic, Finland, France, Ireland, Norway, Russian Federation, Spain, Sweden, Switzerland
$0.9 \leq E < 1$	8	18.2	Albania, Belarus, Bulgaria, Hungary, Italy, Poland, Slovak Republic, Slovenia
$E = 1$	21	47.7	Croatia, Cyprus, Estonia, Georgia, Greece, Iceland, Latvia, Lithuania, Luxembourg, Moldova, Portugal, Romania, Serbia, Turkey, Ukraine

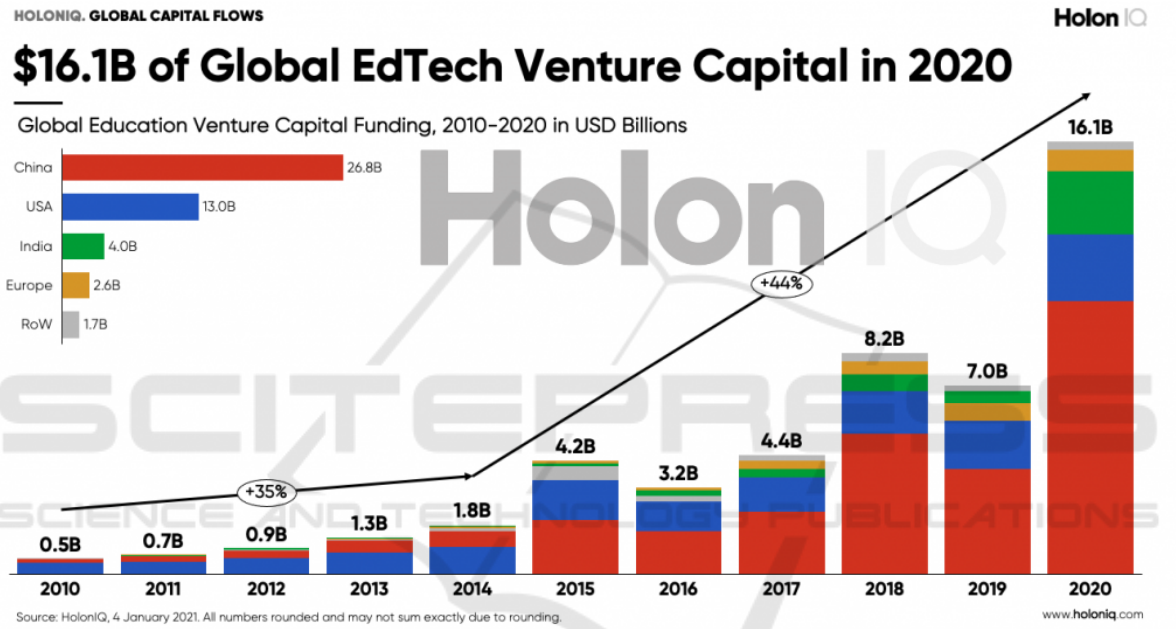

Figure 2: Global education venture capital funding, 2010–2020 in USD Billions (HolonIQ, 2021).

Ukrainian EdTech projects listed in the HolonIQ rating:

- Basenji Apps – applications for English learning;
- EnglishDom – online school of English learning;
- Enguide – service for choosing English courses in Kyiv;
- Speechyard – service for learning English by movies;
- Besmart – preparation courses for final exams at school;
- SkillUp – training courses for IT specialists;
- Skyworker – service for finding IT vacancies;
- Jooble – job search service;
- Parta – educational portal;
- Studway – media about education;
- Vseosvita – service for continuing education.

As we can see, the most popular are services for learning English. But there are nearly 80 digital education projects in the Ukrainian EdTech landscape. EdTech Landscape map of Ukraine (figure 4) was proposed by Vadym Synzheretskyi (CEO and co-founder of BUKI online platform for tutors).

3.3 Ukraine EdTech Ecosystems Analysis

Synzheretskyi (Synzheretskyi, 2020) proposed to cluster EdTech ecosystem of Ukraine in such a way: Tutoring; Language learning; MOOC; School Education (K-12); STEM & coding, Robotics; Information platforms; For teachers; LMS (learning management system); IT Education; Upskilling; Tools; Tal-

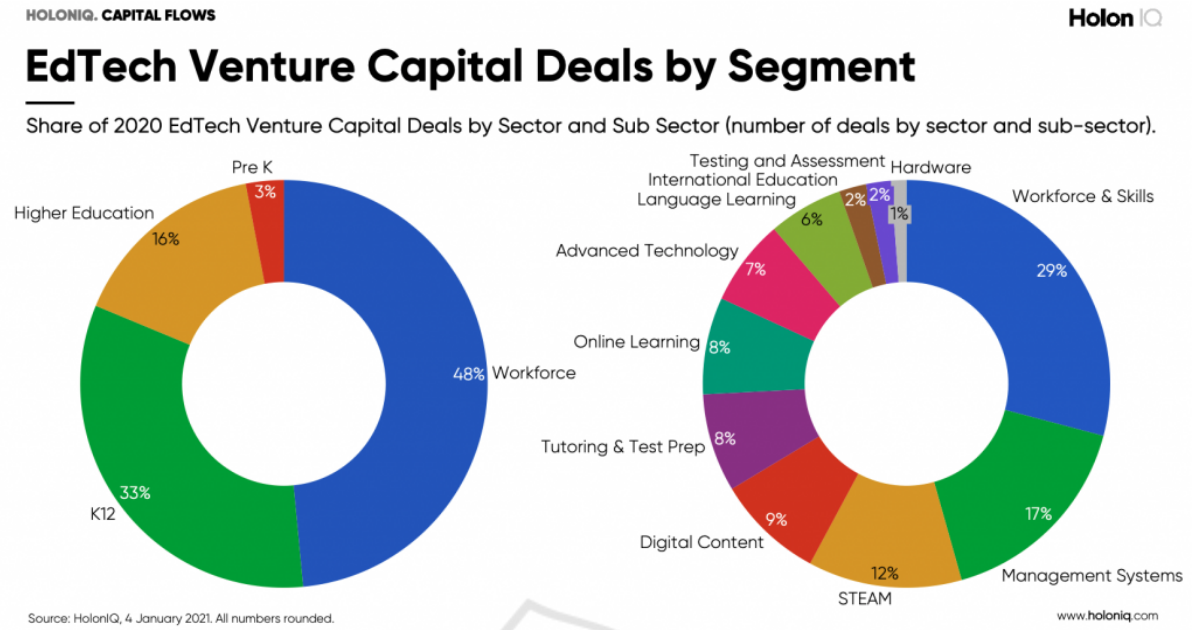

Figure 3: EdTech Venture capital deals by Segment (HolonIQ, 2021).

ent. Let's look at the examples from each group.

Preply (Preply, 2021) is an online educational platform that connects tutors and teachers (from 185 countries) with students, locally or virtually via Skype. In March 2020, the Ukrainian EdTech marketplace for the study of foreign languages Preply got $ 10 million, almost twice the amount of all previous investments ($ 5.6 million). The service uses machine learning algorithms to match tutors. The company plans to launch new tools for teachers that will help assess homework, monitor progress, and help students more effectively. The company also plans to develop a mobile application for Android and iOS.

EnglishDom (EnglishDom, 2021) is an online English school and at the same time an IT company that inspires to learn English through technology. The company is one of the leaders in the field of EdTech in Eastern Europe. The EnglishDom platform includes 5 innovative services for learning English, including mobile applications and an interactive digital textbook. The service unites more than 500 English teachers and 50,000 users.

Prometheus (Prometheus, 2021) is a mass online courses platform called "Ukrainian Coursera". The main goal of the project is to provide free online access to university-level courses to anyone, as well as to provide opportunities to publish and distribute such courses to leading professors, universities, and companies. Upon completion of the course, the student receives a certificate signed by the best teachers of Ukrainian universities. Today the platform has more than 300 thousand active users. Prometheus has organized its free online in-service training courses for educators in accordance with the requirements of the Procedure for in-service training of pedagogical and research and teaching staff. Prometheus online course certificates for educators can be officially credited as advanced training.

EdPro (EdPro, 2021) is one of the few Edtech solutions for school education. This interactive panel can replace several objects in the classroom at once – a blackboard, a projector, an interactive screen, and a computer. In such panels, teachers can show students presentations, videos, graphics, or images during lessons. Instead, students can solve learning tasks, count, or edit texts right away. Along with the board, they also developed an interactive software solution for education with illustrations and animations. Apparently, the next interesting area of EdTech will be the use of augmented and virtual reality technologies. The development of this area will lead to the fact that students will increasingly move from passive to active learning and will be able to interact in real-time with educational material, which will stimulate their motivation and increase the level of interest. This opens up exciting prospects for teaching new generations.

Osvitoria (osvitoria.org, 2021) propose interesting and up-to-date news about modern education and stories on how to change the system of education in any conditions and become a better version of yourself every day. They create a user-friendly platform for teachers and parents to help them find answers to

Figure 4: EdTech Landscape of Ukraine (Gritcyk, 2020).

their children's education and upbringing and to involve parents in the learning process. They try to give teachers effective tools for communication, the opportunity to learn about the best practices of teaching abroad, the latest news on education reform.

In addition to quality analytics, there are many different selections, articles about the needs of students and teachers with options for proposals that can be done in a particular situation. Teachers can take great advice to improve their work, and parents – to improve the well-being or performance of their children.

The educational project **Na Urok** (naurok.com.ua, 2021) aims to objectively cover the modern educational process and bring it to a qualitatively new level. This became possible due to the implementation of versatile and thorough work: writing informative articles related to school and extracurricular life; conducting thematic webinars; introduction of various educational competitions; attracting the best developments in school subjects from teachers from all over Ukraine. The project aims to help teachers feel their own significance because each teacher in the project

Table 2: Comparative study of the EdTech projects.

EdTech project	Type	Advantages	Disadvantages
Preply	Tutoring	Reaching a large audience. The use of machine learning in management.	Communication local or Skype. Absents of mobile applications.
EnglishDom	Language learning	Use innovative services and mobile applications. Reaching a large audience.	Lack of offline support.
Prometheus	MOOC	Use mobile applications. Reaching a large audience.	The audience is limited to Ukrainian-speaking users.
EdPro	School Education	Use innovation technologies. Good motivation for students. Opportunities for different applications.	High cost of the product
Osvitoria. Media	LMS	A large amount of information about various aspects of the educational process	Lack of mobile application
Na Urok	Information platforms	A good motivational approach. Coverage of a large number of educational topics.	No mobile application. A small audience of parents and students.
eTutorium	For teachers	A successful solution for organizing online learning. Great prospects for further development.	Having strong competitors with free solutions.
Mate academy	IT Education	Opportunities to expand the audience. Large set of programming courses.	Risks of non-payment for training.
Grammarly	Tools	Ease of use. Wide audience of users. Constant demand for products.	English spelling only.

will be able to publish their own professional achievements or use the work of colleagues. The project is set up to work closely with educators who want to share their experiences on the Internet. The Na Urok team makes a significant effort to ensure that teachers, parents, and students can find the maximum amount of useful theoretical and practical materials for the school on the portal.

The **eTutorium** (eTutorium, 2021) project aims to organize distance learning through the implementation of effective IT solutions. The project arose in 2008 from attempts to create their own webinar platform to conduct online events. After analyzing the needs of the eLearning market, in 2010 the team moved on to developing solutions for online tutors. Today, the platform hosts between 3,200 and 5,000 webinars per month. In 2015, we launched the eTutorium project, combining an updated platform for eTutorium Webinars and eTutor Academy – the Academy of Tutors, where we share our experience and knowledge in the field of online learning. In 2019, they created eTutorium LMS – a system of distance learning, with which you can not only collect courses but also fully organize the learning process online.

Mate academy (Mate academy, 2021) is an online platform for learning programming and finding your first job in IT. The training lasts 4-5 months and takes place online. Now in the portfolio of Mate academy courses includes Java, Front-end, Full Stack Web, UI / UX Design. The peculiarity of the platform is that students pay for their studies only in case of employment, giving a percentage of the new salary. During the existence of Mate academy, more than 200 students got jobs. In 2020 the company was planning to open a business in new markets; They looked at the country, where there is a great demand for engineers and the road, for no worse than the knowledge. The aim of the company in 2022 there were a number of thousands of engineers in Ukraine and the English regions – for example, Great Britain and India.

Grammarly (Grammarly, 2021) is one of the most famous Ukrainian startups. This is a service for checking written texts. It helps to correct grammatical and stylistic errors. A free version is available, as

Table 3: SWOT analysis on EdTech system.

INTERNAL FACTORS	
Strengths	**Weakness**
The government starts to implement digital technology in education. There is a demand for digital education and innovative technologies in education from both business and private. Effective solutions that promise an increase in productivity	The high cost of innovative technologies. Problems with finding financing. The delayed effect of digital technologies implementation can decrease the effect of its realization. Unreadiness for change. The established habits of teachers and the lack of new skills and abilities. Bureaucratic hurdles for starting a business. Underdeveloped IT infrastructure Lack of information on the effectiveness of EdTech.
EXTERNAL FACTORS	
Opportunities	**Threats**
Education is a big area with a lot of students and pupils, which can demand many EdTech projects. The application of EdTech produces a lot of data that can be used for agriculture development. EdTech can significantly reduce the need for teachers and administrated staff.	If the EdTech is not reliable enough and accessible to attackers, the danger may arise for education. The probability of different EdTech results in different conditions. Access to data can increase inequalities, impede competition, and create economic barriers.

well as Premium, which expands access to additional features. The company's head office is now located in Silicon Valley, and the service was founded by three Ukrainians. In 2019, it became known that the total amount of investment in Grammarly is about $ 200 million (5 billion hryvnias). This funding has raised the company's total value to more than $ 1 billion. So from now on the Ukrainian startup can be officially called a "unicorn". Grammarly services are now used by millions of regular users around the world. We are talking only about English-speaking users, the developers do not plan to expand the number of languages for testing yet. As of 2020, 30 million people use Grammarly services every day.

3.4 SWOT Analysis on EdTech System of Ukraine

The key task of education in modern conditions is to change, adapt to new conditions, and develop. The analog world is becoming increasingly fragile, and the digital world is becoming antifragile. COVID-19 not only posed threats to agriculture but also opened up new opportunities, in particular in digitalization and the introduction of innovative technologies. In our opinion, education in Ukraine needs the introduction of a significant number of EdTech, which will accelerate the development of education and increase its efficiency. SWOT analysis of the EdTech startup ecosystem is presented in table 3.

4 CONCLUSION AND FUTURE WORK

Nowadays education needs to improve and increase efficiency. EdTech can become exactly the direction that will promote the active development of education, increase its accessibility and improve its quality. Analysis of the effectiveness of education has shown that the countries of Europe and Central Asia have significant potential for the development of education.

The EdTech startup ecosystem is characterized by more weaknesses and threats than strengths and opportunities. Ukrainian education has significant potential for increasing efficiency and development. To ensure the realization of this potential, it is necessary to do the following:

- increase government spending on education, in particular on the development of innovative technologies;
- ensure access of EdTech to financing;
- accelerate the process of digitalization of education, in particular, to promote the spread of affordable ICT and introduce e-government;
- increase the interest of non-governmental organizations in the introduction of innovative technolo-

gies in education;

- create favorable conditions for the development of EdTech ecosystems.

Further development of the EdTech startup ecosystem can be a key solution for the development not only in Ukraine but also around the world.

REFERENCES

Abad-Segura, E., González-Zamar, M.-D., Infante-Moro, J. C., and Ruipérez García, G. (2020). Sustainable management of digital transformation in higher education: Global research trends. *Sustainability*, 12(5). https://www.mdpi.com/2071-1050/12/5/2107.

Abdel-Basset, M., Manogaran, G., Mohamed, M., and Rushdy, E. (2019). Internet of things in smart education environment: Supportive framework in the decision-making process. *Concurrency and Computation: Practice and Experience*, 31(10):e4515. https://onlinelibrary.wiley.com/doi/abs/10.1002/cpe.4515.

Babenko, V., Panchyshyn, A., Zomchak, L., Nehrey, M., Artym-Drohomyretska, Z., and Lahotskyi, T. (2021). Classical machine learning methods in economics research: Macro and micro level examples. *WSEAS Transactions on Business and Economics*, 18:209–217.

Charnes, A., Cooper, W. W., and Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2(6):429–444.

Dimitrov, I., Davydenko, N., Lotko, A., and Dimitrova, A. (2019). Comparative study of main determinants of entrepreneurship intentions of business students. In *2019 International Conference on Creative Business for Smart and Sustainable Growth (CREBUS)*, pages 1–4.

EdPro (2021). Interaktyvna panel EdPro. https://edpro.ua/.

EnglishDom (2021). Anhliiska po Skaipu - navchannia anhliiskii movi po Skype v EnglishDom. https://www.englishdom.com/.

eTutorium (2021). Platforma eTutorium Webinar — maidanchyk dlia provedennia vebinariv ta treninhiv. https://etutorium.com.ua/.

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society. Series A (General)*, 120(3):253–290. http://www.jstor.org/stable/2343100.

Grammarly (2021). Free Online Writing Assistant. https://www.grammarly.com/.

Gritcyk, T. (2020). Predstavlena vtoraia versiia karty ukrainskikh obrazovatelnykh proektov — EdTech Landscape 2.0 (The second version of the map of Ukrainian educational projects is presented – EdTech Landscape 2.0). https://ain.ua/2020/09/16/edtech-landscape-2-0/.

Hariharasudan, A. and Kot, S. (2018). A Scoping Review on Digital English and Education 4.0 for Industry 4.0. *Social Sciences*, 7(11). https://www.mdpi.com/2076-0760/7/11/227.

Hashim, H. (2018). Application of technology in the digital era education. *International Journal of Research in Counseling and Education*, 2(1):1–5. http://ppsfip.ppj.unp.ac.id/index.php/ijrice/article/view/2.

Haywood, J. (2018). Leading innovation: digital education in a traditional university. In Zorn, A., Haywood, J., and Glachant, J.-M., editors, *Higher Education in the Digital Age: Moving Academia Online*. Edward Elgar Publishing.

HolonIQ (2018). Global Impact Intelligence. https://www.holoniq.com/.

HolonIQ (2021). $16.1B of Global EdTech Venture Capital in 2020: EdTech VC has grown 32x since 2010, reaching a record $16.1B in 2020. https://www.holoniq.com/notes/16.1b-of-global-edtech-venture-capital-in-2020/.

Kholiavko, N., Zhavoronok, A., Marych, M., Viknianska, A., Kozlovskyi, S., and Herasymiuk, K. (2020). Countries disposition in the global scientific and educational area: management and clustering. *International Journal of Management*, 11(5):400–415. https://www.researchgate.net/publication/342656713_Countries_disposition_in_the_global_scientific_and_educational_area_management_and_clustering.

Kuzminska, O., Mazorchuk, M., Morze, N., and Kobylin, O. (2020). Digital learning environment of ukrainian universities: The main components to influence the competence of students and teachers. In Ermolayev, V., Mallet, F., Yakovyna, V., Mayr, H. C., and Spivakovsky, A., editors, *Information and Communication Technologies in Education, Research, and Industrial Applications*, pages 210–230, Cham. Springer International Publishing.

Mate academy (2021). Kursy Prohramuvannia i Dyzainu onlain z pratsevlashtuvanniam v Kyievi. https://mate.academy/.

Nagaraju, K. C., Madhavi, K., and Murthy, J. N. (2020). Research on efficacy of webinars organized for faculty during lockdown of COVID-19. *CEUR Workshop Proceedings*, 2879:287–303.

naurok.com.ua (2021). Osvitnii proekt “Na Urok” dlia vchyteliv. https://naurok.com.ua/.

osvitoria.org (2021). Osvitoria. https://osvitoria.org/en.

Pareto, V., Marchionatti, R., and Mornati, F. (2007). *Considerations on the Fundamental Principles of Pure Political Economy*.

Pinchuk, O., Burov, O., Ahadzhanova, S., Logvinenko, V., Dolgikh, Y., Kharchenko, T., Hlazunova, O., and Shabalin, A. (2020). VR in Education: Ergonomic Features and Cybersickness. In Nazir, S., Ahram, T., and Karwowski, W., editors, *Advances in Human Factors in Training, Education, and Learning Sciences*, pages 350–355, Cham. Springer International Publishing.

Polhun, K., Kramarenko, T., Maloivan, M., and Tomilina, A. (2021). Shift from blended learning to distance one during the lockdown period using moodle: test control of students’ academic achievement and analysis

of its results. *Journal of Physics: Conference Series*, 1840(1):012053.

Preply (2021). Learn languages with expert online tutors. Book your lesson today! https://preply.com/.

Prometheus (2021). Naikrashchi onlain-kursy Ukrainy ta svitu. https://prometheus.org.ua/.

Salem, A.-B. M. (2019). Computational Intelligence in Smart Education and Learning. In *Conferences of the department Informatics*, number 1, pages 30–40. https://ideas.repec.org/a/vrn/katinf/y2019i1p30-40.html.

Salem, A.-B. M. and Voskoglou, M. G. (2020). Smart learning systems. *International Journal of Applications of Fuzzy Sets and Artificial Intelligence*, 10:103–120. http://eclass.pat.teiwest.gr/modules/document/file.php/523103/Vol.%2010%20%282020%29/SALEM%20%26%20VOSKOGLOU%2C%20103-120.pdf.

Savchenko, L. A., Savchenko, K. Y., Marchenko, A. A., and Pylnik, R. A. (2018). Innovative technologies of pedagogical diagnostics as a means of improving the quality of future specialists' education. *Espacios*, 39(49).

Sousa, M. J., Carmo, M., Gonçalves, A. C., Cruz, R., and Martins, J. M. (2019). Creating knowledge and entrepreneurial capacity for he students with digital education methodologies: Differences in the perceptions of students and entrepreneurs. *Journal of Business Research*, 94:227–240.

Synzheretskyi, V. (2020). [TechUkraine news] EdTech Landscape of Ukraine 2020. https://techukraine.org/2020/04/16/techukraine-news-vadym-synzheretskyi-ceo-of-%D1%80%D0%B5/.

Syvyi, M. J., Mazbayev, O. B., Varakuta, O. M., Panteleeva, N. B., and Bondarenko, O. V. (2020). Distance learning as innovation technology of school geographical education. *CEUR Workshop Proceedings*, 2731:369–382.

Tkachuk, V., Semerikov, S., Yechkalo, Y., Khotskina, S., and Soloviev, V. (2020). Selection of mobile ICT for learning informatics of future professionals in engineering pedagogy. *CEUR Workshop Proceedings*, 2732:1058–1068.

Vlasenko, K. V., Chumak, O. O., Sitak, I. V., Achkan, V. V., and Kondratyeva, O. M. (2021). Methods for developing motivational and value-orientated readiness of math students at teacher training universities for implementing educational innovations. *Journal of Physics: Conference Series*, 1840(1):012008.

Volkova, N. P., Rizun, N. O., and Nehrey, M. V. (2019). Data science: Opportunities to transform education. *CEUR Workshop Proceedings*, 2433:48–73.

Yuliati, Y. and Lelawati, I. (2019). Design support education innovation on digital era. *Manajemen Pendidikan*, 14(1):25–30. https://journals.ums.ac.id/index.php/jmp/article/view/8644.

Zhilenkova, E., Budanova, M., Bulkhov, N., and Rodionov, D. (2019). Reproduction of intellectual capital in innovative-digital economy environment. *IOP Conference Series: Materials Science and Engineering*, 497:012065.