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ALGORITHM FOR THE DEVELOPMENT OF A WEB-ORIENTED ENTERPRISE DIGITALIZATION APPLICATION

Abstract. *This paper describes the Digitalization of Enterprises which plays a key role in the modern world as it helps enterprises to increase efficiency and competitiveness. Your algorithm for enterprise digitalization, which takes into account the current experience of countries that have succeeded in digitalization, such as the UK, the US and the European Union, looks very thoughtful and comprehensive. It also needs to take into account the specifics of e-services in Ukraine, the professional orientation of employees of enterprises, and the level of complexity of specialized equipment and technologies used. This allows for the development of a wide range of skills required for mastering digital technologies and hardware by different categories of Ukrainian industrial workers. This approach to the formation of areas and components of the enterprise digitalization algorithm in the form of a structure that covers all components of the modern ecosystem of electronic services formed in Ukraine seems to be very productive. Digitalization includes a number of key elements, such as process automation, the use of big data for decision-making, the introduction of artificial intelligence and machine learning, and the use of cloud technologies. All of these elements can help businesses increase productivity, reduce costs, and improve customer service. It is also important to note that digitalization requires businesses to invest heavily in training and development of their staff, as new technologies require new skills. Education and training are key success factors in digitalization. Digital transformation uses digital technologies to create new or modify existing business processes, culture, and customer experiences to respond to changing business and market demands. This transition from old to new business and technology models involves certain key areas. Digital transformation is not just about introducing new technologies, but also about rethinking the way an enterprise operates at all levels, and includes rethinking customer experience, how data is handled, internal processes, and company culture. Digital transformation can be a challenge, but it can also bring significant benefits to those who implement it. The algorithm for the digitalization of enterprises starts with competencies for Ukrainian industrial workers – a key tool developed to improve the level of digital skills of workers. This tool is aimed at supporting government agencies in policy-making and planning educational programs that focus on the development of digital literacy and the practical application of digital technologies in all areas of industry in Ukraine.*

Keywords: *digitalization; digital transformation; digital technology; digital data; digital culture algorithm of enterprise digitalization*

Introduction

Analyzing the level of development of the digitalization policy and the achievements of the digitalization process within Ukraine and around the world. It is impossible to quantify the digitalization

policy, so it is worth focusing on the quantitative and qualitative assessment of the results of digitalization implementation, i.e. the achieved level of digitalization and trends in the development of digitalization in Ukraine and the world in recent years [1 – 5].

There are methods for assessing digitalization, namely:

- Networked Readiness Index (NRI) (Fig. 1)
- Digital Economy and Society Index (DESI) – index of the digital economy and society;
- Global Innovation Index (GII) – Global Innovation Index;
- Digital Evolution Index (DEI) – Digital Evolution Index;
- Digital Adoption Index (DAI) – Digitalization Adoption Index;
- World Digital Competitiveness Ranking (IMD) – World Digital Competitiveness Ranking, etc.

Ukraine, unfortunately, is not represented by statistical data on all of these indicators, they are not relevant for consideration, as they do not provide a real understanding of Ukraine's position and comparison with other European countries. The Network Readiness Index and its components are presented and quite well developed sphere.

Objective of the work

The object of research is the concept of digitalization and business processes of digitalization.

Subject of research: properties, features, characteristics and algorithm of digitalization in Ukraine.

Purpose: to analyze the peculiarities of digitalization of enterprises in Ukraine and the world with a substantiation of the specifics of digitalization in Ukraine and analysis of its development.

Digital transformation is a dynamic and accelerated process that has been actively developing over the past decade. Nowadays, artificial intelligence, online work, electronic document management and many other concepts are already a common and widespread reality.

The very concept of digital transformation is quite new, so there is no single and universal terminological interpretation of this concept, it cannot be unified due to the wide range of issues covered by this concept and

different approaches to their interpretation and identification of the main components. Each country develops its own approaches to digital transformation and corresponding strategic development plans, which are related to the country's uniqueness: socio-cultural, economic, political development, etc.

Digital transformation is a process that continues to unfold and deepen, it cannot be avoided or ignored, so it is necessary to study it, analyze the course of development, the processes that have already taken place and those that are taking place, and predict those that will take place in the short and long term.

Summary of the main material

Taking into account the specifics of e-services in Ukraine, the professional training of employees and the level of complexity of specialized technologies and equipment, this approach allows for the development of a wide range of skills required for different categories of Ukrainian industry workers. This approach to the formation of the components of the algorithm for the digitalization of enterprises, which takes into account all elements of modern electronic services (mastering digital technologies and hardware) in Ukraine, looks quite productive.

Digitalization itself covers several key aspects, including process automation, the use of big data for decision-making, the introduction of artificial intelligence and machine learning, and the use of cloud technologies. These elements can significantly increase productivity, reduce costs, and improve customer service. It is also important to note that digitalization requires significant investment in staff training and development, as new technologies require new skills. Education and training are critical to success in the digitalization process.

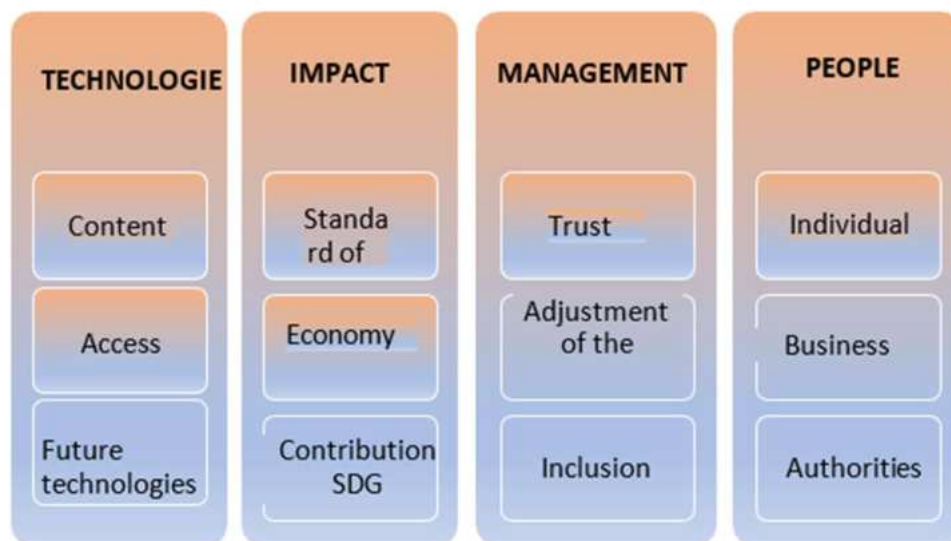


Figure 1 – Components of the Networked Readiness Index (NRI), where SDG (Sustainable Development Goals) are the goals of sustainable development [1]

The digitalization of enterprises is critical in the modern world as it contributes to efficiency and competitiveness. The proposed digitalization algorithm, based on the experience of successful countries such as the UK, the US, and the European Union, looks comprehensive.

Digital transformation is the process of implementing digital technologies to create new or modify existing business processes, cultural aspects, and consumer experience in accordance with changing market requirements. The transition from old to new models includes three key areas:

1. Digital technologies. The use of new and rapidly changing digital technologies to solve problems is a common feature of all digital transformations. Companies must be flexible and ready to adapt to new technologies to remain competitive.

2. Digital data. Digital transformation involves the use or creation of digital data to improve processes. This includes the use of big data, machine learning and analytics to gain new insights, as well as the use of digital platforms to collect data from customers.

3. Digital culture. This aspect includes changing the organizational culture to support rapid adaptation to change. This may include changes in the organizational structure, processes, skills, and culture of the company.

Digital transformation is not limited to the introduction of new technologies; it is also a review of the way an enterprise operates at all levels, including customer interaction, data management, internal processes, and corporate culture. It has the potential to bring significant benefits to those who successfully implement it.

Since 2016, digital transformation has been the subject of in-depth theoretical research that forms the key ideas of development in national economies. Modern scientists (UNCTAD experts [10] and experts from the US Department of Commerce [11]) characterize the process of digitalization as a socio-economic transformation caused by the introduction of digital technologies, IT for creating, processing, exchanging and transmitting information:

- “digital infrastructure, which is necessary for the existence and functioning of a computer network (digital enabling infrastructure);
- digital transactions that can be carried out through the use of digital technologies (e-commerce);
- users of the digital economy who create content (digital media)” [1 – 6].

To date, the concept of the “third wave of society development” has become widespread, authored by the American sociologist and futurist E. Toffler [8]. For comparison, let us present the following scheme of social

development (Table 1): the third wave, the main features of which are the dominant role of information and knowledge; the second wave – industrial civilization; the first wave – social and labor sphere.

The tasks and directions for the development of enterprises through the digitalization of Ukraine's economy are outlined in the Digital Agenda of Ukraine 2020 [1 – 6]. It states that “digitalization is the introduction of digital technologies into all spheres of life: from human interaction to industrial production, from household items to children's toys, clothing, etc. It is the transition of biological and physical systems into cyberbiological and cyberphysical systems (combining physical and computational components). It is the transition of activities from the real world to the virtual world (online).”

The variety of definitions of the term “digital economy” is due to the relevance of the phenomenon and different approaches to its study. In our opinion, the digital economy is part of the information society based on the creation and distribution of goods and services using the latest information and communication technologies. It implies a decrease in the share of physical labor and an increase in the share of mental, highly skilled and creative activity, which enhances the role of the human factor, leads to changes in the nature of work, labor relations, employment structure and the emergence of new types of work.

The proposed algorithm in Fig. 2 assesses the level of digitalization of an enterprise, which is based on the patterns and principles of digitalization of enterprise personnel management systems. The algorithm involves the following actions (formation of a system of indicators characterizing the level of digitalization of an employee's personal data; introduction of criteria for forming a database by the level of digitalization, determination of correct and incorrect data; analysis of complex indicators of digitalization; testing and identification of the causes of deviations and identification of the most important problems).

As part of the technology for developing and synchronizing a web-based application as part of the process of digitalizing the information space of an enterprise, the task is to ensure the transfer of personal data about employees of the enterprise to a global database in a convenient form and with minimization of errors [12].

For the successful implementation and active use of modern digital technologies, it is necessary to combine the efforts of business processes and government business structures. This will allow regions to move to a new level of development and increase their competitiveness. To do this, it is important to:

1. Develop, approve, and implement an enterprise development strategy that takes into account current challenges and the need for digital transformation of the economy to improve the efficiency of management processes.

2. Create an investment-friendly climate to attract investment in the development of digital infrastructure.

3. Promote digital communications between employees and management, as well as increase digital literacy.

4. Support the development of IT education to ensure the operation and maintenance of digital processes within production activities.

SCOPE	SIGN	THE FIRST WAVE	THE SECOND WAVE	THE THIRD WAVE
INFOSPHERE	Communication and Information exchange	Available for the elite	Mass availability	Demassified specialized media Simplified information by the consumer Widespread use of communication tools in business
SOCIOSPHERE	Family	A big family	The nuclear family	Diversity of family types
	Education	Mostly domestic	Mass education	Growing need for individualization of education increasing the role of home education
	Form of business organization	Individual Company	Corporation	Changed corporations with diverse objectives
	Art	Designed to serve the elite	Mass	De-standardization and demassification
SOCIAL AND LABOR SPHERE	Labor market	Universalization of labor Improving skills and abilities throughout life Self-reliance	Narrow specialization Routinization of work Interchangeability of Workers Work for hire Sweatshop, exhausting labor Full-time employment Work for one employer under a an open-ended contract	Atomization of labor Emergence of a class of intellectual workers Emergence of new forms of employment Lifelong learning is the key to success in the labor market Part-time employment Working for several employers under short-term employment contacts
TECHNOSPHERE	<i>Energy sources</i>	Physical force, sun, wind, water Renewable Multiple sources Distributed sources	Fossil fuels Non-renewable Few sources Concentrated sources	Solar, wind, water, geothermal Renewable Multiple sources Distributed sources Environmental Friendliness of energy sources
	Production	Artificial, individual For own consumption	Mass Division into producer and consumer	Small-scale, demassified production “to order” “Smart technologies Developing production for yourself”
	Distribution system	Individual	Mass trade World market Complications of economic relation	The changing role of the market and mass trade under the influence of the development of production for oneself
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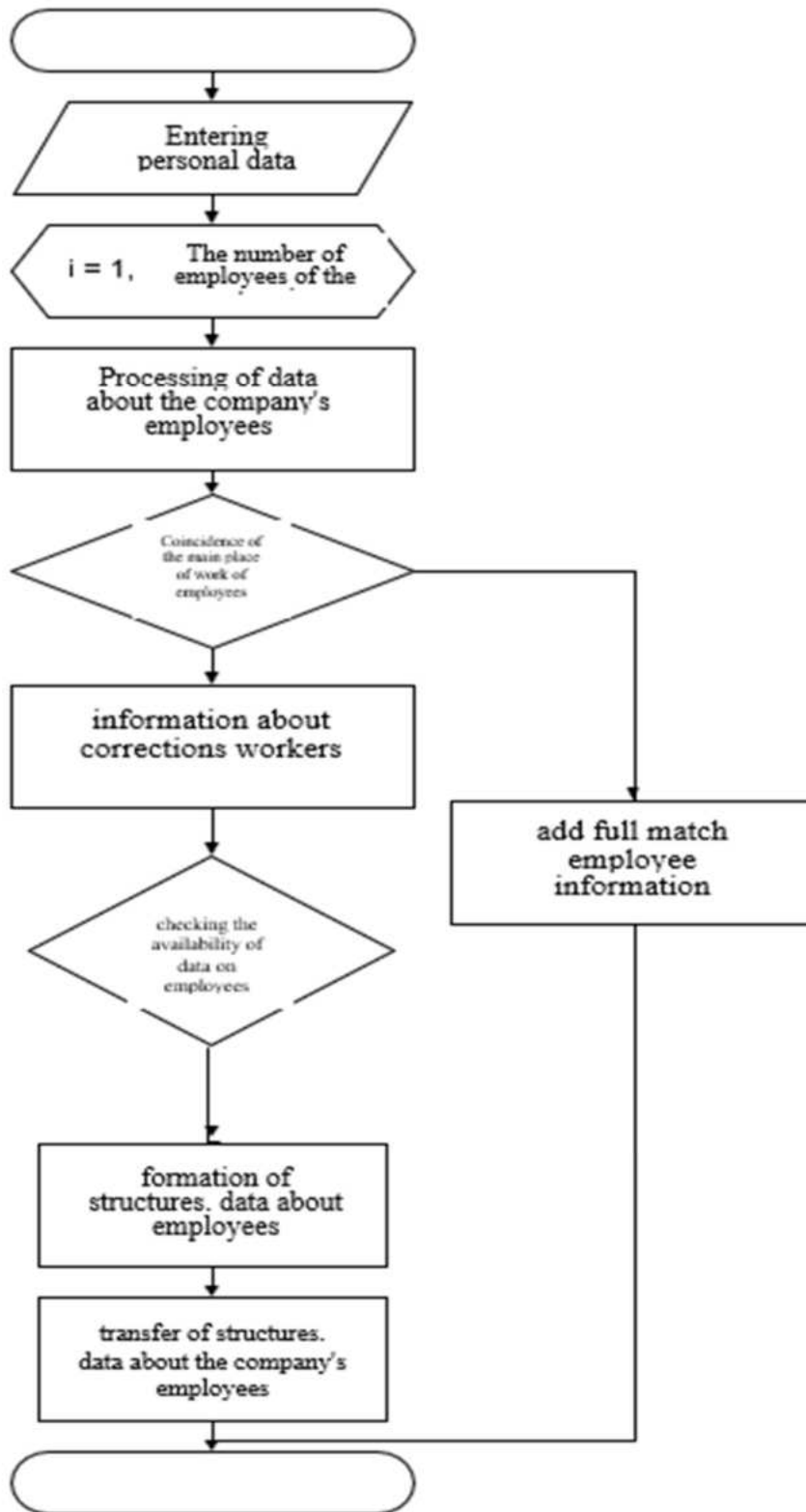


Figure 2 – Algorithm for distributing personal data about employees [7–9]

To study the impact of digitalization on the development of economic systems of an enterprise, it is proposed to use the method of correlation and regression analysis. This will allow modeling how the composite index of digitalization affects the change in gross product. The choice of this methodology allows for a

more accurate assessment of the impact using mathematical tools.

For the correlation and regression analysis, we recommend using a comprehensive digitalization index consisting of three components: infrastructure readiness, employment in the ICT sector, and consumer activity in

Internet services. This will allow us to build a model that shows the impact of the composite digitalization index on gross domestic product.

The analysis of statistical information shows that the impact of digitalization on enterprise development can be described using single-factor models, in particular, the cubic type to improve the accuracy of the results.

The cubic single-factor regression model is as follows:

$$w = a_0 + a_1v^3 + a_2v^2 + a_3v + \varepsilon, \quad (1)$$

where w – is the value of the output variable; v – is the value of the independent variable; a_0, a_1, a_2, a_3 – are heterogeneous parameters; ε – is the relative error.

This expression reflects the modeled process of the enterprise's functioning in the real socio-economic environment. It is necessary to take into account the presence of a relative error, which, at low values, will allow modeling the dependencies between heterogeneous indicators. And the estimated cubic one-factor model will have the form:

$$\hat{w} = a_0 + a_1\hat{v}^3 + a_2\hat{v}^2 + a_3\hat{v}, \quad (2)$$

where w – is the estimated value of the output variable (determined within the estimated model); v – actual values of the independent variable (statistical data); \hat{v} of statistical data); a_0, a_1, a_2, a_3 – estimated heterogeneous model parameters.

The error is calculated by the formula:

$$\varepsilon = w - \hat{w}, \quad (3)$$

The heterogeneous parameters a_0, a_1, a_2, a_3 are found using the least squares method, which is often used

to build typical econometric models. The main task is to find an estimated model of the dependence between the indicators, within which the error will be minimal:

$$\varepsilon \rightarrow \min. \quad (4)$$

The model will correspond to a real functioning system of relationships when the error value tends to the minimum:

$$\sum_{i=1}^n \varepsilon = \sum_{i=1}^n (w_i - \hat{a}_0 + a_1\hat{v}^3 + a_2\hat{v}^2 + a_3\hat{v}), \quad (5)$$

The sum of deviations w from the trend value, which describes the approximate relationship between v and w to find the model parameters a_0, a_1, a_2, a_3 , it is necessary to determine a regression in which the sum $\sum_{i=1}^n \varepsilon$ of errors is minimal.

Conclusions

The author analyzes the processes of digitalization as an integral part of the information society, which is based on the production and provision of goods and services through the use of the latest information and communication technologies, an increase in the share of highly skilled, intellectual labor, which enhances the role of the human factor, and the emergence of a new nature of labor.

The author proposes a structural and logical scheme of the algorithm for ensuring the State regulation of the priority areas of digitalization of enterprises, which includes basic, rule-making and content components corresponding to each level.

References

1. Fishchuk, Valeriy. (2018). Ukraine 2030E – a country with a developed digital economy [Electronic resource]. <https://strategy.uifuture.org/kraina-z-rozvinutouy-cifrovoyu-ekonomikoyu.html#6-2-1> (accessed April 12, 2024).
2. Law on Digital Content and Digital Services. Official web portal of the Verkhovna Rada of Ukraine. 2023. URL: http://w1.c1.rada.gov.ua/pls/zweb2/webproc4_1?pf3511=73687 (accessed January 12, 2023).
3. On Amendments to Certain Legislative Acts of Ukraine to Ensure the Conclusion of an Agreement between Ukraine and the European Union on Mutual Recognition of Qualified Electronic Trust Services and the Implementation of European Union Legislation in the Field of Electronic Identification: Law of Ukraine dated December 01, 2022, No. 2801-IX: as of December 31, 2023. 2023 p. URL: <https://zakon.rada.gov.ua/laws/show/2801-20#Text> (accessed January 12, 2023).
4. On information: Law of Ukraine of 02.10.1992 № 2657-XII. URL: <https://zakon.rada.gov.ua/laws/show/2657-12#Text> (accessed January 11, 2023).
5. Results of the work of the Ministry of Digital Transformation 2023. Ministry of Digital Transformation of Ukraine <https://www.kmu.gov.ua/news/mintsyfry-pidsumky-2023>
6. Kunanets, N. E., Nebesnyi, R. M., Matsiuk, O.V. (2016). Features of the formation of goals of social and socio-communication components in smart city projects. *Bulletin of Lviv Polytechnic National University, Information systems and networks*, 854, 257–274.
7. Skoryk, O. O., Ryabokon, N. P. (2024). Digital transformation of the public administration model: foreign experience and domestic realities. *Public administration: improvement and development*. URL: http://www.dy.nayka.com.ua/pdf/7_2020/52.pdf (accessed April 11, 2024).
8. Toffler, E. (2000). *The Third Wave*. Kyiv: Vsesvit Publishing House, 480.
9. Tulchynska, S., Solosich, O., Marych, M., Marusiak, N., Lashuk, O. (2021). Applied Principles for Ensuring Economic Security of Economic Systems in the Conditions of Digitalization. *WSEAS Transactions on Systems and Control*, 16, 600-609. URL: <https://wseas.com/journals/articles.php?id=736> (accessed April 11, 2024).
10. What Defines the Digital Sector? Office for National Statistic. Newport: ONS, October 08, 2015. 11 p. URL: <http://webarchive.nationalarchives.gov.uk/20160105160709/> (accessed 03.04.2024).

11. Telecom front: how mobile operators resist blackouts, restore communication, rebuild the destroyed and help the Armed Forces. Mind.ua. 2022. URL: <https://mind.ua/publications/20250790-telekom-front-yak-mobilni-operatori-protistoyat-blekautam-povertayut-zvyazok-vidbudovuyut-zrujnov> (accessed April 12, 2024).

12. Gaming industry in numbers: how much Ukrainians spend on video games. Mind.ua. 2022. URL: <https://mind.ua/publications/20222353-igrova-industriya-v-cifrah-skilki-ukrayinci-vitrachayut-na-videoigri> (accessed March 12, 2024).

13. Newage research. 2022: Digital market of Ukraine. Newage. 2022. URL: <https://newage.agency/uk/blog-uk/doslidzhennya-newage-2022-digital-rinok-ukraini/> (accessed April 11, 2024).

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АЛГОРИТМ РОЗРОБЛЕННЯ ВЕБ-ОРІЄНТОВАНОГО ЗАСТОСУНКУ ЦИФРОВІЗАЦІЇ ПІДПРИЄМСТВА

Анотація. У пропонованій роботі описано цифровізацію підприємств, яка відіграє ключову роль у сучасному світі, оскільки вона допомагає підприємствам підвищити ефективність і конкурентоспроможність. Алгоритм цифровізації підприємств, який враховує сучасний досвід країн, що досягли успіху в цифровізації, таких як Великобританія, США та країни Європейського Союзу, виглядає дуже обдуманим та всебічним. Потрібно також врахувати специфіку надання електронних послуг в Україні, професійну орієнтацію працівників підприємств та рівень складності спеціалізованої техніки і технологій, що використовуються. Це уможливує формувати широкий спектр необхідних навичок для опанування цифровими технологіями й апаратним забезпеченням різними категоріями працівників промисловості України. Такий підхід до формування сфер і компонентів алгоритму цифровізації підприємств у вигляді структури, що охоплює всі складові сучасної екосистеми електронних послуг, сформованої в Україні, виглядає дуже продуктивним. Цифровізація включає в себе низку ключових елементів, таких як автоматизація процесів, використання великих даних для прийняття рішень, впровадження штучного інтелекту та машинного навчання, а також використання хмарних технологій. Всі ці елементи можуть допомогти підприємствам підвищити продуктивність, зменшити витрати і покращити якість обслуговування клієнтів. Важливо також зазначити, що цифровізація вимагає від підприємств великих інвестицій у навчання і розвиток персоналу, оскільки нові технології вимагають нових навичок. Освіта і навчання є ключовими факторами успіху в цифровізації. Цифрова трансформація використовує цифрові технології для створення нових або модифікації наявних бізнес-процесів, культури та споживчих досвідів для відповіді на змінювані бізнес та ринкові вимоги. Цей перехід від старих до нових моделей для бізнесу і технологій включає в себе певні ключові сфери. Цифрова трансформація – це не просто впровадження нових технологій, а й перегляд способу, за яким підприємство працює на всіх рівнях, вона включає в себе перегляд взаємодії з клієнтами, способу роботи з даними, внутрішніх процесів, а також культури компанії. Цифрова трансформація може бути викликом, але вона також може принести значні вигоди для тих, хто її впроваджує. Алгоритм цифровізації підприємств починається з компетентностей для працівників промисловості України – це ключовий інструмент, розроблений для підвищення рівня цифрових навичок працівників. Цей інструмент спрямований на підтримку урядових органів у формуванні політики і плануванні освітніх програм, які зосереджені на розвитку цифрової грамотності та практичного застосування цифрових технологій у всіх сферах промисловості України.

Ключові слова: цифровізація; цифрова трансформація; цифрова технологія; цифрові дані; цифрова культура; алгоритм цифровізації підприємств

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