European Vector of Modern Education, Science and Production – 2025

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CHAPTER 1. MODERN BASICS OF ECONOMICS, MANAGEMENT AND TOURISM

1.1. Containerized Transportation - History, Application, Prospects, Actualization

The transport sector of any country is a vital and integral part of its production and socio-economic system. The overall pace of development of the industrial-transport complex creates conditions for the economic growth of national production and the improvement of the population's living standards.

Global practices in freight transportation by rail indicate the growing importance of intermodal transport, including cross-trailer shipments using specialized vehicles. This allows for the implementation of an intermodal approach and enhances transportation services in Ukraine. Intermodal transport refers to a method of freight movement that utilizes multiple modes of transport (road, rail, water, etc.) for shipping cargo in a specialized container, often along with the transport vehicle itself [1].

Containerized transportation is one of the most relevant methods of freight delivery in the modern globalized world. Its popularity is attributed to several factors, including versatility, cost efficiency, and enhanced security. In the context of growing global trade, container transport enables the fast and reliable movement of goods between countries and continents. Containers are standardized, facilitating the seamless combination of different modes of transport (maritime, rail, road) while minimizing additional handling operations.

The prospects of container transportation lie in reducing transportation costs and minimizing environmental impact.

Firstly, the use of containers lowers the risks of cargo damage and loss, providing reliable protection against mechanical impacts and adverse weather conditions. This benefits the economy of any country by ensuring the preservation of goods, reducing losses, and increasing customer trust in logistics companies.

Secondly, container transportation is part of sustainable development, allowing for more efficient logistics planning and reducing harmful emissions into the atmosphere, particularly CO_2 emissions. This is especially crucial in the context of environmental commitments.

In the context of globalization and the active development of international trade, cross-trailer transportation is becoming increasingly relevant. Most countries choose this type of transport to optimize logistics processes and improve the environmental situation.

Intermodal freight transport involves using multiple modes of transportation (trains, ships, airplanes, trucks, etc.) to move goods in mixed containers or transport vehicles without handling the cargo itself during the transition between modes. This method reduces cargo handling, enhances security, minimizes damage and loss, and enables faster transportation of goods [2].

Cross-trailer transportation, as a type of combined transport service, operates as follows: a truck delivers the cargo to a railway station, where the semi-trailer or container is loaded onto a specialized railway platform for long-distance transportation.

Upon arrival at the final railway terminal, another truck picks up the cargo for further delivery to the customer. This transportation method is part of an intermodal transport system, allowing the combination of multiple modes of transport without the need for unloading and reloading the goods.

The advantage of this type of transportation is the reduction of costs compared to using road freight transport. Cost savings are achieved by minimizing the time required for short-distance road transportation.

Other benefits include resource savings, reduced environmental impact, decreased road congestion, and enhanced safety, as rail transport is considered one of the most reliable and secure methods of freight delivery. Additionally, it is fuel-efficient, particularly for long-distance shipments.

Cross-trailer transportation can be divided into two types:

1. **Accompanied transportation**, where the driver remains in a separate passenger car during transportation on the mainline.
2. **Unaccompanied transportation**, which does not involve a driver escort. This method is used for the delivery of containers, detachable trucks, trailers, semi-trailers, and similar units.

The high efficiency of unaccompanied cross-trailer transportation is achieved by allowing a greater number of logistical units to be utilized over a longer period. As a result, there is a pressing need for driving personnel, equipment at specific departure and destination points, and infrastructure for the storage and handling of semi-trailers, trailers, and road trains.

The practical application of cross-trailer transportation can be explained as follows: to optimize logistics routes, reduce downtime, and ensure driver rest, cross-trailer (rail container) transportation has been introduced on certain routes, where semi-trailers or trucks are loaded onto railway platforms.

Among the countries with successful transport systems implementing container transportation are France, Switzerland, Austria, Italy, and Germany. Railways adapted for transporting vehicles (Rolling Highways) pass through regions such as the Alps.

A successful example of cross-trailer transportation implementation is the operation of the French company Lorry-Rail SA. This operator provides services on a 1,050 km railway line, enabling rail container transport between Luxembourg and Perpignan in 14.5 hours compared to 17–22 hours required for traditional road freight.

Other major cross-trailer routes in France include "VIIA Britanica" (Calais – Le Boulou), "Alpine" (between Chambéry and Turin), as well as routes from Sète to Paris and Zeebrugge.

Over 15 years, more than 1 million trucks have been transferred from roads to rail transport. This has significantly reduced carbon dioxide emissions into the atmosphere. As a result, European governments even subsidize this mode of transportation.

The main challenge in launching cross-trailer train routes in Europe was the inability to transport trucks on standard platforms due to the limited dimensions of tunnels. This issue was resolved by developing a low-floor platform design (only 225

mm above the railhead). These wagons were introduced by the French company Lohr. They can accommodate standard 4-meter-high trucks.

A train can consist of 18 double platforms, capable of carrying up to 36 trucks, with a maximum operating speed of 100 km/h.

A specialized rapid loading and unloading technology was also developed, enabling the loading process to take as little as 15 minutes. Corresponding terminals have been equipped to support this system.

However, not all regions can expand the use of cross-trailer (rail container) transportation. The challenges preventing the simplification of logistics include difficulties with customs inspections, the lack of agreements between carriers or freight forwarders regarding the regulation and coordination of multimodal transportation (delivery using various transport modes), and the absence of adequate infrastructure. This includes insufficient loading and unloading equipment, an inadequate number of fitting platforms (rail rolling stock for container transportation), and other necessary facilities.

The implementation of this type of transportation helps reduce delivery costs by providing rest time for driving personnel. It also ensures the convenience of loading and unloading operations, improves the interaction between different modes of transport, such as rail container shipping, and accelerates delivery times.

Thus, logistics optimization enables the regulation of material flow loads on highways, shifting part of the burden to railways. Additionally, the diversification of transport systems worldwide promotes the development of intermodal transportation on international routes. Rail container shipping also contributes to addressing environmental issues in congested transport hubs [3].

For Ukraine, this direction is particularly relevant due to its strategic geographic location between Europe and Asia, which opens up significant opportunities for the development of transit transportation. The country’s railway infrastructure requires substantial modernization, which is one of the main factors hindering the development of this type of transport. Given the current environmental requirements and the need for economic development, cross-trailer transportation potential must become one of the key elements of Ukraine's logistics system.

The history of cross-trailer transportation shows that it all began in 1872 when an American circus applied an innovative plan to load its equipment onto a train platform. It took them a long time to load and secure the trailer on the road, but they managed to transport it safely. Transport companies recognized this technology as an opportunity to move various types of cargo. However, it was not until 1926 that a working prototype was created, allowing for this type of freight transportation on an industrial scale.

Initially, this system was used in Austria under the name "Running Highway." In 1960, a revolutionary invention — the roll-trailer — was created. This transport vehicle was a combination of a regular trailer and a railway car. The trailer was equipped with railway wheels, allowing it to stand on rails and move as part of a train. However, this

type of rail transport had several issues, one of which was its enormous additional weight, which prevented it from traveling on most American roads.

Research continued, and human thinking progressed. As a result, in 1990, a new approach to cross-trailer transportation was invented in the United States. The process involved rolling the trailer onto a railway carriage.

The carriage was brought to the truck with the trailer, and the trailer, on its own air suspension, would be lifted. At this moment, the tractor would roll it onto the carriage, and then, using its own hydraulics, the trailer would be lowered onto the railway carriage. Only one trailer could fit on the carriage, while the second trailer was secured behind the first one, which was fixed on the carriage. Once the two trailers were secured, it was only necessary to connect the hoses that supply air to the braking systems of the carriage, and the journey could begin.

As a result of this, a new type of light rail transport emerged that can efficiently transport goods [4].

Today, one of the main methods of cross-trailer transportation and their installation on platforms is the use of standard lifting devices, such as portal cranes.

Cross-trailer transportation has the advantage of combining the qualities of two dominant modes of transport — the maneuverability, speed, and efficiency of road transport with the high productivity, weather independence, and safety of rail transport. Thus, the most attractive "door-to-door" delivery principle is realized in the transportation services market.

When it comes to European experience, cross-trailer transportation is not new. It has been known since 1960, with the same classic American wagons. However, the main difference is that European countries actively support this type of transportation due to its environmental benefits. Companies involved in such transportation receive compensation from the government under environmental protection regulations, which can amount to €220,000 and €500,000 under road quality support programs.

In Europe, an organization has been established to integrate leading countries that use cross-trailer transportation. These countries include Slovenia, Italy, Belgium, Estonia, the Czech Republic, Germany, Luxembourg, Spain, Austria, France, Hungary, Switzerland, the United Kingdom, Bulgaria, Romania, and Greece.

Each country has several company representatives developing this method of transportation, who work together on integration and the development of new solutions for this transport type.

Europe has five main corridors used by cross-trailers, with a total length of approximately 4,800 km. These corridors currently handle a significant freight turnover of over 70 million tons annually. According to the European Railways Association, cross-trailer transport in the EU grows by 5-7% annually. In Germany, in 2022, cross-trailer transportation accounted for around 15% of the total freight rail transport volume, whereas in Ukraine, this figure remained below 1%.

The dynamics of cross-trailer transport in Ukraine and the EU have certain characteristics and differences in scale. In the European Union, cross-trailer transport is actively developing and plays a significant role in the transport system. Cross-trailer

freight flows in the EU grow by 20% annually, which significantly increases their volume. This growth is driven by government subsidies to support this type of transport, as well as the environmental benefits and efficiency of international transport.

The issue of financial support for environmentally friendly transport, including cross-trailer transport, is one of the key aspects of European sustainable development policy. Cross-trailer transport, as an efficient way of transporting large cargo over long distances, has traditionally been associated with the use of diesel-powered tractors, which significantly pollute the environment. However, recognizing the need to transition to more environmentally friendly types of transport, European countries are implementing a range of measures aimed at promoting the development of electric and gas-powered cross-trailer transport [5].

One of the most common financial support tools is direct subsidies to companies that invest in eco-friendly transport. Governments reimburse part of the costs for purchasing or leasing electric and gas-powered tractors, as well as for the installation of charging stations. In addition, tax benefits are widely used, which reduce the tax burden on companies using environmentally friendly transport.

Credit lines provided on favorable terms to finance investments in eco-friendly technologies also play an important role. Another incentive for fleet renewal is premiums for the recycling of old diesel tractors. Moreover, companies using eco-friendly transport can expect preferential tariffs for infrastructure use, including toll road access and parking in designated areas.

Among European countries that actively support the development of eco-friendly cross-trailer transport, Germany, the Netherlands, Sweden, and France stand out. Each of these countries has its own specific approach to implementing policies that encourage eco-friendly transport.

Such active support for eco-friendly cross-trailer transport is driven by several factors. First, there is a desire to reduce greenhouse gas emissions and improve air quality. Second, it reflects the goal of reducing dependence on fossil fuels and ensuring energy security. Finally, it aims to create new jobs in promising sectors of the economy.

However, despite significant progress, certain challenges remain on the path to fully transitioning to electric transport in the cross-trailer sector. These include the high cost of electric trucks, limited charging infrastructure, and the lack of unified standards.

Ukraine's integration into the European Union requires modern organizational forms and the adoption of advanced technologies in the transportation sector. Cross-trailer transport is one of the tools for developing Ukraine's transportation system, whose implementation demands the harmonious integration of all components. Despite the potential for trade and transport network development, as well as its unique and advantageous transport-geographical position, Ukraine does not fully utilize the opportunities offered by cross-trailer transport [6].

The main reasons for this are:

1. Limited demand for cross-trailer transport.
2. Existing trade conditions.

3. Imbalances in cross-trailer flow.
4. Complexity of customs procedures.
5. Low efficiency in coordination and cooperation between different modes of transport.
6. Instability of transport tariffs.
7. Lack of critical infrastructure elements of adequate quality (e.g., absence of routes, transport-logistics centers, inadequacy of border checkpoints).
8. Unsatisfactory condition of transport vehicles, service infrastructure, and differences in technical requirements between Ukraine and EU countries.
9. Differences in permit systems, insurance conditions, quotas, control measures, etc.
10. Shortage of railway rolling stock for container transport, specifically fitting platforms.
11. Insufficient quality of cargo preservation during transportation.

In Ukraine, despite significant potential, the development of cross-trailer transport is progressing slowly. One of the reasons for this is the limited demand and complexities in customs procedures, which impact the overall volume of transportation. From 2019 to 2024, the development of such transportation in Ukraine mainly occurred within strategic programs, such as the "Ukrzaliznytsia" Development Strategy.

In 2019, the Cabinet of Ministers of Ukraine approved a strategy aimed at developing multimodal transportation, including cross-trailer transport. However, its share in the total volume of railway transportation remained low [7].

In Ukraine, the first regular cross-trailer trains were launched in 2003. However, the technology did not develop further and is no longer in use. In recent years, Ukrzaliznytsia has conducted test runs on routes such as Kyiv-Budapest and Kyiv-Poland, indicating progress toward creating conditions for expanding this type of transportation.

The development of cross-trailer transportation in Ukraine is crucial given its advantageous geographical location and role as a transit state, especially within the context of international transport corridors between Europe and Asia. Implementing such technologies requires significant investment and the development of appropriate infrastructure. Global examples demonstrate that the success of cross-trailer transportation depends on active government involvement, such as subsidies for rail transport and partial reimbursement of costs to vehicle owners.

Competition with road transport is another factor influencing the development of cross-trailer transportation in Ukraine. Road transport remains a more flexible and faster solution for freight transport, especially over short distances. To make cross-trailer transportation competitive, it is necessary to offer attractive tariffs and develop a logistics infrastructure that optimizes the transportation process.

One practical example of cross-trailer transportation in Ukraine is the project for transporting goods along the Odesa-Krakovets route. On this route, semi-trailers with containers are loaded onto railway platforms at the Port of Odesa and transported by rail to the Krakovets border checkpoint on the Ukrainian-Polish border. There, they are

transferred to trucks for further delivery to EU countries. This route is actively used for transporting agricultural and industrial goods.

In 2020, cross-trailer transportation between Ukraine and Slovakia was launched on the Kyiv–Košice route. This connection successfully reduced logistics costs, shortened transportation times, and improved environmental impact by reducing CO2 emissions.

In Ukraine, according to estimates from the Ministry of Infrastructure, the volume of cross-trailer transportation in 2021 amounted to approximately 200,000 tons of cargo. In 2022, this figure increased by 10% due to active efforts to develop transport corridors between Ukraine and the EU [8].

Table 1

SWOT-analysis of the use of containerized transportation in Ukraine

Strengths	**Weaknesses**
• Ukraine's favorable geographical location between Europe and Asia. • High speed and guarantee of cargo delivery in accordance with the train schedule (Just in time). • Safe transportation in all weather conditions. • Reduced time for border and customs control. • Fuel savings and reduced costs for long-distance transportation. • Preservation of highways. • Reducing CO2 emissions and improving the environment. • Cost savings on shipping documents. • There are virtually no weight restrictions for the transportation of road trains by rail. • Potential for integration with European transport corridors.	• Underdeveloped railway infrastructure. • A limited number of specialized platforms for container transportation. • High dependence on public funding and investment. • Competition with road transport on domestic routes.
Opportunities	**Threats**
• Expansion of international transportation corridors between Europe and Asia. • Investments in infrastructure and new deadlines. • Cooperation with European partners to develop joint projects. • Implementation of innovative technologies to optimize transportation. • Attracting foreign investment to modernize transport infrastructure.	• Political instability and economic crises. • Insufficient government funding for the development of railway infrastructure. • Rising energy prices. • International competition on key routes.

In the future, cross-trailer transportation could significantly reduce road traffic and fully integrate Ukraine into the European transport system. The primary requirement for organizing combined transportation is the availability of technical resources.

Against the backdrop of the Russian-Ukrainian war, Ukraine is rapidly reorienting its logistics toward a European focus. Since Western neighbors perceive military risks in this process, domestic companies must be constantly prepared for various scenarios involving shifts in cargo flow directions.

Diversification could become a key operational strategy. Flexibility and adaptability to different situations are skills that Ukrainians have honed over the past three years. One option for such flexibility is the ability to transport road freight by rail, both in emergencies and on a regular basis.

Cross-trailer transportation in Ukraine began testing even before the war. Semi-trailers were delivered by ferry from Turkey to Ukraine, and tractors distributed the cargo to local shippers. However, this initiative, which lasted about six months, was discontinued when the full-scale war started, and the sea route was closed.

When considering the transportation of semi-trailers by rail through western crossings, cargo is transported between Ukraine and EU countries for both imports and exports. Last year, such transportation did not exist at all, but this year regular trains are already operating, indicating a positive trend.

Unfortunately, the current shortage of drivers could become an additional incentive for companies to utilize domestic cross-trailer transportation. Especially since Ukrzaliznytsia has announced its full support for this type of transport.

The main limiting factor today is that cargo owners compare the costs of cross-trailer and road transportation as the sole criterion. The costs of road logistics are highly volatile. For comparison, the price of cross-trailer transportation may be cheaper today, but more expensive next week.

Rail transportation is more stable in terms of pricing and offers many other advantages. A key condition for the development of cross-trailer transportation is understanding that, beyond the situational price advantage, there are other factors that provide businesses with predictability and ultimately offset this cost difference. These include delivery times of up to 7 days and the ability to transport large shipments of up to 1,000 tons of products at once.

The more shippers adopt this approach, the more platforms will be needed for transporting semi-trailers by rail. As always, business serves as the driving force behind the development of logistics.

Cross-trailer transportation, as an integral part of modern logistics, is undergoing significant changes under the influence of technological progress. Thanks to the integration of modern solutions, this industry is transforming into a high-tech sector that ensures efficiency, safety, and transparency at all stages of freight delivery [9].

One of the key elements of this transformation is the implementation of intelligent Transportation Management Systems (TMS). These systems, equipped with artificial intelligence algorithms, are capable of optimizing routes by considering multiple

factors, from road conditions to the congestion of transport hubs. The result is a reduction in delivery times, lower fuel costs, and a decrease in environmental impact. Additionally, TMS allows for real-time vehicle movement monitoring, which enhances safety and helps respond promptly to unforeseen situations.

The Internet of Things (IoT) also plays an important role in modern cross-trailer transportation. Thanks to numerous sensors installed on vehicles and containers, detailed information about the cargo's condition, temperature, humidity, and other parameters can be collected. This data ensures the preservation of goods during transport and allows for the timely detection of potential issues. Additionally, IoT technologies are used for forecasting the technical condition of vehicles, minimizing the risk of breakdowns and downtime [10].

Artificial intelligence (AI) is increasingly being applied in logistics. AI algorithms are capable of analyzing large volumes of data and predicting demand for transportation services, which helps optimize the use of vehicles and improve planning efficiency. Furthermore, AI is used to automate routine operations, such as creating schedules and optimizing vehicle loading.

Blockchain technology provides a new level of transparency and security for cross-trailer transportation. Thanks to blockchain, it is possible to create a unified, independent register of all operations related to the movement of goods, from the manufacturer to the consumer. This allows for tracking the product's history, protecting against counterfeiting, and ensuring trust among all participants in the supply chain.

Conclusions. Modern logistical challenges require the search for innovative solutions that can ensure efficient freight transportation with minimal environmental impact. One such solution is intermodal transportation, which integrates the advantages of road and rail transport. It helps optimize costs and improves the environmental situation, making it an attractive choice for many countries.

Intermodal transportation in Ukraine holds significant potential not only for the development of the national transport system but also for integration into European transport corridors. Supporting this approach can help reduce the ecological footprint of the transport sector and make the Ukrainian logistics system more flexible and stable. The implementation of this type of transport ensures a reduction in transportation costs, improvement of the environmental situation, and an enhanced economic outlook for both national and international market participants.

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1.2. E-Commerce Market in Current Conditions of Uncertainty: Trends and Challenges

Introduction. The Internet appearence and digital technologies has revolutionized the way business is conducted, giving rise to a new phenomenon known as e-commerce. E-commerce involves the buying or selling of goods online. E-commerce services have the potential to radically transform the global marketplace. This virtual marketplace removes the limitations of physical distance and opens up new ways for businesses to connect with consumers, making it an essential aspect of modern commerce.

The e-commerce industry is rapidly growing worldwide as consumers prioritize convenience in their shopping. Global e-commerce sales exceeded $6 trillion in 2024, accounting for 24% of all online retail purchases. The e-commerce market is expected to exceed $7.9 trillion by 2027, with $2.71 billion of people currently shopping online. E-commerce revenue is projected to grow at a compound annual growth rate (CAGR) of 9.49% from 2024 to 2029, reaching $6.48 trillion by 2029. Globally, China accounts for more than 50% of all online sales worldwide. The country's annual e-commerce sales are over $3 trillion. US retail sales are forecast to show steady to moderate growth through 2028, while e-commerce will grow more than four times faster than in-store sales [1].

However, despite positive forecasts, business should rely on market trends, taking into account the conditions of uncertainty. After all, understanding the concept essence of uncertainty in modern conditions is very important for developing strategies and making decisions in complex and changing situations. Uncertainty in the modern world is manifested in the fact that the conditions in which society and business find themselves are constantly changing and often cannot be predicted or known in advance. Uncertainty covers various aspects, such as economic instability, political turbulence, social and military conflicts, technological changes, natural disasters, etc. In this regard, business management in the e-commerce sector must be flexible, adaptive and respond to current challenges and changes in the environment [2].

Results. E-commerce has evolved from a new concept into a multi-trillion dollar industry, transforming the traditional retail process and changing consumer behavior. The ease of access, convenience, and endless variety of products and services available on e-commerce platforms have attracted a huge number of customers, fundamentally changing the way people shop and interact with companies. The e-commerce landscape is characterized by constant evolution, driven by innovations in payment systems, logistics, user interaction, and data analytics [3]. Key factors driving the growth of the global e-commerce market:

1. COVID-19 Pandemic: adoption of e-commerce as consumers shifted to online shopping due to safety concerns and lockdowns. 19% worldwide e-commerce market growth between pre-and-post COVID-19 timeframes in 2020 observed (Fig.1).

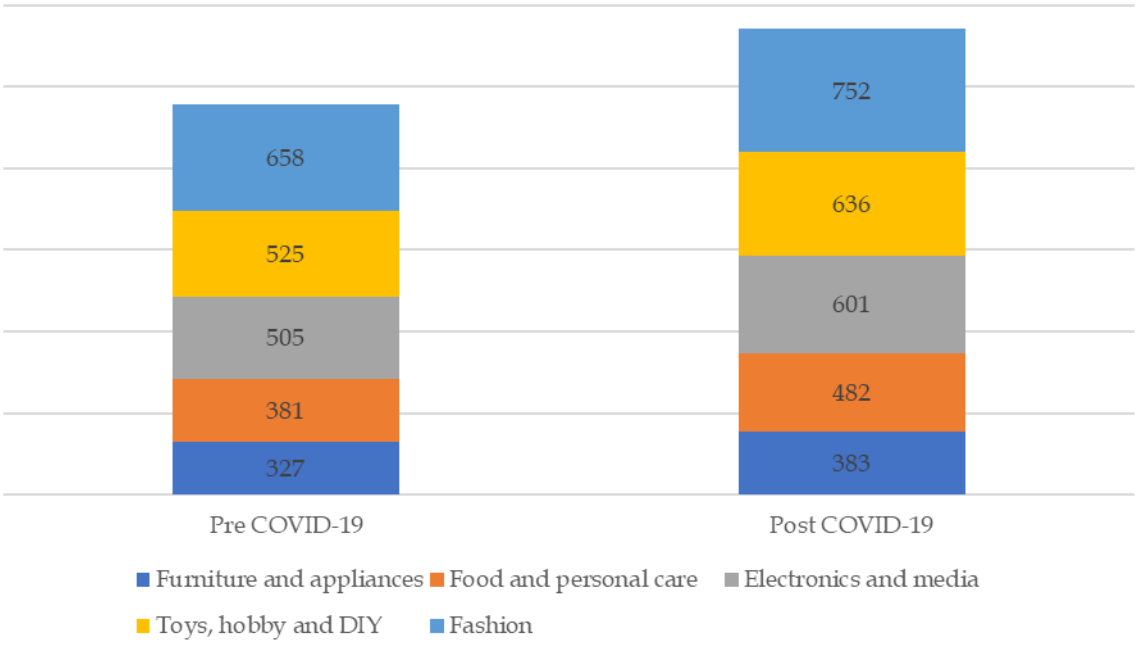

Fig.1. E-commerce market growth between pre-and-post COVID-19 timeframes in 2020, billion $
Source: [4]

2. Digital Transformation: the shift towards online shopping due to digital transformation, accessibility and convenience. The widespread Internet availability, coupled with increased access via smartphones and other devices, has enabled a larger portion of the world's population to shop online. According to the Digital 2024 Global Report, of the world's 8.08 billion people, 5.61 billion (+2.5% annual growth) use mobile phones, and 5.35 billion (+1.8% annual growth) use the Internet for various purposes, spending 6 hours and 40 minutes of their time on it [5]. As more people gained access to the Internet, the potential customer base for e-commerce continued to expand.

3. Product Diversification: a wide range of product categories, from electronics and fashion to food and groceries, attract a broad consumer base. The most popular categories for online shopping are considered from two perspectives: how much money the category brings in and how popular it is. The electronics category is the sales leader (fig. 2), which offers a wide range of products from smartphones to drones and smart home gadgets. On the other hand, fashion is the highest-paying category among shoppers [6].

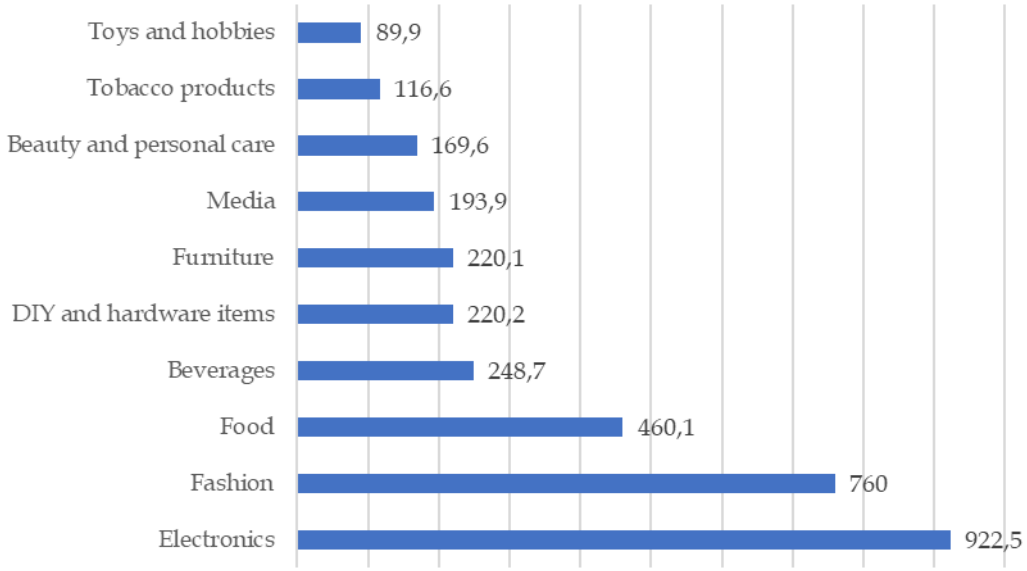

Fig. 2. Top e-commerce products categories worldwide in 2024, billion $
Source: [6]

4. Global Expansion: E-commerce platforms expanding internationally and reaching untapped markets contribute to market growth. The growth of e-commerce has led to an increase in the supply of platforms for commerce. E-commerce platforms offer comprehensive solutions for scaling businesses and have expanded their range of marketing functions to ensure efficiency. The larger the platform, the more difficult the competition. List of main players in the E-Commerce Market: Amazon.com Inc., Alibaba Group Holding Limited, JD.com Inc., Walmart Inc., eBay Inc., Shopify Inc., Rakuten Inc., Zalando SE, ASOS Plc., Flipkart Online Services Pvt. Ltd., Noon AD Holdings Limited, MercadoLibre Inc. and others. Figure 3 shows the main sales channels for e-commerce products in 2024.

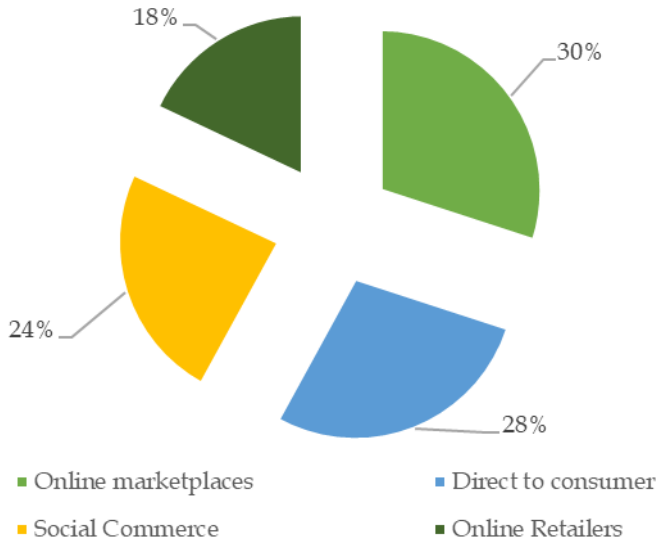

Fig. 3. Global e-commerce market by sales channel
Source: [7]

5. Improved Logistics: efficient logistics and delivery services contribute to customer satisfaction and growth in e-commerce. The integration of e-commerce experiences into everyday life has significantly changed consumer expectations regarding delivery times for different product categories. New features that enhance consumer convenience are often taken for granted. The average number of days that consumers are prepared to wait for their orders across all product categories fell from 2,36 days in 2022 to 2,15 days in 2023 (fig. 4).

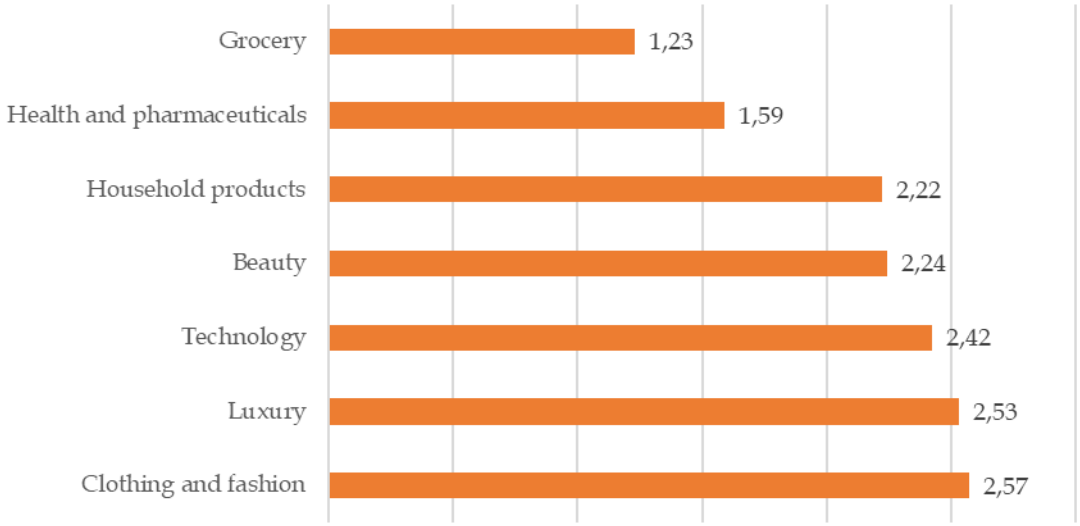

Fig. 4. Average number of expectation days by product categories
Source: [8]

For many consumers, e-commerce has significantly changed their expectations regarding delivery times for different product categories. Although the average consumer is prepared to wait under 24 hours until they receive their online grocery order, a surprising percentage of consumers is much more impatient: 40% of respondents expect grocery delivery within two hours (fig. 5).

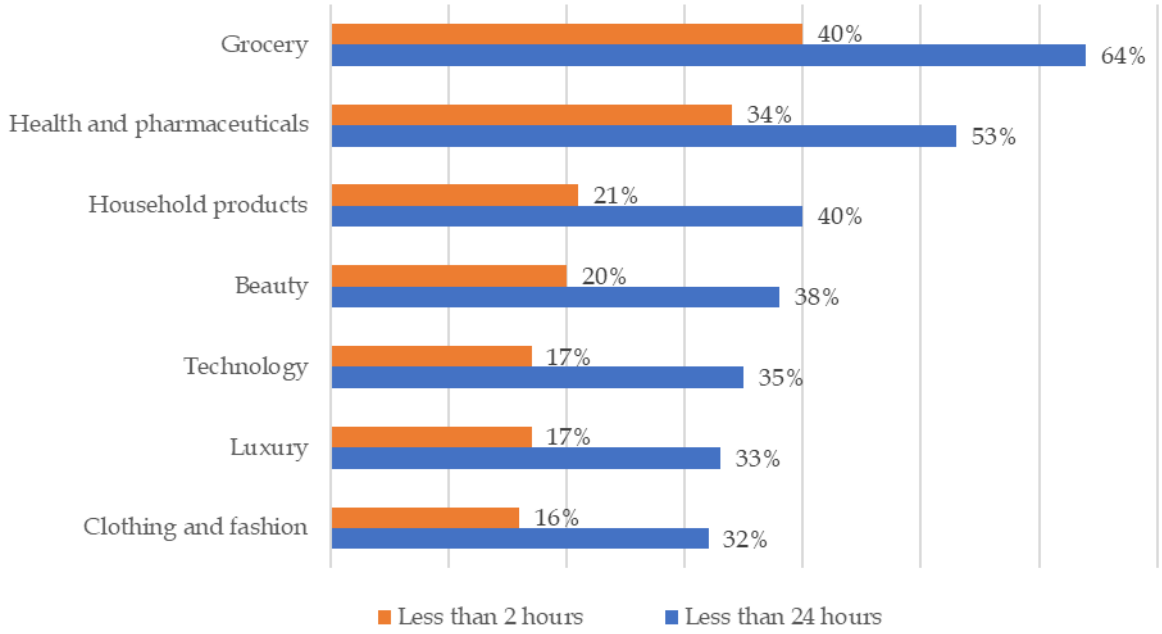

Fig. 5. Share of consumers expecting delivery within 2 or 24 hours by product category in 2023
Source: [8]

6. Payment Innovations: various payment methods and secure online transactions make e-commerce more accessible. In today's fast-paced technological realities, the online payments sector is one of the most dynamic. Technological changes have led to changes in the payment space, replacing cards, checks, and cash with cryptocurrency, e-wallets, and one-click online payments (fig. 6). The emergence of modern payment gateway software helps optimize online transactions.

E-commerce has become integrated into consumer purchasing behavior and will only expand over the years. The proliferation of smartphones and the Internet, along with improved supply chains and payment systems, have made online shopping accessible to people in all corners of the world. Fig. 7 shows the share of e-commerce revenue in the total income by countries in 2023. This share will only grow if businesses timely and correctly take into account the trends and challenges of modernity, especially functioning in conditions of uncertainty.

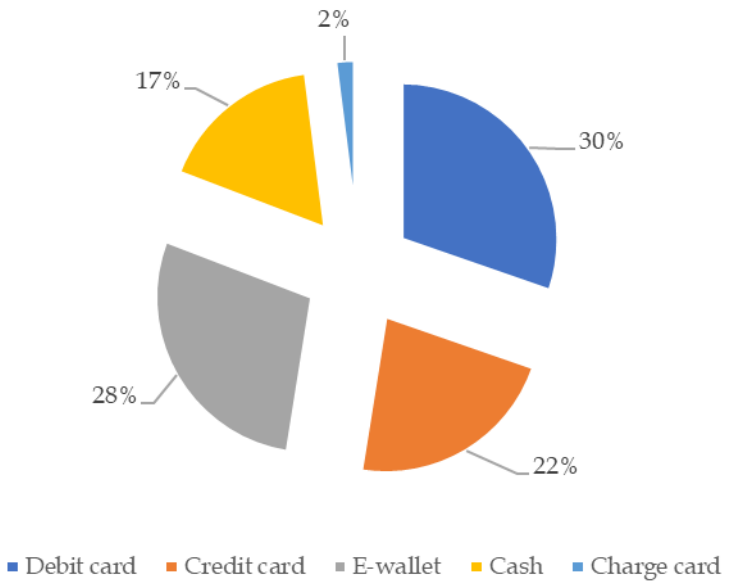

Fig. 6. The most popular online payment methods for consumers in 2023
Source: [9]

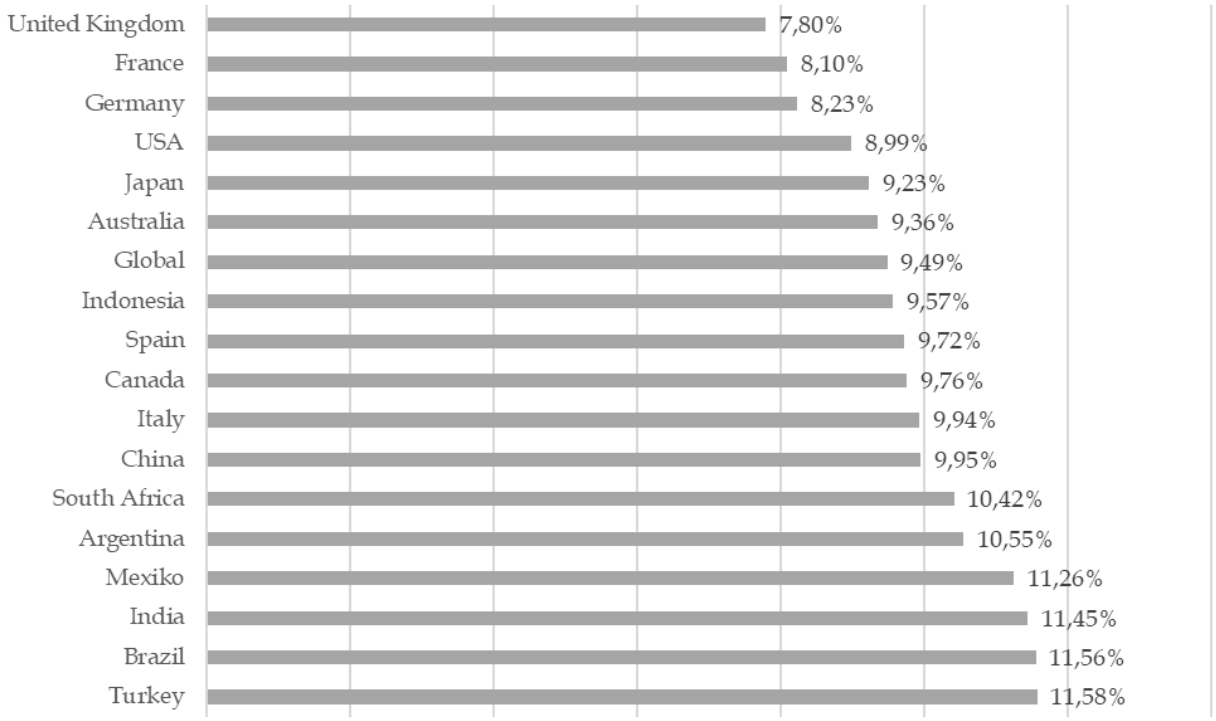

Fig. 7. Share of e-commerce revenue in total income in 2023, by countries
Source: [10]

The Ukrainian e-commerce market has been growing rapidly over the past decade, driven by growing internet penetration, smartphone adoption, and digital literacy.

However, the war in Ukraine that began in 2022 has had a profound impact on all aspects of the country's life, and the e-commerce sector has been no exception. [11]:

1. Reducing in purchasing activity and changes in consumer behavior. In conditions of uncertainty and economic instability, from 2022 Ukrainians began to primarily purchase goods such as grocery, medicines and household goods.
2. Logistics problems and rising shipping costs. The war caused major disruptions in logistics, including port closures and difficulties with international deliveries. This led to increased shipping costs and order fulfillment times.
3. Infrastructure Challenges: Power and Internet. Missile attacks on Ukraine's energy infrastructure have led to frequent power outages and unstable Internet connections. This directly impacts online stores, slowing down their operations and lowering customer service.

Despite the ongoing war with russia, Ukraine's digital economy remains resilient, and e-commerce is playing a key role in the country's economic recovery. Given the scale of russian aggression, it was expected that it would take a long time to reach pre-war levels. However, the market has begun to recover rapidly, and by 2023, volumes had reached $1.7 billion [12].

According to the press service of the EVO group of companies (owner of the country's largest online stores), in 2024, almost $4 billion worth of transactions were made in the Ukrainian e-commerce segment, which is about a third more than in 2023. The orders number is growing, with analysts boldly predicting that by 2040, 95% of all purchases in the world will be online [11].

As in the rest of the world, in Ukraine, orders are mostly placed from mobile devices. This, by the way, is one of the factors behind the growth in the number of orders. Mobile internet coverage is improving, especially in large cities, as is the growing network of delivery services - receiving an order from a courier or picking it up at a post office is easier and faster than going to the store. Saving time is one of the reasons why consumers prefer online shopping, in addition to lower prices and the availability of a wide range of products (Figure 8).

Consumer purchasing habits in Ukraine have changed significantly due to the war. Consumers have changed their values, needs and expectations from brands, becoming more frugal and cautious. They are buying fewer goods and switching to more affordable brands. Fig. 9 shows the categories of goods where sales volumes have increased.

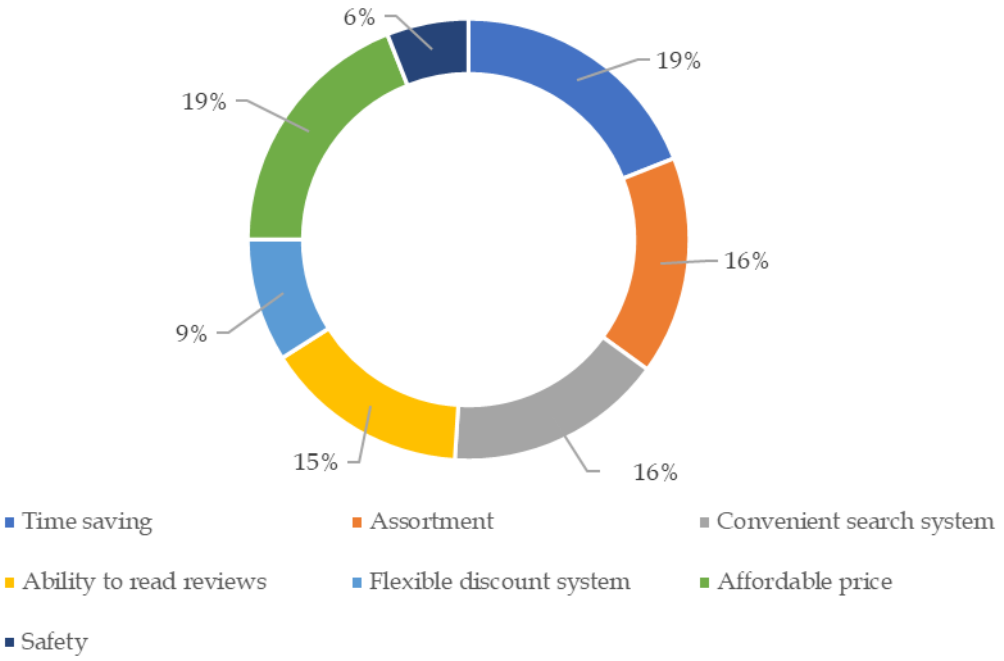

Fig. 8. Patterns of purchasing goods online by Ukrainian customers
Source: [13]

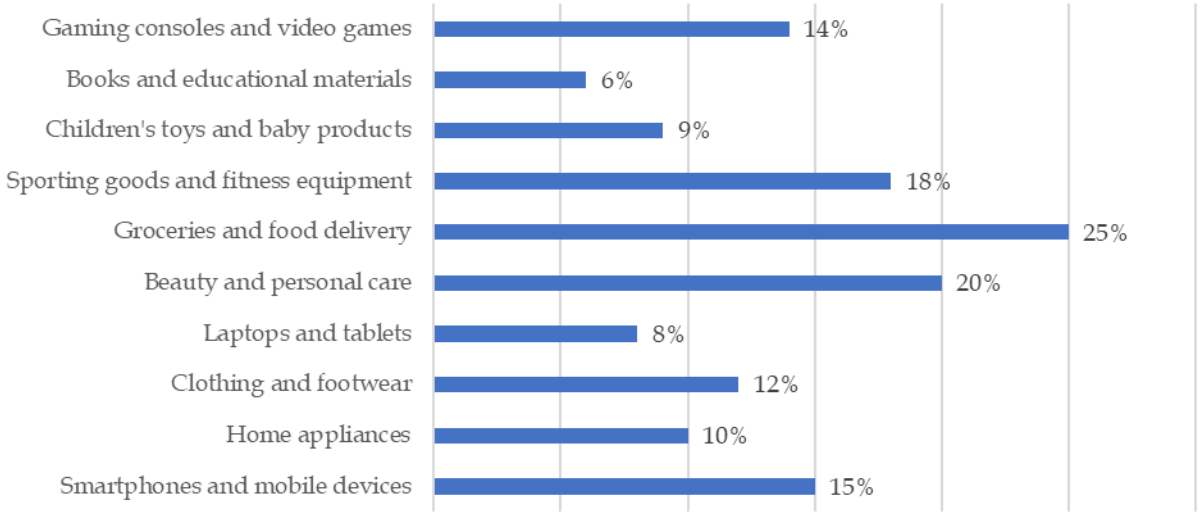

Fig. 9. Growth of best-selling products in Ukrainian e-commerce in 2024
Source: [14]

The growth in some product categories is explained as follows [14]:

- The 15% share increase of smartphone and mobile devices sales is driven by the growth of mobile commerce and increased mobile Internet coverage.
- The 10% share increase of household goods sales is driven by the increase in demand for energy-efficient household goods due to the energy crisis.

• The 12% share increase of clothing and footwear sales is explained by consumers' adaptation to life in wartime conditions and a focus on functional, high-quality and durable clothing, especially Ukrainian-made.

• The 8% increase share of laptop and tablet sales is explained by the transition to remote work and online education, which requires arranging a workspace at home.

The widespread introduction of new technologies in the online payment security field has also helped Ukrainians get used to online payments in just a year. According to EVO, approximately 15% of orders in 2023 were paid by card at the purchase time, which is almost twice as much as in 2020, and the share of marketplaces in the e-commerce segment is 60% and continues to grow (fig. 10).

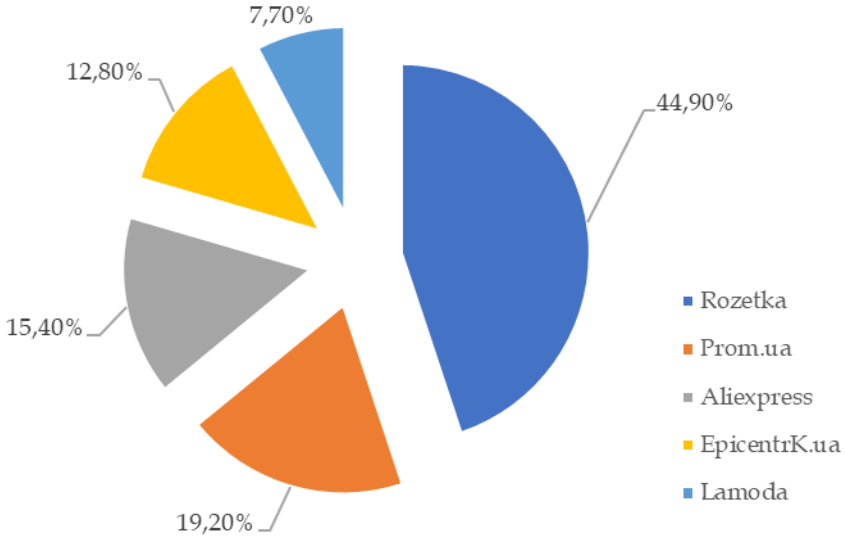

Fig.10. Market share of major Ukrainian marketplaces in 2024
Souyce: [14]

Despite the challenges posed by the russian invasion, the Ukrainian e-commerce market has adapted to operating in an environment of uncertainty for both businesses and consumers. However, to ensure the projected growth, businesses must take into account the following trends [14, 15]:

1. Growth of mobile commerce (M-commerce). In 2024, mobile shopping accounted for 72,9% of total e-commerce due to the growth of mobile internet penetration. Ukrainian consumers are increasingly choosing to shop via mobile apps due to the convenience, personalized user experience, and affordability of smartphones. Retailers are actively investing in creating mobile platforms and mobile-optimized sites.
2. Social commerce. Social media has become an important sales channel in Ukraine, and platforms like Instagram, Facebook, and TikTok allow companies to directly engage with a young audience who engage in interactive shopping through live broadcasts, especially in the fashion and beauty sectors.
3. Marketing automation. The widespread use of software to automate routine marketing campaign tasks such as email sending, social media posting, and ad

management. This allows brands to increase the efficiency and productivity of their marketing efforts, as well as improve customer personalization and segmentation.

4. Growth of Payment Solutions and Fintech Integration. The expansion of digital payment methods has been a key driver of Ukrainian e-commerce growth. In 2024, over 80% of e-commerce transactions were paid for electronically, including using credit cards, mobile banking apps, and e-wallets such as Apple Pay and Google Pay.

5. Security and Trust Issues. Ukrainian consumers are still wary of online shopping due to concerns about fraud and privacy. Despite improvements in cybersecurity, payment fraud and personal data security remain common. To support sustainable growth, e-commerce platforms need to invest in encryption technologies and fraud detection systems.

6. Augmented Reality. Augmented reality allows to add virtual objects to the real world. AR can be used to enhance shopping, learning, entertainment, and other experiences. Clothing and cosmetics brands are using AR to allow customers to try on products without leaving their homes.

Conclusions. E-commerce is one of the most promising sectors of global retail, growing despite the financial and logistical crisis. To succeed in 2025, it is important for e-commerce companies to be flexible and present where their customers are. This means working on completely different platforms: promotion on marketplaces and social networks, as well as promotion of their own online stores. People are used to switching between platforms and gadgets, they can start looking for furniture or clothes on a smartphone, continue on a laptop, go to YouTube and return to Instagram. Therefore, it is important for businesses to adapt strategies to different sales channels. In the face of high competition and the availability of multitude offers, customers expect to receive not only the highest quality product, but also exceptional service at all stages of the purchase process. People increasingly prefer brands that are able to provide fast and convenient service. Conversely, companies that do not meet these expectations risk losing customers. To remain competitive in changing conditions, it is important for businesses to adapt strategies to current market trends.

The e-commerce market is developing in Ukraine. The peculiarity of e-commerce is that the poorer the buyer, the more chances e-commerce has. This is because buying online is cheaper and the buyer has more choice than offline. Therefore, online in Ukraine is developing and increasing its market share. In the long term, the Ukrainian e-commerce market will continue to grow, with a projected compound annual growth rate (CAGR) of 15-20% in 2025. The main drivers will be mobile commerce, the development of payment technologies and improved logistics infrastructure. However, companies must take into account the conditions of uncertainty and be flexible to solve problems related to security, regulation, war. As the digital environment develops, e-commerce will continue to play a key role in shaping economic recovery.

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1.3. Logistics Services Market: Digital Transformation and Innovation

The logistics market is a dynamic and complex ecosystem encompassing various modes of transport, technologies, and industries. Its primary function is to ensure the efficient movement of goods between destinations. In today's digital transformation, the logistics industry is undergoing significant changes, especially in cargo transportation. The growth of e-commerce has increased the demand for fast and accurate delivery of the "last mile," which stimulates the automation of transport logistics. Using multimodal transportation - road, rail, water, and air transport - allows you to optimize routes, reduce costs, and increase transportation efficiency. In addition, the popularity of environmentally friendly transport solutions, such as electric trucks and alternative fuels, which contribute to reducing environmental emissions, is growing. Innovative technologies, particularly blockchain, artificial intelligence (AI), and the Internet of Things (IoT), are key in improving transport logistics. Real-time monitoring systems allow companies to track cargo movements, predict delays, and minimize risks. Sensor technologies and augmented reality are used to improve warehouse management and increase the accuracy of navigation and transport routing. The logistics market serves various industries, including manufacturing, pharmaceuticals, retail, and defense. Outsourcing logistics services and cooperation with third-party logistics operators is shared, allowing companies to focus on their core business while ensuring efficient transportation of goods. Trade agreements, intelligent transport systems, and digital technologies are shaping the future of the logistics industry. Route optimization, Internet of Things-enabled devices, and automated logistics chain management increase the accuracy and speed of delivery. Thus, transport and logistics continue to evolve under the influence of the digital revolution, driving innovation, efficiency gains, and sustainable development on a global scale.

Recent publications on innovative technologies in transport and logistics focus on key areas of digital transformation in the industry. In particular, Marinov E.'s study analyzes the impact of IoT, AI, autonomous transport, blockchain, big data analysis, and cloud solutions on transport logistics management [1]. Another study on digital transformation and logistics flow management emphasizes that introducing modern digital technologies opens up new opportunities for improving the quality of logistics [2]. At the same time, these studies require further improvement to ensure the optimal functioning of transport logistics and the effective implementation of new approaches to innovative technologies. In this regard, it is advisable to substantiate the research issues more thoroughly, in particular, to identify key aspects of the economic potential

of the logistics services market, particularly in the context of transport logistics, which will contribute to increasing its efficiency and competitiveness.

Digital transportation is the process of converting manual operations into digital format. For example, 30 years ago, freight transportation management was carried out mainly through paper documentation and phone calls between transportation coordinators and shippers working in offices or so-called Transportation Management Centers. Today, most of these tasks are performed semi-automatically, thanks to high-tech transportation software and a well-organized digital workflow. The development of technologies such as GPS, telematics, software solutions, and predictive analytics has contributed to increasing the accuracy of transportation costs, which, in turn, has made the transportation sector more cost-effective. An example of digital transformation is the contactless card system for public transport passengers, which has significantly reduced carriers' operating costs. Thanks to such initiatives, the costs of transport company Transport for London (TfL) revenue collection rates have decreased from 15% to 8%, and in the future, this figure is predicted to reduce to 6% due to the growing popularity of contactless payment [3].

Rapid technological change and growing consumer demands are the main drivers of digital transformation. Logistics and transport companies must accelerate the implementation of models based on data analysis to make the most of new market opportunities. Digital transformation is already happening, and both public authorities and private companies are actively promoting its implementation, as it makes environmental and economic sense.

According to a Business Report Wire, the global AI market in the transportation and distribution sectors reached $3.1 billion, up from $2.6 billion the previous year. The average annual growth rate was 19.4%, indicating this industry's dynamic development of AI applications. Introducing AI technologies in the transportation sector helps accelerate freight transportation processes by optimizing logistics routes, minimizing delays, reducing congestion, and reducing delivery times[4].

The dynamics of global logistics costs show significant fluctuations due to global economic factors (Fig. 1).

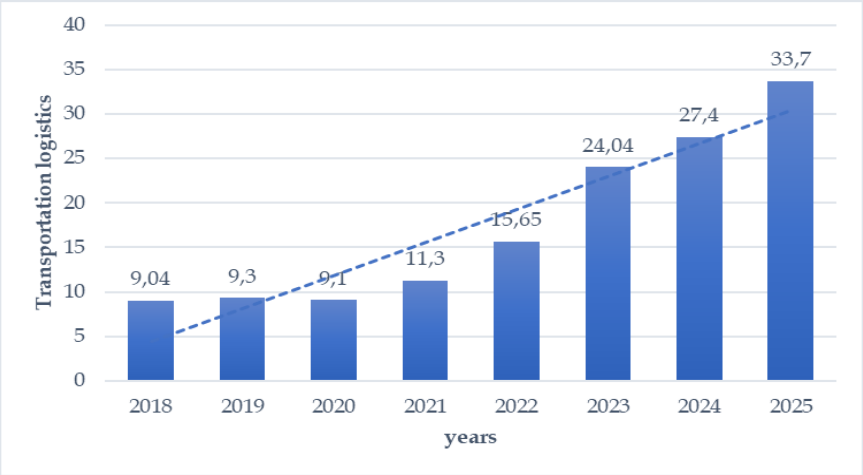

Fig. 1 Dynamics of global transport logistics costs 2018-2025.
Source: [4]

Thus, in 2020, this figure decreased to 9.1 trillion US dollars, probably due to the consequences of the COVID-19 pandemic for the global economy. However, starting from 2021, there has been a rapid growth in logistics costs, which reached 15.65 trillion US dollars, which indicates a fast recovery and development of the logistics sector after the crisis period. Thus, by 2025, it is predicted that the global transport and logistics market will undergo fundamental changes due to the active implementation of innovative technologies and intelligent systems. These processes have already begun, contributing to increasing the efficiency of logistics operations, optimizing supply chains, and the overall digital transformation of the industry [5].

North America is one of the leading players in the global logistics market. In 2021, the market volume was 433.25 billion US dollars and is projected to show a steady CAGR during the forecast period. The main factor in the success of the region's logistics industry is a developed infrastructure, which includes a modern road and rail transport network, contributing to the efficient functioning of supply chains. A high level of integration of transport systems ensures the smooth movement of goods through various modes of transportation, including air, express delivery, freight rail, sea, and road freight transport. The USA plays a key role in the regional logistics sector due to its strategic geographical location and developed trade ties. In 2023, the US share in the logistics market was 23.9%, which confirms its importance in global logistics processes. [6].

The European logistics market is the second largest in the world, driven by the growth of e-commerce and significant investments in logistics research and development. Germany holds the largest market share in Europe, while the UK is showing the fastest growth in the logistics sector in the region. A significant skilled labor supply and developed transport infrastructure in European countries create favorable conditions for developing logistics services. Despite the positive outlook, the development of the logistics sector in Europe is being held back by the slowdown in global economic growth, which is causing a decline in demand for freight transport. This creates specific challenges for the industry, which needs to adapt logistics strategies to changes in the global economy.

The Asia-Pacific region is the global market, holding the largest revenue share, which in 2023 was 35.0%. In addition, the region demonstrates the highest compound annual growth rate (CAGR), equal to 7.6%. Rapid economic growth in countries such as China and India, coupled with government initiatives to modernize transportation infrastructure, drives demand for logistics services. The industry is also driven by a growing middle class and the rise of e-commerce, which require effective supply chain management solutions. The Asia-Pacific region plays a strategic role in global trade, which necessitates further expansion of logistics capacities and improvement of transport processes, making this market one of the most dynamic in the world. [7].

Since transport logistics plays a key role in ensuring the efficient movement of goods and services, contributing to increased productivity and the development of international trade, it is advisable to consider the main aspects of its economic potential (Table 1).

The modern transport industry faces several large-scale challenges, most of which cannot be solved in the short term. In particular, the issue of strengthening state regulation of transportation processes is relevant since companies often do not have time to adapt to dynamic changes in the competitive environment. In addition to these challenges, more detailed problems can negatively affect the smooth operation of the transport system (Table 2).

The transport industry is undergoing a massive digital transformation driven by rapid technological advances and changing consumer behavior. This is shaping the future of transport and creating new opportunities for the industry to modernize. Below are the key trends in digital transformation in transport and logistics in the logistics services market (Fig. 2).

IoT and sensor technologies are key factors in transforming logistics operations. These innovations enable real-time data collection from physical objects and the environment, providing unprecedented supply chain analysis and management opportunities. IoT sensors embedded in vehicles, cargo, and warehouses capture a wide range of metrics, including temperature, humidity, location, and movement of goods. This data enables logistics companies to accurately track the status and location of cargo throughout the supply chain. The integration of these technologies also significantly improves fleet management and dynamic route planning. Real-time traffic data allows for rapid route adjustments based on traffic conditions, helping ensure timely cargo delivery, optimize fuel consumption, and reduce carbon emissions. Analytics obtained through IoT and sensor technologies enable logistics companies to make informed decisions, increase operational efficiency, improve customer service, and drive innovation in the industry [9].

Table 1

Key aspects of the economic potential of transport logistics

Elements economic potential	Characteristic
Decrease expenses	By optimizing logistics processes, companies can reduce transportation, storage, and chain management costs for supplies. This leads to a reduction in the cost of production and increasing competitiveness in the market.
Increase efficiency business	Efficient logistics helps companies reduce delivery times, increase the turnover of goods, and reduce the risk of losses due to delays.
Global integration	Logistics contributes to the expansion of international trade by ensuring access to new markets and facilitating the transportation of goods between countries. This stimulates the development of foreign economic relations and increases imports and exports.
Constant development	Transport logistics has the potential to contribute to environmentally sustainable development. Investments in energy-efficient vehicles, use of alternative energy sources, and emission reduction of greenhouse gases during transportation contribute to developing a green economy.
Development regions	Infrastructure projects related to transport logistics (development of ports, railway junctions, and highways) stimulate regional economic development, attract investments, and create new jobs.

Source: [1]

Table 2

The main challenges of the transport industry

Challenge	Description
Network complexity	The high complexity of transport networks and dependencies in supply chains make the transportation planning process uncertain and unpredictable. The interaction of numerous carriers, logistics partners, and other supply chain participants requires effective information exchange and digitalization of documentation.
Automation	Increasing the productivity of companies is possible through the automation of work processes, which contributes to the optimization of data exchange, improved task planning, more accurate routing, and effective tracking of vehicles. The lack of such capabilities leads to reduced productivity and increased costs.
Integration	Stakeholders in the transportation industry work across multiple information systems that require effective integration based on standardized electronic data exchange methods. This is especially true when using legacy ERP systems that are rarely updated. Lack of proper integration makes it difficult to interact with modern software solutions and limits the possibilities of digital transformation.
Adaptability	Flexibility in the transport industry is a key factor for effectively responding to market fluctuations and growing demand. The lack of adaptation mechanisms complicates the management of transport activities and limits the opportunities for strategic development of companies.

Source: [8]

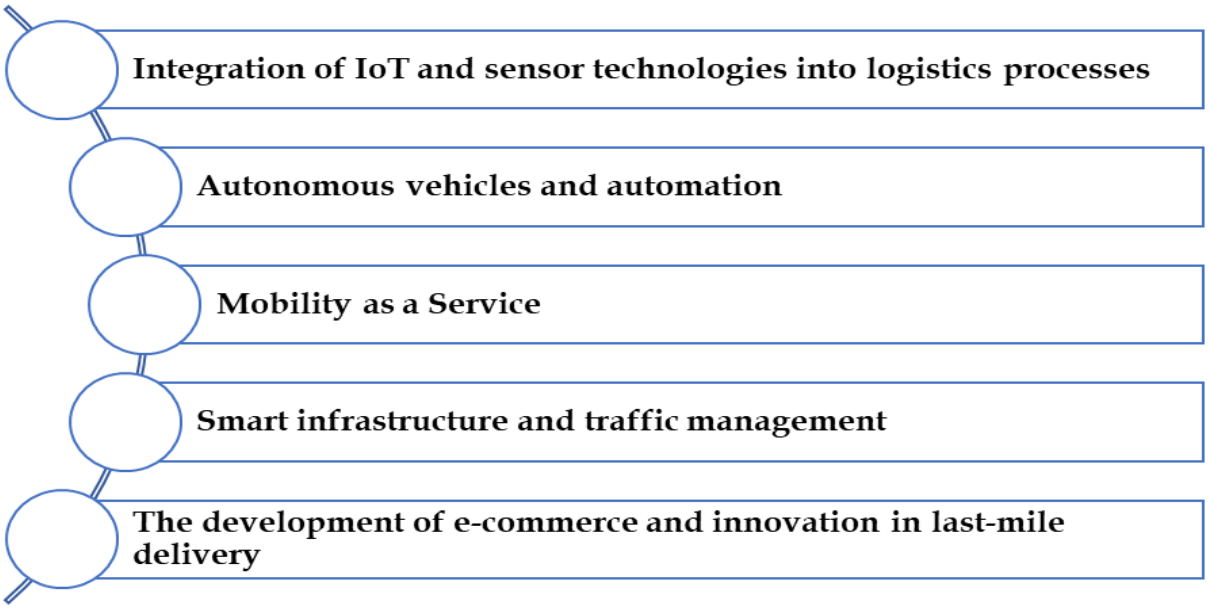

Fig. 2 Main trends of digital transformation in the logistics services market
Source: own development based on [3]

Autonomous vehicles, including driverless cars, are one of the key areas of innovation in the modern transportation industry. Using AI, sensor technologies, and machine learning systems allows vehicles to be driven independently without human intervention. Even though fully autonomous cars are still in the testing stage, automation technologies are already actively integrated into various types of transportation, including driverless cars, autonomous trucks, unmanned drones, and

automated rail transport. Autonomous transport is expected to radically change logistics processes, particularly in the last mile, reducing delivery costs, optimizing routes and reducing congestion, improving environmental friendliness, and reducing the risk of accidents. Autonomous transport technologies continue to improve, and their use will likely become widespread in the coming decade. This will significantly change the transportation structure, increase the transport industry's efficiency, and promote the development of intelligent transport systems (Intelligent Transportation Systems, ITS)[8].

The mobility concept as a service (MaaS) involves the integration of different modes of transport into a single digital platform that allows users to plan routes and book and pay for transport services conveniently and centrally. The implementation of this model contributes to increasing the availability of transport services, stimulates the use of environmentally friendly means of transport, and helps reduce road congestion. The main principle of MaaS is integrating transport services from different providers, including public transport, car sharing, taxis, ride-sharing services, bicycle and scooter rental, and other alternative types of mobility. Users can choose between single trips or subscriptions to monthly service packages, depending on individual needs. Public transport plays a central role in MaaS, providing a reliable, environmentally safe, and affordable way of moving. Its integration with other modes of transport allows for a more efficient and convenient transport system[10].

The development of intelligent transport systems, ITS, and digital technologies is significantly changing approaches to road traffic management. The implementation of smart infrastructure is aimed at increasing the efficiency of the transport network, reducing congestion, optimizing mobility, and improving road safety. The main components of innovative transport infrastructure are intelligent road traffic management systems, which use modern technologies for collecting, analyzing, and processing data in real-time. Key elements of such systems include adaptive traffic lights and intelligent intersections, dynamic traffic flow management, intelligent road signs, and information panels. Despite significant advantages, the implementation of intelligent transport infrastructure faces specific difficulties, including high cost - the deployment of systems requires substantial investments; the need for regulatory regulation - compliance with existing legislative norms and the development of new standards; cybersecurity - protection of transport systems from cyberattacks and unauthorized intervention. The development of smart infrastructure and the implementation of intelligent traffic management systems are essential steps for the modernization of urban transport. Introducing modern technologies contributes to reducing congestion, increasing road safety and efficiency, and improving the environmental situation. Therefore, public and private institutions should actively support the development of these technologies to create an innovative transport ecosystem [8].

E-commerce is one of the key drivers of change in the logistics sector, driving rapid innovation in last-mile delivery. The growing demand for fast, accurate, and efficient delivery of goods is driving companies to adopt new technologies that help

optimize logistics processes and improve customer experience. Among the factors influencing the development of e-commerce and last-mile logistics, one can single out the growth of online sales, namely, the expansion of e-commerce causes a significant increase in logistics operations, which requires fast and flexible solutions for effective management of transport flows. Another factor is consumer expectations, i.e., modern customers expect speedy delivery (within one or several days), flexibility in choosing the time and place of receipt of the goods, and the ability to track the order in real-time. The growth of urban populations and infrastructure congestion creates challenges for efficient logistics. The introduction of innovations helps to reduce congestion and optimize delivery routes. Companies strive to reduce carbon emissions by introducing electric transport, autonomous vehicles, and alternative delivery methods. To overcome these challenges, companies are implementing innovative technologies that increase the efficiency of autonomous transport processes, micromobility in urban logistics, and intelligent delivery management systems [3].

The main trends of digital transformation in transport and logistics outlined above provide an opportunity to present the positive aspects of digital transformation (Table 3).

Table 3

Positive aspects of digital transformation in the logistics services market

Positive aspects	Opportunities
Productivity improvement	Digital transformation helps increase operational efficiency by optimizing logistics routes, reducing downtime, and reducing fuel costs.
Improving customer collaboration	Real-time tracking, booking systems, and personalized services contribute to increased customer satisfaction.
New sources of income	The development and implementation of transport technological solutions contribute to forming new sources of profit and expanding partnership relationships.
Increasing security	technologies, in particular collision avoidance systems and real-time traffic alerts, contribute to improving the safety of transportation systems
Infrastructure development	The development of digital infrastructure, particularly a network of charging stations for electric vehicles, creates the prerequisites for attracting investment and contributes to the further development of the industry.
Regulatory compliance	compliance with updated regulatory requirements regarding emissions, safety, and protection of confidential data stimulates the implementation of innovative solutions
Urban planning and sustainable development	Digital transformation contributes to the effective planning of transport systems in cities, which reduces congestion and pollution and improves the overall quality of the urban environment.

Source: own elaboration based on [8]

Modern logistics companies are actively implementing digital technologies to improve the efficiency of operational processes. Some of the most significant innovations in this area are AI, machine learning, IoT, and autonomous vehicles.

Company FedEx is positioning itself as a leader in digital transformation in logistics, actively using modern information technologies. One of the key steps in this direction was the creation of the *FedEx Platform Dataworks* in early 2020, demonstrating the company's commitment to big data analytics and predictive modeling. Integrating digital and physical networks has improved supply chain efficiency and ensured the sustainable development of logistics infrastructure. AI technologies have contributed to improving real-time data collection and analysis, increasing logistics operations' transparency and predictability. This has allowed the company to respond quickly to changes in demand and minimize the risks associated with supply chain disruptions.

China's *JD.com*, one of the leading e-commerce platforms, has made significant progress in its digital transformation by deploying autonomous vehicles to deliver orders. Advanced machine learning and AI algorithms provide safe and efficient movement of such cars in urban environments, allowing for last-mile delivery without human intervention. The use of autonomous vehicles helps improve the efficiency of logistics processes and meets the growing demand for fast delivery in large cities. In addition, *JD.com* is investing in robotic fulfillment centers that automate the picking, packing, and shipping processes. The use of robotic technology optimizes logistics operations, increases productivity, and contributes to increased customer satisfaction. Integrating digital technologies allows JD.com to increase its competitiveness in the dynamic e-commerce environment.

Amazon is one of the largest investors in logistics automation, which allows it to maintain high efficiency and meet customer expectations for fast delivery. Using thousands of automated devices, robotic fulfillment centers play a significant role in this process. This has reduced order processing time by 50%, which has allowed the company to implement the concept of same-day or next-day delivery. In addition to warehouse automation, *Amazon* uses a predictive analytics system based on artificial intelligence. This system analyzes consumer behavior, considers external factors, and optimizes inventory levels, preventing shortages and overstocking of goods. In addition, the company is exploring the possibility of using drones to deliver orders within the *Prime service Air*. Despite regulatory restrictions, the potential of uncrewed aerial vehicles in logistics remains significant, especially for optimizing last-mile delivery [11].

The modern logistics sector is in a profound innovation transformation caused by the rapid development of technologies and the need to adapt to growing market demands. While companies have traditionally used reactive strategies, current trends indicate a transition to innovation-oriented management, which ensures long-term growth, increased efficiency, and resilience to change. The key drivers of this evolution are AI, automation, digitalization, and cloud technologies, which are shaping the new reality of transport logistics. In particular, AI plays a crucial role in modernizing logistics processes, increasing the accuracy of demand forecasting, the efficiency of supply chain management, and the quality of management decision-making. According to DHL Logistics Trend Radar, among the most promising technologies, we can single out Computer Vision, Audio AI, Generative AI, AI Ethics, and Advanced Analytics [12].

Their implementation will contribute to increasing automation, optimizing resources, and ensuring the flexibility of logistics systems. It is predicted that in the period 2023–2030, logistics will become one of the most dynamically growing industries, which will be due to the active development of e-commerce, increased demand for fast logistics solutions, and technological progress. An important direction of digital transformation is transitioning from traditional paper documents to digital solutions, which ensures process automation, error reduction, and overall productivity improvement. The next stage in the development of logistics will be the implementation of IoT, robotic systems, big data analytics, and autonomous transport, which will allow the creation of flexible, adaptive supply chains capable of quickly responding to market changes. In addition, innovations contribute to solving issues of sustainable development, which is becoming increasingly relevant due to regulatory pressure and changing consumer priorities. In particular, companies are actively implementing intelligent monitoring systems that ensure logistics processes' transparency, efficiency, and environmental compliance. Thus, the future of transport logistics directly depends on implementing innovative technologies that will determine the competitiveness and sustainability of companies in the global environment. The integration of advanced solutions will contribute to increasing the efficiency of operations, reducing costs, and meeting the requirements of sustainable development, which are key priorities of the modern logistics industry.

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1.4. Administration and Personnel Management in LLC "Trading House "Galka"

АДМІНІСТРУВАННЯ ТА УПРАВЛІННЯ ПЕРСОНАЛОМ В ТОВ «ТОРГОВИЙ ДІМ «ГАЛКА»

В умовах цифрової трансформації та постійних змін у зовнішньому середовищі управління персоналом набуває особливого значення. Його розвиток та ефективне адміністрування відіграють ключову роль у забезпеченні успіху підприємства та його конкурентоспроможності. Використання передових методів управління персоналом сприяє підвищенню продуктивності, покращенню якості виконуваних робіт, зниженню рівня плинності кадрів і створенню сприятливого психологічного клімату в колективі [1].

Управління кадровим потенціалом охоплює широкий спектр процесів, зокрема планування, підбір і відбір кадрів, навчання, розвиток, оцінювання та мотивацію персоналу [2]. Такий підхід базується на комплексному управлінні, яке передбачає ведення відповідної документації, застосування сучасних інформаційних технологій, ефективну організацію діловодства та формалізацію управлінських процедур.

Згідно з дослідженням Посвалюка О. [3], формування кадрового потенціалу тісно пов’язане з нормативно-правовими регламентами, внутрішніми документами підприємства та фінансовими обмеженнями. У цьому контексті доцільно проаналізувати основні види документації, що застосовуються в процесі адміністрування кадрів (табл. 1).

Таблиця 1

Основні типи документації, необхідної для адміністрування персоналу

Тип документації	Приклади документів
Персональна документація	Особисті справи працівників
	Контракти та трудові угоди
Документація з управління кадрами	Накази та розпорядження
	Посадові інструкції
	Корпоративні кодекси поведінки
	Штатний розпис працівників
Документація з навчання та розвитку	Плани навчання та розвитку персоналу
	Журнали обліку навчання
Документація з оцінки роботи	Атестаційні листи та відгуки
	Оцінювальні картки
	Карти обліку робочого часу
	Системи KPI
Документація з обліку та звітності	Звіти з обліку трудової діяльності
	Аналітичні звіти тощо

* *сформовано авторами*

Отож, під час адміністрування персоналу використовуються різноманітні типи документів, які фіксують кадрові процеси та забезпечують правову основу для прийняття управлінських рішень. Це, своєю чергою, створює основу для застосування різноманітних методів адміністрування персоналу, які дозволяють ефективно управляти людськими ресурсами в організації.

Сучасні методи адміністрування кадрового потенціалу набувають все більшого значення. Серед них можна виділити 360° атестацію, бенчмаркінг, метод асесмент-центру, HR-аналітику та інші інструменти, що сприяють комплексному управлінню та розвитку персоналу.

Законодавча база, що впливає на адміністрування персоналу, відіграє важливу роль у забезпеченні ефективного розвитку людських ресурсів на підприємстві, оскільки визначає правові основи, на яких здійснюється підбір, навчання, оцінка та мотивування працівників. В умовах повномасштабної війни, що триває в Україні, особливу увагу варто приділяти регулюванню трудових відносин, оскільки вони потребують адаптації до нових викликів. Закон України «Про організацію трудових відносин в умовах воєнного стану» [4] ухвалено для забезпечення стабільності в трудовій сфері та захисту прав працівників і роботодавців. Зокрема, спрощується процедура найму і звільнення, скорочуються терміни попередження про звільнення, що дозволяє швидше реагувати на зміни. Комфортні умови праці та безпека працівників виходять на пріоритетний рівень [5]. Законодавча база, що регулює документообіг в управлінні кадровим потенціалом, створює основу для систематизації та організації інформаційних потоків у підприємствах. Обробка та зберігання інформації про працівників, що необхідна для адміністрування кадрів включає використання різноманітних

програмних продуктів. Відповідно до законодавства, підприємство повинно забезпечувати конфіденційність і захист персональних даних, що обробляються в інформаційних системах. Це регулюється законами, зокрема такими як: Закон України «Про інформацію» [6] та Законом України «Про захист інформації в інформаційно-телекомунікаційних системах» [7]. Також збереження, оформлення та обробка персональних даних про працівників відбується згідно з Законом України «Про захист персональних даних» [8]. Інформація, яка необхідна для управління кадровим потенціалом може збиратися з різноманітних джерел, що в свою чергу регулює Закон України «Про доступ до публічної інформації» [9].

Ефективність використання людських ресурсів безпосередньо пов'язана з фінансовими та операційними результатами діяльності підприємства, оскільки стабільність виробництва та ринкові успіхи створюють передумови для вдосконалення управлінських процедур і розвитку персоналу. Таким чином проаналізуємо адміністрування та управління персоналом на прикладі ТОВ «Торговий дім «Галка». Зважаючи на те, що основним видом діяльності ТОВ «Торговий дім «Галка» є неспеціалізована оптова торгівля продуктами харчування, напоями та тютюновими виробами, проведемо ретроспективний аналіз каналів збуту підприємства. (табл.2).

Таблиця 2

Ретроспективний аналіз каналів збуту ТОВ «Торговий дім «Галка» за період 2020-2024 рр.

Період	Канали збуту
До 2020 року	Експорт до країн-сусідів, Іспанії, Ізраїлю, країн Латинської Америки, Канаду та США. участь у тендерах Prozorro; три власні магазини-кав'ярні у м.Львів продаж у фірмовому магазині на фабриці (вул. Заповітна, 1)
2020 рік	Ті ж, що у до 2020 року, а також: вихід на ринок e-commerce; відкриття соціальних мереж (Facebook, Instagram) та їх просування
2021 рік	Вихід на ринок прибалтійських країн у зв'язку з відкриттям заводу в Литві; активна співпраця з місцевими кав'ярнями.
2022 рік	Зміцнення позицій на прибалтійському ринку, співпраця з благодійними фондами
2023 рік	Зміцнення позицій в e-commerce; нові партнери в сфері роздрібного продажу
січень – вересень 2024 року	Поглиблення співпраці з великими торговельними мережами (наприклад: Рукавичка, Епіцентр, Аврора, Фора)

Таким чином, підприємство продемонструвало стабільний розвиток, адаптуючи свою стратегію до змін на ринку. ТОВ «Торговий дім «Галка» здійснило вихід на нові ринки, зокрема e-commerce та прибалтійські країни. Зараз значна увага приділяється розвитку онлайн-продажам, розвитку соціальних мереж, співпраці з благодійними фондами, навчальними закладами. З 2024 року

акцент на співпрацю з великими торговельними мережами свідчить про прагнення до зміцнення конкурентних позицій на ринку.

Проведемо аналіз основних фінансових показників, що відображають витрати на адміністрування, оплату праці, а також здійснимо розрахунок продуктивності праці, зарплатомісткості, зарплатовіддачі (табл. 3). Ці дані дозволять оцінити загальну ефективність роботи персоналу ТОВ «Торговий дім «Галка» та їхній внесок у досягнення фінансових результатів підприємства.

Таблиця 3

Оцінювання ефективності адміністрування і управління персоналом ТОВ «Торговий дім «Галка» за період 2019 - 2023 рр.

Показник	Період					Абсолютне відхилення 2023/2019 р
	2019	2020	2021	2022	2023	
Кількість працівників, ос	50	51	51	53	53	+3
Кількість керівників та спеціалістів, ос	38	39	39	43	43	+4
Відсоток працівників з вищою освітою, %	69	71	71	75	75	+6
Адміністративні витрати, тис. грн	10 949	13 217	16 875	18 149	17 154	+6205
Витрати на оплату праці, тис. грн	14 504	19 722	20 371	23 216	22 911	+8407
Витрати на соціальні заходи, тис. грн	1 451	1 650	1 861	2 152	2 145	+694
Фонд оплати праці, тис грн	15 955	21 372	22 232	25 368	25 056	+9101
Продуктивність праці керівників та спеціалістів за обсягом реалізації продукції, тис.грн на особу	11573	11483	10910	13057	15206	+3995
Зарплатомісткість, %	0,036	0,048	0,052	0,045	0,038	+0,002
Зарплатовіддача, %	27,57	20,96	19,14	22,13	26,10	-1,47
Середньорічний фонд оплати праці на 1 працівника, тис. грн	319,1	419,1	435,9	478,6	472,8	+153,7
Середньомісячна заробітна плата 1 працівника, тис. грн	26,59	34,92	36,33	39,89	39,40	+12,81

Протягом досліджуваного періоду спостерігається поступове зростання кількості працівників, з 50 до 54 осіб, також це відповідає збільшенню кількості керівників та спеціалістів, які безпосередньо задіяні у дистрибуції товарів. Вища освіта співробітників є важливим фактором для успішного функціонування підприємства, оскільки висококваліфіковані працівники можуть більше сприяти інноваціям та краще розвивати свій потенціал. Проте, незважаючи на підвищення рівня освіти, є необхідність у постійному навчанні та розвитку.

Що стосується адміністративних витрат, їхнє збільшення з 10 949 тис. грн у 2019 році до 17 154 тис. грн у 2023 році вказує на зростання витрат, пов'язаних із управлінськими функціями підприємства. Це може бути наслідком не тільки розширення штату, але й впровадження нових технологій та систем управління. Витрати на оплату праці також зазнали істотних змін, оскільки збільшилися з 14 504 тис. грн у 2019 році до 22 911 тис. грн у 2023 році. Це підвищення пов’язане із зростанням середньомісячної заробітної плати, яка становила 26,59 тис. грн у 2019 році та досягла 39,40 тис. грн у 2023 році. Підвищення заробітної плати є важливим аспектом для утримання кваліфікованих працівників, проте також потрібно співвідносити це значення із продуктивністю.

Загалом продуктивність праці керівників та спеціалістів, яка збільшилася з 11 573 тис. грн на особу у 2019 році до 15 206 тис. грн у 2023 році, свідчить про зростання ефективності використання трудових ресурсів. Однак, незважаючи на позитивну динаміку, важливо звернути увагу на тенденції, що вказують на зменшення продуктивності праці з 2019 до 2021 року. Це вимагає пильного контролю з боку керівництва та впровадження нових методів управління, які можуть підвищити ефективність роботи персоналу.

Таким чином, результати аналізу вказують на позитивні тенденції в підвищенні кваліфікації персоналу, проте також виявляють негативні аспекти, такі як зростання зарплатомісткості та зниження зарплатовіддачі, відсутність чітко встановлених ключових показників ефективності та контролю за результатами діяльності окремих працівників, а не підприємства загалом. Це потребує подальшого моніторингу і впровадження стратегій, які сприятимуть підвищенню продуктивності праці, оптимізації витрат та покращенню управлінських процедур в ТОВ «Торговий дім «Галка».

Відповідно до штатного розпису ТОВ «Торговий дім «Галка», на підприємстві працює 53 особи, серед яких найбільша кількість фахівців з методів розширення ринку збуту. Кваліфіковані працівники в цій сфері виконують важливу роль у підвищенні ефективності діяльності ТОВ «Торговий дім «Галка». Завдяки їхньому професіоналізму, ТОВ «Торговий дім «Галка» може розширювати асортимент продукції, вводити нові товари на ринки і знаходити ефективні канали збуту. Це, в свою чергу, призводить до збільшення фінансових показників і росту активів підприємства.

У ТОВ «Торговий дім «Галка» для ефективного адміністрування кадрів використовується різноманітна документація, яка охоплює всі етапи управління персоналом. По-перше, штатний розпис відображає структуру підприємства, визначаючи кількість посад, а функціональні обов'язки кожного із працівників вказані у посадових інструкціях. Це є основою для формування кадрової політики. Трудові договори регулюють відносини між роботодавцем і працівниками, окреслюючи права, обов'язки та умови праці.

Особисті справи працівників містять всю необхідну інформацію, включаючи резюме, копії документів та записи про підвищення кваліфікації. Крім цього в ТОВ «Торговий дім «Галка» збору інформації про працівників приділяється

значна увага. Документування даних, таких як дата народження, рівень освіти та трудова діяльність, дозволяє забезпечити контроль за кадровими ресурсами підприємства та сформувати кадровий резерв.

Внутрішні нормативні акти, такі як політики та інструкції, визначають процедури роботи з персоналом у питаннях найму, звільнення, атестації та навчання. Проте, недоліком у адмініструванні кадрового потенціалу є відсутність систематизованих звітів про виконання планів, які фіксують результативність роботи працівників та демонструють показники продуктивності виконання встановлених цілей. Також на підприємстві немає чітко прописаних щомісячних KPI (ключових показників ефективності) для керівників та службовців і не використовуються спеціалізовані програмні продукти для здійснення управління персоналом.

Прийняття усіх ключових рішень у сфері адміністрування кадрового потенціалу здійснює генеральний директор, який відповідає за загальне керівництво підприємством та стратегічний розвиток. Ним затверджуються рішення щодо кадрової політики, такі як планування потреби в кадрах, визначення основних напрямків розвитку персоналу, а також політики щодо утримання працівників. Це свідчить про доволі високий рівець централізації.

На оперативному рівні деякі рішення можуть прийматися керівниками відділів, які відповідають за реалізацію конкретних управлінських процедур, таких як проведення співбесід спільно з директором, атестацій та навчання персоналу. Начальники відділів, зокрема: начальник відділу роздрібної торгівлі, начальник відділу зовнішньоекономічних зв'язків та начальник відділу фірмової торгівлі відіграють ключову роль у формуванні і реалізації процедур, пов'язаних з безпосереднім управлінням своїми підлеглими.

Проведемо оцінку сильних та слабких сторін системи адміністрування персоналу, а також виявимо можливості та загрози для ТОВ «Торговий дім «Галка» (табл. 4).

Таблиця 4

SWOT – аналіз адміністрування персоналу в ТОВ «Торговий дім «Галка»

Сильні сторони	Слабкі сторони
1. Кваліфіковані працівники з вищою освітою, які мають значний досвід роботи на підприємстві. 2. Активні інвестиції в покращення умов праці та зростання заробітної плати. 3. Внутрішні тренінги для навчання персоналу. 4. Розвинена корпоративна культура.	1. Недостатнє зростання продуктивності праці. 2. Зростання зарплатомісткості та зменшення зарплатовіддачі. 3. Відсутність чітко встановлених KPI для кожного працівника. 4. Високий рівень централізації, оскільки всі ключові рішення щодо адміністрування кадрового забезпечення та управління персоналом приймаються генеральним директором.
Можливості	Загрози
1. Підвищення кваліфікації персоналу	1. Конкуренція на ринку праці, що може

шляхом міжнародних тренінгів та обміну досвідом. 2. Впровадження сучасних програмних продуктів для моніторингу та управління персоналом. 3. Розширення обсягів збуту та вихід на нові ринки завдяки креативним рішенням працівників. 4. Залучення молодих спеціалістів, які приносять нові ідеї та сучасний підхід до роботи.	призвести до дефіциту кадрів та підвищення витрат на їх залучення. 2. Значні інвестиції у навчання працівників, що зумовлені розвитком технологій, трендів тощо. 3. Вплив повномасштабної війни та зміни в економічній ситуації України. 4. Зміни в законодавстві.

За результатами проведеного аналізу сильними сторонами ТОВ «Торговий дім «Галка» є наявність кваліфікованих працівників з вищою освітою та багаторічним досвідом роботи на підприємстві, активні інвестиції в зростання заробітної плати, що підвищує мотивацію працівників, а також внутрішні тренінги для навчання персоналу. Це створює стабільну базу для забезпечення хорошої якості роботи та підвищення конкурентоспроможності на ринку.

Проте, аналіз також виявив кілька важливих слабких сторін, таких як недостатнє зростання продуктивності праці, збільшення зарплатомісткості та зниження зарплатовіддачі. Це свідчить про те, що, незважаючи на інвестиції в оплату праці, продуктивність не зростає на достатньому рівні. Високий рівень централізації в прийнятті ключових рішень щодо адміністрування управління персоналом може обмежувати гнучкість і оперативність реагування на виклики.

Разом з тим, можливості для розвитку включають підвищення кваліфікації персоналу через не лише внутрішні прогами, а й міжнародні тренінги та обмін досвідом. Також автоматизація процесів щодо управління потенціалом вимагає впровадження сучасних програмних продуктів для моніторингу за досягненнями працівників, що є необхідним у сучасному конкурентному середовищі. Використання таких інструментів може значно підвищити ефективність роботи персоналу, покращити контроль за виконанням завдань і знизити кількість помилок в управлінських рішеннях. Розширення обсягів збуту та вихід на нові ринки можна досягнути шляхом розвитку завдяки креативним рішенням працівників, а також шляхом залучення молодих спеціалістів, що принесуть нові ідеї та сучасний підхід до роботи. Це може суттєво підвищити ефективність і продуктивність праці, а також забезпечити стабільне зростання компанії в умовах конкурентного ринку.

Таким чином, для успішного адміністрування і управління персоналом керівництву ТОВ «Торговий дім «Галка» необхідно зосередитися на кількох основних напрямках. Перш за все, важливо зменшити вплив існуючих слабких сторін, що ускладнюють управління персоналом. Для цього необхідно впровадити чіткі механізми моніторингу і оцінки ефективності роботи працівників, а також удосконалити процеси управління кадрами. Крім того, значну роль відіграє запровадження системи мотивації, що буде відповідати

реальним потребам працівників і стимулювати їх до підвищення результативності, генерації нових ідей та професійного розвитку.

Для успішного розвитку адміністрування управління персоналом в ТОВ «Торговий дім «Галка» необхідно вжити заходів, спрямованих на усунення виявлених недоліків та реалізацію потенціалу працівників.

Одним із важливих методів, що допомагає управляти персоналом, є мотивація, яка відіграє ключову роль у підвищенні продуктивності, задоволення роботою та утриманні талановитих кадрів. Зважаючи на це, для ефективного управління персоналом, керівництву слід впроваджувати різноманітні методи заохочення співробітників. У сучасних умовах, особливо під час воєнного стану, традиційні методи мотивації можуть бути доповнені новими підходами, які враховують специфічні потреби та обставини працівників.

Одним з ефективних підходів є надання гнучкого графіка роботи. Цей метод дозволить працівникам краще балансувати між професійними та особистими обов’язками, що особливо важливо в стресових умовах. Програми психологічної допомоги також мають велике значення, оскільки вони підтримують ментальне здоров’я співробітників, допомагаючи їм справлятися зі стресом та підвищувати свою стресостійкість. Додаткові матеріальні стимули, такі як одноразова грошова допомога, оплата оренди житла або надання корпоративного житла, також можуть значно підвищити лояльність працівників. Це особливо актуально для тих, хто стикається з економічними труднощами або потребує додаткової підтримки у зв’язку з переміщенням чи втратами, спричиненими війною.

Крім того, в умовах воєнного стану з’являються нові методи мотивації, що базуються на взаємодопомозі та взаємопідтримці. Спільні волонтерські проекти на підприємстві можуть об’єднувати працівників навколо спільної мети, підвищуючи їхню соціальну відповідальність та згуртованість. Збирання коштів для мобілізованих працівників та членів їхніх сімей створює відчуття спільноти і підтримки, що зміцнює внутрішні зв’язки і підвищує мотивацію працювати на благо підприємства.

До альтернативних напрямків адміністрування персоналу можна віднести такі:

1. Впровадження програм ротації персоналу, оскільки це дозволяє працівникам набувати нових навичок і досвіду, працюючи на різних посадах всередині компанії. Це сприяє гнучкості та адаптивності співробітників, підвищує їх мотивацію і забезпечує більш глибоке розуміння всіх аспектів підприємства та дозволяє розкрити їх потенціал.

2. Інвестування в коучинг і менторство для підтримки розвитку працівників. Це сприятиме передачі знань і досвіду, підвищенню рівня компетенцій і розвитку лідерських якостей.

3. Реалізація програм управління талантами, що полягає у розробці стратегій і програм для ідентифікації та розвитку талановитих співробітників. Це може включати оцінку потенціалу, створення індивідуальних планів розвитку та кар'єри тощо.

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1.5. Public Debt of Ukraine 2024: Current State and Impact on the Country's Economy

Public debt is an objective economic phenomenon caused by the state attracting additional financial resources on credit terms to ensure the implementation of the functions and tasks assigned to it. Public debt deforms the economy, slows down the development of real economic processes and ultimately does not allow the country to develop effectively. A large burden falls on the state budget. It is constantly in a crisis, which is deepening more and more. This determines the formation of a significant part of the domestic debt in Ukraine, which is growing more and more. In the economy of Ukraine, public debt is increasingly becoming not only a financial, but also a socio-political problem, which is directly related to the problem of the country's economic security. The issue of managing and servicing public debt in the context of the economic difficulties that Ukraine is experiencing is gaining importance. On the other hand, public debt is sometimes profitable, it allows you to maintain a constant level of consumption and finance the necessary investments. It is worth noting that the growth of public debt and debt burden is currently characteristic of both developing countries and leading countries.

The issue of public debt becomes particularly relevant during a full-scale war in Ukraine. After all, a significant part of public financial resources will be forced to be directed to defensive actions and measures of our country, which, in turn, also affects the increase in the size of public debt.

Today, in many countries of the world, in particular in Ukraine, the problem of public debt is acute. The example of Greece has shown that excessive debt is dangerous for the economy. An increase in public debt significantly affects the most important economic indicators, such as: inflation, economic growth, interest rates on government bonds.

It is impossible to say for sure whether high public debt hinders the economic development of the country. Theoretically, less economically developed countries, given financial constraints and economic needs, should have a higher level of public debt relative to GDP than highly developed countries. However, comparing data on the ratio of public debt to GDP in EU member states, it can be noted: higher indicators are in more developed countries. The latter, in fact, are the largest creditors of the world economy, while having the largest amounts of public debt both in absolute terms and in relation to GDP.

Such a situation may indicate a relatively positive impact of public debt on the economic development of these countries, or a positive impact of economic growth on the size of public debt. However, the experience of many countries, both economically highly developed and developing, indicates that too high a ratio of public debt to GDP can lead to increased investment risk in the country, an outflow of foreign capital and, as a result, a depreciation of the national currency.

Obviously, this situation will negatively affect the rate of economic growth. It is also possible that a small public debt slows down economic growth, and low growth means a decrease in budget revenues and an increase in debt. A certain number of countries, in particular in Western Europe, are aware of the negative economic

consequences of excessive public sector debt. Some of them have already implemented reforms to save money, others are going to do this. After all, the higher the value of public debt, the greater the likelihood of a public finance crisis. Rising unemployment, falling GDP and declining wages are just some of its consequences that hinder the country's economic development. As a result of the unsatisfactory financial condition of the public sector, household savings are spent on repaying higher-level obligations, rather than financing the development of companies. This will become a problem for future generations - they will have less capital at their disposal.

Public debt is an important component of public finances. The issues of public debt in Ukraine and the world, comparison of public debt indicators, its essence, features of implementing various measures for its repayment, were studied in their works by Ukrainian scientists and economists: O. Baranivskyi, O. Bec, L. Bench, T. Vakhnenko, A. Galchynskyi, S. Horska [3], V. Zhuravel, A. Ilarionova, A. Yerina, V. Lyzovenko, G. Menkiw, A. Sarkiyants.

The presence of public debt, its size, location and repayment methods directly or indirectly affect almost all aspects of the economic life of the state, such as: the state budget deficit, the size of the money supply in circulation, which determines the inflation rate, the narrowing or expansion of aggregate demand and supply, etc. This makes public debt not only a means of raising funds to finance state needs, but also an important instrument of state financial policy, the improper use of which can lead to significant complications or even a financial crisis.

The purpose of the study is to study and analyze the main trends and specific features of the formation of public debt in Ukraine, as well as to develop practical recommendations on the mechanism of its impact on economic growth on this basis.

According to the current legislation of Ukraine, public debt is defined as the total amount of debt obligations of the state for the repayment of received and outstanding credits (loans) as of the reporting date, arising as a result of public borrowing. In Art. 2 of the Budget Code of Ukraine defines that public debt is the total amount of debt obligations of the state to repay received and outstanding credits (loans) as of the reporting date, arising from public borrowing; state-guaranteed debt is the total amount of debt obligations of entities - residents of Ukraine to repay received and outstanding credits (loans) as of the reporting date, the performance of which is secured by state guarantees [1].

In the global economy, the total world debt is growing annually and is 2.5 times higher than the annual earnings of the world's population. This was preceded by a number of different reasons, due to which states were forced to borrow funds. Today, the problem of public debt is one of the main ones in Ukraine. This is due to the fact that our country, like many other states in the world, regardless of the level of their financial and economic development, is unable to concentrate in the budget enough funds for its functioning. The full-scale war in our country undoubtedly has a significant impact on the growth of the amount of public debt.

As of September 30, 2024, the total state debt amounted to 6,404,002.0 million UAH. The state debt itself arises as a result of financial borrowings by the state,

contracts and agreements on the provision of credits and loans, prolongation and restructuring of debt obligations of previous years. The total debt obligations of the state also include state-guaranteed debt, which arises as a result of guarantees assumed by the state for the obligations of third parties, or third party obligations assumed by the state. The full structure of state and state-guaranteed debt according to the Ministry of Finance of Ukraine as of September 30, 2024 is provided in Table 1. The total amount of Ukraine's state debt in dollars is 155,563.8 million USD. According to research, Ukraine's total debt has been growing steadily over the past five years, and in 2022 there was a sharp jump, as a result of which the state debt increased by 52.4%.

Table 1.

Structure of the state and state-guaranteed debt of Ukraine as of 30.09.24 (mln. UAH)

(mln. UAH)	external		internal		total	
national debt	4 393 214,9	68.6%	1 723 806,8	26.9%	6 117 021,7	95.5%
guaranteed debt	219 776,4	3.4%	67 203,9	1.0%	286 980,3	4.5%
cumulative	4 612 991,3	72.0%	1 791 010,7	28.0%	6 404 002,0	100.0%

The dynamics of the state debt in 2024 are given in Table 2:

Table 2.

State and state-guaranteed debt of Ukraine in 2024 (mln. UAH)

	Total debt		External debt	Domestic debt
As of 31.12.23	5 519 483,9	7.8%	3 862 987,6	1 656 496,3
As of 31.01.24	5 488 047,3	-0.6%	3 817 649,8	1 670 397,5
As of 29.02.24	5 490 098,4	0.0%	3 824 714,5	1 665 383,9
As of 31.03.24	5 924 253,8	7.9%	4 239 526,2	1 684 727,6
As of 30.04.24	6 010 422,3	1.5%	4 298 920,3	1 711 502,0
As of 31.05.24	6 115 263,5	1.7%	4 410 115,9	1 705 147,6
As of 30.06.24	6 167 972,6	0.9%	4 456 377,7	1 711 594,9
As of 31.07.24	6 374 089,1	3.3%	4 633 078,9	1 741 010,2
As of 31.08.24	6 371 687,6	0.0%	4 621 215,7	1 750 471,9
As of 30.09.24	6 404 002,0	0.5%	4 612 991,3	1 791 010,7

Table 3.

Dynamics of Ukraine's total public debt and GDP from 2009 to 2024 (million UAH)

Public debt (total)				Gross Domestic Product (GDP)				public debt / GDP
31.12.09	316 885			2009	913 345			34.7%
31.12.10	432 235	+115351	36.4%	2010	1 082 569	169224	18.5%	39.9%
31.12.11	473 122	+40886	9.5%	2011	1 316 600	234031	21.6%	35.9%
31.12.12	515 511	42389	9.0%	2012	1 408 889	92289	7.0%	36.6%
31.12.13	584 114	68604	13.3%	2013	1 454 931	46042	3.3%	40.1%
31.12.14	1 100 564	516450	88.4%	2014	1 566 728	111797	7.7%	70.2%
31.12.15	1 572 180	471616	42.9%	2015	1 979 458	412730	26.3%	79.4%

31.12.16	1 929 759	357579	22.7%	2016	2 383 182	403724	20.4%	81.0%
31.12.17	2 141 674	211916	11.0%	2017	2 982 920	599738	25.2%	71.8%
31.12.18	2 168 627	26953	1.3%	2018	3 558 706	575786	19.3%	60.9%
31.12.19	1 998 275	-170352	-7.9%	2019	3 974 564	415858	11.7%	50.3%
31.12.20	2 551 936	553660	27.7%	2020	4 194 102	219538	5.5%	60.8%
31.12.21	2 671 828	119892	4.7%	2021	5 459 574	1265472	30.2%	48.9%
31.12.22	4 071 683	1399856	52.4%	2022	5 191 028	-268546	-4.9%	78.4%
31.12.23	5 519 484	1447801	35.6%	2023	6 537 825	1346797	25.9%	84.4%
30.09.24	6 404 002	884518	16.0%	2024				

Analyzing the data, we can state the fact that Ukraine's public debt is negligible compared to the leading countries of the world, which allows us to draw the following conclusion: the amount of total debt directly depends on the level of economic development, that is, the more developed a country is, the greater its debt.

For many years, economists have attempted to assess the dependence of GDP growth on the size of public debt. K. Reinhart and K. Rogoff, in their work "Growth in the Time of Debt," investigated the question of whether public debt slows down economic growth. The scientists analyzed data from 44 countries over 200 years and obtained about 3,700 development models [4]. As it turned out, public debt is of little importance until it exceeds 90% of GDP. Otherwise, real economic growth slows down significantly. The dynamics of Ukraine's total public debt and GDP from 2009 to 2024 are shown in Table 3[2]. As we can see from the data provided by the Ministry of Finance in Table 3, the ratio of public debt to GDP has been constantly growing in recent years and in 2023 amounted to 84.4%. The significant increase in this indicator is due, first of all, to the full-scale war in our country.

At the same time, it would be appropriate to mention the largest debtor - the USA, whose public debt in 2023 exceeded 34 trillion dollars [5], most of which is domestic debt. However, despite this, the USA is one of the world's main lenders, as well as the most economically developed country. According to research, only 2 countries out of 206 have zero public debt [7]. These are East Timor and Macau (autonomy within China). 25% of Macau's GDP belongs to the tourism sector, and 40% to the gambling business. In terms of revenue received from this business, Macau has long overtaken Las Vegas. The basis of the economy of Brunei and Libya (countries with the lowest public debt) is oil and gas production; about 90% of GDP is provided by this industry.

Among the EU member states, Estonia (8% of GDP), Luxembourg (21.7%) and Bulgaria (23.1%) have the lowest debts [7]. Estonia is the only post-socialist country that has managed to avoid excessive debt, although it does not have rich natural resources. This country has managed to achieve success thanks to a responsible economic strategy and high state reserves. Japan has the worst ratio of public debt to GDP, it is 236%. The advantage is that the main creditors of the state are its citizens. Greece's public debt is 324 billion euros, or 183% of GDP.

The US is a debtor to China, Japan, the UK, Switzerland, Taiwan, Brazil, that is, those states that export oil, hold bonds, have mutual investment funds. But the bulk of the US debt is owed to its citizens, companies and government organizations. The

largest debt is to the Federal Reserve System (FRS), which serves as the country's central bank. Since GDP grows by 3% annually, this makes it possible to maintain record low Fed rates - debt servicing costs only 0.25-0.5% of GDP per year [5].

The national debt of Ukraine is the total debt obligations of the state to all creditors (legal entities and individuals, foreign states, international organizations, etc.). The national debt consists of the debts of the central government, regional and local authorities, as well as the debts of all corporations with state participation, proportional to the state's share in their capital" [6].

Undoubtedly, the causes and consequences of public debt in different countries are very different. Therefore, public debt can have a negative, positive and neutral impact on economic development. For example, 1,000 euros spent by the governments of the Netherlands and Portugal have completely different meanings for domestic development and public debt, in particular due to differences in GDP sizes and the presence of a shadow economy.

The feasibility of public debt depends on the effectiveness of the organization of fiscal policy, political, judicial systems and many other factors. However, one cannot definitely hope that a large loan will provide significant growth, and the consequence of increasing debt may be a slowdown in economic development and rising inflation. In most countries of the world, the size of public debt is regulated by law. Of course, any country is interested in reducing or completely repaying public debt. In Ukraine, the issue of public debt management is determined by medium-term strategies (3-4 years), as well as short-term (annual) public debt management programs. According to Article 16 of the Budget Code of Ukraine, such a strategy is developed by the Ministry of Finance of Ukraine, approved by the Cabinet of Ministers of Ukraine every year, no later than June 1 of the year preceding the planned one. The strategy itself is formed on the basis of indicators determined by the Budget Declaration and the Law on the State Budget of Ukraine. At the moment, these strategies are not entirely relevant, as they are designed for a stable economic situation within the country, however, starting from February 2022 with the introduction of martial law, as a result, revenues to the state budget aimed at repaying this debt were reduced, which leads to a discrepancy between the current situation and the defined strategy. They were reduced as a result of the destruction of critical infrastructure of cities, a decrease in tax revenues, an increase in spending on defense and critical infrastructure and ensuring national security.

Currently, several main factors that form national security are recognized: political, economic, ideological-cultural and military. The level of state debt and budget surplus/deficit are currently not considered separate factors of national security, both in society and in the government. First of all, this is due to the fact that state debt and budget deficit are purely economic factors, according to the government. But it affects both the economic state of the country and the political one.

In Western countries, the state budget not only provides for the accumulation of resources that finance a number of specific financial and economic issues, but also to maintain the right social mood within the state and strengthen security. In Ukraine,

such functionality has not been developed even theoretically, not to mention practical developments.

The government should form an effective debt management system that would ensure financial stability. Important measures to improve debt policy are the development of a medium-term debt strategy, the use of borrowing for development purposes, debt structure diagnostics, orientation to the domestic market and stimulation of business activity, etc. [8].

One of the most effective measures to reduce Ukraine's public debt is the de-shadowing of the country's economy. It should be noted that the amount of funds that the state budget of Ukraine received from de-shadowing in 2024 can be compared to the assistance provided by Canada for this year. Canada is among the top 5 countries in terms of the volume of support for Ukraine. Thus, the removal of businesses from the shadows and the elimination of illegal schemes brought the country $ 1.67 billion. Revenues from de-shadowing on taxes administered by the State Tax Service reach 6.1% of the international assistance provided this year.

Resolving the problem of servicing the public debt is one of the most important factors in ensuring macroeconomic stability in Ukraine. The nature of the debt problem determines the country's fiscal potential, the state of its foreign exchange reserves and, thus, the stability of the national currency, interest rates, the investment climate, the behavior of all segments of the domestic financial market and the impact of government borrowing on the financial system and the economy.

The main problem is the lack of a permanent strategy for working with debt and certainty regarding debt instruments, which are currently quite chaotic and situational. It is difficult to predict future participation in international capital markets due to uncertainty and situational factors in the choice of debt instruments. Thus, international investors have a certain interest in Ukrainian debt instruments, their activities are largely restrained, speculative and conditioned by excessively high interest rates from the point of view of global lending.

At the same time, the general trend indicates a gradual increase in investor confidence in the Ukrainian economy. It is especially encouraging that foreign investors are paying more attention to the Ukrainian Eurobond market, which has demonstrated positive development dynamics in recent years. Periodic improvement of Ukraine's creditworthiness as a sovereign borrower, assignment of credit ratings to a number of Ukrainian companies and banks contributes to Ukraine's increased participation in international debt capital markets and contributes to more favorable lending conditions.

Since external borrowing is an actual export of capital outside the country, since it essentially involves the sale to non-residents (even if they are conditional residents) of the right to receive part of the profit from residents of Ukraine, that is, the capitalization of the national economy, Ukraine's external debt should be kept at a relatively low level. In this context, internal borrowing, as a means of redistributing income within the country, seems more acceptable for an economy with a capital deficit.

However, debt financing of the budget deficit seems acceptable in addition to the needs for servicing past debts only if it represents the potential for future development.

This applies to both direct budget investments and the creation of conditions for sustainable, rapid and high-quality economic growth of the economy as a whole. Such conditions may include, in particular, the improvement of production, transport, energy, information, etc., infrastructure. Part of the investment in the development of human capital should be included in the same category, especially in the training and retraining of workers in accordance with the requirements of the labor market, the development of relevant educational institutions, etc. Today, the above-mentioned challenges for our country, in conditions of martial law, are relevant and to some extent uncertain.

The task of the administration of obligations is strategically to maintain the correct ratio of debt and fiscal financing of budget expenditures. In the short term, the attraction of borrowed funds makes it possible to reduce the tax pressure on the economy in the sense of using additional funds attracted by enterprises for their development. At the same time, in this way, current budget expenditures will be financed at the expense of resources of future value added, so long-term economic development slows down.

Based on the above, the strategy for forming and maintaining the government loan market should be based on scientifically sound principles. To ensure a balanced budget, stable economic growth and a strong financial system, it is necessary to forecast the structure and size of the government debt for several years and even decades. Without such a strategy, the economic crisis will worsen, and the government debt will grow.

The Ministry of Finance needs to constantly analyze and monitor the situation within the country and monitor the reaction of foreign investors to Ukrainian bonds. It is also necessary to be guided by the attraction of long-term credit funds for the implementation of large projects that will become a significant part of the national economy in the future, and not short-term loans only to cover the deficit.

In the long-term post-war period, it is worth paying attention to increasing the return on public investments. Which is the most important factor for the successful receipt and expenditure of borrowed funds. This requires the following main tasks: optimization of programs receiving public investments; reduction of the number of public programs; preparation of a medium-term investment budget; development of economic criteria for the distribution of budget investments. When solving these economic issues, changes should occur that will lead to more effective use of debt and reduce the impact of borrowed funds on the national economy as a whole.

The high volume of Ukraine's public debt, its imperfect structure, and its significant level relative to GDP require decisive action in favor of its limitation.

Based on the above material, it is possible to formulate proposals that will have a significant impact on economic growth and reduction of public debt:

- not external loans, but internal borrowings are economically justified. In this case, debts do not increase the monetary base and the turnover of financial funds is carried out within the state;

- it is necessary to change the structure of public expenditures, which involves increasing the share of development expenditures. It is of principle that expenditures on innovation and entrepreneurship prevail in their structure. It is also necessary to fully and effectively use the resources of international funds;

- entrepreneurship, which will stimulate economic development, requires systematic and consistent support, and this requires stable conditions for the functioning of enterprises in the long term;

- it is necessary to ensure discipline in income and expenditure of public finances along with the simultaneous simplification of the system of fiscal burdens in order to increase the effectiveness of their implementation.

According to the results of the study, it can be noted that there is a direct relationship between the budget deficit and the growth of public debt, which indicates the need for effective financial management and control over budget expenditures. Different methods of financing the budget deficit have their advantages and disadvantages, and it is important to choose the optimal approach for each specific situation, for example, the issue is, although simpler, but more detrimental to the economy than a government loan. The structure of public debt differs depending on the level of development of the country, which may affect its economic stability and ability to repay debt. Also, public debt management both in Ukraine and around the world requires effective strategies and control, which requires further research and improvement.

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1.6. Administration of the Intellectual Potential of a Higher Education Institution in the Context of the Implementation of the European Educational Vector

The Encyclopedia of Modern Ukraine states that "intelligence (from the Latin intellectus - understanding, reason, cognition) is a relatively stable structure of an individual's mental abilities" [2]. Throughout life, a person develops and realizes his or her intellectual abilities. At the same time, the development of an employing organization depends on the level of intellectual potential of employees and the conditions created for its realization.

Intellectual potential (IP) is a category that is constantly in the field of interest of both domestic scholars S. Vovkanych, O. Hridin, V. Doroshenko, V. Kasatkina, Y. Kanygin, O. Kendyukhova, S. Kniaz, N. Kuzminska, B. Malytskyi, V. Mamonov, Y. Sytnyk, as well as foreign scholars L. Edvinson, R. Lucas, S. Palianytsia, O. Plaksiuk, P. Romer, I. Schumpeter, J. Strickland and many others. The problems of formation, development and assessment of intellectual potential are studied in the works of these and many other scholars. However, the problem of administration of the intellectual potential of higher education institutions has not yet been studied sufficiently.

Intellectual potential (IP) is a set of undiscovered capabilities based on knowledge, skills, abilities, and competencies that can be realized to achieve high end results.

Intellectual potential is a system of accumulated knowledge, skills, abilities, qualifications and experience of personnel, which is formed under the influence of natural abilities and investments in them for further economic efficiency of the enterprise, necessary self-development, improvement of the quality of working conditions in modern society, etc.

V. Lapotkov distinguishes primary and secondary components of intellectual potential[5]. As for the primary ones, they are of a personal nature and include:

- employees' intelligence, which is expressed in their knowledge, skills and professionalism;
- the ability to search, research, and analyze
-ability to cooperate with other organizations in the development and exchange of intellectual resources;
- ability to develop corporate culture.

Secondary (representative) components of intellectual potential include the results of intellectual potential realization embodied in certain products:

- innovative goods, services, solutions that are the embodiment of intellectual potential;
- intellectual property objects (inventions, industrial designs, trademarks, rationalization proposals) obtained by the enterprise as a result of intellectual activity of employees;
- the company's brand and reputation.

Some scholars are of the opinion that administration is bureaucratic management, which is realized by means of influence on subordinates through the authority and power of managers, through the use of administrative methods (orders, instructions, resolutions, instructions, etc.).

Administration, according to M. Voynarenko and O. Kostiuk, is a professional activity of managers aimed at finding the best ways to fulfill the tasks received from top management [1].

The definition of the essence of administration, formulated by Y. Myronenko, as a set of interrelated management operations used in the process of implementing administrative activities by making changes to the activities of the object of administration, is quite thorough [3].

In our opinion, IP administration is a type of management activity that is implemented through the influence of the management system on the managed system (employees) in order to identify, develop and implement abilities, knowledge, skills, competencies through the use of formalization and regulation tools in the process of performing management functions (organizational rules, regulations, instructions, standards, guidelines and job descriptions, procedure manuals, etc.)

In today's world, without intellectualization of science and education, it is impossible to ensure the development of the modern economy, solution of social problems and development of Ukrainian society.

I. Prokopenko and O. Melnikova consider higher education as a factor of economic growth in Ukraine. In order for it to really contribute to the economic growth of the Ukrainian economy, in their opinion, it is appropriate to take a number of measures aimed, firstly, at improving the quality of education; secondly, at its informatization; thirdly, at its internationalization [6].

When administering the intellectual potential of scientific and pedagogical staff in Ukraine, a higher education institution (HEI) should aim to increase the competitiveness and integration of the institution, each researcher and student into the European and world educational, scientific and economic space. Thus, V. Mudrak emphasizes that higher education, which promotes the transfer of knowledge, is becoming the main factor in the resource provision of social transformations, social and economic development. It is the knowledge and intellectual potential of an individual who creates new resource-saving technologies, offers new models of socio-economic growth; ultimately, it is the educated, creative individual who becomes the main resource of the postmodern economy [4].

In the context of the development of higher education in Ukraine in the European educational space, the professional competence of the teaching staff, the reorientation of their thinking to the awareness of modern requirements for their professionalism, is of particular importance. The ability of the academic staff to meet these requirements is closely related to the personal qualities of the teacher.

Academic staff should take into account the fact that the new generation of students has high criteria for life and people, well-reasoned judgments, and is acutely aware of the teacher's genuine passion for his or her work, sincere interest in the transfer of knowledge, and the uniqueness of the teacher's personality or lack thereof.

Therefore, the modern academic staff needs not only to adapt to the realities of today, but also to realize the conceptual position of the need for lifelong learning, continuous self-improvement and self-development of their intellectual potential.

Continuous intellectual development of the SPS is a condition for the success of his/her professional career.

The carriers of intellectual potential that ensure the integration of higher education institutions into the European and global scientific and educational space are, first of all, scientific and pedagogical staff working as professors, associate professors, senior lecturers, and assistants at the relevant departments. The conditions created by managers of different levels of higher education institutions determine the ability of the academic staff to realize their intellectual potential in the form of writing scientific papers, educational and methodological activities, conducting research, developing new courses, and participating in various projects.

The administration of intellectual potential at the departments is carried out in accordance with the regulations governing the activities of higher education institutions (HEIs). The quality of administrative measures depends on the professional qualities of managers at different levels of management, on the competence of employees and on the environment in which they work.

Policies, rules and procedures approved at the level of the HEI determine the vector of IP administration in structural units.

When administering the intellectual potential of an HEI, the activities of managers (heads of institutes, faculties, departments) should be based primarily on regulation (establishing rules, norms, standards), administration (issuing orders, instructions, instructions), coordination and control.

The use of certain rules and procedures in the process of IP administration determines the specifics of interaction between managers and subordinates. The effectiveness of intellectual potential administration is determined by the organizational structure, administration methods and organizational culture. The organizational structure of management should be built in such a way as to ensure the participation of employees in the development of management decisions, promote the intensification of intellectual activity, and create conditions for the continuous development and realization of the SPS potential. Administration methods ensure and determine the direction of realization of employees' functional duties, and thus the peculiarities of their intellectual activity. Organizational culture, which is represented by moral values, customs, and the cultural environment of the enterprise, has a significant impact on the realization of employees' IP.

When it comes to administration procedures, they are primarily determined by job descriptions that regulate the types and procedure of management activities and functions of academic staff.

The process of intellectualization of higher education institutions can be divided into the following stages:

- The first stage is the involvement of scientific and pedagogical staff with an appropriate level of intellectual potential, according to the regulation on competitive selection of candidates for vacant positions of scientific and pedagogical staff;
- second - development of the intellectual potential of the SPS;

- third - capitalization of intellectual potential results (transformation of intellectual potential into intellectual property objects and capital of the departments, and thus of the HEI).

The administration of intellectual potential at the institutional level of HEI management should be aimed at forming a personnel policy that would ensure its intellectualization.

The task of department heads should be to ensure the second and third stages of intellectualization:

- determination of the directions of use of the intellectual potential of each research and development center, taking into account the specifics of the potential it possesses;
- formation of a reserve of intellectual potential through the recruitment of graduate students and applicants;
- searching for investors to capitalize on the results of the intellectual potential implementation;
- creating the conditions necessary for the development of intellectual potential.

When forming the intellectual potential, the requirements for the intellectual level of officials are stipulated at the stage of contracting. The HEI has a regulation on the competitive selection of applicants for vacant positions of academic staff, which specifies the requirements for personnel, educational, scientific and international potential that determine the intellectual potential in the relevant areas. Among the main requirements:

- level of education
- knowledge of the state language;
- knowledge of a foreign language at the B2 level;
- advanced training;
- knowledge and experience of working with Internet services;
- publishing activity - availability of articles, manuals, electronic teaching and learning materials, etc;
- ownership of intellectual property protected by a relevant security document;
- performance of economic contracts, research and development works, scientific and technical programs, grants, etc.

An important place in the administration of the intellectual potential of the departments is occupied by the administrative activities of the head of the department and his/her deputies, which are related to

- ensuring the fulfillment of licensing requirements and provisions of the HEI;
- creation of conditions for the realization of the intellectual potential of the academic staff of the department;
- participation in the formation and approval of indicators for assessing the level of intellectual potential;
- control over the fulfillment of the terms of the contract, job descriptions and targets;

- formation of programs for the development of intellectual potential of the scientific and pedagogical staff of the department through internships, advanced training;

- participation in the formation of rules and regulations on organizational aspects of the Department's activities.

When administering the intellectual potential of the departments' academic staff, it is important to take into account the specifics of its components and the factors influencing the personality, and hence its potential. Accordingly, we can distinguish internal and external personal factors that determine the specifics of IP administration. Internal factors are related to the inherent natural potentials, psychological capabilities, and the results of changes in the subject in the process of personal development. External - reflect the conditions of the social environment and the person's reaction to the process of gaining social experience.

Among the internal personal factors that need to be taken into account when administering the IP of scientific and pedagogical staff of the departments are the following:

- physiological state (health, adaptation, quality of rest, external attractiveness);
- the ability to make transformations in the material and spiritual environment, to apply creative abilities (communication skills, creativity, professional activity, self-development);
- mental, motivational readiness of a person to engage in various activities to achieve a goal (professional competence, entrepreneurship, meaningful life, critical thinking);
- emotional and volitional state (stress resistance, values, responsibility, dominant emotions).

The external personal factors of the administration of the IP of scientific and pedagogical staff include:

- the degree of satisfaction of their material needs (availability of housing, financial capabilities, attractiveness of clothes, acceptability of income)
- social relations (social status, family, support of friends, relations with colleagues);
- information space of life, reflecting the specifics of world perception (access to information, availability of Internet resources, security of personal information);
- the environment of professional activity (corporate culture, support for initiative, material and technical support, working conditions).

An important task of department heads is to work with academic staff on: identifying motivational preferences, strengths and weaknesses of an individual; forming innovative and creative thinking; generating ideas; striving for continuous self-development and self-education; continuous improvement of qualifications, skills, abilities, competencies, level of knowledge, etc.

Under martial law, Ukrainian higher education institutions are forced to adapt to extraordinary circumstances. HEIs are making changes to their administration methods, moving from a traditional to a more flexible approach, which helps them better face the

challenges of today, make important management decisions and respond quickly to a changing environment. Nowadays, the problems of rapid implementation of changes, rethinking traditional systems of management of scientific and pedagogical staff and introducing modern management models, strategies and goals are becoming especially important for the departments. These new approaches are aimed at preserving and developing the intellectual potential of the departments, helping to maintain productivity and adapt to new conditions, which is extremely important in such difficult circumstances.

In the context of the war with Russia, the intellectual and, accordingly, mental burden on academic staff increases due to the number of conflict and stressful situations. Scientific and pedagogical staff are constantly in a situation of choice, uncertainty of the future, and several potential courses of action. All this negatively affects the realization of their IP.

An important factor in the preservation and development of intellectual potential is the motivation of SPS. In today's conditions, psychological assistance programs and one-time financial aid may become additional incentives for teachers. Along with the well-known ones, new methods of motivating teachers under martial law can also be identified, such as mutual assistance and mutual support, which are expressed in joint volunteer projects at the departments, fundraising for mobilized employees, their families, etc.

Among the factors that negatively affect the administration of intellectual potential are the factors of the macro environment and the micro environment of the higher education institution.

Macro-environmental factors were formed under the influence of the war in Ukraine and, therefore, their impact is primarily negative:

a) increased migration of labor force and potential applicants abroad;
b) a sharp change in the structure of the economy;
c) shortage of budget revenues;
d) aggravation of social and demographic problems;
e) growth in the number of socially vulnerable groups of the population;
f) inflation;
f) decline in investment activity;
h) weakening of economic sectors;
i) increased spending on military operations and defense;
h) unexpected financial losses due to the war.

Constant risks and significant limitations in state funding lead to a gradual destabilization of the situation in the education system.

The micro-environment of the departments is formed primarily under the influence of the management system of the HEI:

- insufficient funds for the renewal of fixed assets;
- rising cost of educational services;
- reduction of expenses for staff development.

The administration of the intellectual potential of higher education institutions is aimed at strengthening their competitive position in the domestic and foreign markets of educational services, given the limited state funding in times of war. To this end, innovative approaches should be implemented at the university, institute and department level to intensify marketing, investment, management, educational and research activities. Accordingly, the goals of intellectual potential administration will be aimed at its realization in these areas.

At the level of departments, these goals should be achieved by

- fulfillment of orders for research activities on the basis of economic calculation;
- conducting career guidance;
- organization and effective implementation of the contract form of education,
- attracting students from other countries to study;
- attracting investments for the implementation of activities;
- development of the material and technical base on a grant basis, etc.

The recommendations that will improve the administration of the intellectual potential of the departments relate primarily to improving the administration technology in accordance with the specifics of the management object, identifying priority areas for the development of the intellectual potential of scientific and pedagogical staff, and improving administration methods using IT technologies.

The general concept of administration is influenced by the policy of development of the intellectual potential of the SPS chosen by the management of the HEI, which should be aimed at:

1. Adaptation of the individual workload of the teacher based on the revision of the workload, taking into account the situation in the country, to maintain their productivity;
2. Retention / retention of professional scientific and pedagogical staff.
3. Providing psychological support and creating safe working conditions.
4. Stimulation of professional development and participation in international projects. Active use of such teaching methods as coaching, e-learning and self-study.
5. Sharing knowledge among departments by organizing round tables and scientific seminars.
6. Ensuring access to knowledge through access to databases of foreign educational institutions
7. Support in the process of processing documents for the protection of intellectual property of the department
8. Encouraging the conversion of ideas into intellectual objects.

Given the difficult situation in Ukraine, it is necessary to focus on the SPS, the bearers of intellectual potential, who are in difficult psychological, financial and material conditions. These conditions, as well as the results of the analysis of other factors, should be taken into account and the existing strategy and policy of administration of the development of intellectual potential of the academic staff of higher education institutions should be improved.

To improve the administration of IP, it is necessary to adjust the strategic and tactical goals:

1) strategic goals:

- clarification of the strategy of intellectual potential administration;
- clarification of the indicators used to assess the components of intellectual potential (human, scientific, educational potential) in the process of its formation, implementation and development;
- determination of the optimal resource provision for quality IP administration;
- ensuring the development of intellectual potential with due regard to risks.

2) tactical goals:

- analysis of the state of each element that has intellectual potential or is its embodiment;
- organization of work on the implementation of strategic directions of intellectual potential administration;
- assessment of the level of realization of the intellectual potential components (personnel, scientific, educational potential) by the SRP of the Department;
- search and implementation of effective methods of intellectual potential administration.

The conditions of martial law require a deliberate choice of administration methods to preserve and develop the HEI's SPS. Revision of the personnel policy is an important step in ensuring the stability and security of the SPS.

To improve the process of departmental administration, attention should be paid to:

a) monitoring of the IP administration system. At the same time, the objects of monitoring should be the processes of implementation of administration functions;

b) distribution and level of fulfillment of duties, powers and tasks by the subjects of administration (the management of the department and the SPS);

c) the external and internal environment of the departments and the HEI;

d) identification of problematic aspects in the administration of IP of departments with specification of factors and objects, subjects that are the most problematic;

e) conducting an interim assessment of the effectiveness of administration by components of the intellectual potential of the departments;

f) to formulate recommendations for improving the administration of the departments' IP.

The quality of administration of the intellectual potential of the SPS and the level of realization of the intellectual potential of scientific and pedagogical staff is determined by such an important component as managerial intellectual potential. Managerial IP is expressed in the progressive forms and tools of administration used by the manager to comprehensively unleash the potential of subordinates.

Today, most HEIs do not have separate criteria for rating the managerial intellectual potential of managers at different levels of management. Assessment of the intellectual potential of department heads is based on the same criteria as that of the SPS. However, it is necessary to take into account the specifics of the realization of their

managerial potential and assess its specific components. The IP of the managerial component, represented by managers of different levels of management, is an administration tool that ensures the functioning of the HEI and the achievement of the set goals through the realization of the intellectual potential of its own and the SPS. At the same time, the administration should ensure the rational use of all resources, optimize their movement, determine the efficiency of processes and the effectiveness of intellectual activity of the SPS. The managerial intellectual potential is determined by the managerial resource, which should be professional, innovative, creative, should make rational management decisions, and ensure the progressiveness of the management system.

In order to determine the main determinants of the development of managerial intellectual potential, it is necessary to perform the stages of forming the concept of assessment and forecasting of managerial potential development based on a human-centered value approach; systematize the determinants by components; formulate the main approaches to assessing the indicators of managerial potential development and the relationship between its components; determine quantitative indicators of financial support for the components of managerial potential development.

In our opinion, when administering the IP of the departments, attention should be paid to

- formation of information flows about the availability, quality, results of the intellectual potential of the departments;
- monitoring the effectiveness of processes (educational, scientific) as a result of the development of intellectual potential and its implementation;
- analyzing the results of the department's scientific and pedagogical staff rating to assess the effectiveness of administration;
- conducting activities to assess and identify problems of intellectual potential administration;
- improvement of information analysis systems for making optimal decisions in the process of intellectual potential administration.

Let us consider the technology of IP administration in accordance with our vision:

1. Formation of the IP administration strategy.
2. Defining the goals of intellectual potential administration (general and specific).
3. Use of administration tools for the realization of IP (principles, functions, methods, solutions).
4. Determination of criteria for assessing the intellectual component of human, scientific, educational, managerial potential.
5. Evaluation of individual indicators of the level of IP of the SPS, and, on their basis, general for the department.
6. Evaluation of compliance of indicators with the plan, determination of the place of the SPS in the ranking of the department by the level of realization of its potential and the impact of their indicators on the results of the department.
7. Analysis of the influence of the parameters of managerial intellectual potential on the indicators of the use of the department's potential.

8. Implementation of corrective measures in the administration system, if the results of the assessment of the SPS and managers indicate the need to improve the intellectual potential.

9. Checking the effectiveness of corrective measures by determining the change in the indicators of the use of the intellectual potential of the department after their implementation.

The following methods of IP administration should be used:

1) organizational methods - participation in the development and implementation of administrative norms on IP; issuance of orders, instructions and guidelines for the formation, implementation and development of IP; control over the implementation of job descriptions; approval of staffing, approval of individual workload, formation of educational programs, formation of plans for professional development, formation of regulatory documentation;

2) economic methods - search for customers to conclude business contracts, material incentives for the work of the SPS, search for patrons;

3) socio-psychological methods - formation of corporate values, hiring, promotion of persons with high IP; improvement of the positioning of departments using career guidance activities; development of partnerships between teachers and students; mentoring for adaptation of new employees;

4) legal methods - application of regulations on licensing and accreditation of educational programs, copyright regulation, application of regulations on relations between the department and service consumers;

5) technological methods - the use of technological and design documents used in management activities and in the provision of services.

Participation in international projects, most of which are funded by EU countries, is an important area that will allow raising funds for the implementation of measures to administer intellectual potential and implement the ideas of the SPS. These are, first of all, the international educational projects Erasmus+CA2, Erasmus+Jean Monnet. "Horizon Europe, EUREKA (European Research Coordination Agency), the Eurasia Program of the Fulbright Program, and others. Services for finding information about a potential international partner for the implementation of educational and research projects are:

The services for finding information about a potential international partner for the implementation of educational and research projects are:

1. The European Commission's Funding & Tender Opportunities portal, where you can find information about EU-funded projects.

2. The CORDIS platform, which contains information on all research projects funded by the EU under its framework programs: research areas, participants, repoSPS, links to publications.

3. The EURESEARCH search service, which contains information on cooperation opportunities under the EU's Horizon Europe program.

4. The Net4Society database, which aims to provide advice to researchers and other relevant stakeholders in their effoSPS to obtain EU funding.

5. The Enterprise Europe Network Cooperation Opportunities database, which helps enterprises, including universities and research institutes, to innovate and grow internationally.

6. The website of the National Agency Erasmus+ Ukraine, which is related to education and aims to develop human potential.

7. Otlas offers a variety of international projects and partners for their implementation.

8. The eTwinning platform, which promotes the development of international cooperation in education through the implementation of joint projects, participation in professional development activities, obtaining quality awards, and participation in conferences.

9. EPALE platform, which is designed for adult learning, funded by the European Union through Erasmus+.

Another area that should be addressed by the IP administration is the licensing of new educational programs that will be practical, modern and interesting for applicants. Even more ambitious for Ukrainian higher education institutions is to obtain a certificate of compliance of the educational program with international standards from the European Association for Quality Assurance in Higher Education.

Thus, improving the administration of IP will contribute to the implementation of the intellectual potential of the SPS in concrete results, such as quality educational services, development of research and scientific activities, innovative intellectual products presented in scientific publications in foreign and domestic editions, participation in international programs and projects.

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CHAPTER 2. INNOVATIVE AND MODERN FOUNDATIONS OF PEDAGOGY AND PSYCHOLOGY

2.1. Inclusive Education of Children With Intellectual Disabilities in the Context of Ensuring Their Right for Quality Education

In the context of the current historical changes in the country, we are witnessing the implementation of more reforms in the field of education than have been carried out since Ukraine's independence. And one of them is the introduction of inclusive education, which brings us closer to the European principles and standards of life chosen by the people of Ukraine. After all, the level of consciousness of the nation and the degree of development of the society in which we live is determined by the level of support, humanism and tolerance towards people with developmental disabilities.

Every person, regardless of their health status and the presence of a psychophysical disability, has the right to receive an education of the same quality as a person with normal development.

This principle is reflected in numerous international documents and is implemented in the organisation of inclusive education to ensure that children with special educational needs have the right to choose an educational institution and form of education at their place of residence, and the state guarantees the provision of all the necessary conditions for this.

Inclusive education *is a system of educational services based on the principle of ensuring a child's fundamental right to education and the right to study at the place of residence in a general education institution.*

The United Nations Convention on the Rights of the Child, ratified in Ukraine by a resolution of the Verkhovna Rada in 1991, as an internationally recognized legislative act, immediately imposes requirements on each state to bring its national legislation into line with this ‘universal constitution of the rights of the child’. Ukraine, as a sovereign state, a member of the United Nations, is making progress on this path. In recent years, the state's support for children with psychophysical developmental disorders and the promotion of an inclusive, harmonious educational space have been intensifying.

A study of international experience in the rehabilitation of children with physical or mental disabilities shows that the realisation of their right to education and the maximum development of their abilities is of particular importance for the full life of such children and the well-being of society.

The Law of Ukraine ‘On Education’ guarantees access to education for all and gives parents the right to choose educational institutions, educational programmes, types and forms of education for their children.

Inclusive education has become one of the most important topics in Ukraine in recent years. The Ukrainian government has passed laws and developed programmes aimed at developing inclusive education in the country. However, inclusive education in Ukraine has its own peculiarities.

A number of prominent Ukrainian scholars have explored the role of inclusion in general and inclusive education in terms of helping children with special educational needs and humanising society as a whole.

Inclusive education for children with psychophysical developmental disorders in foreign countries and in Ukraine is analysed in detail in the research of A. Kolupaieva, S. Mironova, V. Hladush, V. Syniov, and I. Kuzava.

In her monograph, A. Kolupaieva conducted a study of historical and scientific approaches to the process of involving people with disabilities in the general education space; analysed international and Ukrainian legislation on the organisation of education for this category of people; revealed the peculiarities of introducing inclusive education in the national education system.

I. Kuzava substantiated the methodological foundations of the conceptual framework of inclusive education in preschool; conducted an experimental study of the peculiarities of the readiness of subjects and objects of inclusive education; outlined the essence of modern technologies for the practical implementation of the inclusive education system aimed at correcting the development and socialisation of preschoolers with psychophysical developmental disorders.

V. Gladush analysed the introduction of inclusive education in the educational system of Ukraine. He provided statistical data on the development of inclusive education in Ukraine in recent years, critically analysed the problems inherent in the current situation that need to be addressed, and convincingly formulated promising areas of pedagogical activity and psychological support for inclusive education of children with special educational needs.

The world experience of correctional and rehabilitation work with children with physical or intellectual disabilities proves that ensuring their right to education and maximising their opportunities is crucial for the full life of this category of children and the well-being of society. solving this problem. New, non-standard, innovative approaches are needed to address these issues.

The modern education system is becoming more and more mobile, more open to international experience. Therefore, the issue of the optimal choice of the form of education for children with special educational needs (special (special school, educational and rehabilitation centre), integrated, inclusive, individual forms), as well as raising the level of professional competence of teachers, is becoming crucial today.

In Ukraine, the right to education for children with special educational needs is enshrined in law and provides them with the opportunity to receive education in all educational institutions and to receive psychological, pedagogical, correctional and developmental assistance.

Inclusive education is not only a change in pedagogical approaches, the use of new methods and the placement of children with special educational needs in general education institutions, but also a means of socialisation and integration that will help them find their own place in the human community. Pre-school and, especially, general education institutions are trying to meet the needs of all children, making the necessary changes to curricula and seeking new resources to ensure equal opportunities for all

children. It is through inclusive education that children with developmental disabilities can feel part of society, find friends and adopt generally accepted behavioural patterns.

The basic principle of inclusive education is:

-all children should be educated together whenever possible, regardless of any difficulties or differences that exist between them;

-educational institutions should recognise and accommodate the diverse needs of their students by providing different types and paces of learning;

-ensuring quality education for all through the development of appropriate curricula, organisational arrangements, teaching strategies, use of resources and partnerships with their communities;

-children with special educational needs should receive any additional assistance they may need to ensure their success in the learning process. They are the most effective means of guaranteeing solidarity, participation, mutual respect and understanding between children with special needs and their peers.

Undoubtedly, the introduction of inclusive education has many advantages and is a progressive form of organising the educational process.

For children with special educational needs:

-targeted communication with peers improves children's cognitive, motor, language, social and emotional development;

-peers play the role of models for children with special educational needs;

-mastering new skills and abilities is functional;

-learning is based on children's strengths, abilities and interests;

-children have opportunities to build friendships with healthy peers and participate in community life.

For other children:

-Children learn to naturally accept and tolerate human differences;

-children learn to establish and maintain friendships with people who are different from them;

-children learn to cooperate;

-children learn to behave in a non-standard way, to be creative, and to empathise with others.

For teachers and professionals:

-Teachers in inclusive classrooms have a better understanding of the individual characteristics of students;

-teachers master a variety of pedagogical methods, which enables them to effectively promote the development of children, taking into account their individuality;

-professionals (doctors, special educators, other specialists) begin to perceive children more holistically and learn to look at life situations through the eyes of children.

Without questioning the need to introduce inclusive education, participants in the educational process should be prepared for the various difficulties that will inevitably be overcome.

When it comes to developing an inclusive culture in educational institutions, it is first and foremost important to create an environment in which diversity is respected. This includes respect not only for physical diversity, but also for the diversity of ideas and opinions, cultural, historical and religious backgrounds, and personal traits.

Components of creating a culture of inclusiveness in an educational institution.

Respect for the individual.

An inclusive culture means respect for every person, regardless of their physical or mental-emotional development. This respect is manifested in the adaptability and flexibility of the space (e.g. colours, comfortable and functional ramps, lifts, furniture, etc.) Respect for the individual is fostered in an environment where the problem is not a child with special educational needs who cannot, for example, move around the school in a wheelchair, but rather the lack of adaptability of the school or the institution's unwillingness to provide quality educational services to such a child. In times of war, it is also worth paying special attention to children who have lost their homes and loved ones because of the war. The material should be adapted so as not to traumatise children when studying the topics of 'my family', 'my apartment' or organising family trips with parents. Mentioning one's own home, room, relatives, etc. can be traumatic for the child's psyche.

Respect for cultural and religious experiences.

In order to respect cultural and religious diversity, you need to know it. This can be done by studying the traditions of ethnic groups living in the area where the school operates, celebrating holidays together and learning about their traditions. In this way, the school will set an example of a tolerant environment that is enriched by learning about different cultures.

Respect for the family.

All families are respected and valued, regardless of race, colour, language, religion, political or other beliefs, citizenship, social origin or property status. Everyone has equal rights and freedoms. Fostering a sense of belonging Every child should feel wanted and valued, and have a clear and stable sense of 'their' school, where they are safe, comfortable and engaged. To ensure this, educational institutions should pursue a policy of unconditional pedagogical support for students in the learning process and promote a psychologically comfortable environment that is tolerant of violence.

Sensitivity to the emotional state of children and teachers, understanding of emotions and the ability to control them.

The issue of sensitivity to the emotional state of children and teachers, especially in wartime, is an important aspect of building an inclusive culture in schools. First and foremost, it is the task of educational leaders to know, understand and take into account the traumas and losses faced by participants in the educational process.

Content of education.

All school students study according to the educational programme of the educational institution. However, it is important to organise the educational process with a focus on each individual child. By taking into account the child's educational needs, adapting and/or modifying the school's curriculum, it will be possible to achieve the maximum realisation of the child's potential and ensure the progress of his or her

development. In this process, it is important for teachers to think through the content of educational materials, homework, and classroom discussions in order to avoid creating additional traumatic situations for students.

Creating a non-discriminatory space.

Accessibility, barrier-free and safe educational space characterise the degree to which a school is adapted to the needs of children. After all, it is the school that should do everything possible to make the child feel comfortable, independent and not in need of additional assistance by eliminating areas that can be excluded, such as high thresholds, narrow doors, lack of handrails, ramps and classrooms not on the ground floor. The main task of schools in this area is to provide an environment where children with special educational needs feel safe and can work at their own pace and ability, and to ensure communication with other children in the team.

Support for all.

Inclusion means access to education, socialisation and individualisation. Therefore, creating an individual support model for each student can help educational institutions provide quality education and prevent children from being overwhelmed or falling behind in the classroom.

Ensuring a comfortable psychological environment.

Teaching children with special educational needs in the classroom does not require changes to the curriculum or the curriculum. At the same time, the psychological comfort of children is facilitated by the adaptation of the learning space, materials and an individual approach based on the needs of a particular child. A comfortable psychological environment is an environment of coordinated cooperation, partnership and tolerance to bullying/harassment and discrimination. **Encouraging children to take responsibility for their own learning.**

Encouraging children to be motivated to learn, to follow through and to take responsibility for their own decisions helps to develop perseverance and responsibility. Success in empowering students and children to take responsibility for their own learning is considered successful. Consider the needs of learners and ensure that they know, accept, understand and progress towards their ultimate goals at different stages of learning. A culture of inclusion in schools promotes positive student development, prepares students for a diverse world, and helps create a community where all students can fulfil their potential and succeed.

Encourage helping others.

Ordinary acts of kindness, such as opening the door for a mum pushing a wheelchair, helping a child with SEN get ready for class or starting a conversation with a shy classmate, are simple things that can help foster a culture of tolerance and communication. Teachers and parents should motivate children to do the same:

- enable students with special educational needs to participate in groups and activities; - share their knowledge and skills and teach each other;

- participate in the arrangement of educational space with due regard to the special needs of children;

- advocate for the rights of classmates with special needs when they face discrimination and abuse.

Use of correct designations and terminology.

An inclusive culture in an institution is also reflected in the language used. It should always be remembered that we are talking about a person, not their characteristics. Therefore, the correct use of names and terminology speaks about the culture of the institution even before the child enters the physical environment.

Most children with special needs are in the preschool age group together with their peers, while the smallest proportion of integrated students with special educational needs are in the senior grades. Analytical data shows that the attitude of teachers in educational institutions to working with students with special needs largely depends on their experience, level of professional training and proper support from the administration and parents of students. The least willing to integrate students with special needs are teachers in educational institutions when it comes to emotional or behavioural disorders.

A study of the experience of educating children with special educational needs in European countries shows that in most of them inclusive education is the main form of education for people with developmental disabilities, while they have the opportunity to receive education in both special educational institutions and general education institutions.

The main humanistic experience of democratic education is that special institutions function and provide assistance to children with psychophysical disabilities, but they are not segregated locations. The boundaries between special and general education are transparent, as the values of civil society are promoted, based on the ideas of equality, tolerance and inclusion.

According to Professor Stangvik S.: 'The process of inclusion has several stages: from overt or covert resistance, through passive perception to active acceptance. Today we are approaching the final stage. However, it took about 20 years to get there.'

Instead, for many years in Ukraine, the majority of children with special educational needs were educated in special general education institutions, and the traditional system of special education was quite comprehensive. At the present stage, the decrease in the number of students in residential institutions is explained by the fact that children with developmental disabilities are studying in inclusive education institutions together with their peers.

A basic requirement for the success of inclusive education in any institution is the cooperation of teachers with parents, doctors and other specialists to identify the needs of a child with developmental disabilities, develop high-quality curricula based on information about the development of students, appropriate professional training of teachers and their continuous professional development. The educational institution should create conditions for all children to feel valued and to take an active part in all school affairs. The active participation of parents in the educational process is an extremely important condition for establishing partnerships and organising joint teamwork.

Parents should be the main link in the team. **According to A. Kolupayeva, there are three main models of teamwork:**

- *Multidisciplinary model:* the child and family are in the centre of attention, but specialists do not contact each other, there is no interaction between team members, research and services are isolated;
- *Interdisciplinary model:* the focus is on the child and family, but professionals are more connected to each other;
- *Transdisciplinary model:* the child and family are at the centre of attention and there is a strong relationship between them and professionals. There is also a mixed approach, in which the child is seen in a holistic way, i.e. all achievements and services are fully integrated.

The most appropriate approach to working with children with special needs is a multidisciplinary approach, which involves effective information sharing between team members and a sense of shared responsibility for the overall outcome. All team members should actively cooperate in the development of the child's individual educational plan.

In correctional work with children with special needs, it is more correct to evaluate the child's individual achievements in accordance with the set goals than to compare them with the achievements of developmentally typical peers. An important aspect of the correctional component is the process of observing children's development in the dynamics. Analysis of the results helps teachers identify the strengths, abilities and needs of children with special needs. All this is a step towards developing appropriate measures to solve the child's problems. The child is monitored on a regular basis, the results are analysed and further actions of teachers and other specialists are adjusted based on the results of the analysis. Planning individual work with a child is a kind of prediction of the child's area of immediate development.

Since children with developmental disabilities need more time to acquire functional skills, teachers should focus on teaching children with developmental disabilities skills that expand their independence and give them a sense of self-esteem. The primary task of teachers in inclusive classrooms is to promote the formation of a strong children's team. All children, regardless of their health status, should have the same rights and opportunities. An enabling environment encourages all children, regardless of ability, to explore, be motivated and creative, ensuring successful learning and development. A sense of belonging is crucial for children. Therefore, educators should create favourable situations of social relationships for students. By interacting with peers, children develop emotionally and socially and build self-esteem.

Significant progress in the socialisation of children with special educational needs can only be achieved with the active involvement of the family, especially parents. In this regard, the problems of families of children with developmental disabilities are among the most pressing. The Concept of Family and Family Education emphasises that ‘a modern family should become the main link in the upbringing of a child, providing him or her with appropriate material and pedagogical conditions for physical, moral and spiritual development’. It is impossible to build a full-fledged national school without the active participation and support of families.

With the recent introduction of inclusive education, which actively involves parents in the educational process, pedagogical theory and practice are increasingly focusing on the study of families raising children with special needs. Experts focus not only on the development of new skills and abilities in children, but also on the family as the main stabilising factor in the child's adaptation. It is from the family that children first get an idea of moral and human values, norms of behaviour and the nature of relationships. In the family, children not only imitate their relatives, but also focus on their social and moral attitudes. That is why the psychological maturity of parents, their ideals and experience of social communication are crucial for the child's development.

The family is the microsociety in which a child's moral qualities, attitude towards people and understanding of the nature of interpersonal relationships are formed. And this fact should not be overlooked either in the diagnosis of children with developmental problems or in further correctional work.

Unfortunately, the conditions of upbringing in modern families are not always favourable for the growth and development of children with mental and physical disabilities. In addition, raising a child with developmental disabilities is a particularly difficult and demanding responsibility. Parents have a responsibility to their children and to society. If a child with special needs is deprived of proper care, his or her personal development is exacerbated and he or she may become a burden to the family and society.

The process of development of children with special educational needs is extremely complex, and the family is their first social and educational institution.

Psychological and pedagogical assistance to parents should be aimed at breaking down unnecessary barriers built by the wounded psyche of parents: 'My child is not like other children, worse'. Such resentment and disappointment will disappear when the child's first successes appear. The role of parents is important when children with special needs are in an inclusive environment. This is due to the fact that parents are partners, active participants in the educational process, who choose the child's future path and ensure his or her first successes.

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2.2. Equine-Assisted Therapy as an Innovative Method Rehabilitation of the Soldiers at Educational and Rehabilitation Institution of Higher Education «Kamenets-Podilskyi State Institute»

ІПОТЕРАПІЯ ЯК ІННОВАЦІЙНИЙ МЕТОД РЕАБІЛІТАЦІЇ ВІЙСЬКОВОСЛУЖБОВЦІВ У НАВЧАЛЬНО-РЕАБІЛІТАЦІЙНОМУ ЗАКЛАДІ ВИЩОЇ ОСВІТИ «КАМ'ЯНЕЦЬ-ПОДІЛЬСЬКИЙ ДЕРЖАВНИЙ ІНСТИТУТ»

Однією з найактуальніших сучасних проблем нашого суспільства є вивчення негативних емоційних станів військовослужбовців учасників бойових дій і розробка на цій основі системи їх соціально-психологічної реабілітації.

Сучасні психологічні дослідження переконують, що військовослужбовці учасники бойових дій практично завжди перебувають у стані фізичного та психічного напруження [8; 11; 16]. Слід враховувати те, що при цьому вони отримують не лише фізичні, а й численні психічні травми. Навіть за відсутності значних тілесних ушкоджень та соматичних захворювань адаптація

військовослужбовців учасників бойових дій, які повертаються до мирного життя, ускладнюється функціонуванням посттравматичних станів, які призводять до численних соціально-психологічних проблем. Тому спеціалістам потрібно у найкоротший термін знайти відповідь на запитання: яким чином психологи можуть допомогти лікуванню ран війни, як підтримувати і повертати до повноцінного життя наших ветеранів [4; 5].

Основним змістом поняття «реабілітація» є комплексна допомога, спрямована не лише на компенсацію розладів, а й на повернення постраждалої людини до суспільства, її якомога повнішу особисту і професійну інтеграцію в соціум. Серед видів реабілітації зазвичай виділяють дві великі групи: медичну і соціально-психологічну. Соціально-психологічними технологіями реабілітації особистості є сукупність прийомів, методів, технік, що використовуються для підтримання і відновлення здатності особистості до життєтворення [4; 11].

Окремим нестандартним методом у реабілітації є іпотерапія – лікування за допомогою верхової їзди на коні під наглядом лікаря іпотерапевта або ж спеціально навченого інструктора верхової їзди. Це всесвітньо визнаний метод реабілітації після різноманітних захворювань. Унікальність такої терапії полягає в одночасному фізичному, психологічному та емоційно позитивному впливах на пацієнтів із неврологічними, психічними, фізичними та іншими порушеннями [2; 6; 12].

Те, що тварина здатна мати позитивний вплив на людину, не є новиною. Є навіть офіційний напрямок в психології та медицині, який має назву анімалотерапія – це іпотерапія, тобто використання в якості «ліків» коней та верхової їзди. Хоча цей метод ще залишається не дуже відомим, але він не такий уже і новий. Найперший здогад про те, що коні можуть лікувати, належить Гіпократу, лікарю часів Стародавньої Греції. Учений стверджував, що безпосередній контакт із цими тваринами допомагає хворим одужати набагато швидше та результативніше ніж унаслідок лікування звичними методами. За його спостереженнями, верхова їзда звільняє хворих людей від темних думок і викликає світлі, веселі та позитивні емоції [2].

Розробником іпотерапевтичної концепції вважається французький лікар і психолог Ю. Лаллері, який побачив у цьому методі можливості психосоматичної терапії і визначив його основну мету – надати хворій людині можливість пристосуватися до нових обставин її життя, допомогти досягненню рухової та психологічної незалежності від оточуючих. Ю. Лаллері вважав, що здібності коней до лікування людей величезні. З лікувальною метою спілкування з кіньми показано пацієнтам з порушенням рухових функцій після поліомієліту та дитячого паралічу, хворим, які страждають на хвороби психічні, серцево-судинні, хвороби нирок, а також людям з тяжкими захворюваннями органів чуття та глухотою.

Значну зацікавленість цим видом терапії спеціалісти реабілітологи почали виявляти лише у другій половині XX століття. Найбільший розвиток цей вид

лікування отримав у країнах Західної Європи, Скандинавії, США, Польщі, країнах Балтії та в Україні.

У 50-х роках XX ст. іпотерапія набула поширення в Європі, а з кінця 60-х – у США. Початком історії сучасної іпотерапії вважають 1950 рік. Це був рік XV Олімпійських ігор у Гельсінкі, де друге місце було завойовано данською спортсменкою Ліз Хартелл, важко хворою на поліомієліт. Її лікар, розуміючи депресивний стан своєї пацієнтки, для експерименту протягом багатьох років рекомендував спортсменці верхову їзду. Результат виявився сенсаційним: дівчина змогла не лише домогтися майже повного одужання, але й здобула перемогу на Олімпійських іграх [3].

Перший у світі спеціальний Центр лікувальної верхової їзди (іпотерапії) для дітей-інвалідів був створений у 1953 році в Норвегії. Надалі центри з іпотерапії стали відкриватися в багатьох країнах світу. На сьогодні в США їх уже більше 1000, тоді як у Великобританії – більше 700. Зараз іпотерапію успішно застосовують у багатьох країнах світу як офіційно визнаний вид лікування. До прикладу, у Франції підготовкою професійних фахівців із іпотерапії займаються на державному рівні. Факультет іпотерапії відкрито в Паризькому університеті спорту та здоров'я. У Тбілісі в Грузинській медичній академії відкрита кафедра ЛФК і райдтерапії. Питанням іпотерапії був присвячений спеціальний конгрес у Гамбурзі в 1982 році. Останнім часом в західних країнах з'явились організації Animal Assisted Therapy (терапія з допомогою тварин), котрі використовують тварин для лікування хворих з фізичними або психічними проблемами [3].

У США вважають, що верхова їзда розвиває як зовнішню поставу так і внутрішню стійкість, маючи на увазі фізичне і психічне оздоровлення дітей із порушеннями психічного розвитку. Власну іпотерапевтичну стратегію реалізує берлінський легастенічний центр (легастенія – порушення психічних механізмів читання та письма). Автор проекту, професор Зігфрід Шубенц, переконаний, що коні контактують з дітьми краще ніж кішки та собаки і вважає коней «природженими психотерапевтами». У його центрі лікуються діти з тяжкими розладами психіки, які не здатні сприймати правила читання та письма [12].

Найчастіше іпотерапевтичні заняття використовують для фізичної та соціально-психологічної реабілітації дітей та дорослих із захворюваннями нервової системи та опорно-рухового апарату. Сутність іпотерапії у тому, що верхова їзда надає суттєве фізичне навантаження всім групам м'язів. Розвивається координація, рівновага, покращується фізичний стан. Лікувальні заняття призводять і до емоційної гармонії. Поступово відбувається відновлення втрачених навичок і порушених функцій організму хворої людини.

Сучасна фахова література містить достатньо публікацій про позитивний досвід численних досліджень, пов'язаних із вражаючим впливом іпотерапії на загальну рухову функцію, когнітивну та афективно-емоційну активність дітей [2; 9]. Автори цих досліджень визначають іпотерапію як новий вид терапії, який використовує коней у поєднанні з фізичною, професійною і мовленнєвою

терапією, покращує мотивацію, увагу і загалом якість усього терапевтичного втручання [14].

На думку Д. Завітренко, програма іпотерапевтичних занять повинна складатися з декількох модулів: перше заняття, посадка на коня, пробне заняття, основні заняття [3]. Перший етап націлений на створення сприятливої лікувальної атмосфери. Іпотерапевт знайомить пацієнта з конем, показує, де будуть проводитися заняття, дозволяє погладити тварину. У пацієнтів виникає позитивна мотивація на заняття. Посадка на коня – складний етап для пацієнтів, які мають проблеми з руховою діяльністю. Роль фахівця у цей час дуже активна і відповідальна. Уже коли пацієнт оволодіє мінімальними навичками, іпотерапевт обирає пасивну стратегію: притримує, допомагає втриматися.

Перше заняття (тривалість 10-15 хвилин) проводиться з метою формування інтересу до занять (поступово тривалість занять збільшується до однієї години). Інструктор перевіряє фізичні можливості вершника, складає план вправ. Основні сеанси вимагають регулярного відвідування занять, виконання плану реабілітаційних заходів. Вправи доповнюються, видозмінюються відповідно до того, які навички формуються у вершника. Після занять відбувається моніторинг самопочуття і психологічного стану пацієнта. План занять складається іпотерапевтом відповідно до того, з якою проблемою звернувся пацієнт. Важливо, що над розробкою іпотерапевтичної реабілітаційної програми працюють паралельно декілька фахівців, тому що іпотерапія є методом, що передбачає комплексний підхід.

Періодичність занять – декілька разів на тиждень; курс займає від місяця і довше залежно від ефекту терапії і власного бажання пацієнта. Зцілення від важких форм хронічних захворювань іноді вимагає не місяців, а багатьох років регулярної іпотерапевтичної реабілітації [3].

Потрібно враховувати, що на даний час ще немає конкретно розробленої загальної програми та чітких наукових рекомендацій для іпотерапевтичного лікування. Успіх лікування багато в чому залежить від досвіду лікаря і досвіду інструктора.

Як вважає О.Борисюк, іпотерапія, як і усі напрями анімалотерапії, покликана виконувати такі функції:

— психофізіологічна функція (взаємодія з тваринами може знімати стрес, нормалізувати роботу нервової системи, психіки в цілому);

— психотерапевтична функція (взаємодія людей з тваринами може істотним чином сприяти гармонізації їх міжособистісних відносин);

— реабілітаційна функція (контакти з тваринами є додатковим каналом взаємодії особистості з навколишнім світом, що сприяє як психічної, так і соціальної її реабілітації);

— функція задоволення потреби в компетентності (потреба компетентності, що виражається формулою «я можу», є однією з найважливіших потреб людини);

— функція самореалізації (однією з найважливіших потреб людини – потреба в реалізації свого внутрішнього потенціалу, потреба бути значущим для інших);

— функція спілкування (однією з найважливіших функцій, яку можуть здійснювати тварини в процесі взаємодії людини з ними – це функція партнерів спілкування) [2].

Форми іпотерапії поділяються на наступні:

— власне іпотерапія – форма іпотерапії, з якої починається застосування цього лікувального методу для будь-якого пацієнта. Доведено, що для частини пацієнтів ця форма є лише першою сходинкою до подальшого використання інших, значно складніших форм іпотерапії відповідно до їх психофізичних можливостей. Цей вид іпотерапії залишається єдино прийнятним для тривалого процесу реабілітації. Заняття із «власне іпотерапії» завжди плануються, враховуючи індивідуальні особливості, можливості і бажання пацієнта.

— лікувальна верхова їзда. Це форма іпотерапії, коли пацієнт починає використовувати засоби контролю коня. Заняття на цьому етапі можуть бути індивідуальними і груповими, але починаються обов'язково з індивідуальних. Безпосередньо до цього етапу можна віднести прогулянкову верхову їзду, якою звичайно займаються більш здорові пацієнти, які мають власних коней і особистих тренерів. Ці пацієнти, залежно від їхніх можливостей і умінь, їздять самостійно або під наглядом тренера в парку, лісі, на полі;

— кінний спорт для інвалідів – потужний чинник соціальної та особистісної реабілітації осіб із обмеженими можливостями, це найвищий ступінь лікувальної верхової їзди;

— інші форми іпотерапії. Існують ще три розповсюджені форми іпотерапії, які безпосередньо пов'язані з участю в них коней, але не пов'язані з їздою верхи як такою: вольтижировка (гімнастика на коні); керування кінними упряжками (драйвінг); ігри та вправи верхи на конях [3].

Специфіка іпотерапії полягає в тому, що:

— коні створюють відчуття ходіння людини тривимірним рухом. Рух коня передається вершнику, змушуючи рухатися вперед і назад, схилятися вбік, провокуючи обертальні рухи навколо вертикальної осі хребта. Біомеханічно ці рухи практично ідентичні коливальним рухам таза при ходінні, тому відпрацьовуються нормальні рухи від плечей вниз до тазу, що дає можливість людині навчитися ходити «без ходіння»;

— кінь зменшує м'язову напругу. Пошкодження центральної нервової системи може призвести до збільшення напруги м'язів, особливо в кінцівках. Під час іпотерапії скорочення можливо шляхом розігріву м'язів і простого використання м'язів для їх релаксації;

— кінь відновлює порушену симетрію м'язів тулуба. За допомогою руху тварини у пацієнта попеременно напружуються і розслабляються м'язи постави лівої та правої сторін тіла, слабші м'язи зміцнюються;

— коні запобігають обмеженості руху в суглобах. За допомогою рухів «таз вершника – його хребет – плече – рука» пацієнт починає ритмічно і м'яко працювати усіма м'язами і суглобами;

— кінь стимулює відчуття і сприймання, тобто рух стимулює відчуття рівноваги і зору; щетина і волосся з гриви та хвоста стимулюють відчуття і сприймання температури; запах стимулює нюхові відчуття, а слухові відчуття стимулюють шуми навколишнього середовища і звуки, що видає кінь;

— іпотерапія надає необмежені можливості для прогресування і диференціації рівноваги. Прискорюючись і сповільнюючись, змінюючи напрямок, розгойдуючись, зупиняючись, рухаючись, використовуючи спеціальні розкладки, відповідні вправи та ігри, рух коня стає потужним генератором рівноваги;

— кінь поліпшує роботу органів (стимулюючи ендокринну систему, їзда верхи покращує кровообіг, дихання, роботу кишківника і навіть імунітет) [3; 9].

Критерії оцінки ефективності іпотерапії поділяють на дві групи: медичні та соціальні.

Медичні критерії:

— зміцнення й особливе тренування м'язів. Відбувається одночасна стимуляція ослаблених або непрацюючих м'язів і розслаблення груп м'язового апарату, що перебувають у напруженому стані;

— зміцнення рівноваги. Внаслідок необхідності зберігати рівновагу протягом усього заняття відбувається тренування вестибулярного апарату;

— покращення координації та орієнтації у просторі. Під час тренування пацієнт орієнтується на майданчику або в манежі, виникають зорові асоціації, розвивається слухова і зорова координація;

— покращення психоемоційного стану, підвищення рівня самооцінки. Під час занять зникає відчуття того, що людина хвора і безпорадна. Завдяки сидінню верхи на коні і управлінню ним формується лідерська нотка, поліпшується настрій і з'являється бажання жити і боротися із захворюванням. При верховій їзді не використовуються предмети, які використовує людина з інвалідністю в звичайних побутових умовах, що практично наближає її до відчуття перебування в світі здорових людей.

Соціальні критерії:

— поліпшення комунікативних можливостей;

— покращення якості й ефективності процесу соціалізації людини з обмеженими можливостями за допомогою зміцнення фізичного здоров'я, вирівнювання психологічного балансу і стабілізації емоційного стану;

— зростає інтеграція людини з інвалідністю в суспільстві, розширюються горизонти їх можливостей, відбувається подолання психологічних бар'єрів;

— відбувається розвиток трудових навичок під час догляду за конем.

Доведено, що іпотерапія дає лікувальний ефект не лише від верхової їзди, а ще й завдяки безпосередньому контакту та догляду за твариною. Такий комплексний підхід до лікування допомагає усунути стресовий стан, позбутися

напруги, страхів і тривоги. Іпотерапевтичні заняття також допомагають розвитку таких особистісних якостей як уважність, чуйність, швидкість реакцій, впевненість, позбавляють агресивності, збудливості та замкнутості. Відбувається психологічна та соціальна адаптація хворої людини, зникає страх, невпевненість, спостерігається позитивний вплив на мотивацію та волю, зникає почуття неповноцінності, безпорадності і ряд подібних психологічних комплексів [9].

Щодо фізичних позитивних змін від іпотерапевтичних занять фахівці зазначають відновлення втрачених навичок і порушених функцій, покращення координації рухів. Покращується кровообіг, адже температура тіла коня на 1-2 градуси вища, ніж в людини, здійснюється унікальний мікромасаж кінцівок вершника, спостерігається також і поліпшення роботи нервової та ендокринної систем, що позитивно впливає на функціонування внутрішніх органів. При їзді на коні тренуються всі групи м'язів вершника, а завдяки посиленій роботі серця стимулюється мозковий кровообіг. Деякі вчені припускають наявність біоенергетичного обміну, коли ритм рухів вершника та скакуна входить у резонанс із біоритмом мозку людини [9; 14].

Дуже важливо, що реабілітація за допомогою іпотерапії не має вікових обмежень. Більше того, іпотерапія дозволена при складних захворюваннях, коли протипоказано більшість реабілітаційних прийомів [3; 14].

Виходячи з вищесказаного, іпотерапія є досить ефективним сучасним методом у реабілітації військовослужбовців учасників бойових дій при лікуванні неврозів, депресії, страхів, ПТСР, оскільки у процесі взаємодії з твариною, знижується агресія і збудження, відновлюється душевний спокій та рівновага, що сприяє швидшому одужанню.

Іпотерапія в Україні як лікувальний метод лише починає розвиватися. У багатьох містах відкрито реабілітаційні центри, де діє програма іпотерапії для соціально-психологічної реабілітації військових. У Навчально-реабілітаційному закладі вищої освіти «Кам'янець-Подільський державний інститут» (ректор – Заслужений працівник освіти України, академік НАН вищої освіти України, доктор економічних наук, доцент, професор кафедри фінансів, обліку та оподаткування імені С. Юрія Мар'ян Тріпак) 10 січня 2025 року відбулось урочисте відкриття Центру ветеранського розвитку, де одним із напрямків реабілітації військовослужбовців учасників бойових дій започатковано програму іпотерапії. Ректор Мар'ян Тріпак зазначив: «Наш заклад є прикладом того, як освіта може об'єднувати людей і бути рушієм позитивних змін. Ми з гордістю відкриваємо двері Центру ветеранського розвитку для наших героїв і готові працювати для їхнього блага».

Оскільки у Навчально-реабілітаційному заклад вищої освіти «Кам'янець-Подільський державний інститут» навчаються здобувачі з інвалідністю, то іпотерапевтичні заняття для їх реабілітації успішно проводяться уже не перший рік [1]. Отже, перед працівниками закладу на сучасному етапі стоїть завдання розробити і втілити в життя таку програму комплексної реабілітації, що

дозволить стабілізувати стан психіки військових, які перебувають на ротації, які прийшли з поля бою і знаходяться у стресовому стані.

Проєкт, який реалізується Центром ветеранського розвитку Навчально-реабілітаційного закладу вищої освіти «Кам'янець-Подільський державний інститут», дуже важливий для наших військовослужбовців. Метою такого проєкту має бути оздоровлення тіла, розуму та духу військовослужбовців за допомогою терапевтичної роботи. Наслідки участі в бойових діях, зокрема й перебування в полоні, потребують серйозної роботи з відновлення психічного здоров'я наших воїнів.

Слід зазначити, що для забезпечення виконання необхідних реабілітаційних заходів з військовослужбовцями учасниками бойових дій у відділ психологічної підтримки Центру ветеранського розвитку залучені психологи, реабілітологи, медичні працівники, соціальні працівники, волонтери, психотерапевти. Спеціалісти вважають, що комплексний підхід до реабілітації військовослужбовців принесе більш ефективний результат. Практичні заходи комплексної реабілітації військовослужбовців учасників бойових дій Центру ветеранського розвитку Навчально-реабілітаційного закладу вищої освіти «Кам'янець-Подільський державний інститут» передбачають поєднання різноманітних інноваційних методів, ефективність яких буде визначатися своєчасністю, послідовністю, наступністю реабілітаційних заходів і максимально індивідуалізованим підходом до кожного військовослужбовця із урахуванням його психоемоційного й фізичного стану, особистісних цілей та уподобань.

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2.3. Methodological Aspects of the Use of Artificial Intelligence in Vocational Education

Introduction

Despite the difficult political and economic circumstances caused by Russian armed aggression and the COVID-19 pandemic, Ukraine continues to actively implement electronic government services. In 2021, the Cabinet of Ministers of Ukraine approved a strategic document that defines the directions of development of artificial intelligence (AI) in the country until 2030. This document provides for the active use of AI technologies in education, economy, public administration and other areas to increase Ukraine's competitiveness in the global market. The following year, the Ministry of Education and Science presented an ambitious program «Education 4.0» designed to modernize the education system in accordance with modern challenges and taking into account the recovery plan of Ukraine. This program is part of the national strategy for the development of artificial intelligence (National strategy for the…, 2021).

Ukraine is demonstrating significant progress in artificial intelligence research. Scientists from institutions such as the Institute of Cybernetics named after Glushkova, the Institute of Artificial Intelligence Problems, and Taras Shevchenko National University of Kyiv are actively working on the development of new algorithms, models, and applications of AI. Their research covers a wide range of areas and has already yielded a number of important results that have significant potential for the development of Ukrainian science and economy (Baranovsky, Bomba, Lyashko, 2022; Awasthi, Soni, 2023). According to V. Bykov, D. Mykulovsky, O. Muravchyk, S. Svitsky, and M. Shyshkin (2020), education 4.0 is a new paradigm of education that is designed to prepare people for life and work in the era of digital technologies. It is based on the principles of flexibility, individualization, collaboration, and extended learning. One of the key components of education 4.0 is the use of artificial intelligence. AI systems can analyze data about each vocational education student to create personalized curricula; can automate numerous tasks that are typically performed by teachers, such as assessment, lesson planning, and administration. Artificial intelligence programs have the potential to make education more accessible to students around the world; can be used to create simulations and virtual environments that allow students to practice their skills in a safe and realistic environment, and can make learning more interesting and engaging for students by using games, quizzes, and other interactive elements.

In his research, S. Chaka (2023) proves that the use of artificial intelligence in vocational education can automate numerous educational processes, opening up new paths for students and facilitating the work of teachers. In order to compensate for the lack of time in the era of education 4.0, when the world's information base is updated every day at a fairly rapid pace, teachers need to use artificial intelligence programs to make learning more diverse and interesting. This can be done by creating creative tasks of varying levels of complexity. AI is able to generate different task options. Thanks to artificial intelligence, it becomes possible to experiment with different question formats and teaching methods, taking into account the different capabilities and opinions of students. However, it is important to note that many experts believe that the presence

of a teacher in classes remains irreplaceable. AI can only complement and facilitate the work of a teacher, but not completely replace him.

The world of work is changing rapidly due to technological progress, and vocational education must keep pace with these changes. In numerous scientific works, C. S. González-González, J. Muñoz-Arteaga, C. A. Collazos (2021) argue that AI offers many opportunities to improve vocational education and train future professionals in this field who meet the needs of the modern labor market. The researchers identified the main key arguments in favor of using AI in vocational education: personalization of learning, improvement of practical skills, increasing accessibility of education, preparation for working with artificial intelligence, improving the effectiveness of teachers. It is proven that the use of artificial intelligence in vocational education also has certain challenges, such as the potential bias of artificial intelligence systems, the need to ensure cybersecurity and data privacy, as well as ethical considerations regarding the use of artificial intelligence in education. However, the benefits of using artificial intelligence in vocational education far outweigh the risks. AI has the potential to revolutionize vocational education, making it more personalized, accessible, effective, and relevant to the needs of the modern labor market. It is important to note that AI should not replace teachers, but complement their work. Teachers play an important role in ensuring that students receive high-quality vocational education based on the use of digital educational resources.

The purpose of the study was to comprehensively study, evaluate, and improve the process of applying artificial intelligence systems in the professional training of future vocational education specialists.

Taking into account the above statements, the objectives of the study are as follows:

1. To investigate the methodological foundations of the application of artificial intelligence systems in vocational education in higher education institutions of Ukraine.
2. Identify readiness components and develop a model for the successful implementation of the process of effective implementation of artificial intelligence programs in vocational education.
3. Identify methodological tools aimed at improving the process of using artificial intelligence in vocational education.

Materials and methods

As part of the experimental study, the methodology for using artificial intelligence in vocational education was implemented. The methodology included the development of a model for training future specialists in the field of vocational education and the selection of readiness components for the implementation of the outlined model, namely: motivational, content-technological and criterion-evaluation. Also, as part of the study, a selection of methods was carried out to check the formation of readiness components at the ascertaining and formative stages of the experiment.

The study was conducted during the 2023-2024 academic years and was carried out at Khmelnytskyi National University (Khmelnytskyi National University, 2024). The sample consisted of 42 respondents studying at the Humanitarian and Pedagogical

Faculty at the Department of Technological and Vocational Education and Decorative Arts in the Educational and Professional Program «Professional Education. Technology of light industry products (Sewing products)» and «015 – Vocational education. Transport (Maintenance and repair of cars)». The control group included 20 higher education applicants, and the experimental group included 22 participants.

It is recommended to implement the motivational component of readiness by implementing project activities (involving students in creating their own projects that allow them to apply the knowledge gained in practice); involving respondents in group work (creating conditions for cooperation and mutual assistance between students); contests and competitions (organizing educational competitions and contests to increase motivation); mentoring (collaboration with more experienced students or teachers). To implement the content-technological component of readiness, the discipline «Fundamentals of Artificial Intelligence» was introduced into the educational process of training applicants for vocational education in the context of studying the educational and vocational programs «Vocational education. Technology of light industry products (Sewing products)» and «015 – Vocational education. Transport (Car Maintenance and Repair)».

The purpose of the academic discipline «Fundamentals of Artificial Intelligence» is to form in students systemic knowledge about the principles of design and development of intelligent systems that are capable of learning, reasoning and decision-making in conditions of incomplete information. As part of the course, students are introduced to classical methods of artificial intelligence, modern approaches to knowledge representation and machine learning, as well as current problems and prospects for the development of the industry.

The implementation of the criterion-based evaluation component was carried out by developing an evaluation scale that took into account the theoretical knowledge and practical skills of students in using artificial intelligence systems; conducting regular reports, where the effectiveness of task performance was assessed. The implementation of the criterion-based evaluation component was carried out by developing an evaluation scale that took into account the theoretical knowledge and practical skills of students in using artificial intelligence systems; conducting regular reports that assessed the effectiveness of task performance.

To assess the theoretical knowledge and practical skills of students in using artificial intelligence systems according to the criterion-based evaluation component, a four-point evaluation scale was developed that took into account the following criteria: depth of theoretical knowledge, ability to apply knowledge in practice, creativity, ability to self-study and adherence to ethical norms. Regular, monthly reports were made in the form of presentations, during which students presented the results of their work. The evaluation was carried out using rubrics that took into account the correspondence of the work to the tasks set, the quality of design, originality of the approach and compliance with deadlines.

At the ascertaining stage of the experiment, an anonymous survey was conducted among respondents in the control and experimental groups. The questionnaire

contained 8 questions related to the methodology of using artificial intelligence in education. The questionnaire included the following questions: Are you familiar with artificial intelligence programs SlideBot, Quizlet, DALL-E, Bard, ChatGPT. Do you use the ChatGPT program to complete assignments in academic disciplines. Does the use of AI programs affect the use of plagiarism in works. Indicate the role of using artificial intelligence systems in professional education. Is there a need for universities to develop rules for using artificial intelligence in the educational process.

After the introduction of the model of implementing artificial intelligence in professional education, repeated testing of respondents from the control and experimental groups who studied using the experimental method was conducted.

Results

Substantiation of methodological aspects of the use of artificial intelligence in vocational education

The term «artificial intelligence» in the framework of the study refers to a powerful field of computer science with great potential, which seeks to create intelligent agents that can reason, learn and act autonomously. Artificial intelligence systems are able to process large amounts of data, detect patterns in them, make predictions and make decisions, similar to how people do it (Velykanova, Korchak, Klepikova, Kibets-Pashutina, Shyrokova-Murarash, 2022).

The rapid development of artificial intelligence demonstrates its enormous potential. AI is increasingly used to analyze data, automate routine tasks and develop innovative solutions, demonstrating significant potential. Its advantages, such as the ability to replace humans in routine tasks, increase productivity and make effective decisions, are becoming increasingly obvious. Artificial intelligence algorithms are capable of processing data sets inaccessible to human perception (Pisica, Edu, Zaharia, Zaharia, 2023; Kovachev, Sychikova, 2023).

Modern vocational education in Ukraine is increasingly faced with the problem of ensuring a continuous educational process in conditions of unstable power supply. The use of artificial intelligence and cloud technologies can be an effective solution. They allow you to diversify learning by creating interactive materials and personalize the educational process, improve access to knowledge by providing students with the opportunity to independently study complex topics using AI tools, and increase the efficiency of learning by automating routine tasks (Marienko, Shyshkina, Konoval, 2022; Jackson, 2022).

AI undoubtedly affects the pace, forms and results of scientific progress in the field of vocational education. With the help of artificial intelligence programs, it is possible to automate routine tasks, such as collecting, cleaning and analyzing data, freeing up time for creative and analytical work; to identify hidden patterns and connections in data that people might miss; to minimize human error and bias, making research more reliable; to integrate data from different sources, which stimulates cooperation between scientists from different fields.

However, the introduction of artificial intelligence into vocational education is associated with a number of challenges, namely: the risk of a digital divide and the

need to adapt to new working conditions. For the successful implementation of artificial intelligence in vocational education, it is necessary to ensure access to retraining programs for teachers, develop research in the field of artificial intelligence by stimulating scientific developments in Ukraine, and create a favorable environment for innovation by involving business in cooperation with education.

However, in addition to the advantages, the use of artificial intelligence programs also has disadvantages that cannot be ignored. In particular, there is a risk of establishing total control over people and collecting a huge amount of personal data, which can lead to the restriction of personal freedom (Nguyen, Ngo, Hong, Dang, Nguyen, 2023). Artificial intelligence algorithms can be complex and opaque, which makes it difficult to understand how they make decisions. This can lead to distrust of research results and ethical issues related to bias and discrimination. Using artificial intelligence, it is possible to automate many tasks that were previously performed by specialists. This can lead to job losses and the degradation of scientific skills. AI can be used to personalize learning, adapt educational programs to the needs of higher education students, and automate assessment. However, this can lead to the standardization of education and a decrease in the role of teachers (Moroianu, Iacob, Constantin, 2023).

However, given the rapid development of technologies, there is reason to believe that in the future the active implementation of AI will be able to overcome the existing shortcomings. Thanks to a smart combination of artificial intelligence, the human factor, state control and a qualitatively developed methodological system for the use of artificial intelligence in vocational education, it will be possible to create an effective and safe system of vocational training in higher education institutions in Ukraine based on digitalization. It is important that the use of artificial intelligence in vocational education is carried out ethically and responsibly, taking into account all possible risks and benefits. It is necessary to develop clear ethical principles and standards that will regulate its use in scientific research and educational activities. The use of artificial intelligence in the educational process causes ambiguous assessments from the point of view of academic integrity. On the one hand, there is a risk of plagiarism and other violations, because artificial intelligence programs can be used to generate texts, translate languages, and perform tasks without a deep understanding of the material. On the other hand, AI can be a tool for better understanding and assessing students' knowledge, as well as for personalizing learning.

It is important to note that the ethical and responsible use of AI programs is a key factor in maintaining academic integrity. Educators need to clearly outline the rules and expectations for the use of AI in the educational process, as well as teach students the ethical principles of working with this technology (Ungerer, Slade, 2022; Popenici; Kerr, 2017). AI systems and professional education are becoming increasingly inseparable. Professional education students are already actively using AI systems to search for information, complete homework assignments, and prepare for exams. It is important for educators to understand and use AI to improve the educational process, making it more dynamic, interactive, and personalized. AI can help educators: automate routine

tasks such as checking work and assessing knowledge, create individual learning plans for each vocational education student and provide them with access to additional learning resources and tools, evaluate the effectiveness of learning and make necessary adjustments. Neural networks are complex machine learning algorithms that can simulate the work of the human brain. They are able to learn from data and make predictions, which makes them a valuable tool for vocational education.

In vocational education, neural networks can be used for: recognizing speech and visual images, personalizing learning and adapting it to the needs of each vocational education seeker, automatically assessing knowledge and providing feedback, creating interactive learning environments (Ouyang, Zheng, Jiao, 2022). In Ukraine, artificial intelligence systems in vocational education and academic integrity are new concepts that have been actively developing over the past decades (Glazunova, Shyshkina, 2018).

Ukrainian society is still getting used to these new directions, so it is important to have a constructive dialogue about their ethical and legal aspects. AI has significant potential to transform education, making it more dynamic, interactive, and personalized. It is important to use artificial intelligence ethically and responsibly. Modern artificial intelligence technologies offer a wide range of tools that can significantly facilitate the work of teachers and make vocational education more effective. The following artificial intelligence programs have been proposed for use in the field of vocational education.

SlideBot – automatic creation of presentations based on entered text. This tool saves time on preparation, allowing the teacher to focus on teaching methods. SlideBot also offers an optimal slide structure for better assimilation of the material by vocational education students.

Quizlet – creation of cards with questions and answers, automatic generation of tests, interactive games, automatic checking of answers, analysis of results, recommendations for further learning. Quizlet helps the teacher better understand the needs of vocational education students and offers an individual approach to learning.

DALL-E – creation of images and videos based on text descriptions. DALL-E allows you to visualize historical events, generate videos with audio description, make learning more exciting and promote deeper immersion of students in the material (Pankratova, Sholokhov, 2019; Sabzalieva, Valentini, 2023).

The introduction of artificial intelligence into the educational process of vocational education can significantly increase its efficiency and quality by reducing preparation time, automating routine tasks, saving resources, using an individual approach to learning, adapting to the needs of each vocational education student, differentiating tasks, increasing motivation and interest in the subject, deeper immersion in the material, using interactive and exciting learning formats, collecting data on learning outcomes, identifying topics that require additional study, and monitoring the progress of vocational education students (Holzinger, Keiblinger, Holub, Zatloukal, Müller, 2023).

For the effective introduction of artificial intelligence into vocational education, it is necessary to clearly define the priority areas of its application. Analysis of successful

cases will help to formulate recommendations for the development and implementation of new AI solutions that will be most relevant for Ukrainian vocational education institutions. AI has significant potential to revolutionize scientific research and the educational process. However, it is important to be aware of the ethical dilemmas associated with its use and take measures to resolve them. Only with an ethical and responsible approach can artificial intelligence become a truly valuable tool for the development of vocational education.

Features of improving methodological aspects of the use of artificial intelligence in vocational education

The methodology for introducing artificial intelligence into the field of vocational education opens up new opportunities for improving the quality of education, personalizing the educational process and training specialists who meet the challenges of the modern labor market. However, for the effective use of artificial intelligence in this area, a clear methodology is needed that takes into account the specifics of vocational education and the needs of its participants.

In the process of conducting an experimental study, the methodology for using artificial intelligence in vocational education was implemented. The outlined methodology consists of the following components.

1. Analysis of needs and opportunities. Assessment of current processes (detailed analysis of existing curricula, assessment methods, infrastructure and resources). Identification of problem areas (identification of areas where AI can bring the greatest benefit, for example, personalization of learning, automation of routine tasks, analysis of large volumes of data). Assessment of technical readiness (analysis of the availability of the necessary equipment, software and infrastructure to support AI systems).

2. Development of an implementation strategy. Definition of goals (clear formulation of the expected results from the implementation of AI, for example, improving the quality of learning, increasing student motivation, optimizing the work of teachers). Selection of AI tools (research and selection of appropriate AI tools that meet the needs of the educational institution). Creation of a roadmap (development of a detailed implementation plan, including stages, deadlines, responsible persons and necessary resources).

3. Training of pedagogical personnel. Teacher training (conducting trainings and seminars to familiarize teachers with the capabilities of AI and providing them with skills to work with new technologies. Changing the role of the teacher (rethinking the role of the teacher in the context of using AI, focusing on the development of creative and communicative skills). Creating a community of practitioners (forming a community of teachers to exchange experience and support each other).

4. Building infrastructure. Technical support: Ensuring the availability of the necessary equipment (computers, network, software) for the operation of AI systems. Data protection (implementing measures to ensure the security and confidentiality of student data). Systems integration (integrating AI systems with existing information systems of an educational institution).

5. Phased implementation and evaluation. Phased implementation (starting with small projects and gradually expanding the scope of AI applications). Collecting feedback (obtaining feedback from students, teachers, and administration on the effectiveness of the implemented AI tools). Monitoring and evaluation (regular monitoring of the results of the implementation and making the necessary adjustments).

6. Continuous development. Updating technologies (monitoring the latest achievements in the field of AI and timely updating of the tools used). User support (providing users with constant support and assistance in solving problems). Improving curricula (constantly updating curricula taking into account new AI capabilities).

Key aspects of successful implementation of the methodology in vocational education are taking into account the specifics of each educational institution and the needs of its students. Involving all stakeholders in the implementation process (teachers, students, administration, parents). Phased implementation of AI to avoid overloading the system. Regular evaluation of the results of the implementation and making the necessary adjustments. Providing constant support to users and teachers.

Taking into account the outlined components of the model, a survey was conducted at the ascertaining stage of the experiment, the results of which determined that 82% of respondents are familiar with artificial intelligence programs SlideBot, Quizlet, DALL-E, Bard, ChatGPT, 43% of respondents used ChatGPT to complete assignments in academic disciplines, 78% of respondents understand that the use of artificial intelligence systems can lead to plagiarism, 14% of respondents admitted that they used artificial intelligence systems to complete assignments, passing off the result as their own, 52% of respondents believe that the use of artificial intelligence systems in professional training can be useful if it is used ethically, 87% of respondents believe that universities need to clearly define the rules for using artificial intelligence in the educational process. Thus, the conclusions were drawn that vocational education students, in general, have a positive attitude towards the use of artificial intelligence programs in education and use them.

To determine the levels of readiness of higher education students to use artificial intelligence in professional education at the stage of the ascertaining experiment, a model was built based on which three components were distinguished: motivational-target, content-technological, and effective. The motivational-target component provides a methodological basis for the use of artificial intelligence in professional education. The purpose of creating the model was the need to improve the methodological component of the use of artificial intelligence in professional education; motivation of vocational education students to use artificial intelligence in their professional activities. The following approaches were taken as a basis: systemic, personality-oriented, activity-based, conceptual, and multi-subject. The following principles were used in the work: clarity (use of visual materials, such as pictures, diagrams, tables, for better understanding and assimilation of information); nature-conformity; activity (stimulating the active participation of vocational education students in the educational process, using interactive teaching methods and artificial

intelligence); systematicity and consistency (ensuring a logical connection between topics and classes, gradual complication of educational material); perspective and continuity (taking into account the prospects for the development of students' knowledge and skills, ensuring a connection between the previous and subsequent educational material); humanization (creating an atmosphere of trust and cooperation, respect for the student's personality, his thoughts and feelings).

In the context of the formation of the cognitive-activity component of readiness, knowledge of the methodology and the ability to apply artificial intelligence systems in vocational education are included. For this purpose, a methodology for using artificial intelligence in vocational education was developed. Software based on artificial intelligence was selected and a methodology for their use was presented. The results of training were regularly evaluated in order to make the necessary adjustments.

The performance-evaluation component in the context of the digital transformation of education plays a key role, as it allows assessing the effectiveness of using artificial intelligence systems in the educational process. The outlined component helps to adapt the educational process to the requirements of modernity and ensure high-quality preparation of vocational education students for life in a digital society.

The results of the formation of readiness components at the ascertaining stage of the experiment are presented in Figure 1.

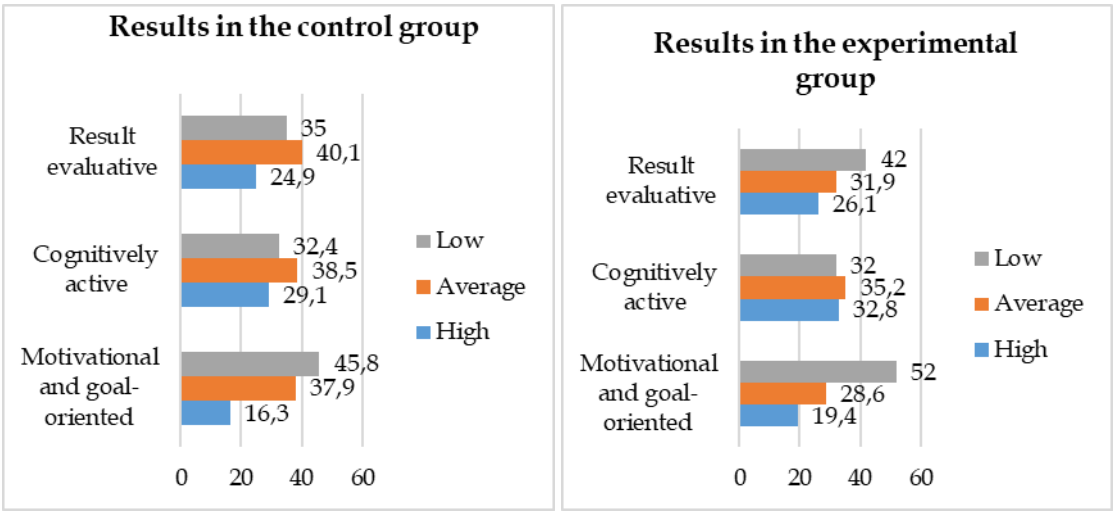

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Figure 1. Results of the assessment of the development of professional competencies using the updated methodology for using artificial intelligence in vocational education in the control and experimental groups at the stage of the ascertaining experiment

Considering the obtained research results, there is a need to develop clear rules for using artificial intelligence in vocational education, including the definition of permissible and unacceptable practices; conduct training of students on the ethical use of artificial intelligence systems and academic integrity; offer students alternative

methods and tools for performing tasks that do not require the use of artificial intelligence; develop a model of the updated methodology for using artificial intelligence in vocational education, conduct further research on the impact of artificial intelligence on the educational process of vocational education and academic integrity.

The results of the study at the ascertaining stage of the experiment showed that respondents from both the control and experimental groups have a low and medium level of motivation to use artificial intelligence systems in their professional activities. This indicates their unwillingness to develop in a professional direction. The insufficient level of formation of the cognitive-activity component also emphasizes the need to update the methodological system for using artificial intelligence in vocational education. The conceptual-target component of readiness needs improvement. This is due to the fact that it is important to be able to evaluate one's achievements and knowledge in this area. Thus, there was a need to conduct a formative stage of the experiment. Its goal was: to introduce a methodological system for using artificial intelligence in vocational education into the educational process. This methodology is an author's model of professional training of future teachers of vocational education with technologies for forming its components. In the control group, classes were conducted according to the traditional methodology, and in the experimental group - according to the proposed methodology, using digital educational resources based on artificial intelligence.

The proposed model includes the following stages. Analysis and definition of needs (conducting a comprehensive study of the needs and expectations of vocational education stakeholders (teachers, students, employers, government agencies, etc.), identification of key competencies and skills that should be formed in students as part of vocational training, analysis of available resources and infrastructure for the implementation of artificial intelligence in vocational education). Development of methodological principles (definition of methodological principles for the use of artificial intelligence in vocational education, taking into account ethical norms, principles of accessibility and inclusivity, development of methodological recommendations for the selection and integration of artificial intelligence tools in vocational education; creation of curricula and courses for training teachers to use artificial intelligence in vocational education). Implementation and piloting (development and implementation of pilot projects on the use of artificial intelligence in vocational education in different fields and at different levels of training, assessment of the effectiveness of the use of artificial intelligence tools and their impact on student learning outcomes, adjustment of methodological principles and recommendations based on the results of the pilot implementation). Scaling and dissemination (development of a strategy for scaling the use of artificial intelligence in vocational education at the national and regional levels, creation of platforms and resources to support teachers and students in the use of artificial intelligence, ensuring cooperation with government agencies, employers and other stakeholders to promote the use of artificial intelligence in vocational education). Monitoring and evaluation (ensuring continuous monitoring and evaluation of the effectiveness of the use of artificial

intelligence in vocational education, collecting and analyzing data on the impact of artificial intelligence on learning outcomes, student motivation, teacher and employer satisfaction, making changes to the methodology and practice of using artificial intelligence based on the results of monitoring and evaluation).

The implementation of this model of improving the methodological aspects of the use of artificial intelligence in vocational education expects: improving the quality and efficiency of vocational training, personalizing the educational process and adapting to the individual needs of students, developing new competencies and skills in students that meet the challenges of the modern labor market, increasing the motivation and involvement of students in learning, improving cooperation between teachers, students, employers and government agencies.

The use of AI has significant potential for transforming vocational education and training specialists who meet the needs of the modern economy. The proposed model of improving the methodological aspects of the use of artificial intelligence can serve as a guideline for the development and implementation of effective strategies for using artificial intelligence in this area.

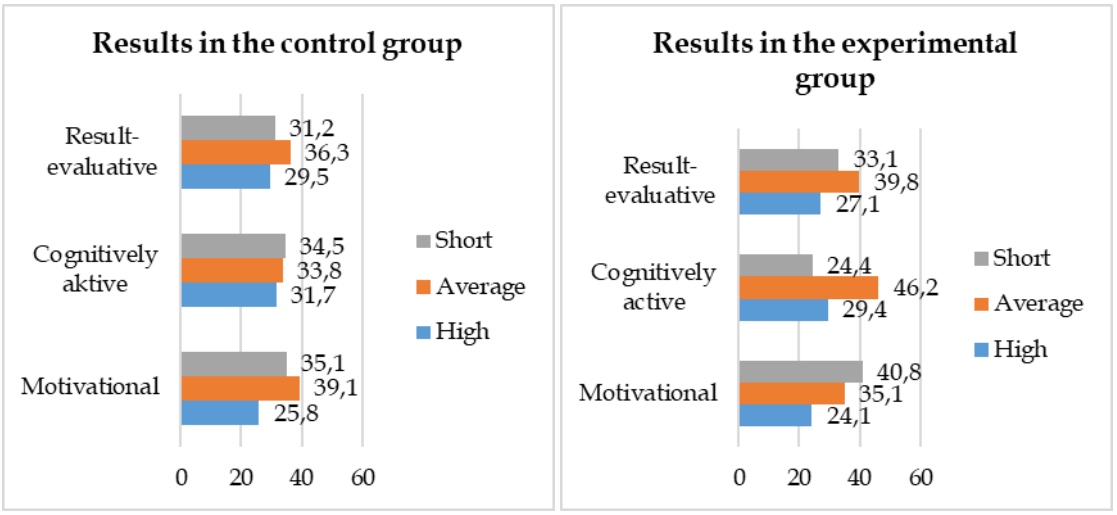
AI is flowing into education, transforming it into an individual and adaptive process. E-learning platforms such as Enlearn use machine learning to create personalized curricula that meet the unique needs of each student. This approach not only accelerates the acquisition of knowledge, but also makes learning more interesting and effective (Khan; Lulwani, 2023).

Learning management systems (LMS) play a key role in this transformation. They not only centralize learning processes, but also facilitate collaboration between teachers and students. Thanks to LMS, organizations can create flexible and dynamic learning environments that meet modern requirements. AI transforms e-learning from passive content consumption to an active process of interaction. For Generation Z, which strives for self-development and continuous learning, AI opens up new opportunities to achieve their goals.

Systems like ALEKS adapt learning to the needs of each vocational education seeker, analyzing his knowledge and offering personalized tasks. The uniqueness of ALEKS lies in the fact that it does not just provide learning materials, but creates an individual learning path for each vocational education seeker. The system first assesses the student's level of knowledge and then builds a personalized plan that helps him focus on important topics and consolidate new material. AI is used in education for various purposes: from creating individualized lesson plans (as in ALEKS and Squirrel AI) to automating routine tasks such as checking homework (Holmes, Porayska-Pomsta, Holstein, Sutherland, Baker, Shum, Santos, Rodrigo, Cukurova, Bittencourt, Koedinger, 2022).

Thus, after conducting the ascertaining stage of the experiment, information was obtained about the initial state of the use of artificial intelligence systems in the process of training vocational education applicants, artificial intelligence programs were studied and the methodology for their use was outlined, and an experimental updated methodological system for the use of artificial intelligence in vocational education was

developed and implemented. The updated methodology was verified by determining the readiness of vocational education applicants to use the outlined components of artificial intelligence systems. The results of the distribution of respondents by levels at the stage of the formative experiment are presented in Figure 2.



Source: created by the author

Figure 2. Results of assessing the development of professional competencies using the updated methodology for using artificial intelligence in vocational education in the control and experimental groups at the stage of the formative experiment

Based on the obtained research results, it was found that the updated methodology for using artificial intelligence in vocational education makes sense, since in the experimental group at the formative stage of the experiment the indicators increased to an average and high level compared to the data obtained at the ascertaining stage of the experiment.

It was determined that students in the experimental group showed greater motivation to use artificial intelligence in their educational activities. Factor analysis allowed us to identify three main factors that influence students' readiness to use AI: motivation, digital competence, attitude towards technology. The results of the regression analysis showed that the level of digital competence is the strongest predictor of students' readiness to use artificial intelligence.

Analysis of the survey results showed that students in the experimental group who participated in educational activities using SlideBot, Quizlet, DALL-E, Bard, ChatGPT demonstrate a significantly higher level of knowledge about the principles of artificial intelligence and the possibilities of its application in the educational process compared to students in the control group.

The use of artificial intelligence in scientific research opens up new opportunities for improving the efficiency and quality of work. However, to ensure academic integrity, clear rules must be followed. Plagiarism, data falsification, and the use of AI for the mass production of low-quality publications are unacceptable. Each researcher

must independently analyze the results obtained using AI, and ensure correct citation of all sources used, including data and AI algorithms. In addition, it is important to consider the potential risks associated with algorithm bias and data privacy protection. Thus, artificial intelligence is closely related to open science through work with big data. It organizes information, analyzes it, and facilitates further research. In education, artificial intelligence can be a teacher's assistant, creating personalized learning. However, there are risks: reducing the role of the teacher, reducing the creativity of vocational education students, and deepening the digital divide.

AI opens up new horizons in education and scientific research. In the training of future professionals in the field of vocational education, artificial intelligence systems can personalize learning, providing an individual approach to each student. In science, artificial intelligence automates routine tasks, analyzes large data sets, and helps generate new hypotheses. However, it is important to understand that artificial intelligence does not replace human intelligence, but is its powerful tool. For the effective use of artificial intelligence, it is necessary to develop ethical standards and take into account potential risks, such as reducing the role of the teacher in education and possible biases in artificial intelligence algorithms.

AI has the potential to revolutionize education by making it more personalized, effective, and accessible. However, it is important to understand that AI does not replace the teacher, but is a powerful tool for him. The key to successfully using AI in education lies in the intelligent combination of technology and the human factor.

Discussion

Ukraine aspires to become a leader in the field of artificial intelligence. To achieve this goal, a large-scale strategy has been developed for 8 (2023–2030) years. It provides for the phased implementation of measures under the control of the government. The legal basis of the strategy is provided by the country's Basic Law and a number of specialized laws. This document will serve as a roadmap for the development of AI in Ukraine, as it will be used to develop state programs and adopt new laws (Cabinet of Ministers of Ukraine, 2024).

The above document justifies the need for urgent transformation of educational programs in Ukraine in order to train highly qualified specialists in the field of artificial intelligence. According to the presented strategy, it is planned to introduce elements of artificial intelligence into the school curriculum and educational programs of higher education institutions in order to form basic knowledge and interest in this field among young people. The creation of specialized bachelor's, master's and doctoral programs focused on training researchers and engineers in the field of artificial intelligence is a modern requirement. There is a need to develop online courses, mobile applications and other interactive tools for distance learning and advanced training, to intensify the interaction of universities with IT companies to develop joint curricula, conduct internships and create research laboratories. Inviting leading world experts in the field of AI to conduct lectures, seminars and joint scientific research. Ensuring stable financing of scientific projects in the field of AI from the budget and through private investments (Crompton; Burke, 2023).

The expected results include increasing Ukraine's competitiveness in the global technology market, creating new jobs in high-tech industries, accelerating the development of the innovative economy, and strengthening the country's scientific potential. Key advantages of the proposed strategy: coverage of all levels of education from school to postgraduate studies, emphasis on obtaining practical skills and implementing innovations, combining the efforts of specialists from different fields of knowledge, including Ukraine in the international scientific and educational space. Implementation of the proposed strategy will allow Ukraine not only to catch up with world leaders in the field of artificial intelligence, but also to become one of the centers of global innovation (Uzwyshyn, 2023).

Investigating the issue of using artificial intelligence in education, I. García-Martínez, J. M. Fernández-Batanero, J. Fernández-Cerero, S. P. León (2023) revealed the key characteristics of artificial intelligence. In particular, the researchers' opinion on the need to introduce artificial intelligence into the educational process of training vocational education applicants as a requirement of the digital society is continued. The use of the outlined approach is considered appropriate because artificial intelligence systems use complex algorithms to analyze and interpret data from various sources, such as texts, images, audio, and sensory data. They are able to learn from their own experience and improve their work over time. This can be done through machine learning, which involves automatically detecting patterns in data without explicit programming. Artificial intelligence systems can make autonomous decisions based on the data they analyze and the knowledge they have accumulated. They can perform various tasks, such as image recognition, machine translation, text generation, planning, and navigation.

S. Z. Salas-Pilco, Y. Yang (2022) actively studied the methodology for implementing artificial intelligence in the training of future specialists. Researchers have identified the following types of artificial intelligence: narrow (focused on performing one specific task or set of tasks, for example, face recognition or playing chess); general (possesses general cognitive abilities); superintelligence (surpasses human intelligence in all aspects). The use of the outlined approach is considered appropriate, since the types outlined by the researchers were used in the process of developing a methodological system of artificial intelligence. It is proven that the implementation of the developed methodology is quite relevant, since in the near future the emergence of «digital universities» based on virtual reality and artificial intelligence is predicted. This indicates the active implementation of digital technologies in the transformation of the educational process. However, given the problems with material and technical support, the primary task is to transform the education system precisely to overcome these problems. For this purpose, a variety of educational resources and digital platforms are being created to support educational content, as well as to create it.

The study by O. Yara, A. Brazheyev, L. Golovko, V. Bashkatova (2021) is based on the concept of adaptive learning, which involves the constant modification of the educational process in accordance with the individual achievements of higher education students. Analyzing the results obtained during the study, it is clear that the

next stage of development of the application of machine learning algorithms allows AI systems to analyze large volumes, identify patterns and predict the further development of each higher education student. The authors of the study demonstrate that artificial intelligence in vocational education can not only automate routine tasks of a teacher, but also contribute to a deeper understanding of the educational process.

For example, H.-C. Chu, G.-H. Hwang, Y.-F. Tu, K.-H. Yang (2022) in his numerous studies indicated that the readiness of higher education students to effectively use artificial intelligence is a complex phenomenon that includes not only technical skills, but also understanding, attitude and willingness to adapt to the changes that the development of artificial intelligence brings. The researchers continued their opinion and the main components of readiness are divided into the following groups. Technical skills include understanding the basic principles of artificial neural networks, machine learning, deep learning and other key concepts, the ability to work with programming languages used to develop AI models (Python, R, Java, etc.), the ability to work with various tools and platforms for creating, training and deploying AI models (TensorFlow, PyTorch, Google Colab), the ability to collect, clean, process and analyze data for training AI models. Digital literacy includes knowledge of modern digital technologies and their application in various fields of activity, confident use of a computer, the Internet and various software products, the ability to critically evaluate information obtained from different sources and detect fakes. Soft skills consist of the ability to generate new ideas and non-standard solutions, the ability to analyze information, identify errors and make informed decisions, effectively communicate with people, work in a team and present the results of one's work, understanding the ethical aspects of using artificial intelligence and responsibility for the consequences of one's actions. Understanding the potential and limitations of artificial intelligence: knowledge of the potential negative consequences of using AI (for example, job loss, algorithm bias), the ability to assess the quality of the work of an AI model and identify its shortcomings. Willingness to cooperate with artificial intelligence lies in the understanding that artificial intelligence is a tool that helps a person, not replaces him, and the ability to adapt to new ways of working that arise due to the use of AI. The development of these components in higher education students is an important task for universities and educational institutions.

This will allow preparing specialists in the field of vocational education who will be able to effectively use artificial intelligence to solve complex problems and contribute to the development of an innovative economy. K. Alhumaid, S. Naqbi, D. Elsori, M. Mansoori (2023) believe that in modern conditions there are several models that try to describe the future development of artificial intelligence. Some of them are: exponential development: (assumes that the development of AI will occur exponentially, i.e. faster and faster); S-curve (assumes that the development of AI will occur along an S-shaped curve, i.e. first slowly, then quickly, and then slowly again); technological singularity model (assumes that in the future AI will surpass human intelligence and lead to radical changes in society). The use of the outlined approach is considered appropriate,

as the outlined models are reflected in the presented study of methodological aspects of the use of artificial intelligence in vocational education.

Thus, the application of artificial intelligence in vocational education has a number of advantages. Artificial intelligence systems allow for the creation of personalized curricula that meet the needs and learning style of each higher education student, can automate many tasks, freeing up teachers' time for more creative work with higher education students, artificial intelligence can make education more accessible to students with different abilities. AI is becoming an increasingly powerful tool for improving education. Due to its capabilities for personalization, automation and accessibility, artificial intelligence has the potential to revolutionize this field.

Conclusions

Artificial intelligence is increasingly integrated into the educational process, offering new opportunities for personalizing learning and automating routine tasks. At the same time, the widespread use of AI raises concerns about its impact on the role of the teacher, the development of creativity of vocational education students and the deepening of the digital divide. The study proved that ensuring high-quality implementation of professional training of vocational education applicants in higher education institutions of Ukraine should be based on a high-quality methodology for organizing work with artificial intelligence programs.

It was determined that artificial intelligence is becoming a driving force of global changes. Its influence is felt in all spheres of life, from economy to culture. The content of the concept of "artificial intelligence" is determined and its features and features are revealed. This work presents a model and an updated methodology as a component of the model for the successful implementation of the introduction of artificial intelligence systems in the training of specialists in the field of vocational education. A model for the successful implementation of the methodology for using artificial intelligence in the process of professional training of future specialists has been developed, which includes three interrelated components: motivational-targeted, content-activity, and criterion-evaluation.

The conducted analysis of scientific literature allowed to systematize the idea of the application of artificial intelligence systems in professional education and to determine the main ways to solve this problem in the training of future specialists. An innovative model was developed, which provided for the structuring of the educational process according to three main components: motivational, content-technological and criterion-evaluation. To empirically verify the effectiveness of the proposed model, ascertaining and formative experiments were conducted, during which appropriate diagnostic methods were used.

Promising areas of use of artificial intelligence in the educational process are ethical aspects of using AI in education (development of ethical principles for using AI in education, ensuring fairness and preventing discrimination); data protection (development of effective methods for protecting students' personal data used by AI systems); cooperation between humans and artificial intelligence (research of optimal models of interaction between humans and AI in the educational process); development

of detailed methodological manuals and instructions, creation of specialized courses and trainings, development of university standards and codes of ethics, cooperation with IT companies and scientific institutions, systematic assessment of effectiveness, creation of a community of practitioners.

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CHAPTER 3. THE LATEST BASICS OF AGRICULTURAL DEVELOPMENT

3.1. Determination of Parameters for a Crimp-Roller Shredder

Problem Statement. One of the pressing challenges in Ukraine's agricultural production is the maximization of efficiency in implementing advanced crop production technologies at every stage of technological processes. Among these, particular emphasis is placed on technologies such as minimum tillage, direct seeding, harvesting with retention of crop residues and other plant debris on the field surface, and similar practices. The decreasing application of organic fertilizers during crop production is a concerning trend, observed in nearly every farming enterprise. This issue is primarily associated with the decline of the livestock sector and farmers' efforts to reduce operational costs in agricultural production. A direct consequence of this phenomenon is the rapid depletion of humus content and a general decline in soil fertility.

The experience of leading agricultural nations demonstrates that effective utilization of crop residues remaining on the field surface after the harvest of the preceding crop, coupled with their timely and efficient preparation, can significantly improve the physical and mechanical condition of the soil. It also partially addresses the issue of organic matter deficiency in the soil environment, reduces humus losses, and mitigates the effects of wind and water erosion. Moreover, timely preparation and shredding of crop residues on the field surface can serve as a foundational element of soil conservation farming. Importantly, it does not require substantial financial investment or the use of complex, energy-intensive machinery.

Given this context, the introduction of operations for preparing crop residues left on the field surface after harvesting the preceding crop, along with the improvement of machines and tools for handling plant residues, can enable the establishment of soil conservation systems within farming operations.

Research Justification. The degradation of soil fertility due to declining levels of organic matter has become a critical issue in modern agriculture. This situation is exacerbated by the insufficient incorporation of plant residues into the soil and the lack of effective field preparation technologies. Current agricultural practices in Ukraine frequently overlook the importance of plant residue management, which could serve as a cost-effective alternative to mitigate the challenges posed by the scarcity of organic fertilizers.

The introduction of plant residue management technologies, including shredding and even distribution of residues across the soil surface, offers a practical solution for maintaining soil structure and fertility. These technologies contribute to improving the soil's physical and mechanical properties, enhancing moisture retention, and promoting organic matter decomposition. Additionally, the use of specialized shredding equipment minimizes the need for multiple soil preparation operations, thus reducing fuel consumption and operational costs while ensuring sustainable soil management practices.

Objectives of the Research. The primary objective of this research is to enhance the operational efficiency of agricultural machinery designed for plant residue management. This includes optimizing the performance parameters of shredders equipped with active working elements to ensure uniform residue shredding and distribution. By doing so, the research aims to:

1. Improve the integration of plant residues into the soil to mitigate humus loss and enhance fertility.
2. Develop and validate technical solutions for improving the design and functionality of shredding equipment.
3. Reduce the dependence on energy-intensive soil preparation methods, contributing to overall energy efficiency in agricultural operations.
4. Address the challenges of wind and water erosion by promoting sustainable residue management practices.

Expected Outcomes. The study anticipates several benefits from implementing improved plant residue shredding technologies, including:

- Enhanced soil conservation through better residue management.
- Increased cost-efficiency of field preparation operations due to reduced machinery usage and lower fuel consumption.
- Improved ecological safety of agricultural practices by minimizing carbon emissions and mitigating erosion risks.
- Long-term sustainability in crop production through the preservation and enhancement of soil fertility.

This research underscores the critical importance of advancing plant residue management systems as a cornerstone of sustainable agricultural practices in Ukraine. By focusing on practical, scalable solutions, the study aims to provide farmers with effective tools and techniques to overcome the challenges of modern agricultural production.

Analysis of Key Studies and Publications. Despite the proven and well-substantiated benefits of utilizing crop residues of preceding crops during the cultivation of agricultural products, subsequent technological operations—such as minimum tillage, direct seeding, and others—are often performed under extreme conditions. This challenge arises due to the substantial volume of plant residues, which hinders the implementation of technological processes, leading to clogging, reduced stability of soil penetration, and impaired movement of implements such as tillage tools and seed drills. Consequently, these operations are carried out with performance indicators that fail to meet existing agrotechnical requirements.

For an extended period, disc implements—mainly heavy and medium disc harrows and disc cultivators—have been utilized for shredding crop residues [1, 2]. However, spherical discs are recognized as some of the most erosion-prone tools. Furthermore, their efficiency in shredding crop residues, particularly high-stalk crops like sunflower and maize, remains suboptimal. For these reasons, such implements are not recommended for use in residue management [3, 4].

A clear alternative to disc implements is the use of crop residue shredders [5], which, depending on their design and purpose, can efficiently shred stubble, weeds, straw windrows, maize stalks, and sunflower stems into fragments of up to 20 cm in length, with subsequent even distribution across the field surface.

Considering the technical capabilities of crop residue shredders, both domestically and internationally, special attention should be given to non-driven machines, whose primary working element is a roller equipped with prominent blades [6, 7]. These crimp-roller shredders are characterized by relatively simple designs, high operational productivity, and the ability to ensure high-quality shredding processes at working speeds of up to 25 km/h. Numerous studies [8] confirm that such high-speed operation modes of crimp-roller shredders provide sufficient quality in residue shredding. However, a significant drawback has been noted: the clogging of the inter-blade space with plant-soil mass, a problem that intensifies with increased soil moisture and moisture content in large crop residues.

This issue necessitates the identification of solutions to ensure the effective use of crimp-roller shredders for shredding plant residues following the harvest of high-stalk crops, such as sunflower and maize. Addressing this challenge will help optimize residue management technologies and improve the sustainability and efficiency of agricultural operations.

Thus, the objective of this study is to justify the design and experimentally determine the optimal parameters of crimp-roller shredders for crop residues, ensuring the prevention of clogging in the inter-blade space with plant-soil mass.

Presentation of the Main Material. The technological process of shredding crop residues with crimp-rollers involves the rolling of the roller over the field surface, during which flat blades fixed to the roller's surface press the plants to the ground, cutting them with the blade edges and leaving them on the field surface. It is worth noting that ensuring reliable and high-quality execution of this shredding process is not always achievable.

According to the requirements for the performance of crop residue shredders established by the National Scientific Center "Institute of Mechanization and Electrification of Agriculture" (NSC IMESA) [9], such machines must shred all crop residues remaining on the field surface into particles smaller than 20 cm. Under these conditions, the shredded residues can either be easily incorporated into the soil during subsequent tillage operations or not hinder the following sowing processes.

To meet these performance criteria, two conditions must be fulfilled. The first condition is that the spacing between the blades fixed on the cylindrical drum of the shredder must correspond to the desired length of the plant stem fragments, which is typically 20 cm. The second condition relates to the mass of the crimp-roller or the mass applied per blade, which must be sufficient to cut or crush the most resilient stems of crops like maize, sunflower, weeds, and other plants.

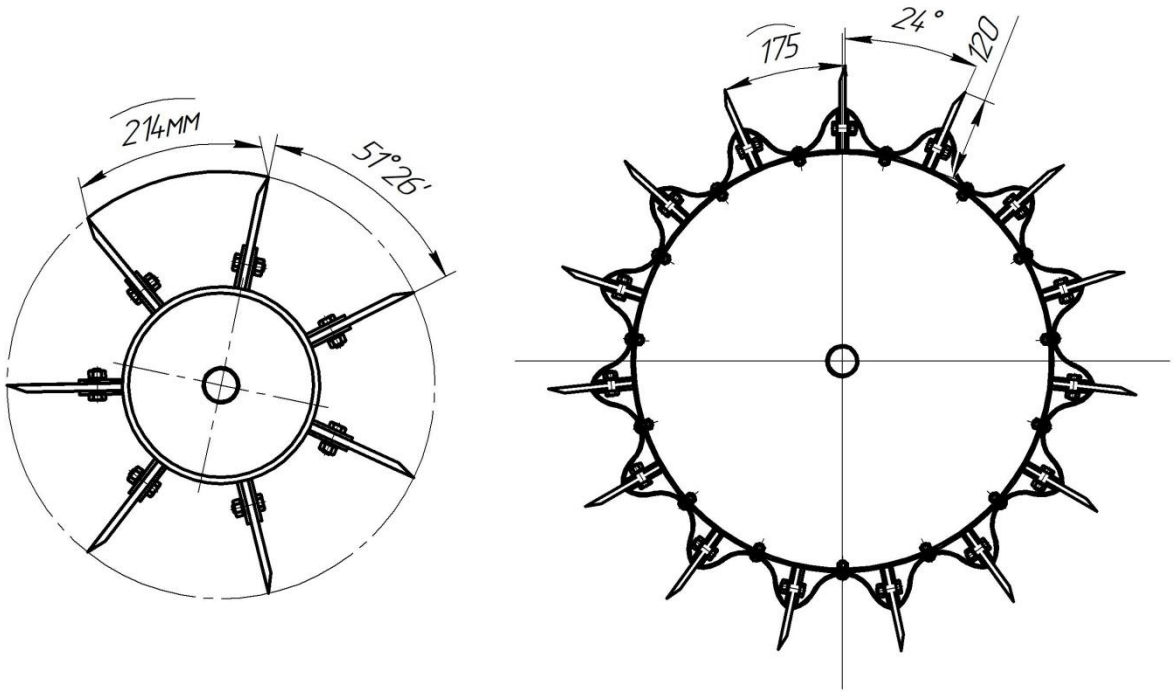
The standard blade height for commercially produced machines of this type ranges between 12 to 15 cm. When shredding porous plant residues with stems that easily break upon contact with blades, cylindrical drums with base diameters of 200 to

250 mm are commonly used. Considering this, to maintain the required distance between the blade edges on the cylindrical drum surface, no more than 7 to 8 blades can be attached (Fig. 1, a). The angle between the working planes of these blades is approximately 50°.

With such a design, even when the cylindrical drum blades partially penetrate the soil, only one blade will be in full contact with the soil and plant residues at a time. The next blade will begin its function sequentially as the preceding blade lifts off the field surface. Under these working conditions, the plant-soil mass cannot become trapped between adjacent blades, and the likelihood of clogging is minimal.

However, crimp-rollers with small drum diameters, due to their low weight, perform poorly in fields with significant plant residue and are unable to effectively cut through high-stalked plant residues.

A closer analysis reveals that these conditions are closely interdependent. For a blade to effectively cut through crop residues, it must have a certain height. This blade height must be sufficient to exert pressure on the plant stems, pressing them against the soil surface or, in some cases, embedding them into soft soil to a depth where the reaction force of support cutting occurs, effectively breaking the stem.



a b

Figure 1 – Blade Arrangement on the Surface of the Crimp-Roller Drum for Plant Residues:
a – Small Diameter Roller; b – Large Diameter Roller
Source: Developed by the authors using [12]

For operation on fields with a large amount of plant residues and for shredding tall-stemmed crops, it is advisable to use crimp-rollers with a large mass, often reaching up to one ton [10]. These working organs operate under entirely different conditions, and such mass is achieved by significantly increasing the working diameter of the drum and enabling the option to fill the drum with water or other materials. Under these working conditions, based on the requirement to shred plant residues to a length of no more than 20 cm, the specified distance between the blade edges, and the large drum diameter, the number of blades on the drum increases significantly, which immediately leads to a substantial reduction in the angle of divergence between them (Figure 1, b). This particular roller design ensures the simultaneous full contact with the soil of two or, in some cases, three blades, which, during operation, results in the cutting of stems, accompanied by their compression along with soil particles between neighboring blades. The likelihood of blade clogging with plant-soil mass sharply increases as the material's moisture content rises. Consequently, as a certain critical amount of plant-soil mass accumulates between the blades of the crimp-roller, the technological process halts.

One approach to solving this issue is the justification of rational design parameters for large-diameter knife drums. However, for this, it is necessary to have information about several, at least, key influencing factors on the process and the nature of these factors' impact on the clogging of the space between the blades with plant-soil mass.

According to the results of previous studies [5], it was established that among the most influential factors on the probability (P) of clogging the space between blades are: among the design parameters – the angle of divergence between adjacent blades (α), and among the technological parameters – the working speed of the aggregate (V).

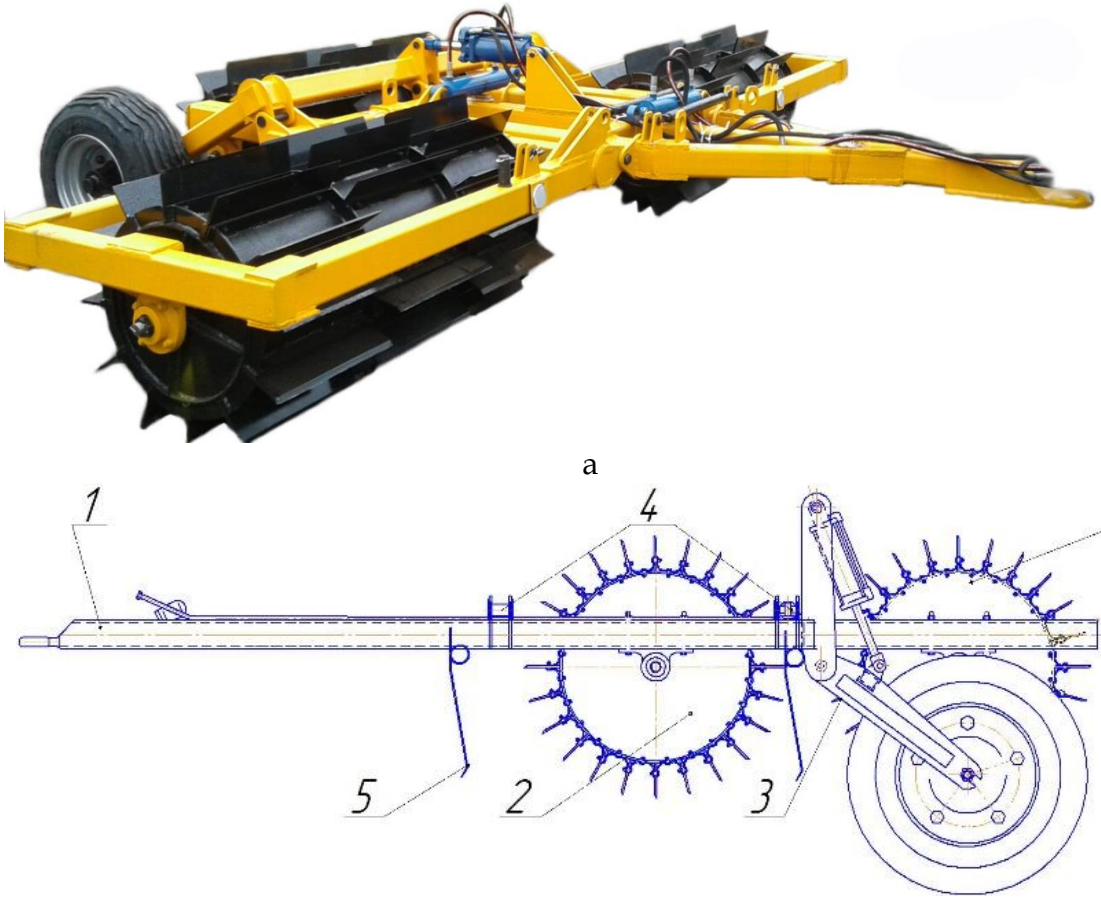
Information about the interrelationship between the above parameters allows for solving this problem by selecting rational design-technological parameters for the shredder's knife drum. To achieve this, a standard method for planning a multifactorial experiment was applied, during which experimental studies were conducted to examine the effect of the angle of divergence of the knives (x_1) and the working speed of the aggregate (x_2) on the optimization parameter (Y_1), which is the probability of clogging the space between the blades with plant-soil mass (Table 1) [6]. During the conducted studies, an evaluation was made of the number of clogging cases detected over twenty measurement plots, each 50 linear meters in length.

Table 1

Factors and levels of their variation for experimental studies of the crimp-roller operation

No	Factor Name	Symbol	Upper Level (+)	Lower Level (-)	Variation Interval
1	Angle of blade divergence (α °, degrees)	x_1	25	45	10
2	Working speed of the aggregate (V , m/s)	x_2	1,4	7,0	2,8

During the experimental studies, the MTZ-130 tractor was used as the aggregation means, and the experimental crimp-roller was the serial plant residue shredder PK-4.5, produced by the company "Savitsky M.I." (Fig. 2). The experimental research was conducted in the fields of the agricultural firm "Zlagoda," located in the Malovyskivsky district of Kirovohrad region.



a

b

Figure 2 – Overall view of the experimental plant residue crimp-roller PK-4.5:
a - Crimp-roller during field testing. b - Drawing of the plant residue crimp-roller:
1 - Frame with hitch device; 2 - Crimp-rollers with knives; 3 - Hydraulic transport position mechanism; 4 - Hydraulic cylinders for lifting the side crimp-rollers; 5 - Spring-loaded guide fingers.
Source: Developed by the author using [8]

The machine is designed for shredding both green plants, cover crops, and their residues after harvest. It does not require a drive for the working components and operates at working speeds of up to 25 km/h, ensuring high productivity of up to 8 hectares per hour [5]. The increased shredding efficiency is also ensured by the presence of spring-loaded guide fingers 5, which are designed to orient the plant stems relative to the knives in the transverse direction. The number of knives on the drums and their

arrangement are optimized to prevent clogging with plant residues. When shredding tough plant residues (for example, corn stalks), the drums are filled with water, which increases the overall weight of the machine, thus enhancing its shredding capacity. During transportation, the side sections of the drums 2 are raised by hydraulic cylinders 4 into a vertical position, ensuring a transport width within 2.5 meters. The transport mechanism 3 provides a ground clearance of up to 50 cm, guaranteeing safe transportation.

During the field experiments, the field was divided into 20 experimental plots, each 50 meters long. If, during the operation of the crimp-roller, the inter-blade space of the drum became clogged with plant residues and soil at least once in any of the 20 plots, the probability of clogging was considered 5%. Furthermore, if clogging occurred across all 20 plots, the probability was considered 100%.

The angle of the knives on the crimp-roller drum was changed by adjusting the number of knives fixed to the cylinder's surface. This adjustment process was simplified by the fact that, in the serial machine design, knives were mounted in three rows on the crimp-roller drum with a specific offset. This design feature allowed a significant reduction in the number of test runs since, on a single crimp-roller, three different angles of knife inclination could be installed simultaneously (see Figure 2).

The results of the experiments were recorded in a journal. Under stationary conditions, the probability of clogging was calculated in percentage terms, which was considered in the subsequent statistical analysis of the process.

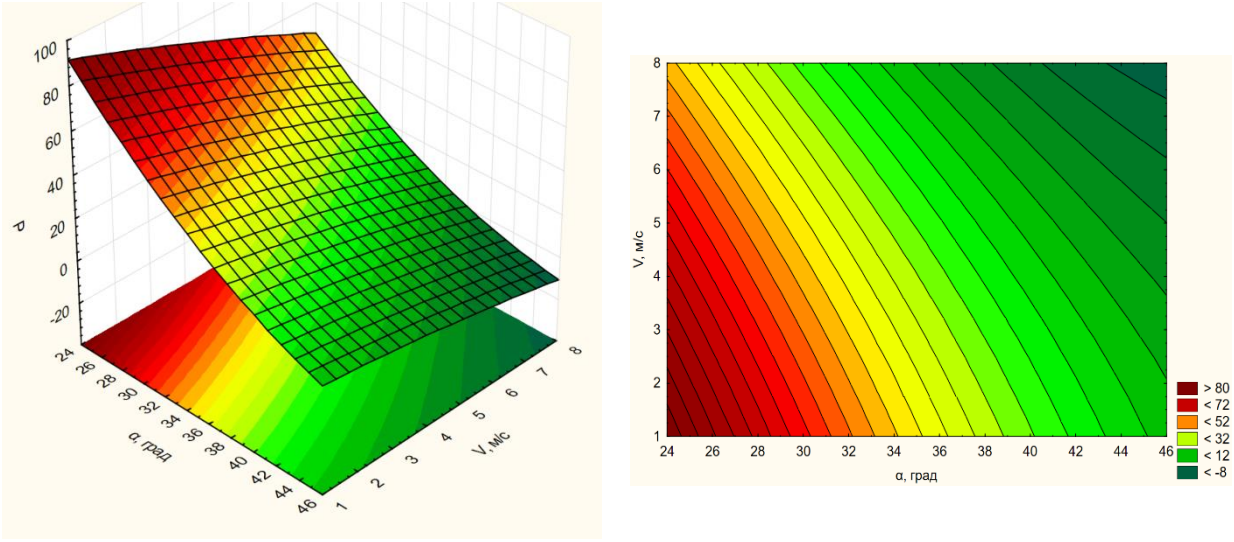
According to the standard methodology, in the STATISTICA 10 software suite, after conducting the experiment, a regression equation was obtained, which allows assessing the influence of the factors on the optimization criterion. The equation has the following form:

$$Y(P) = 280,7264 - 9,6474x_1 - 9,1932x_2 + 0,0829x_1^2 + 0,1612x_1x_2 - 0,1345x_2^2.$$

The obtained equation indicates that both the angle of inclination between adjacent knives and the working speed of the aggregate have the most significant impact on the probability of clogging of the inter-blade space with plant and soil mass. Additionally, there is a significant effect of the pairwise interaction of both factors and the quadratic term of the working speed.

The graphical interpretation of the experimental data in the form of a response surface and contour lines (Figure 3) shows that both an increase in the working speed of the aggregate and a higher angle of inclination between adjacent knives contribute to reducing the probability of clogging of the inter-blade space with plant and soil mass.

For a crimp-roller similar to the ПК-4,5 design, the recommended working speed is in the range of V = 7 - 8 m/s, with the angle of inclination between the adjacent knives α = 42 - 46°. At these constructively-technological parameters, the probability of clogging of the inter-blade space (P) does not exceed 8%.



a b

Figure 3 – The dependence of the probability of clogging between the knife spaces with plant-soil mass (P, %) on the angle of divergence between the knives of the shredder (α, °) and the operating speed of the aggregate (V, m/s):
- a – response surface; - b – contour lines.
Source: developed by the author.

The experimentally determined range of speeds from 15 to 24 km/h considers the specific conditions under which the crimp-roller operates in the field, including the movement of the aggregate over both slopes and humps of the terrain in both vertical and horizontal planes [11, 12]. With these velocity values, it is important to account for the air resistance force [4]. A drum with knives behaves similarly to a lobed wheel. At operational speeds, the knives generate resistance to its rotation, both in the soil and in the air. It has been established that traction resistance increases by 12% at speeds ranging from 15 to 25 km/h [1, 12].

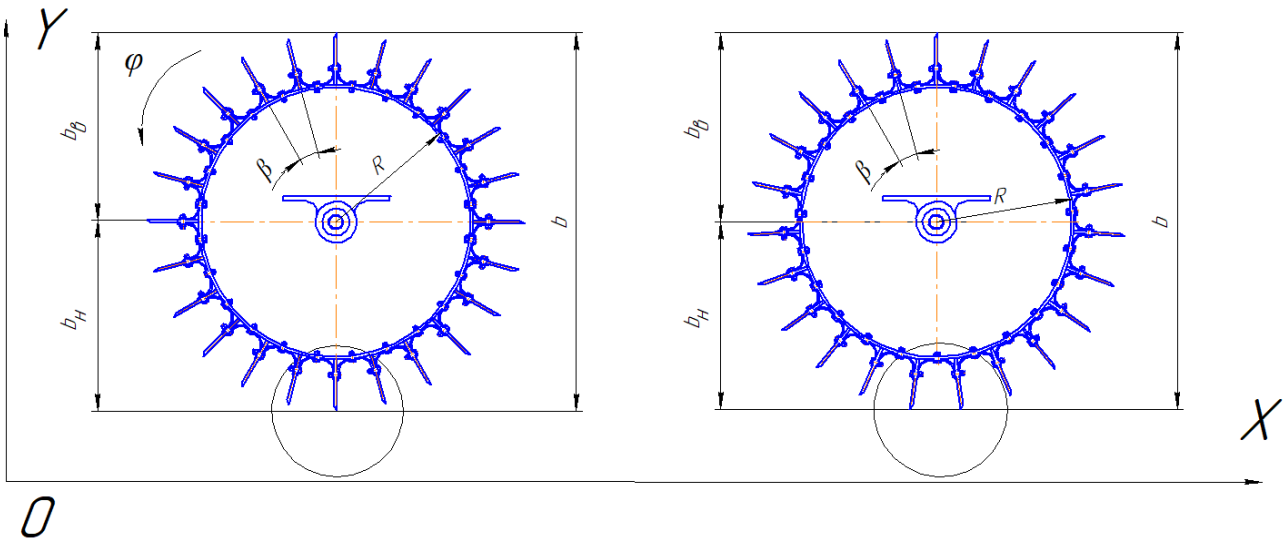
Let us consider height b_B of the half cylinder drum with blades cross-section with the angle values $-\frac{\beta}{2} \le \varphi \le \frac{\beta}{2}$ (Fig. 4).

We determine the height projection b_e in relation to the angle φ if $b_e \ge R$,

- $$b_B = (h + R) \cdot \cos\varphi \text{ [m]}, \quad (1)$$

where: R – radius of the cylinder drum, m;
h – height of the blade, m.

When the crimp-roller is operating with a certain number of blades z it may happen that the surface of the cylinder drum is seen between the blades $b_B < R$ (Fig. 4, b), then $b_B = R$.



a b

Figure 4 – Cases with blade placement:
a – even number of blades (z=24 pieces);
b – odd number of blades (z=23 pieces);
β – angle between the blades, $\beta = \frac{2 \cdot \pi}{z}$;
b - cross-section of the height of half cylinder drum with blade on the axis 0Y.

Let us consider the cases with even and odd numbers of blades z. With even number of blades the value of the height projection b_B on the axis 0Y is $b_н = b_B$. Let us consider the case with odd number of blades on the cylinder drum of the crimp-roller.

With odd number of blades:

$b_н = (h+R) \cdot \cos\left(\frac{\beta}{2} - \varphi\right)$, where $0 \le \varphi \le \frac{\beta}{2}$; $b_н = (h+R) \cdot \cos\left(\frac{\beta}{2} + \varphi\right)$, where $-\frac{\beta}{2} \le \varphi \le 0$.

So, we have general expression to determine the height projection of the half cylinder drum's cross-section with a blade, where $-\frac{\beta}{2} \le \varphi \le \frac{\beta}{2}$:

$$b_н = (h+R) \cdot \cos\left(\frac{\beta}{2} - |\varphi|\right). \text{ [m]} \quad (2)$$

Much the same, when the crimp-roller is operating with a certain number of blades z it may happen that the surface of the cylinder drum is seen between the blades $b_н < R$, then $b_н = R$.

Mechanically, the blades are fixed on the cylinder drum of the crimp-roller in such a way that the case when $b_в < R$ and $b_н < R$ cannot be possible.

In general situation the height projection of the cylinder drum's cross-section with even and odd numbers of blades z will be determined in the following way:

$$b(\varphi) = (h+R) \cdot \left(\frac{3-(-1)^{z+1}}{2} \cdot \cos(\varphi) + \frac{1-(-1)^{z}}{2} \cdot \cos\left(\frac{\pi}{z} - |\varphi|\right) \right), \text{ [m]} \quad (3)$$

where the angle value will be in the limits of $-\frac{\pi}{z} \le \varphi \le \frac{\pi}{z}$.

There is no sense to use formula (3) for further calculations because it is impossible to set the initial angle of the cylinder drum with blades. There is a need to have additional calculations which will take into account the calculation's errors. That will enable introducing equal-area projection of the height of cylinder drum's cross-section.

Let us determine the equal-area height $b_{ек}$ for

$$b_{ек} = \frac{z}{2 \cdot \pi} \cdot \int_{-\frac{\pi}{z}}^{\frac{\pi}{z}} b(\varphi) d\varphi, [\text{m}] \tag{4}$$

For an even number of blades

$$b_{ек} = \frac{z}{2 \cdot \pi} \cdot \int_{-\frac{\pi}{z}}^{\frac{\pi}{z}} b(\varphi) d\varphi = \frac{2 \cdot z \cdot (R+h)}{\pi} \cdot \sin\left(\frac{\pi}{z}\right), [\text{m}] \tag{5}$$

Let us find the ratio error δ, which is formed as a result of taking into account equal-area projection of the height of the bladed cylinder drum's cross-section during one complete revolution.

The function $\cos\left(\varphi - \frac{\pi}{2 \cdot z}\right)$ where $-\frac{\pi}{z} \le \varphi \le 0$ increases to its highest level value, if $\varphi = 0$.

Let us consider the cylinder drum revolution on one blades $-\frac{\pi}{z} \le \varphi \le \frac{\pi}{z}$ for the even number of blades

$$\frac{b(\varphi)}{b_{ек}} = \frac{2 \cdot (R+h) \cdot (\cos\varphi)}{\frac{2}{\pi} \cdot (R+h) \cdot z \cdot \sin\left(\frac{\pi}{z}\right)} = \frac{\pi \cdot \cos(\varphi)}{z \cdot \sin\left(\frac{\pi}{z}\right)},$$

where $-\frac{\pi}{z} \le \varphi \le \frac{\pi}{z}$.

The highest value of the error δ is when the cylinder drum is rotating with the values of the angle $\varphi = -\frac{\pi}{z}$ та $\varphi = \frac{\pi}{z}$, will be

$$\delta = \left| 1 - \frac{\pi \cdot \cos\frac{\pi}{z}}{z \cdot \sin\frac{\pi}{z}} \right| \cdot 100\% = \left| 1 - \frac{\pi}{z} \cdot ctg\frac{\pi}{z} \right| \cdot 100\% . [\%] \tag{6}$$

Let us assess the error of the accuracy of the force determination as a result of introduction of $b_{ек}$ for the odd number of blades when $-\frac{\pi}{z} \le \varphi \le 0$

$$\frac{b(\varphi)}{b_{ек}} = \frac{\pi \cdot \cos\left(-\frac{\pi}{2 \cdot z}\right) \cdot \cos\left(\varphi + \frac{\pi}{2 \cdot z}\right)}{z \cdot \sin\frac{\pi}{z}}.$$

where $0 \le \varphi \le \frac{\pi}{z}$

$$\frac{b(\varphi)}{b_{ek}} = \frac{\pi \cdot \cos\left(\frac{\pi}{2 \cdot z}\right) \cdot \cos\left(\varphi - \frac{\pi}{2 \cdot z}\right)}{z \cdot \sin\frac{\pi}{z}}.$$

the highest value of the error δ is when the cylinder drum is rotating with the values of the angle $\varphi = -\frac{\pi}{z}$, $\varphi = 0$ and $\varphi = \frac{\pi}{z}$:

$$\delta = \left|1 - \frac{\pi}{2 \cdot z} \cdot ctg\frac{\pi}{2 \cdot z}\right| \cdot 100\%. \quad [\%] \tag{7}$$

Let us determine the error δ_t, which is introduced by the indeterminateness of the initial angle set of the cylinder drum with blades while applying the exact determination of the height projection of the cylinder drum's cross-section b. For the even number of blades

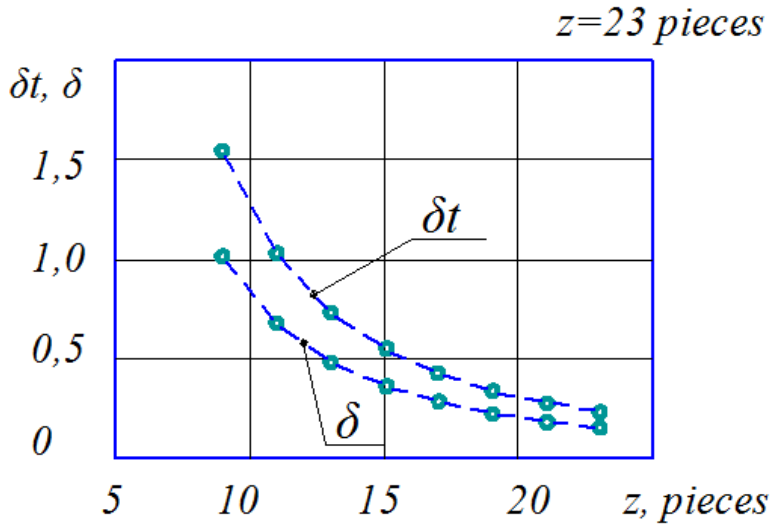
$$\delta_t = \left|1 - \frac{2 \cdot (h+R) \cdot \cos 0^o}{2 \cdot (h+R) \cdot \cos\frac{\pi}{z}}\right| \cdot 100\% = \left|1 - \frac{1}{\cos\frac{\pi}{z}}\right| \cdot 100\%. \quad [\%] \tag{8}$$

For the odd number of blades

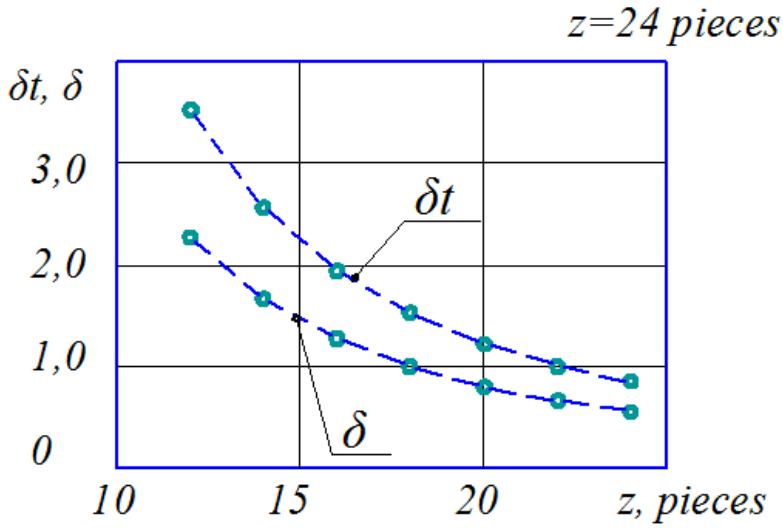
$$\delta_t = \left|1 - \frac{(h+R) \cdot \left(\cos\varphi_{\max} + \cos\left(\frac{\pi}{z} - |\varphi_{\max}|\right)\right)}{(h+R) \cdot \left(\cos\varphi_{\min} + \cos\left(\frac{\pi}{z} - |\varphi_{\min}|\right)\right)}\right| \cdot 100\% = \left|1 - \frac{1}{\cos\frac{\pi}{2 \cdot z}}\right| \cdot 100\%, \quad [\%] \tag{9}$$

where: $\varphi_{\min} = 0 = -\frac{\pi}{z}$, $\varphi_{\max} = -\frac{\pi}{2 \cdot z}$.

Graphic interpretations (Fig. 5) of the research findings of the influence of the equal-area projection of the height b_{ek} on the accuracy of the description of the air resistance force showed that the ratio error decreases by 1,5 times. That is explained by the indeterminateness of the initial angle set of the cylinder drum with blades and equals: for the odd number of blades is $\delta = 1\%$, $\delta_t = 1{,}6\%$; for the even number of blades is (z=24 pieces) (z=23 pieces) $\delta = 2{,}2\%$, $\delta_t = 3{,}5\%$.



a



b

Figure 5 – Dependence of the ratio errors δ and δ_T on the number of blades z:
δ – the error which is formed as a result of introduction of $b_{ек}$ equal-area projection of the height of the cylinder drum with blades;
δ_T – the error which is formed as a result of the indeterminateness of the initial angle set of the cylinder drum with blades;
a – odd number of blades (z=11…23 pieces);
b – even number of blades (z=10…24 pieces).

Taking into consideration formulae (5, 6) the force to overcome the air resistance can be determined in the following way

$$P_c = k \cdot k_0 \cdot L_н \cdot b_{ек} \cdot \left(\vartheta_0 - \vartheta_{агр}\right)^2, \text{ [N]} \quad (11)$$

where: k is the number of cylinder drums with blades on the crimp-roller, pieces;
k_0 is a coefficient which takes into account the type of environment;
$L_н$ is the length of the blade, m;
ϑ_0 is the wind speed, m/s;
$\vartheta_{агр}$ is the speed of the aggregate, m/s.

The purpose of the field trials is to assess the quality of the plant residue shredding process for corn under farm conditions, depending on the speed of the aggregate. Research objective: To determine the effect of the aggregate's movement speed on the shredding performance. Object and methodology of the study. The object of the study was the technological process of shredding plant residues using agricultural machinery with non-driven working components. The crimp-roller PK-4.5 was tested in the fields of the Kirovohrad region, Kompaniivskyi district, on a 7.15-hectare field after corn harvesting. The testing conditions were in line with the regional average (Table 2).

Table 2

Testing Conditions (Agricultural Crop – Corn)

No.	Parameter	Unit of Measurement	Value
1.	Crop	-	Corn
2.	Row spacing between stems	cm	75
3.	Distance between stems in the row	cm	22-25
4.	Stem diameter (corn)	mm	9-21
5.	Stalk moisture content	%	89
6.	Plant residue mass	kg/m²	0.72
7.	Crimp-roller aggregation	-	Towed
8.	Working width	m	4.5
9.	Aggregate movement speed	km/h	15-23

Results of the study. On the measured area of the field, which was marked by a wooden frame of 1x1 meters, all plant residues were collected from the field surface, their total mass was determined, and the ratio of their lengths was established. The repeatability of measurements was five times. Based on the analysis of the obtained results, a histogram of the distribution of corn plant residues by length l was generated using an applied software package (Fig. 6). The resulting graph-analytical dependence indicates that most corn plant residues had a length in the range of 40-80 cm.

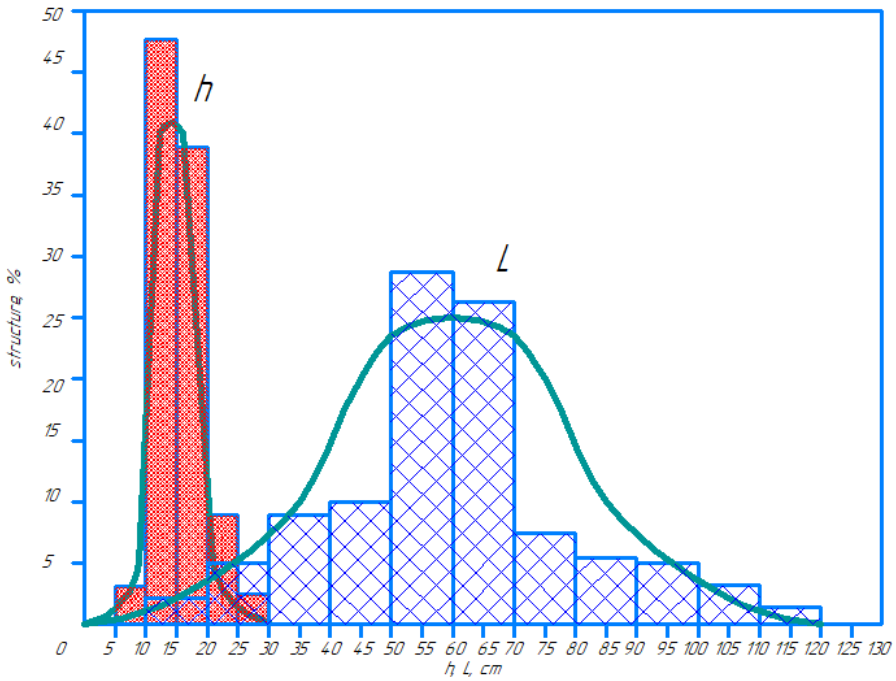


Figure 6 – Histogram of the distribution of the length of the plant residues of corn before cutting (L) and after (h)

Numerical tests of the crimp-roller were conducted in fields after harvesting corn and sunflower [5-6]. The quality indicator was the percentage of plant residues, the size of which, after shredding, did not exceed the established limit value L_{gr} = 200 mm.

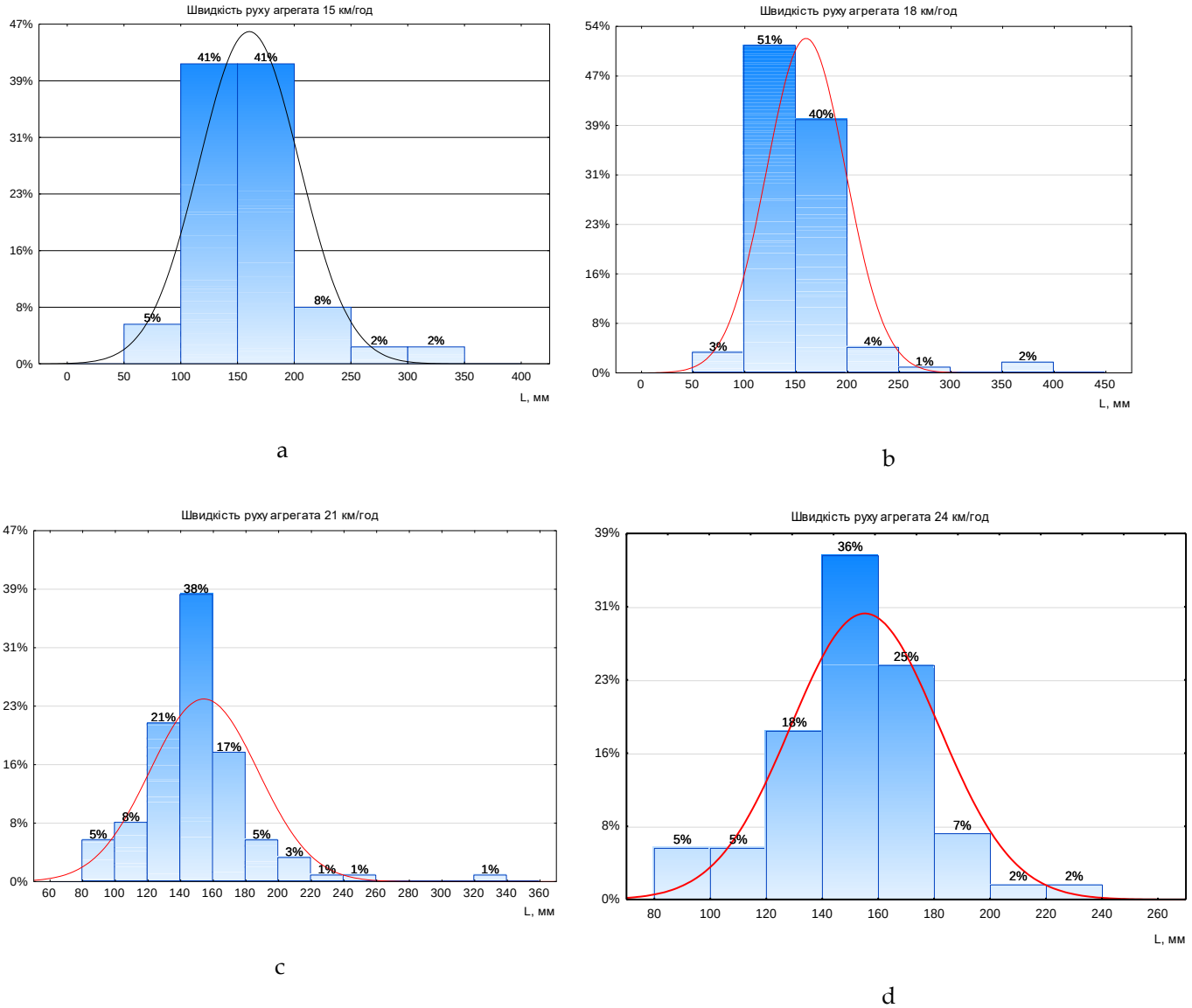


Figure 7 – Histogram of corn stalk residue distribution by length (L) after processing at different implement speeds:
a – fragmentation degree C = 88% at a speed of 15 km/h;
b – fragmentation degree C = 93% at a speed of 18 km/h;
c – fragmentation degree C = 94% at a speed of 21 km/h;
d – fragmentation degree C = 96% at a speed of 24 km/h.

The analysis of the histogram of corn stalk residue distribution by length (L) after processing (Fig. 7a-b) showed that the largest number of residues has a length of 100-200 mm. This length is explained by the fact that the distance between the knives of the shredder roller is 150 mm. An increase in the implement speed ensures the

fragmentation of plant residues into smaller sizes. In other words, the number of plant residues with a length up to 150 mm increases, while the number of residues longer than 200 mm decreases. It should also be noted that the number of unshredded or incompletely shredded plant residues decreases. The experimentally determined speed range of 15 to 24 km/h takes into account the operating conditions of the shredder roller in the field, specifically the movement of the implement on slopes and inclines, both vertically and horizontally. Exceeding a speed of 24 km/h may affect the maneuverability of the implement and increase the load on the frame, the working parts of the shredder roller, and the tractor hitch mechanism. According to the requirements for the execution of the shredding process proposed by the National Scientific Center "IMESG" of the Ukrainian Academy of Agricultural Sciences, the size of plant residues should not exceed 200 mm. In this regard, almost 100% of the shredded plant residues (Fig. 7a-b) do not exceed the specified maximum value.

Similar field studies were conducted on a 6.4-hectare field after sunflower harvest. The conditions for the trials corresponded to the regional average in the Kirovograd region (Table 3).

Table 3

Testing Conditions (Agricultural Crop – Sunflower)

No.	Parameter	Unit of Measurement	Value
10.	Crop	-	Sunflower
11.	Row spacing between stems	cm	75
12.	Distance between stems in the row	cm	22-25
13.	Stem diameter (corn)	mm	9-21
14.	Stalk moisture content	%	89
15.	Plant residue mass	kg/m²	0.72
16.	Crimp-roller aggregation	-	Trailed
17.	Working width	m	4.5
18.	Aggregate movement speed	km/h	15-23

Figure 8 – Sunflower field area after processing.

Figure 9 – Determining the quantity of residues and the size of sunflower stems per 1 m² using a frame.

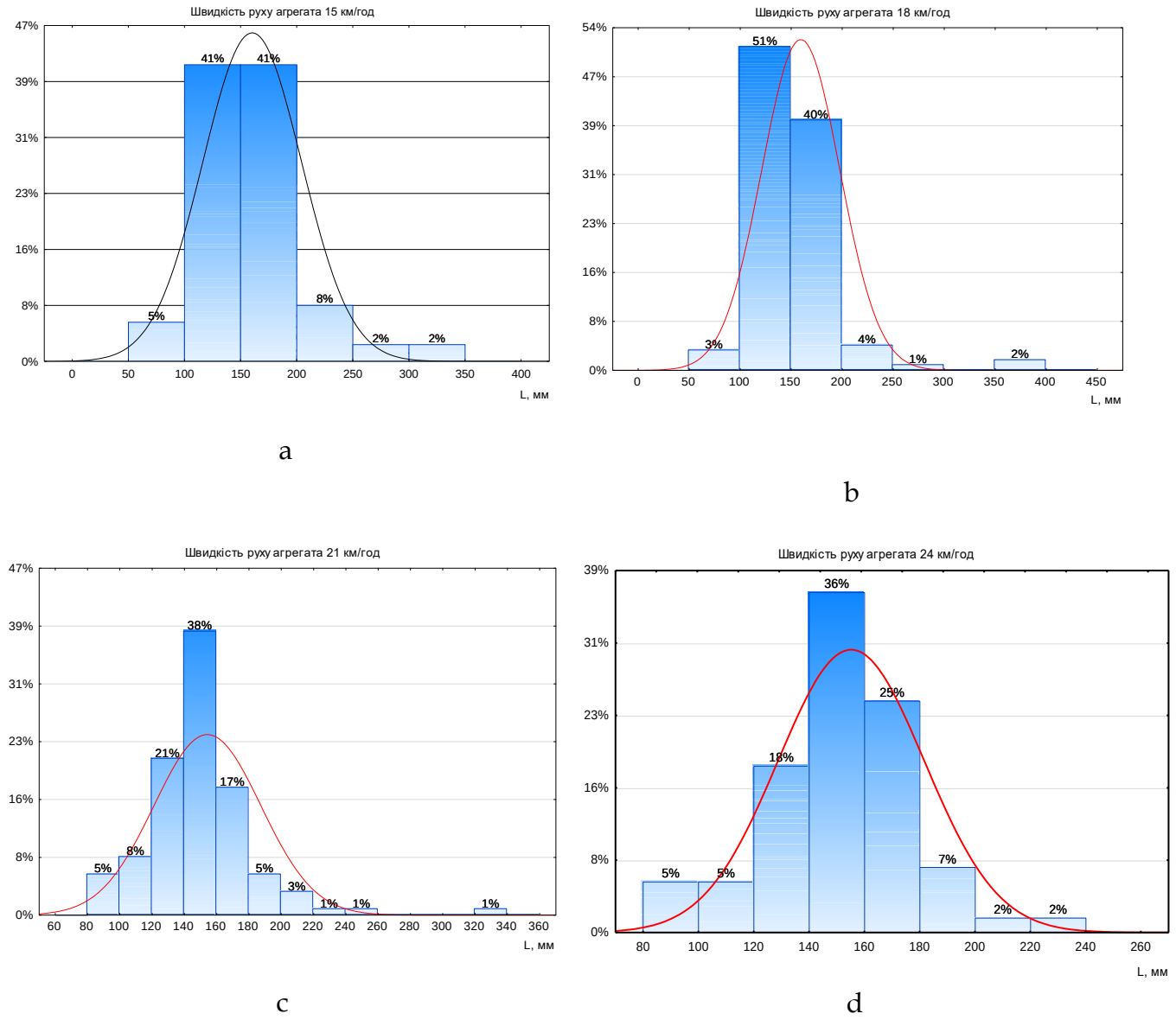


Figure 10 – Histogram of sunflower stalk residue distribution by length (L) after processing at different implement speeds:
a – fragmentation degree C = 88% at a speed of 15 km/h;
b – fragmentation degree C = 93% at a speed of 18 km/h;
c – fragmentation degree C = 94% at a speed of 21 km/h;
d – fragmentation degree C = 96% at a speed of 24 km/h.

The analysis of the histogram of sunflower stalk residue distribution by length (L) after processing (Fig. 10 a-b) showed that the largest number of residues has a length of 100-200 mm. This length is explained by the fact that the distance between the knives of the roller-crimper is 150 mm. An increase in the implement speed ensures the fragmentation of plant residues into smaller sizes. In other words, the number of plant

residues with a length up to 150 mm increases, while the number of residues longer than 200 mm decreases. It should also be noted that the number of unshredded or incompletely shredded plant residues decreases. The experimentally determined speed range of 15 to 24 km/h takes into account the operating conditions of the roller-crimper in the field, specifically the movement of the implement on slopes and inclines, both vertically and horizontally. Exceeding a speed of 24 km/h may affect the maneuverability of the implement and increase the load on the frame, the working parts of the roller-crimper, and the tractor hitch mechanism.

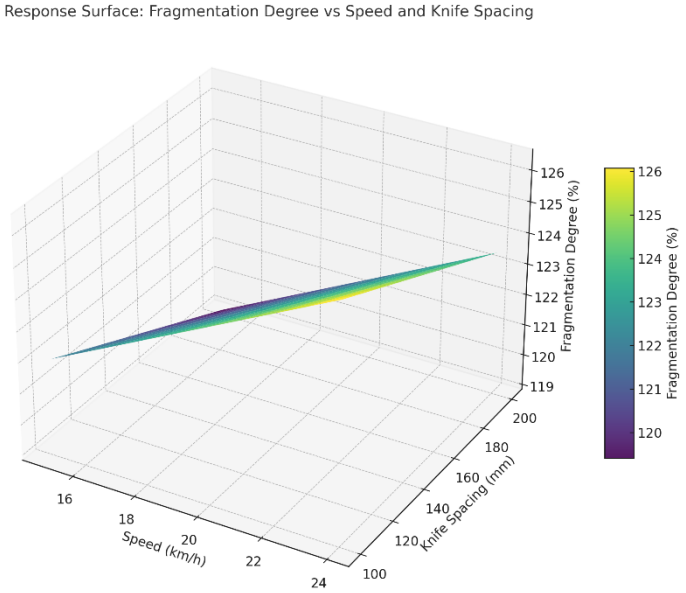


Figure 11 – The response surface that illustrates the dependence of the fragmentation degree of plant residues (C) on the implement speed (km/h) and the knife spacing of the roller-crimper (mm).

The experimental results demonstrate that increasing the implement speed positively impacts the fragmentation degree of plant residues, resulting in smaller residue sizes. At the same time, reducing the knife spacing further enhances the shredding efficiency, leading to a higher percentage of residues with lengths below the critical threshold of 200 mm. The optimal speed range for achieving a fragmentation degree above 90% lies between 18 and 24 km/h. Exceeding 24 km/h, however, may introduce operational challenges such as reduced maneuverability and increased mechanical stress on the roller-crimper's frame and components. These findings emphasize the importance of balancing implement speed and knife spacing to achieve effective residue management while maintaining equipment reliability in field conditions.

According to the requirements for the execution of the shredding process proposed by the National Scientific Center "IMESG" of the Ukrainian Academy of Agricultural Sciences, the size of plant residues should not exceed 200 mm. In this regard, almost 100% of the shredded plant residues (Fig. 10 a-b) do not exceed the specified maximum value.

Conclusions:

1. The implementation of technological processes for effective preparation of plant residues in crop production will initiate a soil conservation system within the farm.

2. It is most advisable to carry out the shredding of plant residues using non-driven shredder rollers, with the main working organs being a roller with knives fixed on the cylinder. Depending on the intended use, quantity, and type of plant residues, rollers with both large and small diameters are practically applied.

3. For shredding tall plant residues, it is recommended to use large-diameter shredder rollers with the following parameters: aggregate speed V=42-45 m/s and an angle of divergence between the knives α=7-8°. These parameters of the shredder roller reduce the probability of clogging between the knife spaces (P) to 8%.

4. The theoretical determination of the equal-area height projection as a function of the angle of blade setting and the number of blades enables the calculation of the force required to overcome the air resistance encountered by the crimp-roller. The theoretical relationships, derived for the first time, facilitate the assessment of the energy consumption and fuel requirements needed to overcome air resistance at operational speeds ranging from 15 to 25 km/h. Further research is essential to deepen the theoretical foundation of the rational design and technological parameters of the crimp-roller, ensuring optimized performance in agricultural machinery applications.

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CHAPTER 4. FEATURES PROFESSIONAL TRAINING OF ENGINEERING, EDUCATIONAL AND TECHNOLOGICAL SPECIALISTS IN DISTANCE LEARNING CONDITIONS

4.1. Theoretical Aspects Professional Training of Specialists in Engineering, Pedagogical and Technological Fields in Distance Learning Conditions

Distance learning has become an integral part of modern education, especially in the training of specialists in engineering, pedagogical and technological fields. Recent years have been characterized by a rapid growth in the use of distance technologies in the field of higher education. The main prerequisite for the effective implementation of this format is the development of information and communication technologies (ICT), which allow providing access to educational materials, organizing communication between teachers and students, as well as implementing interactive learning methods. Distance platforms such as Moodle, Google Classroom, Microsoft Teams and Zoom contribute to flexible management of the educational process [18].

One of the most noticeable trends is the development of adaptive learning, which allows personalizing the educational process according to the individual needs of students. Adaptive systems use artificial intelligence to determine the level of preparation of students, assess their success and offer appropriate educational materials. This allows significantly improving the efficiency of learning, since each student receives exactly the content that matches his knowledge and abilities. Adaptive platforms can also recommend additional resources to study the student's weaknesses, thereby contributing to the individualization of education [43].

Another important trend is the development of microlearning, which involves the presentation of educational materials in the form of short, easy-to-learn blocks of information. Microlearning allows students to learn new material in a short time, which is especially relevant in the context of limited opportunities for deep immersion in the topic. Short video lessons, interactive tasks and test modules allow for effective learning of new knowledge while maintaining the student's concentration. Improvements to platforms such as Coursera, Khan Academy, as well as specific microlearning tools, are actively integrated into the educational process [35].

Also important is the trend towards the integration of virtual reality (VR) and augmented reality (AR) technologies into distance learning. These technologies allow the creation of realistic learning environments in which students can interact with objects and processes in virtual space. For engineering, pedagogical and technological fields, AR and VR open up new opportunities for conducting laboratory work and modeling complex technological processes. For example, VR can be used to simulate experiments, and AR allows you to visually demonstrate 3D models for a deeper understanding of complex technical aspects [34].

Another significant trend is blended learning, which combines the advantages of face-to-face and distance learning. This approach allows you to use both traditional teaching methods and modern digital technologies. Students get the opportunity to learn both in the classroom and through online platforms, which increases their

motivation and provides flexibility in the learning process. Blended learning contributes to the development of important skills of independent learning, critical thinking and the ability to adapt in a rapidly changing world of technologies [11].

Among the latest trends, one can note the use of big data analytics to improve learning outcomes. This allows teachers to receive detailed information about the success of each student, identify problems at an early stage and adjust the educational process. For example, using big data to analyze course attendance, forum participation, and assignment completion allows us to more accurately predict students' needs and provide them with additional support if necessary [39].

The integration of mobile technologies into distance learning is also important, allowing students to access learning materials from anywhere in the world. Mobile platforms and learning applications allow for teaching and learning at a convenient time, providing students with the necessary tools for effective learning. This is especially important for students who have limited access to stationary computers or for those who wish to learn in a mobile format [23].

One of the key features of distance learning is the use of various pedagogical models that allow adapting the learning process to new technological capabilities and students' needs. In this context, several main models can be distinguished, among which the most popular are blended learning, asynchronous and synchronous learning, as well as individualized learning based on adaptive technologies.

Blended learning combines traditional teaching methods with online resources, providing students with greater flexibility in choosing the learning format. This model allows for the integration of face-to-face classes with online content, which allows for the optimization of the learning process. The use of platforms such as Moodle or Google Classroom allows students to access lecture materials, tests, and the ability to communicate with the teacher and other students through forums or chats. Blended learning is extremely effective for engineering, pedagogical and technological education, as it allows for the combination of theoretical knowledge with practical skills that can be practiced using online simulations and virtual laboratories [31]. Another important approach is asynchronous learning, which involves students working independently with educational materials at a time convenient for them. This model is especially useful for students who have limited access to online resources or work on a flexible schedule. In this case, the teacher only provides course materials, but does not conduct classes in real time. Students can complete assignments, watch video lectures, take tests, and submit assignments through specialized platforms. Asynchronous learning allows each student to move at their own pace, which contributes to a deeper assimilation of the material [13].

On the other hand, synchronous learning allows students to be actively involved in the learning process in real time through video conferences, webinars and online lectures. This model provides instant feedback from the teacher, as well as the opportunity to collectively discuss the topic with other students. Synchronous learning is especially effective for conducting laboratory work or practical classes, where interaction with the teacher is important for adjusting the learning process [37].

It is also necessary to consider the impact of ICT on the training of specialists in engineering, pedagogical and technological areas. Thanks to the use of ICT, approaches to learning are changing significantly, in particular in the field of providing access to educational materials, organizing interactive forms of learning, as well as developing practical skills in a virtual environment. The integration of modern technologies into education allows for the creation of new forms of interaction between teachers and students, and also significantly expands the possibilities for conducting educational and research work.

One of the most significant aspects is the use of virtual laboratories and simulators, which allow students to acquire practical skills without having to be physically present in laboratories. This is especially relevant for specialists in engineering, pedagogical and technological areas, where the practical component of training is important. With the help of virtual laboratories, students can perform experiments, manipulate technological processes, simulate situations, which gives them an idea of the real production process [20].

Another important aspect is the use of methods focused on the development of critical thinking, independent work and creative skills. ICTs contribute to the implementation of interactive forms of learning, such as simulations, modeling, online quizzes and tests, which activate student participation in the learning process. This allows students to immerse themselves more deeply in the learning process and develop analytical skills, which is an important component in the training of specialists in the engineering, pedagogical and technological fields [36].

The use of ICTs also facilitates the process of assessing students' knowledge and skills. Using digital platforms, teachers can create interactive tests, surveys, tasks, and also carry out automatic verification of results. This not only speeds up the assessment process, but also allows monitoring the progress of each student in real time. In addition, electronic assessment provides more objectivity and transparency in calculating results, which is especially important for engineering, pedagogical and technological disciplines [12].

No less important is the impact of ICT on the organization of distance and blended learning. With the development of digital technologies, it has become possible to combine traditional learning with online components. The use of various digital tools, such as video conferencing, webinars, electronic textbooks, allows for more flexible and accessible learning. Students can combine independent study of the material with active participation in lectures and seminars held online, creating new opportunities for interaction and collaboration [41].

In general, the introduction of ICT in education not only improves the learning process, but also significantly increases its efficiency. The use of technologies, such as simulators, virtual laboratories, online courses and platforms for collaboration, allows students to master complex engineering and technological concepts and skills, which is important for their further professional activities. Technologies not only create new forms of learning, but also open up new horizons for self-improvement, mobility and accessibility of educational resources.

The development of distance courses is a key aspect in the implementation of distance learning, since the effectiveness of the educational process depends on the quality of the course. The development process includes not only the creation of educational materials, but also the consideration of pedagogical principles such as accessibility, interactivity, adaptability and assessment of results. All these components should contribute to the achievement of educational goals and the creation of a comfortable learning environment.

One of the main aspects in the development of distance courses is to ensure the accessibility of educational materials for all students, regardless of their level of training and technical capabilities. To do this, it is necessary to use simple and understandable interfaces, provide access to materials on different devices, and also take into account the needs of students with disabilities, for example, by adding subtitles to videos or using text alternatives for images and graphics [5, 14, 32]. The use of multimedia resources such as videos, graphics, animations, simulations allow you to significantly increase the effectiveness of the perception of educational material.

Another important component of distance learning is the interactivity of the educational process. Since distance learning involves greater independent work of students, it is important that courses contain elements that stimulate active participation in learning. These can be interactive tests, tasks for independent work, as well as the opportunity for students to ask questions or participate in discussions through forums and chats. Such methods not only help to better learn the material, but also contribute to the development of self-control and independent thinking skills [4].

Particular attention should be paid to the development of adaptive learning systems that allow personalizing the learning process. The use of algorithms that analyze student performance and recommend additional resources or tasks according to their level of knowledge is one of the most progressive approaches in distance learning. These systems allow for an individual approach to each student, providing them with materials that meet their current needs and progress [40]. In this way, courses become more flexible and effective, increasing the level of material assimilation.

Didactic principles, such as gradualness and consistency of presentation of the material, are also an integral part of the development of distance courses. The course should be structured in such a way that students gradually deepen their knowledge, moving from simple to complex topics. To do this, it is important to carefully consider the logic of presenting the material, determine the main stages of the course and the learning objectives of each of them. In addition, it is important to include various types of learning tasks that allow you to check the assimilation of the material, such as testing, project work, reviews, etc. [19].

The development of a distance course also includes the stages of testing and feedback. After creating the course, it is necessary to test it among students, which will allow you to identify possible shortcomings in the materials or in the organization of the educational process. It is also important to provide a mechanism for receiving feedback from students so that they can express their comments on the course, which will allow you to make adjustments and increase the effectiveness of learning. Taking

into account the opinions of students allow you to constantly improve the course and adapt it to changes in educational needs [26, 27].

Special attention should be paid to the use of technologies for integrating virtual laboratories and simulations in courses. For engineering, pedagogical and technological areas, this is an important element, as it allows creating realistic conditions for performing practical tasks. Virtual laboratories make it possible to model various scenarios of production processes, conduct experiments and testing, which in traditional conditions is difficult or impossible. Thus, the development of virtual laboratories significantly expands the possibilities of distance learning in technical and engineering disciplines [21].

Thus, pedagogical models of distance learning are constantly evolving, integrating new technologies and adapting teaching methods to the needs of modern students. The choice of a specific model depends on the purpose of the course, the specifics of the discipline and the capabilities of the educational institution. It is important to use combined approaches that allow the most effective combination of the advantages of different learning models. And modern trends in the development of distance learning include not only the use of the latest technologies, but also changes in approaches to organizing the educational process. Personalization of learning, VR/AR integration, the development of blended learning and big data analytics are just a few aspects that will define the future of distance learning in education.

4.2. Practical Aspects Implementing Distance Learning in the Training of Specialists in Engineering, Pedagogical and Technological Fields

In the context of implementing distance learning, teacher training is a key aspect that determines the effectiveness of the educational process. Teachers must not only have professional knowledge of the discipline, but also have a high level of digital competence to use modern technologies in the educational process. Therefore, the first step is systematic training of teachers, which should include both technical skills in working with distance learning platforms (Moodle, Google Classroom, Zoom) and pedagogical aspects related to the organization and management of a distance course. In this regard, it is important to organize trainings and seminars for teachers, where they learn to use various digital tools. Such tools include creating online tasks, using simulation programs, conducting interactive lectures and seminars. Teachers should also know how to organize feedback with students through platforms and other means of communication. For this purpose, tools such as chat rooms, discussion forums, video conferencing, as well as tools for testing and assessing learning outcomes are used.

The main goal is to ensure that teachers have all the necessary knowledge and skills to manage the educational process in distance learning conditions, in particular, how to develop curricula, create content for online courses, and organize effective communication with students.

Another important aspect is to take into account the specifics of engineering, pedagogical, and technological disciplines, where the practical component plays a significant role. Therefore, teacher training should also include studying the methods of

using virtual laboratories, modeling technical processes, and using software for technical design. In addition, teachers should have the skills to create interactive lectures and seminars that allow students not only to listen to the material, but also to actively interact with it, completing various exercises and tasks.

In order to ensure effective distance learning for students, the organization of the educational process should take into account not only technological tools, but also appropriate pedagogical strategies. This includes the use of blended learning, combining online lectures with practical tasks, as well as providing students with opportunities for self-education and independent work using interactive platforms. In addition, an important component is the integration of adaptive systems that allow personalizing the educational process according to the needs and level of each student.

One of the effective methods of organizing the educational process is the combination of synchronous and asynchronous learning. Synchronous learning includes real online lectures and webinars, where the teacher can directly interact with students, and asynchronous learning provides flexibility, giving students the opportunity to independently work with course materials at a time convenient for them. This allows you to create an individual learning schedule and adapt the educational process to the different needs of students.

The use of digital platforms makes it possible to effectively monitor student progress. Thanks to electronic testing systems and automated assessment, teachers can quickly receive data on student performance, which allows them to adjust the learning process and provide feedback in real time.

In turn, interactive learning tools are an important element in distance learning, as they allow students not only to gain knowledge, but also to actively interact with the learning material. This approach provides better motivation for students, contributes to a deeper understanding of the subject and the development of critical thinking. In the context of distance learning, interactive tools make it possible to create a learning environment that supports active learning, promotes the development of collaboration skills and allows for the practical application of theoretical knowledge.

The main interactive learning tools include forums, chats, video conferences, electronic tests, as well as learning platforms that allow students to participate in real learning processes, perform practical tasks and receive feedback. Platforms like Moodle or Google Classroom allow for the integration of various multimedia resources, making learning more dynamic and effective. They enable teachers to create interactive lessons where students can interact with content, discuss material, and work on joint projects.

One of the main advantages of interactive tools is that they stimulate students to actively work. They allow teachers to create learning scenarios that increase interest in the learning process and contribute to the formation of practical skills. For example, when using virtual laboratories, students can work with models that simulate real production processes, which is especially relevant for engineering, pedagogical, and technological specialties.

Interactive tools also allow for the creation of personalized learning paths for students, which is important in distance learning environments, where each student can

have their own learning pace and individual needs. Adaptive systems that are integrated into online courses allow for automatic adjustment of the level of complexity of tasks according to the student's performance, which ensures a high level of involvement and progress in learning.

Among the popular tools for implementing interactive teaching methods are various online games and simulators that allow you to create learning situations where a student can learn through practical activities. Such tools are used to develop critical thinking, solve real-world problems, and develop problem-solving skills. For example, in technological disciplines, simulators can be used to study software or manage production processes, which are important for specialists in these areas.

The use of video conferencing and online seminars makes it possible to conduct synchronous classes during which students can ask questions to the teacher, participate in discussions, and work on collective projects. This is especially useful for creating a sense of presence and interaction among students, which is important in distance learning.

Thus, interactive learning tools significantly increase the effectiveness of the educational process in distance learning, allowing you to create dynamic, personalized, and actively engaging learning environments. They contribute not only to the acquisition of knowledge, but also to the development of skills necessary for professional activity, which is especially important for specialists in engineering, pedagogical and technological fields.

Another important aspect of distance learning for engineering, pedagogical and technological specialists is the use of virtual laboratories and simulations. These tools significantly expand the possibilities for practical learning, allowing students to gain experience that would normally be unavailable due to limited physical resources or the dangers associated with conducting real experiments.

Virtual laboratories are specialized software products or online platforms that simulate real laboratory conditions. They give students the opportunity to conduct various experiments, interact with hardware and software without leaving the computer classroom. For example, in technological and engineering disciplines, simulators can be used to model complex technical processes or to work with physical objects, which is impossible in standard laboratories.

Virtual laboratories have several significant advantages. First, they allow students to perform complex practical tasks that usually require significant time and resources. For example, a student can work with models of car engines or study complex physical phenomena such as electrical circuits or thermal processes without the need for special equipment or safety risks. Second, these tools allow for repeated experiments, which is important for deeper learning of the material and development of skills.

Additionally, simulations allow students to receive real-time feedback, which is an important part of the learning process. For example, in software simulators, students can see the result of their actions and immediately correct mistakes, which stimulates them to independently solve problems. This is especially useful for developing critical thinking and the ability to solve non-trivial tasks.

The use of virtual laboratories in distance learning is especially relevant for training specialists, where it is important to combine theoretical knowledge with practical skills. In conditions where a student cannot directly interact with physical equipment, virtual simulations provide an opportunity to develop important professional skills. For example, future engineers can work with virtual models of machines and mechanisms, testing them for operability, which significantly increases the effectiveness of their training.

Modern virtual reality (VR) technologies are also actively integrated into the distance learning system, providing an even deeper level of immersion in the learning process. The use of VR allows students to "visit" real production facilities or experiment with equipment, as in physical laboratories, without the need to be on site. This opens up new opportunities for training in professions where there is a need for practical classes.

Thus, the use of virtual laboratories and simulations is a necessary element in the training of specialists in the field of engineering and pedagogy. They allow organizing high-quality practical training that directly supports students' theoretical knowledge and provides them with the necessary skills to work in real conditions. The introduction of such technologies has enormous potential for the development of modern education.

The introduction of distance learning requires the adaptation of traditional methods of assessing students' academic achievements, since new conditions require a different approach to measuring their knowledge and skills. Assessment in a distance learning format should not only be an indicator of the achievement of learning goals, but also part of a process that supports interactive and active student learning. Let's consider the main methods of assessment in distance learning.

One of the important aspects of assessment is the use of various forms of feedback, which allows students to immediately receive corrections and recommendations for further learning. This is especially important in the context of asynchronous learning, where the student has more freedom in choosing the time to complete the tasks, but at the same time it is necessary to have a clear understanding that the result will be checked.

One of the most popular assessment methods is the use of tests and online exams, which automate the process of checking knowledge and allow the teacher to quickly receive the result without the need for manual checking. Modern distance platforms, such as Moodle or Google Classroom, offer a wide range of test types – from simple multiple-choice questions to more complex tasks requiring essay writing or analysis.

For a more comprehensive assessment of students' knowledge and skills, project-based learning methods that involve the completion of practical tasks are effective. In distance learning, this can be implemented through the development of projects, the use of simulations or the creation of models, which allows students to apply theoretical knowledge in practice. This assessment method stimulates critical thinking and the ability to solve problems independently.

Forum and video discussions are also used to assess student participation in the educational process. This format allows students to actively engage in discussions of

important theoretical and practical aspects, which allows them to test their ability to argue their point of view and interact with other participants. The use of video discussions can provide a more in-depth analysis of the arguments presented and allows students to demonstrate their ability to communicate in an online environment.

Additionally, distance learning uses combined assessment methods, when students' results are assessed based on the sum of scores from several different tasks, including tests, projects, discussions and other forms of assessment. This allows for a more objective and comprehensive picture of a student's academic achievements.

Assessment in distance learning is not limited to determining student success, but also contributes to their development by providing feedback. This helps students to realize their weaknesses and correct them in a timely manner, and also provides an opportunity for further improvement in the learning process.

Assessment methods in distance learning should take into account the specifics of this format: greater student autonomy, the ability to obtain results in real time, as well as the use of various digital tools to improve the interactivity of the educational process. This allows to increase the level of student motivation and promotes their active participation in the educational process.

The introduction of digital technologies into the educational process is an important step for the development of effective distance learning, as they provide new opportunities for interactive, accessible and personalized learning. To achieve maximum results, it is necessary to consider several key aspects and recommendations that allow for the effective integration of these technologies into the educational process.

The first thing to consider is choosing the right digital platform for organizing learning. Platforms such as Moodle, Google Classroom, Microsoft Teams, or Zoom provide functionality for lectures, sharing materials, conducting tests, and organizing interactive classes. The choice of platform should be based on the specifics of the training course, the accessibility of the interface for students and teachers, and the possibility of integration with other learning management tools [31].

The next important step is to organize the effective use of digital tools for interactive learning. Modern technologies allow you to create online laboratories, conduct simulations of production processes, or use virtual and augmented reality to solve practical problems. For example, in technical and engineering disciplines, digital simulators can be used to model technical processes or to study mechanisms and systems in an interactive environment, which significantly increases the level of practical training of students [24–32].

Interactive learning tools, such as forums, video conferencing, and virtual classrooms, allow students to actively engage in the learning process. The ability to discuss course materials in real time is especially important, which allows the teacher to adjust the lesson depending on the needs of the students, ask additional questions, or explain difficult points.

Another important recommendation is the implementation of adaptive learning systems that allow for the creation of a personalized program for each student. Thanks

to systems such as adaptive tests or intelligent learning platforms, it is possible to provide an individual approach to each student, taking into account his previous knowledge and learning needs [24–32]. Such systems help to maximize the potential of each student, allowing him to move at his own pace.

It is also important to teach students to use digital tools effectively. Since not all students may have experience with modern technologies, it is important to conduct additional training in the use of selected platforms and software. This will avoid unnecessary delays in the learning process and help students adapt more quickly to distance learning conditions.

The final stage is the assessment of the effectiveness of the implementation of digital technologies. Regular assessment and feedback from students allow you to identify weaknesses in the organization of the educational process in a timely manner and identify problems in working with platforms. Using data to analyze student success and interaction with content makes it possible to adjust the distance learning strategy to ensure maximum efficiency.

Distance learning, as one of the main trends in higher education, has great potential for development in the coming years. Modern technologies, in particular ICT, are changing traditional approaches to organizing learning, creating new opportunities for students and teachers. In the future, we can observe a significant expansion of digital platforms, the integration of the latest technologies, such as artificial intelligence (AI), augmented and virtual reality, as well as further personalization of the educational process.

One of the most promising areas of development is the use of adaptive learning systems that can automatically adjust the educational process depending on the needs of each student. Such systems use AI algorithms that analyze student performance, identify their weaknesses, and provide individual recommendations for further learning [24–32]. This allows for the creation of a personalized learning environment where each student can receive materials that match their level of knowledge and learning needs.

Another important perspective is the use of augmented reality (AR) and virtual reality (VR) technologies. These technologies are capable of creating interactive learning environments that allow students to work with real objects and processes without leaving home. This is especially relevant for engineering, pedagogical and technological specialties, as it allows for practical classes, laboratory work and even modeling of production processes [24–32]. In particular, VR laboratories can replace physical experiments, which will allow students not only to see, but also to interact with models of complex technical systems in real time.

Another important direction is the development of microlearning, which involves the presentation of educational material in short modules or video lessons. This format allows for effective use of time and the acquisition of new knowledge even using mobile devices, which is convenient for students who have limited time for study. The use of microlearning in combination with interactive platforms makes it possible to gain deep knowledge in a short time [24–32].

In the future, it is also important to develop hybrid learning models that combine online courses with traditional teaching methods, which allows combining the advantages of both approaches. Such models are already actively used in some universities, which allows not only to increase the accessibility of education, but also to improve its quality through interactive and flexible approaches to learning [4, 5]. Blended learning also allows you to adapt the educational process to the specific needs of students, ensuring more effective learning.

Given the rapid development of technology, an important prospect is also the further integration of distance learning with other areas of life. For example, the use of online courses in professional development, where employees can undergo specialized training without leaving the workplace. This allows for continuous improvement of professional skills and advanced training in the conditions of a changing labor market [4, 5].

Thus, the prospects for the development of distance learning are multifaceted. The use of new technologies, such as artificial intelligence, virtual reality, as well as innovative approaches to learning, create new opportunities for improving the educational process, ensuring greater accessibility and quality of education. Taking into account development trends, distance learning will become even more flexible, personalized and effective in the future.

The introduction of distance learning in the training of specialists in engineering, pedagogical and technological areas is a relevant and necessary step in modern education. The combination of theoretical knowledge with practical skills, the use of modern technologies and interactive teaching methods contributes to the formation of competent and sought-after specialists. The preparation of pedagogical staff for work in distance learning conditions is the key to the successful implementation of educational programs and ensuring high quality education.

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ANNOTATION

CHAPTER 1. MODERN BASICS OF ECONOMICS, MANAGEMENT AND TOURISM

1.1. Nataliya Hryniv, Tetiana Gryniv, Kateryna Roshko CONTAINERIZED TRANSPORTATION - HISTORY, APPLICATION, PROSPECTS, ACTUALIZATION

The article explores intermodal transportation with a focus on rolling road (Ro-La) services as a crucial component of modern logistics. It delves into the historical development, current status, implementation perspectives, and relevance of such transportation systems in the context of globalized supply chains. The paper reviews the origins of rolling road services in Europe, their introduction in Ukraine, and the key challenges and advantages associated with this type of freight transport. Special emphasis is placed on analyzing international experiences, including the economic and environmental benefits of Ro-La operations.

The article highlights successful projects implemented both in Ukraine and abroad, analyzing the role of government support and investments in developing infrastructure for intermodal transportation. Additionally, it examines the potential of integrating Ukraine into the European transport network through the expansion of rolling road services. The authors emphasize the importance of adopting advanced technologies, such as artificial intelligence, the Internet of Things, and blockchain, to enhance the efficiency, transparency, and security of this transportation mode.

Keywords: rolling road transport, logistics, multimodal transportation, transport infrastructure, combined transport, Internet of Things, blockchain.

1.2. Nadiia Vasyltsiv E-COMMERCE MARKET IN CURRENT CONDITIONS OF UNCERTAINTY: TRENDS AND CHALLENGES

The global e-commerce market has been analyzed. The main factors that have caused the growth of the global e-commerce market have been identified and formed. The current state of the e-commerce market in Ukraine development and changes in consumer purchasing behavior in conditions of uncertainty have been analyzed. The main challenges caused by the military invasion of the russian federation, to which the Ukrainian e-commerce segment must adapt, have been identified. The main trends of the e-commerce market in Ukraine have been identified and formed, which it is important for businesses to integrate into their activities in order to maintain competitive positions in conditions of uncertainty.

Keywords: e-commerce, conditions of uncertainty, marketplaces, payment methods, purchasing behavior, social networks, mobile commerce.

1.3. Olha Hirna LOGISTICS SERVICES MARKET: DIGITAL TRANSFORMATION AND INNOVATION

The publication examines the current state and trends in the development of the logistics services market in the context of digital transformation. The key factors determining the economic potential of transport logistics and the industry's main challenges are analyzed. The impact of innovative technologies on improving transport logistics is considered, including integrating IoT technologies, developing autonomous

vehicles, the concept of Mobility as a Service (MaaS), and intelligent transport systems (ITS). Examples of successful implementation of digital technologies in logistics companies are given.

Keywords: logistics services market, supply chains, digital transformation, innovation, transport logistics.

1.4. Orysya Pshyk-Kovalska, Olena Mazurchuk ADMINISTRATION AND PERSONNEL MANAGEMENT IN LLC "TRADING HOUSE "GALKA"

The article explores administration and personnel management using the example of LLC "Trading House "Galka". In particular, it examines the theoretical aspects of human resource administration, considers key methods and influencing factors, and evaluates regulatory and legal documents affecting personnel management and administration. A general analysis of the administration of human resources at LLC "Trading House "Galka" has been conducted.

Keywords: administration, human resource potential, human resource management.

1.5. Yevhenii Podakov PUBLIC DEBT OF UKRAINE 2024: CURRENT STATE AND IMPACT ON THE COUNTRY'S ECONOMY

Public debt is an important component of a market economy. Today it is difficult to find a state that would be able to do without borrowing. The state's use of loans is due to the lack of its own financial resources, which are necessary for financing the state budget. The purpose of the study is to study and analyze the main trends and specific features of the formation of the national debt of Ukraine, as well as to develop on this basis practical recommendations regarding the mechanism of its influence on economic growth.

Keywords: public debt, budget deficit, internal public debt, external public debt, detinization of the economy.

1.6. Lesia Sai ADMINISTRATION OF THE INTELLECTUAL POTENTIAL OF A HIGHER EDUCATION INSTITUTION IN THE CONTEXT OF THE IMPLEMENTATION OF THE EUROPEAN EDUCATIONAL VECTOR

The article clarifies the essence of the concepts of "intellectual potential" and "administration of intellectual potential". The internal and external factors that determine the specifics of intellectual potential administration are generalized. The peculiarities of administering the intellectual potential of a higher education institution in Ukraine are investigated. The technology, process and tools for administering the intellectual potential of teachers for the active integration of higher education institutions into the European educational space are proposed. The problems that have been exacerbated by the war, which need to be addressed at the level of the higher education institution and its structural subdivisions - departments to improve the administration of the intellectual potential of scientific and pedagogical staff, are analyzed. Recommendations have been formulated that will ensure the realization of the intellectual potential of scientific and pedagogical staff and the quality of its administration.

Keywords: administration, intellectual potential (IP), higher education institution (HEI), scientific and pedagogical staff (SPS), European Education Area.

CHAPTER 2. INNOVATIVE AND MODERN FOUNDATIONS OF PEDAGOGY AND PSYCHOLOGY

2.1. Liudmyla Lukaniova INCLUSIVE EDUCATION OF CHILDREN WITH INTELLECTUAL DISABILITIES IN THE CONTEXT OF ENSURING THEIR RIGHT FOR QUALITY EDUCATION

Education is a factor that determines the success of any person in society and the national vector of development in general. It is extremely important to create a new educational space, which includes inclusive education. In modern conditions, there is a constant search for innovative ways to organise the education of children with developmental disabilities.

Keywords: inclusive education, intellectual disability, speech disorder.

2.2. Marian Tripak, Olha Stoliarenko EQUINE-ASSISTED THERAPY AS AN INNOVATIVE METHOD REHABILITATION OF THE SOLDIERS AT EDUCATIONAL AND REHABILITATION INSTITUTION OF HIGHER EDUCATION «KAMENETS-PODILSKYI STATE INSTITUTE»

This article highlights the problems that our society faces in rehabilitating combatants. The results of the implementation and study of the therapeutic effect of the hippotherapy rehabilitation strategy at the Educational and Rehabilitation Institution of Higher Education «Kamianets-Podilskyi State Institute» are presented.

Keywords: hippotherapy, motor function, neurological diseases, riding, therapy, rehabilitation.

2.3. Inna Marynchenko, Yevhenii Marynchenko METHODOLOGICAL ASPECTS OF THE USE OF ARTIFICIAL INTELLIGENCE IN VOCATIONAL EDUCATION

The need for reorganization of the methodological system for the implementation of programs based on artificial intelligence in vocational education is theoretically proven and the prospects for using the proposed methodology to improve the training of future specialists in vocational education in the context of educational transformations are identified. The content of the concept of «artificial intelligence» is determined and its main features and features are revealed. In the context of implementing the methodology, the following artificial intelligence programs are recommended for use in the field of vocational education: SlideBot, Quizlet, DALL-E, Bard, ChatGPT in the process of studying the discipline «Fundamentals of Artificial Intelligence» in the process of studying the educational and vocational programs «Vocational Education. Technology of Light Industry Products (Sewing Products)» and «015 - Vocational Education. Transport (Car Maintenance and Repair)». A model for using artificial intelligence in vocational education is proposed, which includes the following stages: analysis and definition of needs, development of methodological principles, implementation and piloting, scaling and dissemination, monitoring and evaluation. The presented model is based on three interconnected components of readiness, namely: motivational-goal, content-activity and criterion-evaluation. The relevance of the presented methodology was assessed at three levels: high, medium and low.

Keywords: neural networks, digital technologies, readiness components, implementation model, electronic services.

CHAPTER 3. THE LATEST BASICS OF AGRICULTURAL DEVELOPMENT

3.1. Dmytro Bohatyrov DETERMINATION OF PARAMETERS FOR A CRIMP-ROLLER SHREDDER

Evaluated the drum parameters for shredding plant residues to ensure the reliability of the technological process. Analyzed the designs of crimp-rollers, including their structural and technological parameters. Investigated the influence of the blade inclination angle and the operating speed of the aggregate on the clogging of the inter-blade space. It has been proven that increasing the speed and blade inclination angle reduces clogging, even under high moisture conditions.

Keywords: crop residue shredders, crimp-roller, inter-knife space, rotor rolling, clogging of the inter-knife space, plant-soil mass, knife decay angle, unit operating speed.

CHAPTER 4. Serhii Onyshchenko FEATURES PROFESSIONAL TRAINING OF ENGINEERING, EDUCATIONAL AND TECHNOLOGICAL SPECIALISTS IN DISTANCE LEARNING CONDITIONS

This section of the collective monograph examines the features of professional training of specialists in engineering, pedagogical and technological areas in terms of distance learning. An analysis of modern trends and teaching methods used in the distance format has been conducted, and methodological recommendations have been developed for the effective implementation of distance learning in the training of future specialists in engineering, pedagogical and technological areas.

Keywords: distance learning, engineering, pedagogical education, technological education, information and communication technologies, teaching methodology.

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