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SCIENCE AND TECHNOLOGY

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CONTENT

Words from the Editor

Welcome to the latest edition of *Nauka i tehnologija / Science and Technology*, the esteemed scientific journal of the International University Travnik in Travnik. Published biannually, our journal is dedicated to addressing pressing issues in the fields of social, artistic, and technical sciences with a blend of scientific rigor and professional insight.

Our mission is to engage our readers with groundbreaking ideas and goals from these diverse areas, fostering a deeper understanding and appreciation of the advancements shaping our world. Each issue of *Nauka i tehnologija* offers a platform for scholars and professionals to share their innovative research and thought-provoking perspectives. We take pride in featuring not only original scientific and professional papers but also comprehensive review papers and insightful conference proceedings.

As a testament to our commitment to excellence, *Nauka i tehnologija* is indexed by several prominent services, including Google Scholar, Scilit, Dimensions, Semantic Scholar, Lens.Org, J-Gate, ErihPlus, Road, Open Alex, EconBiz, Ceeol, Miar and Index Copernicus. This ensures that the valuable contributions of our authors are accessible to a wide audience, amplifying the impact of their work.

In this edition, Vol. 13, No. 1, 2025, we are proud to present a diverse array of papers that reflect the broad scope of our journal:

1. **Predictive Maintenance in the Era of Artificial Intelligence: How Algorithms Are Changing the Telecom Industry** by Amila Muratbegović and Goran Popović explore how the application of artificial intelligence algorithms enhances predictive maintenance in the telecommunications industry.
2. **Multifunctional Furniture and Its Impact in Residential Buildings with Limited Space** by Saleh Hamed and Vladica Ristić The paper analyzes the impact of multifunctional furniture on the more efficient use of space in residential buildings with limited square footage.
3. **The Future of Voluntary Pension Funds in Bosnia and Herzegovina** by Selma Omerović explores the prospects and challenges of the future development of voluntary pension funds in Bosnia and Herzegovina.
4. **Cryptocurrencies: The Digital Revolution of the Modern Financial System** by Zlatko Sviben analyzes how cryptocurrencies are changing the modern financial system and explores their advantages, risks, and impact on traditional forms of financial operations.
5. **Stabilization of Slope Instability: Applied Methods for Landslide Remediat**ion by Merisa Grahović describes various methods for stabilizing landslides and techniques for remediating unstable slopes with the goal of preventing further soil movement and reducing the risk of catastrophic consequences.
6. **AI in Education** by Fatima Abazović and Amila Rubanović, they write about the application of artificial intelligence in education, emphasizing how AI technologies improve personalized learning, automate administrative tasks, and enhance access to educational content.
7. **Understanding the Versatile Impacts of AI on Competency Development** by Kagan Cavusoglu explores how artificial intelligence influences the development of various competencies, including technical, interpersonal, and critical thinking skills, as well as the adaptation of educational and professional development processes.

Thank you for your support and interest in *Nauka i tehnologija*. We look forward to presenting you with the latest advancements and discussions in the upcoming issues.

Sincerely,

Editor-in-chief

Prof. dr. Rajko Kasagić

PREDICTIVE MAINTENANCE IN THE ERA OF ARTIFICIAL INTELLIGENCE: HOW ALGORITHMS ARE CHANGING THE TELECOM INDUSTRY

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Abstract

In the rapidly evolving telecommunication world, minimizing downtime and optimizing infrastructure efficiency are critical needs. Artificial intelligence (AI)-enabled predictive maintenance is revolutionizing the way telecom operators perform network asset maintenance and avoidantly repair imminent failures. Through the utilization of machine learning algorithms and real-time analytics, AI-enhanced predictive maintenance enables early fault detection, reduces operational costs, and enhances service uptime. It explains how cutting-edge predictive models are being integrated into telco operations, refers to the role played by big data and IoT in this transition, and highlights the strategic benefits and challenges of using AI in predictive maintenance operations. With increasing complexity in the telecom ecosystem, predictive maintenance comes across as a key enabler of intelligent and more robust networks.

Keywords: *predictive maintenance, artificial intelligence, telecom industry, machine learning, network optimization*

1. INTRODUCTION

The telecommunications industry is undergoing a root-and-branch transformation, driven by rapid technology shifts and an ever-expanding demand for reliable, high-speed connectivity. As networks become increasingly sophisticated and data-hungry, delivering peak performance and minimizing downtime have emerged as the overriding operational priorities. Traditional methods of maintenance—reactive or scheduled—can no longer meet the dynamic demands of modern telecom infrastructure.

In this context, predictive maintenance, powered by artificial intelligence (AI), has emerged as a game-changing solution. By analyzing large volumes of real-time and historical data, AI-driven systems can predict equipment failure before it happens, enabling telecom operators to initiate pre-emptive action. This not only reduces unplanned service downtime but also lowers maintenance spend, prolongs asset life, and results in higher customer satisfaction.

The intersection of machine learning algorithms, IoT devices, and big data analytics is enabling telecom operators to shift from reactive to predictive strategies. With AI continuing to evolve, predictive maintenance is becoming ever more precise, scalable, and essential to maintaining competitive advantage in the marketplace.

This article explores the basic concepts of predictive maintenance in the age of AI, outlines the technologies making it possible, and discusses its practical applications, challenges, and future influence on the telecom sector.

2. UNDERSTANDING PREDICTIVE MAINTENANCE

Predictive maintenance is a proactive approach that depends heavily on data analysis to predict when equipment is likely to fail. It stands in contrast to other maintenance approaches—such as reactive maintenance or preventive maintenance, which follows a predetermined schedule irrespective of the machine's condition—by basing its schedule on the real condition of the equipment. This transition has been possible due to the widespread adoption of IoT sensors and big data analytics that continuously monitor equipment in real time.

At the core of predictive maintenance lies the use of available data—like temperature, vibration, and other operating parameters—to foresee potential issues prior to their occurrence. This is made possible with sophisticated algorithms that learn from the past data and run predictive analytics. By successfully forecasting failures, organizations are able to plan maintenance during suitable windows instead of interrupting mission-critical operations, significantly enhancing overall productivity.

The growing popularity of predictive maintenance speaks to its valuable role across industries from manufacturing and aerospace to energy. As more businesses embrace smart technologies and connected devices, the implementation of predictive maintenance systems has become crucial to

staying competitive and achieving operational excellence.

3. TYPES OF PREDICTIVE MAINTENANCE ALGORITHMS

There are many different kinds of algorithms used in predictive maintenance technologies, but they can be roughly divided into three groups: hybrid approaches, machine learning algorithms, and statistical methods. Regarding efficiency and implementation, each of these categories offers particular benefits and difficulties.

4. BACKGROUND OF THE TELECOMMUNICATIONS INDUSTRY

As the backbone of modern communication, the telecommunications sector faces the crucial challenge of ensuring network reliability, minimizing downtime, and optimizing overall performance. Moreover, statistical models may find it difficult to capture complex relationships or nonlinear dynamics commonly present in operational data. The telecommunications sector is essential to the global connection of individuals, businesses, and societies. The transition from traditional voice-based communication to the current data-driven networks has ushered in a new era of possibilities.

5. IMPORTANCE OF NETWORK RELIABILITY

Every telecommunications company bases its operations on dependable network systems. Network failures create continuous problems for all users while generating negative effects throughout business operations and emergency service provision and vital sectors. Network failures create multiple effects which include financial loss and decreased public safety. The telecommunications sector depends on a robust network infrastructure to achieve continuous growth and stability.Predictive maintenance marks a significant deviation from reactive maintenance methods by focusing on future predictions. Predictive maintenance merges data analytics to detect possible failures before they happen which enables preventive measures. The telecommunications sector specifically benefits from this methodology because it operates complex networks with various interconnected elements.

6. OVERVIEW OF AI IN PREDICTIVE MAINTENANCE

Through AI implementation, predictive maintenance programs benefit from improved efficiency and effectiveness. Telecommunication companies receive substantial value from machine learning algorithms alongside neural networks and advanced analytics that help them gain useful information from large datasets. The acquired insights support data-driven decision-making and prompt actions which lead to network performance optimization. The telecommunications industry adopts

Industry 4.0 through AI-based predictive maintenance to protect network reliability and optimize operational performance. The current research focuses on the examination of AI-dependent predictive maintenance methods applied across the telecommunications sector. The paper aims to deliver a thorough analysis of AI-driven predictive maintenance through three specific research areas which examine existing maintenance practices and AI technologies and case studies for practical application. This research paper presents multiple sections that will reveal essential information alongside in-depth assessments and applicable guidelines for both industrial stakeholders and academic professionals.During maintenance operations, AI systems rely on natural language processing (NLP) to analyze log data and user manuals for valuable information extraction from semistructured and unstructured text. The integration of expert advice alongside hands-on experience into predictive models produces substantial improvements in their operational effectiveness.

The long-term learning capabilities together with adaptive functions represent a significant AI feature for maintenance predictions. AI systems achieve lifelong evolution through their ability to analyze both fresh data sets and operational feedback which leads to better prediction outcomes. This continuous learning process represents a critical element for achieving high accuracy during the entire lifespan of equipment while adapting to different operational circumstances.

AI systems present information and knowledge in a more available form through their interactive dashboard and reporting tools. Through these visualizations organizations can access real-time understanding of AI outputs for making strategic decisions about resource allocation and gaining a complete picture of plant health and maintenance requirements.

7. CASE STUDIES FROM THE TELECOM INDUSTRY

AI-driven predictive maintenance implementation demonstrates substantial success throughout multiple worldwide telecommunications operators. This section examines multiple representative case studies which demonstrate AI algorithms that improve operational resilience and network efficiency in telecommunications.

The implementation of AI predictive maintenance in telecommunications has led to substantial benefits for various global operators. This section examines several representative case studies which demonstrate AI algorithms that enhance operational resilience and network efficiency in telecommunications.

7.1. AT&T – AI for Network Event Prediction

AT&T has been a pioneer in integrating machine learning to improve the reliability of its vast network infrastructure. The company developed a system known as **Network AI**, which leverages machine learning models to detect anomalies and predict network events before they impact customers.

Key Highlights:

- Utilizes real-time data from network switches, routers, and base stations.
- Applies deep learning models to identify patterns leading to potential failures.
- Reduced unexpected network outages by over **30%** in pilot regions.
- Enhanced customer experience by proactively resolving issues.

This initiative is part of AT&T's broader push toward software-defined networking (SDN) and automation through AI.

7.2. Deutsche Telekom – Predictive Analytics in Equipment Maintenance

Deutsche Telekom, through its innovation labs, implemented predictive maintenance for physical telecom infrastructure, including **power systems, air conditioning units**, and **optical transmission equipment**.

Key Technologies:

- Data fusion from IoT sensors (temperature, vibration, humidity) with historical failure logs.
- Gradient boosting and Random Forest algorithms for fault classification and time-to-failure prediction.
- Visualization dashboards for field technicians.

Impact:

- Reduced on-site interventions by **20%**.
- Increased mean time between failures (MTBF).
- More efficient scheduling of maintenance personnel and parts logistics.

7.3. China Mobile – Big Data and AI for Tower Maintenance

China Mobile, with its enormous network of over **1 million base stations**, adopted a big data platform integrated with AI to conduct predictive diagnostics on telecom towers and associated hardware.

Highlights:

- AI models analyze tens of millions of sensor readings daily (e.g., voltage, current, weather conditions).
- Use of reinforcement learning to optimize maintenance decision policies.
- Integrated with drone-based visual inspections and thermal imaging.

Outcomes:

- Improved predictive accuracy to **over 85%** for power supply failures.
- Saved millions in operational expenses by avoiding unnecessary site visits.

1 7.4. Telefónica – Cognitive Intelligence for Customer-Affecting Incidents

Telefónica deployed AI to not only maintain physical infrastructure but also to **predict and prevent service-affecting issues** experienced by customers.

Key Aspects:

- Customer call data, ticketing systems, and network logs are used to train natural language processing (NLP) and time-series models.
- Predictive insights are provided to customer service teams in real-time.
- AI also supports root cause analysis by correlating faults across different layers of the network.

Results:

- **15% reduction in customer complaints** related to service interruptions.
- Increased first-time resolution rates in support centers.

7.5. Ericsson – AI-Powered Maintenance-as-a-Service

As a network vendor and operator, Ericsson launched its **AI-powered Maintenance-as-a-Service (MaaS)** offering for telecom providers.

Features:

- AI-driven fault prediction models tailored to each client's infrastructure.
- Preconfigured anomaly detection for radio access networks (RAN), transport, and core systems.
- Edge AI deployment for faster local decision-making.

Effect:

- Clients reported improved network availability (up to **99.999%** in some deployments).
- Predictive maintenance enabled dynamic resource allocation and spare part planning.

8. FUTURE TRENDS AND INNOVATIONS

The telecommunications sector experiences a revolutionary advancement in predictive maintenance systems as artificial intelligence merges with its technological developments. The telecommunications sector uses IoT sensors to monitor its infrastructure which creates vast networks of real-time information from base stations and towers. Edge computing platforms serve as the main processing centers for this data to achieve quicker response times and reduce the need for cloud server data forwarding. The fast data transfer speeds of 5G networks combined with minimal delay times enable AI-based maintenance to detect problems quickly and perform automatic resolution. The combination of 5G technology with artificial intelligence allows the deployment of automatic drones and robotics for maintaining difficult-to-reach locations which results in improved operational efficiency and enhanced safety practices.There will be increased usage of in the field of deep learning show combined traditional statistical methods with contemporary machine learning tools for generating accurate and stable predictions. The growing emphasis on sustainability along with green energy pushes AI development to enhance telecommunication equipment maintenance efficiency thus reducing industry carbon emissions. The future direction of predictive maintenance in telecommunications stems from the

combined power of IoT alongside edge AI and 5G technologies and automation systems to develop swifter and environmentally-friendly maintenance processes.

9. CHALLENGES AND LIMITATIONS

As predictive maintenance together with AI technology becomes increasingly important, scientific studies investigate the implementation challenges and business prospects for the telecommunications sector. The research conducted by A. Yang along with D. Radev demonstrates that AI-based predictive maintenance delivers decreased operational downtime with operational efficiency improvements as well as lower costs. The implementation of AI-driven predictive maintenance in the telecommunications sector faces obstacles regarding data security together with workforce expertise and initial financial requirements according to H. Pinheiro and O. Serradilla. Through their work, these studies examine AI-driven predictive maintenance in telecommunications to understand its multiple aspects.

Telecommunications networks need to remain operational by adapting to new equipment types along with altered traffic flows and emerging equipment failure patterns which demands continuous monitoring along with improvement. These difficulties must be resolved to achieve the complete benefits of AI-based predictive maintenance together with ensuring dependable telecommunications operations that remain cost-effective and safe. operations.

CONCLUSION

The telecommunications sector experiences a revolutionary transformation through predictive maintenance which artificial intelligence enables network infrastructure management to achieve enhanced efficiency and speed and intelligence. Machine learning together with advanced algorithms and big data analytics enable telecom operators to detect potential failures in advance while minimizing downtime and lowering operational expenses. The future of predictive maintenance depends on the successful implementation of innovative technologies which enable the creation of sustainable and resilient telecom networks. The telecommunications industry will need to adopt AI-based predictive maintenance systems to stay competitive and provide flawless services to their customers as the world becomes more interconnected.

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MULTIFUNCTIONAL FURNITURE AND ITS IMPACT IN RESIDENTIAL BUILDINGS WITH LIMITED SPACE

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Abstract

One of the problems of today's life is the limited living spaces and the way furniture is used in them, and the reasons for this are changes at multiple levels, including family size, age groups and income levels. Therefore, an engineer who designs furniture must think about a design that is more flexible and useful, cheaper and more efficient.
Hence, the idea of smart furniture has come to meet human needs within architectural spaces with limited spaces without resorting to changing the size of the space or space.
Furniture design is an ideal solution to meet the changing needs of the inhabitants of these spaces and is compatible with their culture and customs. Modern technology for designing furniture and housing has created several solutions including what is known as the computer home, the digital home and the interactive home, making pieces of furniture more flexible and useful, as they take up less space than the limited free space and perform more than one function for the users of these spaces.
The idea of smart furniture that interacts with everything around it has emerged to meet the necessary and changing human needs in terms of function, use, space or spatial arrangement through the use of geometric shapes that are easy to shape and understand, far from extravagance and complexity in spaces and decorations, using materials and raw materials that help achieve the goals needed to solve the problem of limited space.

Keywords: *furniture/design/function/limited spaces .*

1 INTRODUCTION

Development, population growth and increasing demand for housing and housing care, have led to the emergence of several variables in the design of housing projects, some of which are compatible with meeting humanitarian needs, and in some there are shortcomings in meeting human needs in the long term, in accordance with the continuous change of daily and functional needs.

One of the forms of this lack of long-term satisfaction of needs has clearly emerged in the limited living spaces. With the development of age groups and changing life circumstances, several design ideas have emerged to solve these problems in order to make these limited spaces more flexible and useful with the presence of smart and interactive furniture.

Research Problem:- Failure to meet changing human needs within limited spaces using traditional furniture design ideas.

Research Significance: The emergence of the problem of insufficient satisfaction of changing human needs clearly requires pause, reflection and finding innovative and advanced solutions to the problems found in architectural design, such as limited space housing units, which nowadays represent the majority, due to high construction costs, land prices and increasing human growth.

Research Objective: To keep pace with the development of smart furniture design and the solutions it provides for the problems of limited space housing.

Research Hypothesis: By developing the use of flexible and multifunctional smart furniture design, changing human needs in limited accommodation can be satisfied

Research Methodology: Descriptive and analytical approach, which describes and analyses models of smart furniture units in order to arrive at smooth and easy design ideas that work to achieve benefits and functionality as needed.

1 - The concept of housing:

A home is a space in which human relationships prevail, ensures the cohesion and progress of the family and in which each individual builds himself and his being.

1.1 - Human needs in the home

The basic needs necessary for a human being to live a life that is different from all other creatures are divided into:

A - Physiological needs

It refers to the way in which physiological activities are carried out and distributed within the housing unit and refers to the following:

* The nature of the activity is related to the instinctive activities of the person and the time it is carried out, such as sleeping, eating, hygiene, etc.

* The way in which activities are distributed refers to the efficiency of coordinating activities and accommodation according to the wishes of the user.

B - Biological needs:

It means the availability of suitable climatic conditions for achieving physiological comfort, which requires the control of all climatic, audio and visual influences in order to create spaces that give a sense of comfort when engaging in different activities.

C - Psychological needs

They refer to a person's psychological makeup, such as feeling of security, confinement and privacy, the need for social communication and friendship formation, the sense of spaciousness and spaciousness of the place and overall reasons of aesthetic, sensory and psychological pleasure represented in the place of residence and surroundings.

D - social needs

They are related to the changes brought by the data of the contemporary cultural reality, considering the change in the style of a complex family to a simple family, which led to a difference in the characteristics and forms of functions in all elements of housing, regardless of their expressive patterns.

A person's comfort in any environment depends on how well social needs are satisfied and satisfied.

1.2 - Classification of living spaces

Living spaces can be classified into two basic types:

* **Traditional space**, which is a space that has been the focus of human life since the emergence of human societies, and its efficiency and significance are related to the culture and behavior of its user.

* **Smart vacuum**, a modern concept that has been achieved only in the light of modern information technologies. It increases in breadth and breadth with the growth of the information environment and is associated with the high level of technology and the productive and creative efficiency of society.

1.3 - Components of living space

Living space can be divided according to human needs within the apartment through Table No. (1).

Types of voids	**Instinctive (fixed) needs**	**Changing needs**
Space intended for carrying out activities	Receiving guests Relaxation (life)- dining	TV and a corner for watching satellite, or using the Internet. Personal space
Space with special purposes	Kitchen (food preparation) Bathroom (for physiological needs)	
Space for fixed objects	Master bedroom Children's bedroom	
Space for movement	Hallways for movement-entrance	

Table No. (1) shows the components of living space according to the basic and changing needs of the person in the apartment.

1.4 - The relationship of furniture to the performance of activities within the living space:

The relationship between man and furniture units is a close relationship that in most places reaches an organic relationship through its proportions and average lengths during walking, sitting, sleeping and eating. On the other hand, a person's judgment about furniture and the distances between it and between them depends on his awareness of proportions. Proportions are what determine the relationships of things in relation to each other on the one hand, and their relationship to the person on the other hand, it is considered a unit of measurement in itself.

It is worth noting that in the early 1970s, designer Joe Colombo developed his primitive model for a small kitchen by designing a comprehensive unit characterized by dynamic features that are compatible with the lifestyle of the occupants, as in *image no. (1)* and the shape of the space can be transformed with the simple push of a button into suitable surfaces for eating, storing and doing work from different heights and places. The vacuum also supports the performance of multiple life functions while changing the nature of the vacuum form.

Image no. (1) shows a model of a comprehensive furniture unit by Joe Colombo

So, the main advantage of this unit is the ability to get more functions in a limited area.

In 2006, Hong Kong architect Gary Chaey designed a new model for the concept of small apartments and managed to create this apartment, which has an area of 32 m^2, has 24 m^2 of room space, and within the walls there is a kitchen, library, laundry and dressing room, a living room with a hammock, a fenced dining room and a bar for mixing drinks, as in *image no. (2)*

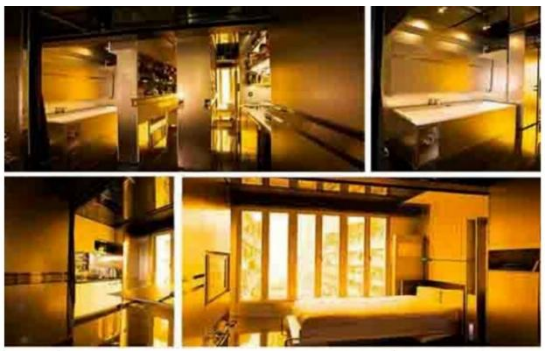

Image no. (2) shows a model of a residential unit by Hong Kong designer Gary Chaey, showing its different state according to the different positions of the movable wall units which allow for versatility of use in different situations .

Perhaps the widespread use of storage systems in contemporary interior design makes the system seem like an innovation for modern design, but the idea of showing or hiding internal components has been implemented in practice since the fifteenth century, when the implementation began with pieces of furniture that hang, bend, push and pull, gradually moving to architectural elements such as walls, ceilings and stairs to manipulate the volume

of the interior space, and with the development of technology, the storage system in the twenty-first century is often implemented in an aerodynamic way, arranged within existing architectural elements with an emphasis on concealment and reducing the possibility of the appearance of devices in order to preserve the view.

Therefore, we believe that this smart system opens up space for the exploitation of a larger number of furniture units, which eliminates the need for floor space and sacrificing the basic components of the space. Also, hiding traces of daily activities provides spatial space in our modern times, which witness population growth and are characterized by an accelerated pace of life.

2 THE CONCEPT OF AN INTELLIGENT SYSTEM

An intelligent system depends on the presence of a mainframe whose functions are similar to the human brain and is connected to an integrated network similar to the human nervous system called artificial neural networks. The branches of this network extend into space, and consist of a group of sensors and mechanical actuators. The actuators become an integral component of its system, which is responsible for acting and reacting in a predictable manner to any external variables in a way that ultimately resembles a pattern of vital functions. Ultimately, the human body is an ideal model or intelligent system at its best" possible images, present in the technical equipment that makes up interactive systems.

2.1 - Characteristics and properties of a smart system:-

A - Immediacy, responding to a stimulus in real time.

B - Ability to respond multiple times, as it responds to multiple environmental conditions at the same time.

C - Self-acting: where the system can act on its own.

D - The ability to direct the response occurs at the location that was exposed to the stimulus.

E - The ability to select a response is discrete and predictable.

2.2 - Characteristics of the Smart System:

1 - Saving energy by using renewable energy alternatives such as sun and wind (sustainability).

2 - Regulating the temperature to achieve thermal comfort.

3 - Automatically controlling the opening and closing of windows during the day and night, so that the curtains automatically fall.

4 - Achieving security through video surveillance.

5 - Reducing the size of the space inside the apartment due to the connection and reduction of the size of some devices.

6 - Smart materials are developing every day and modern materials that interact with people and their requirements appear.

Smart materials, such as the use of glass that achieves visibility from certain angles and prevents it from other angles, contribute to solving the problem of loss of privacy.

2.3 - Disadvantages of the smart system:-

A - The cost is currently high compared to the average income

B - The possibility of a circuit breaker failure.

C - The problem of living in an environment of electromagnetic and radio waves that are harmful to humans.

D - The idea of integration between different systems requires many meetings and studies
between an integrated working team specialized in different systems, in addition to the cost of putting these systems into one system is BAS.

F - The cost of converting a traditional building into a smart building capable of housing advanced systems, which is much higher than the cost of the building.

3 SMART HOME

It is a dwelling equipped with a technical method that has the ability to think, in order to changed its behaviour according to the needs of the occupants and adapted to external conditions, i.e. the ability to program the house electronically with a set of housing options that allow its various components to adapt and act according to the appropriate conditions and pre-known variables.

The philosophy of interior design of contemporary spaces depends on several points that can be summarized as follows:

* The ability of these spaces to adapt to the variables around them and change the traditional concept of spatial arrangement (multiple use of one space) at an economical cost, so that the same space can be used for many different activities, and this is achieved through the possibility of changes and movement between the units that make up the space.

* By using woven and flexible furniture that can be developed according to the changing needs of the user.

Interior spaces are no longer divided into specific spaces using traditional materials as was the practice in the past, but rather strive to achieve the highest degree of flexibility and adaptation to future and technological changes by using smart furniture of various shapes and designs.

4 SMART FURNITURE

It is a woman who primarily responds to modern life demands that are affected by changing social and economic transformations. She works to find more innovative solutions to provide a set of functions to the user within the space using modern technological methods.

CNC programmed intelligent furniture is divided into:

A- Digital Furniture
B- Interactive Furniture
C- Future Furniture

4.1 - Digital Furniture:

It is a new device characterized by the presence of smart electronic equipment. Its origin is another dimension of performance that was not expected to be achieved, which led to an increase in its cognitive and perceptual capabilities to meet the needs of the user. Computer applications have also allowed the rediscovery of the function which performs, such as the multi-purpose smart sofa Q4

Multi-purpose Smart Clutter Q4

It is a sofa that contains wires that are compatible with smart home electronics, and consists of four square-shaped seats, identical in surface area, so that they can be arranged as desired to obtain multiple functions. This means that the sofa can be assembled for a traditional seating arrangement, or it can become like a chaise longue or a unit for work or play.

Smart sofa equipment 04:

* One of the office chairs is backless and has a power cord, which allows it to be connected to a mains power source.
* The buttons on the base of the printer are actually magnetized holes that allow the connection of various types of devices.
* The armrests are hollow inside so that music players can be placed and controlled from the side of the armrests.
* It contains a projector and a lighting unit placed on the attached table.

Image no. (3) shows the Q4 sofa used as a double bed, suitable for sleeping and leisure activities at the same time.
Image no. (4) shows some of the equipment included in Q4

4.2 - Interactive furniture:

This robot communicates with people to become an integral part of technological society and is able to provide practical solutions with the ability to respond to interconnected variables. Interactive furniture is divided into fixed interactive furniture and mobile interactive furniture.

4.2.1 - Fixed Reactive Bed (Somnos):

It is now the most advanced bed in the world. It uses high technology and beautiful design to combine comfort, entertainment and interaction with the modernity of the present era. This bed has attracted the interest of many people, such as the "Yotel" hotel chain in the United Kingdom, as shown in *Image no. (5).*

The bed is equipped with the following accessories:

* Advanced motorized curtain unit that can connect to the Internet via Wi-Fi
* HD video projector, a movable cinema screen that can be pulled out to play video and digital content.
* An under-mattress audio system connected to 4 speakers and a subwoofer, and a programmable LED lighting system under the bed, in addition to a reading lamp, with the ability to control the intensity of the lighting.
* RFID smart card reader, to identify the owner's identity to retrieve his data, in addition to the ability to work, favourite music and the ability to wake people up for meetings and notify them of changes.
* The ability to adjust the position of the mattress and adjust its angles to suit different positions for sitting, sleeping, relaxing, etc.

Image no. (5) shows the "INTERACTIVE BED SOMNUS-NEU"

4.2.2 - The mobile interactive bed

It is a smart bed that is used at night when necessary, and can be converted into a ceiling when not in use, as the bed is raised to the top, relying on a hydraulic system that moves the bed up and down in balance until it is fixed in the desired position, as in *Image no. (6).*

It is also equipped with interactive lighting units that recognize sleep time and different levels of lighting depending on the environment, the required activity in the space, which gives flexibility in using the space in multiple functions to achieve optimal space exploitation.

Image no. (6) shows the mobile bed during use and when not in use

4.3 - Furniture of the Future :

It uses the latest digital technologies to improve the quality of the functional performance of the user by introducing new standards in the concept of activity, making the user feel more comfortable and luxurious than before.

4.3.1 - Bedroom of the Future

Bina Living has designed a bedroom of the future that includes an interactive mirror, smart windows, a wardrobe that displays its contents through an interactive mirror, and a high-tech bed equipped with numerous sensors to achieve user comfort, as shown in *Image no. (7).*

Image no. (7) shows the components of the bedroom of the future, including an interactive bed, smart pillows, and an interactive mirror,

The bedroom of the future consists of:

* an interactive mirror equipped with multiple sensors to set the optimal body temperature and raise an alarm in case of emergency, and lightweight smart pillows equipped with special technology that makes them glow when the user wakes up.

An interactive woman displays the contents of the wardrobe, and clothes can be selected using special technology by selecting based on weather changes.

* Smart windows, which are also television screens through which one can know the time and browse the Internet and social media accounts.

4.3.2 - Robotic furniture "Rumions"

In an idea that aims to transform pieces of furniture into others as needed or move them to make room for people as they pass through the room. Spherical self-configuring robots can disassemble and reassemble by themselves

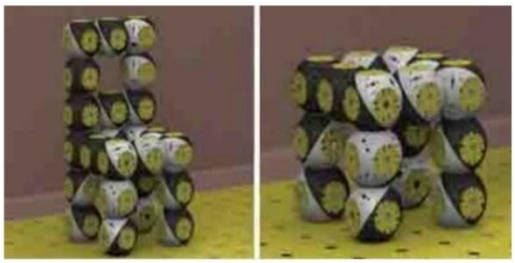

Image no. (8) shows a group of spherical robots assembled to form different pieces of furniture.

The design consists of two cube-shaped units. The cubes are held together, contain a battery and three motors for movement in addition to the wireless communication function, as shown in *Image no. (8).*
In addition to containing cameras to track the user, and a voice recognition tool so that the person can give instructions, the movement of the furniture becomes more flexible with less human intervention. The importance of the design lies in the fact that if the type of furniture is not used for a certain period of time, it can then be disassembled and assembled in a specific place to save space inside the room.

5 THE IMPACT OF USING SMART FURNITURE ON THE DESIGN OF A LIMITED SPACE HOUSING UNIT

1- Area: 250m
2- Multifunctional vacuum cleaner type.
3- Description of the residential unit of your property: Multifunctional for more than one activity, different at different times or at the same time

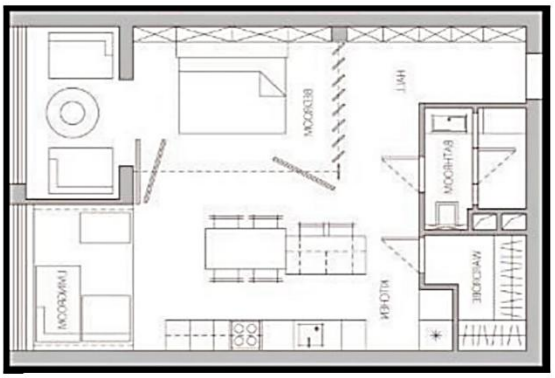

Image no. (9) Schematic diagram showing the horizontal layout of the housing unit
** The main sleeping area is combined with a vacuum*
** Attached vacuum for changing and storing clothes*
** Kitchen vacuum is combined with a food vacuum*
** Bathroom vacuum*

5.1 - Design idea:

A - The use of glass partitions equipped with modern technologies that contain sensors and mechanical actuators to separate the spaces, behind which the sleeping area is hidden during the day, so that the remaining space becomes a seat for sitting, and at night the bed is used as a place to sleep. Performing two different activities at different times.

B - Using digital technology on the shelves of the wall library in the living space to find out the latest news using the "RSS" function.

C - Using chromocarpy glass technology, which changes its degree of transparency directly when exposed to an electric field according to needs. The user is inside the space, as in Figure No. (10).

D - Using a smoke detection cell and an early warning unit to achieve security.

E- Possibility of using a vacuum for night sleep:

* Availability of a double bed unit with two side units attached for storage purposes Availability of a dressing room connected to the bedroom, which contains a wardrobe hidden inside it.

F - the possibility of using the living space during the day through two spaces available next to it. Two separate chairs that can be combined into a library in the shape of the letter L .

* The rear cover of the seating area was used to create a wall-mounted library for storing books, equipped with direct lighting units to achieve optical comfort for the user, as in *Image no. (10).*

Image no. (10) shows glass partitions that change the degree of transparency as needed. The sleeping space is transformed into a living space and the library's independence to store books.

G - Providing a central kitchen unit to increase storage capacity, in addition to the possibility of using its surface for eating and a quick meal sufficient for two people.

H - Providing an additional movable surface (dining table) attached to the central kitchen unit, sufficient for four people to fit the dimensions of the ergonomic food space.

I - Using the space to perform more than one activity at the same time, as in *Image no. (11).*

Image no. (11) shows the merging of the dining room and kitchen into one space using storage units that can be removed and added.

* Using a sliding glass partition to separate sleeping and eating activities in the same space.

* Using a rotating wooden partition to separate the sleeping or living area from the entrance area.

* Hide the space intended for clothes by using doors in the colour of the walls

* The possibility of increasing wall storage units by taking advantage of the wall of the entrance area behind the main door of the residential unit.

Research Results :

1 - The concept of thinking based on acquiring large and spacious areas in order to meet the needs and follow the desires of the user has changed, as the areas of the space can be saved by acquiring small areas that meet the needs of life and provide all kinds of luxuries for the user through smart home technology.

2 - The components of the dwelling are renewed through spaces that require practicing sufficient amount of activities

inside the apartment to ensure that the user achieves comfort and provides privacy and security.

3 - The necessity of studying all basic and changing human needs in order to arrive at realistic design results and radical solutions that allow us to have access to the most suitable housing for the occupants.

4 - Technology and the digital revolution have greatly influenced architectural thought, leading to a change in the concept of interior space from fixed to mobile elements that can adapt to many activities that are carried out in the space.

5 - Smart buildings are generally considered to have a higher cost than traditional buildings, but this increased cost also gives an increase in the return of what is expected from the project due to the high value of the facility.

6 - The use of smart home technology is not only a luxury, but it brings comfort and safety to users, and conserves energy using advanced management systems that allow the user to manage consumption costs during the day.

7 - The greater the user's contact with technological systems, the greater his desire to own this technology and try to apply it in his residential environment due to the numerous advantages it offers and which help to satisfy his maximum needs.

8 - Intelligent design aims to follow the user's actions and desires in order to be able to form automatic responses to achieve those desires. Easy and practical, which saves time and effort.

9 - The smart unit contains special electronic equipment, including sensors and mechanical actuators, which achieve innovative uses that were not previously known, which adds creative aesthetic value to these elements.

10- The use of multifunctional built-in furniture is one of the most important elements that helps users meet their future needs and satisfy their desires permanently and continuously.

Research recommendations:

1 - The necessity of turning to the use of digital technology and artificial intelligence in the interior design and furniture of homes with limited space, thus solving all the problems that the residents of these homes may face.

2 - Interest in studying everything related to limited spaces, because they are one of the biggest problems facing society today.

3 - The economic aspect of smart technology must be studied and it is necessary to come up with scientific solutions that reduce the costs of its implementation.

4 - The instrument designer must be familiar with modern technology because it is considered an important design tool. It helps solve many design and implementation problems that both the designer and the user may face.

5 - The importance of spreading culture and technological awareness in our society to learn how is to be used and developed through scientific research and experiments

for a technology that is compatible with the environment and carries our identity.

6 - It is necessary to limit the acquisition of housing with large areas, which represent a burden for the user on the one hand and for the state on the other.

Expensive areas exhaust the possibilities of land exploitation, which leads to increased opportunities for competition among buyers, and therefore an increase in the price of these lands.

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THE FUTURE OF VOLUNTARY PENSION FUNDS IN BOSNIA AND HERZEGOVINA

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Abstract

In Bosnia and Herzegovina, the pension system is divided into two entity pension systems, the pension system of the Federation of BiH and the pension system of the Republika Srpska. In the world, there are three pension pillars on which the financial and social protection of citizens is based. The first two pillars are mandatory and prescribed by the state, and the third is voluntary and includes savings in voluntary pension funds. Currently, there is one state pension fund in the Federation of Bosnia and Herzegovina, that is, only the mandatory first pillar of pensioner protection is applied, although since 2017 there has been legislation for the third pillar. In the Republika Srpska, in addition to the mandatory state pension fund, there is also the Republika Srpska Pension Reserve Fund, which was established in 2010 and is responsible for ensuring the financial sustainability of the mandatory pension insurance. Although in the Republika Srpska, legislation for the third pillar of pensioner protection has existed since 2009, the first and only voluntary pension fund in this entity was established in 2017. The aim of this paper is to analyze the state and possibilities for the functioning of voluntary pension funds in Bosnia and Herzegovina, because the crisis of the pension system is always a current topic, both in the world and in our country. The reform of the existing pension funds is absolutely necessary, considering the fact that human life expectancy is getting longer, and the number of unemployed is increasing, especially due to the development and use of information technologies.

Keywords: *pension system, pension pillars, reform, voluntary pension fund.*

1 INTRODUCTION

The pension system is an important part of the social security system in all countries of the world, including Bosnia and Herzegovina. Pension and disability insurance is an insurance system based on the principles of reciprocity and solidarity. Thanks to this system, beneficiaries are provided with rights in the event of the risk of old age, disability and physical incapacity, and their family members are provided with rights in the event of the death of the insured person, or the beneficiary of the rights. Therefore, the pension system should function in such a way that it provides security for the above categories of insured persons at all times.

The crisis of the pension system is present even in the most developed countries of the world, because the population of people who will use pensions is increasing dramatically. In addition to unemployment as the biggest problem that every country is struggling with, it is also a fact that human life expectancy has significantly increased in recent years. This has been contributed to by the improvement of medicine and health care.

The pension system in Bosnia and Herzegovina, which is based on intergenerational solidarity, has run into difficulties due to a number of problems. Current problems relate to the constant decline in the population, the increase in the number of unemployed people, and the increase in the number of older people who need to use pension and disability insurance services. Another problem in Bosnia and Herzegovina is the emigration of the working-age population, who, unable to find work, go to other countries. Therefore, the problem is also the outflow of the workforce that should contribute to maintaining the pension system of our country.

The functioning of the pension system in the world implies the existence of three pillars of pensioner protection. The first and second pillars of pension insurance refer to mandatory public pension insurance, and the third pillar involves savings in voluntary pension funds. Given that there are two entity pension funds in Bosnia and Herzegovina, pension systems have entity regulations and function differently. In the Federation of BiH, there is only a state pension fund, i.e. the mandatory first pillar of pensioner protection is applied, while in the Republika Srpska, in addition to the mandatory state pension fund, there is also the Pension Reserve Fund of the Republika Srpska, and one voluntary pension fund that was established in 2017.

The pension system reform is still not being carried out to a certain extent in the entity of the Federation of BiH, because there is still no voluntary pension fund, although a legal framework has been in place since 2017. In the Republika Srpska, the reform process began back in 2010, when the Pension and Disability Insurance Fund of the Republika Srpska established the Pension Reserve Fund, which was formed to ensure the long-term financial sustainability of mandatory pension insurance. Although a legal framework has existed in the Republika Srpska since 2009, the first and only

voluntary pension fund in this entity was established in 2017, which shows that this entity has nevertheless made a step forward when it comes to maintaining the stability and security of pension insurance.

2 STATUS OF EXISTING PENSION FUNDS IN BOSNIA AND HERZEGOVINA

One of the clearest indicators of the difficulties facing the pension system in Bosnia and Herzegovina is the trend in the number of insured persons and pension beneficiaries, and their ratio. According to publicly available statistical data, in the Federation of BiH one job covers one pension, i.e. the ratio of the number of employees to pensioners is currently approximately 1.20, while published statistical data for the Republika Srpska show approximately the same ratio. For the normal functioning of the pension system, it is necessary that four jobs cover one pension, which means that the current pension funds do not even come close to meeting this criterion.

In the last five years, the pension system crisis in Bosnia and Herzegovina has only deepened, with the ratio of the number of insured persons to pensioners remaining unchanged. The average ratio of the number of insured persons to pensioners for the previous five years in the Federation of BiH is 1.23, while in the Republika Srpska it is 1.18. If we compare the growth in the number of insured persons and the growth in the number of pension beneficiaries in the period between 2019 and 2023, it can be concluded that in the Federation of BiH in 2023 the number of pension beneficiaries was 4.25% higher than in 2019, and that the number of insured persons in 2023 increased by 1.80% compared to 2019. In the Republika Srpska in 2023 the number of pension beneficiaries increased by 5.68% compared to 2019, while the number of insured persons increased by 5.40%. The increase in the number of pensioners was significant every year until 2020 and the outbreak of the COVID-19 pandemic, when growth slowed down, which can also be explained by the increased mortality rate of this population in that period.

If we consider only 2023 compared to 2022, in the Federation of BiH the number of insured persons increased by 1.04%, and the number of pension beneficiaries by 2.42%, while in the Republika Srpska a larger increase in the number of pension beneficiaries was also recorded, at a percentage of 2.23% compared to an increase in the number of insured persons of 1.58%. An overview of the trends in the number of insured persons and pension insurance beneficiaries in the observed period from 2019 to 2023 is shown in Table 1.

Table 1. Number of insured persons, number of pension beneficiaries, ratio of the number of insured persons and beneficiaries, situation as of 31.12.

Year	FEDERATION OF BIH			REPUBLIC OF SERBIA		
	Number of insured persons	Number of pension beneficiaries	Insured/beneficiary ratio	Number of insured persons	Number of pension beneficiaries	Insured/beneficiary ratio
2019	531,483	425,770	1.25	315,887	267,479	1.18
2020	520,162	428,117	1.21	315,498	271,004	1.16
2021	525,397	429,545	1.22	321,946	272,585	1.18
2022	535,665	434,167	1.23	327,784	276,503	1.19
2023	541,261	444,666	1.22	332,953	282,671	1.18

Data source: Own processing based on data from the Federal Institute of Statistics of the FBiH, the Republic Institute of Statistics of the RS and the Pension and Disability Insurance Fund of the RS

In the observed period, pension expenditures increased by a significantly higher percentage compared to the increase in the number of pension insurance beneficiaries. The highest percentage of growth in pension expenditures in both entities was recorded in 2022, compared to 2021. In the Federation of BiH, the percentage of growth in pension expenditures was slightly weaker in 2020 and 2021, reaching its peak in 2022, when the growth rate of pension expenditures was 14.08%, and this rapid growth continued in 2023, when pension expenditures increased by 23.70%. In the Republika Srpska, a rapid growth in pension expenditures also occurred in 2022, but did not change significantly in 2023. An overview of data on the amount of pension expenditures, expenditure growth rates, and growth rates of the number of pension beneficiaries is shown in Table 2.

Table 2. Pension expenditures, expenditure growth rate, growth rate of the number of beneficiaries, status as of 31.12.

Year	FEDERATION OF BIH			REPUBLIC OF SERBIA		
	Pension Expenditure (in million)	% growth in pension expenditure	% growth in number of pension beneficiaries	Pension Expenditure (in million)	% growth in pension expenditure	% growth in number of pension beneficiaries
2019	182.98	-	-	93.40	-	-
2020	183.19	0.11	0.55	97.18	4.05	1.32
2021	183.63	0.24	0.33	102.12	5.08	0.58
2022	209.49	14.08	1.08	117.75	15.31	1.44
2023	259.13	23.70	2.42	135.86	15.38	2.23

Data source: Own processing based on data from the Federal Pension and Disability Insurance Institute of the Federation of Bosnia and Herzegovina and the Pension and Disability Insurance Fund of the Republic of Serbia

The previously mentioned data on the number of pension insurance policyholders do not show the actual state of the inflow of funds from pension contributions into pension funds, given the already known fact that some public companies do not regularly settle their contribution obligations, but the total pension service is settled at the moment when the insured person meets the conditions for retirement. Given the above, there is a lack of funds, i.e. insufficient inflow of money into pension funds. Since 2016, the pension and disability system in the Republika Srpska has switched to treasury operations, while the same was done in the Federation of BiH in 2020. In practice, this means that all income from contributions becomes income from entity budgets, but it also means that pensions are paid to the insurance from the entity budget, where the difference between lower income from contributions and expenditures for financing pensions is ensured from other sources, such as from VAT revenues, excise revenues and credit borrowing.

3 PENSION FUNDS REFORM IN BOSNIA AND HERZEGOVINA

Pension reform in Bosnia and Herzegovina began with the adoption of new legal

frameworks, both for mandatory state pension insurance and voluntary pension insurance. When it comes to the first pillar of pension insurance, i.e. mandatory public pension insurance, in the Federation of BiH it is regulated by the Law on Pension and Disability Insurance of the Federation of BiH ("Official Gazette of FBiH" No. 13/18, 93/19, 90/21, 19/22 and 47/24). In the Republika Srpska it is based on the Law on Pension and Disability Insurance of the Republika Srpska ("Official Gazette of the Republic of Srpska" no. 134/11, 82/13, 103/15, 111/21, 15/22 and 132/22). In order to ensure the long-term financial sustainability of mandatory pension insurance, the Pension and Disability Insurance Fund of the Republika Srpska established the Pension Reserve Fund, the operating rules of which are regulated by the Law on the Pension Reserve Fund of the Republika Srpska ("Official Gazette of the Republic of Srpska" no. 73/08, 50/10, 102/12, 20/18 and 111/21).

The reformed first part of the pension insurance increased the age limits for acquiring the right to old-age and early retirement, and changed the formula for calculating the pension. The conditions for old-age pension in the Federation of BiH imply that the insured person has reached the age of 65 and at least 15 years of insurance service, or at least 20 years of pension service or when he reaches the age of 40 years of insurance service regardless of his age. The possibility of early retirement is also given, with the age and service years increasing by six months each calendar year. For each month of early retirement compared to the prescribed age of 65, the amount of the pension earned is reduced by 0.333333%. In the Republika Srpska, the insured person has the right to an old-age pension when he reaches the age of 65 and at least 15 years of insurance service. For an insured person who has not yet reached the age of 65, the right to an old-age pension is acquired when he or she reaches the age of 60 and has 40 years of pensionable service, and a female insured person who has not yet reached the age of 65 is entitled to an old-age pension when he or she reaches the age of 58 and has 35 years of insurance service. It is assumed that there will be a need to increase the age limit for exercising the right to a pension, given the increase in average life expectancy. In both entities, beneficiaries of old-age pensions are enabled to start an employment relationship and receive a bonus for staying in work longer, while continuing to receive a pension.

The pension system reform, which implies the introduction of the second pillar of pension insurance, would imply the allocation of a part of the mandatory contributions of employees to their individual accounts in mandatory pension funds. This would mean a transition from exclusively the first pillar to the existence of the first and second pillars of pension insurance. Given that the contributions from which benefits are paid for existing pensioners would be reduced, this transformation would lead to the unsustainability of the pension system, because the pension system in Bosnia and Herzegovina is already facing a lack of funds for pension expenditures and the existence of only the first pillar of pension insurance.

The third pillar of pension insurance is voluntary pension insurance based on individual capitalized savings. This insurance, in relation to the method of financing and determining pensions, is based on the principles of capitalized savings and defined contributions. The main difference compared to the first and second pillars of insurance is voluntariness, which is why there are fewer restrictions and greater freedom in negotiating the conditions and methods of paying contributions and receiving pensions. The difference is that the state does not guarantee the payment of pensions for the third pillar, as in the first and second pillars of pension insurance, but it encourages voluntary insurance through subsidies and tax breaks. When it comes to the third pillar of pension insurance, in the Federation of BiH there are only regulations that regulate this area, while in the Republika Srpska, the only true and only voluntary pension fund was established in 2017. Payments to the third pillar are accumulated in the personal account of each member of the fund and depend solely on the amounts paid by the members of the fund, the length of the accumulation period and the returns achieved on these funds. Payments are voluntary, flexible in both amount and payment period, and represent the personal property of the fund member.

Voluntary pension insurance in Bosnia and Herzegovina is regulated by entity regulations. In the Federation of BiH, it is regulated by the Law on Voluntary Pension Funds ("Official Gazette of FBiH" no. 104/17), and in the Republika Srpska it is based on the Law on Voluntary Pension Funds and Pension Plans ("Official Gazette of the Republic of Srpska" no. 13/09, 107/19). The competent regulators have also adopted bylaws that regulate the functioning of voluntary pension funds in more detail. In accordance with the aforementioned laws, pension contributions are funds paid into a voluntary pension fund by the payer. A member of a voluntary pension fund may be a domestic or foreign individual residing in Bosnia and Herzegovina, who directly or through the organizer of the pension program, accesses the voluntary pension fund. A pension contribution to a voluntary pension fund may be paid by the insured person, or another individual or legal entity on behalf of the insured person; the organizer, on its own behalf and on behalf of the employee, or union member, in accordance with the pension program; or the employer, on behalf of and for the employee, in accordance with the membership agreement between the member of the voluntary pension fund and the management company. The right of a member of a voluntary pension fund to withdraw and dispose of accumulated funds is acquired upon reaching the age of 58, and the payment of funds, in addition to installments, can also be made in a lump sum up to a certain amount. The security of this type of insurance is at a high level, because the assets of a voluntary pension fund cannot be subject to forced collection, pledge, mortgage, and cannot be included in the liquidation or bankruptcy estate of the management company, depository bank or other persons, nor can they be used to settle the obligations of a member of the voluntary pension fund and other persons towards third parties. In the

event of the death of a member of the fund, the accumulated funds become the subject of a probate proceeding.

The goal of the pension system reform is to establish a long-term sustainable system with balanced income and expenditure, in which the focus of responsibility for social security in old age will shift from the state to the individual. This goal could be achieved by establishing a mixed public-private pension insurance system, in which the first part is mandatory pension insurance based on generational solidarity, and the third part is voluntary pension insurance based on individual capitalized savings. The privatized third part of the pension system should have a positive impact on the development and strengthening of the financial market and population savings, on the redirection of funds from personal consumption to investments, which would stimulate employment growth and the competitiveness of the economy. In relation to the capital market, an increase in the supply of securities, integration into international markets, more efficient allocation of capital, etc. is expected.

The current state of the pension systems in Bosnia and Herzegovina does not promise security in terms of long-term functioning, as there is a possibility that at some point there will be a halt in the payment of pension benefits. The laws regulating mandatory pension insurance also prescribe certain restrictions when it comes to the amount of pension, which in the future calls into question the financial ability to meet basic living needs. Both entity laws on mandatory pension insurance have limited the amount of pension, in such a way that the personal point is limited to five. Therefore, when calculating the pension, the insured will only be recognized for contributions paid whose amount does not exceed the contributions of five average entity gross salaries. For insured persons whose gross salary exceeds five average entity gross salaries, the excess amount of paid contributions will not be used when calculating the pension. Given the above, it is necessary for each insured person to take care of social security in old age, and to take certain steps in terms of investing in voluntary pension insurance.

4 FUNCTIONING OF THE VOLUNTARY PENSION FUND IN THE REPUBLIC OF SRPSKA

In the Republika Srpska, there is also a third pillar of pension insurance, namely voluntary pension insurance, which is an integral part of the comprehensive pension system reform strategy in this entity. The first and only voluntary pension fund in the Republika Srpska and Bosnia and Herzegovina, which was established in 2017, is the European Voluntary Pension Fund (EPF). This Fund is managed by the Voluntary Pension Fund Management Company, which was established in the same year. The founders of the Fund are Skupna pokojninska družba from Ljubljana (now Triglav pokojnine dd), the European Bank for Reconstruction and Development (EBRD) and the Pension Reserve Fund of the Republika Srpska (PREF). The establishment of the European

Voluntary Pension Fund has given citizens in the Republika Srpska the opportunity to later use all payments in personal accounts in the Fund as an additional pension. Payment of funds can be made independently or through employers (by joining a pension plan, which includes the employer as the organizer of the pension plan and payer of contributions for its employees). Immediately after the establishment of the voluntary fund, many business entities in this entity signed a memorandum on the process of joining the European Voluntary Pension Fund, and provided their employees with additional pension insurance.

Amendments to the Income Tax Law ("Official Gazette of the Republic of Srpska" no. 60/15, 5/16, 66/18, 105/19, 123/20, 49/21, 119/21, 56/22 and 112/23), which entered into force on 18.12.2019, stipulate that income tax is not paid on the amount of pension contributions paid for voluntary pension insurance up to 1,200 KM per year, in accordance with the Law regulating voluntary pension funds and pension plans in the Republika Srpska. Also, in accordance with the Law on Contributions ("Official Gazette of the Republic of Srpska" no. 114/17, 112/2019, 49/2021, 119/2021, 56/2022, 132/2022 and 112/2023) and Article 21, contributions are not paid on income that is exempt from income tax, so voluntary pension insurance up to the specified annual amount is also exempt from contributions. In addition to the aforementioned significant tax breaks, the Government of the Republika Srpska has been paying a monthly amount of 20 KM of voluntary pension insurance to all employees who receive a salary from the budget of the Republika Srpska since the beginning of 2020. Although the Republika Srpska has waived a part of the contribution that would have gone to the mandatory Pension and Disability Insurance Fund, that part represents an investment to reduce problems in the future.

The European Voluntary Pension Fund has many different combinations of employer and employee contributions. In practice, most often the employer increases the employee's salary by the amount he pays into the fund, on which he does not pay taxes and contributions. In this way, the employer additionally invests in employees to reduce unwanted fluctuation, while at the same time the employees have savings that are in their name, in their account in the Fund and which they will dispose of in accordance with the regulations as regulated. The amount that is accumulated depends on the period of payment into the European Voluntary Pension Fund, the amount of the monthly pension contribution, as well as the Fund's yield.

4.1 Analysis of the operations of the European Voluntary Pension Fund

The operations of the Management Company and the European Voluntary Pension Fund are strictly supervised by the competent regulators and the depositary bank. As one of the most significant institutional investors on the Banja Luka Stock Exchange, the European Voluntary Pension Fund, in accordance with legal restrictions and

investment policy, invests in securities, and is a significant provider of liquidity on the primary and secondary bond markets. The portfolio of this Fund consists mostly of bonds, followed by deposits with commercial banks, and shares in open-end investment funds.

Based on data from financial reports taken from the official website of the European Voluntary Pension Fund, as of 31.12.2023. the investment structure of the Fund's assets consisted of: investments in bonds in the percentage of 85.87%, investments in deposits with commercial banks in the percentage of 7.27%, investments in shares of open-end investment funds in the percentage of 6.15% and investments in shares in the percentage of 0.71% of the total investment of the Fund. Investments in state, entity or local government bonds account for 97.55%, while investments in corporate bonds account for 2.45% of the Fund's total bond investments. The nominal interest rate ranges from 1.5% to 6% per annum, depending on the type and series of bonds, and the interest rate on cash deposits ranges from 1% to 3% per annum.

If we look at the Fund's operations over the last five years, we can see a significant increase in the Fund's net asset value. One of the causes of the increase in the net asset value is the increase in the number of issued units, with the largest increase in the value of issued units of 440.81% recorded in 2020 compared to 2019. In 2021, the increase in the value of issued units was significantly smaller compared to 2020, at 29.64%, while the increase in 2022 was 7.88% compared to 2021. The smallest increase was recorded in 2023, at 3.60%. The inflow of funds from issued units enabled the investment of funds in financial instruments, which led to an increase in the Fund's investments, which is also one of the reasons for the increase in the Fund's net asset value. Namely, in 2020, the Fund's investments increased by 443.93% compared to the previous year. This was followed by an increase of 97.54% in 2021 compared to 2020, and then an increase of 55.13% in 2022 compared to 2021. And in the case of the Fund's investment, the smallest increase was recorded in 2023 in the percentage of 30.22%. The observed period also saw an increase in operating income related to income from property investments, which in 2020 increased by 386.77% compared to the previous year. A significant increase of 218.25% was also recorded in 2021, while in 2022 it was significantly lower at 53.94%. In 2023, there was another significant increase in operating income of 110.96% compared to the previous year. An overview of data on the value of issued units, investments and operating income of the Fund is presented in Table 3.

Table 3. Value of issued shares, investments and operating income, as of 31.12.

Year	Value of issued shares (in thousands)	% growth in value of issued shares	Investments (in thousands)	% growth in investments	Operating income (in thousands)	% growth in operating income
2019	1,293.52	-	1,521.02	-	21.67	-
2020	6,995.48	440.81	8,273.28	443.93	105.47	386.77
2021	9,068.92	29.64	16,342.72	97.54	335.67	218.25
2022	9,783.23	7.88	25,353.24	55.13	516.74	53.94
2023	10,135.73	3.60	33,016.13	30.22	1,090.10	110.96

Data source: Own processing based on data published on the official website of the European Voluntary Pension Fund Banja Luka

Looking at the investment structure of the European Voluntary Pension Fund, it is evident that the assets of this Fund consist of bonds in the largest percentage. More than 97% of these bonds relate to domestic state, entity or local government bonds, with the aforementioned bodies guaranteeing the repayment of debt to investors with their entire assets. Given that bonds are among the safest financial instruments because they have a low rate of price fluctuation, and their income is known in advance, it can be concluded that the capital of the Fund members is protected.

The European Voluntary Pension Fund also functions thanks to its members. As of 31.12.2023. this Fund had a total of 37,906 active members, which is a significant increase compared to the situation at the end of 2019, when the number of active members was 3,165. One of the possible causes of the increase in the number of Fund members are the measures adopted by the Government of the Republic of Srpska. By introducing tax breaks and co-financing voluntary pension insurance, the Government has stimulated both employers and employees. Employers use these measures to invest in their employees and thus retain them, while employees invest part of their income in capitalized savings, which are safe and can be used in the future.

5 ESTABLISHMENT OF A VOLUNTARY PENSION FUND IN THE FEDERATION OF BIH

With the entry into force of the Law on Voluntary Pension Funds of the Federation of BiH (hereinafter referred to as the "Law"), and the adoption of secondary legislation, a legal basis has been created for the further development of the pension system in this entity and the capital market, where new types of funds should appear, differing in the method and criteria of investment. As already mentioned in the paper, not a single voluntary pension fund has been registered in the Federation of BiH, although the conditions in terms of legal regulations and the existence of competent regulators for the functioning of voluntary pension funds have been met.

The institutions responsible for the functioning of voluntary pension funds in the Federation of BiH are: the Securities Commission of the Federation of BiH (hereinafter referred to as the "Commission"), the Insurance Supervision Agency of the Federation of BiH (hereinafter referred to as the "Agency") and depository banks. The establishment and operation of voluntary pension funds and companies that manage these funds are supervised by the Commission. After the adoption of the Law, the Commission adopted bylaws for the implementation of this Law. If a voluntary pension fund were to be established, with the prior consent of the Commission, a bank would be engaged as a depositary and custodian in the role of controller of the fund's operations. There are banks in the

Federation of BiH that have a license from the Commission to perform depository and custodian activities, which include safeguarding the assets of investors in the fund, and ensuring that investors and the public are provided with truthful reporting on the movement of the value of the fund's assets. In the case of the existence of a voluntary pension fund and the fulfillment of the conditions for acquiring a pension for a fund member, the Agency appears as the competent authority, which supervises the insurance companies that make the payments. Therefore, there is strict supervision for the establishment and operation of a voluntary pension fund in the Federation of BiH, given that the operations and safety of the invested money of members of these funds are taken care of by state institutions, as well as reputable banks and insurance companies.

A voluntary pension fund management company is established in the legal form of a joint stock company, which applies the provisions of the Law on Business Companies of the Federation of Bosnia and Herzegovina ("Official Gazette of the Federation of Bosnia and Herzegovina" No. 81/15, 75/21). A management company can be established by domestic and foreign natural and legal persons, provided that natural persons may only have a non-qualified share, while more than 50% of the share in the capital must be held by a legal entity engaged in banking, insurance or pension fund activities, as well as a person who has more than 50% of the share in the capital, or voting rights, in the aforementioned entity. In addition to establishing and managing voluntary pension funds, the management company also performs organizational tasks, makes investment decisions, makes one-time and scheduled payments, and performs all administrative, marketing and other tasks.

There are many categories of the population that could be interested in voluntary pension savings. In addition to existing and future employees, unemployed people, such as farmers and housewives, could also be interested in this type of savings, who would save money for retirement by investing in voluntary pension funds. As an incentive for investors to establish voluntary pension funds, the Government of the Federation of BiH should be interested in their formation, in terms of amendments to certain legal regulations. At the beginning of 2023, a Proposal for Amendments to the Law on Contributions of the Federation of BiH was established ("Official Gazette of the Federation of Bosnia and Herzegovina" No. 35/98, 54/00, 16/01, 37/01, 48/01, 1/02, 17/06, 14/08, 91/15, 104/16, 34/18, 99/19, 4/21 and 6/23), which has not yet been adopted, and refers to the reduction of contribution rates from a total of 41.50% to 31.50%. In addition to the proposed measure to relieve employers of their obligations, it is necessary to introduce certain tax exemptions for voluntary pension savings, following the example of the Republika Srpska. Namely, if it were prescribed that contributions and taxes are not paid on a certain amount of savings in a voluntary pension fund, interested parties and investors would certainly be engaged in establishing a voluntary pension fund, and thus enable the

existence of a third pillar of pension insurance in this entity. Also, in addition to tax exemptions, one of the ways to encourage this type of savings is to co-finance a certain amount of savings by the Government of the Federation of BiH. The absence of legally guaranteed financial incentives for citizens to invest in voluntary pension funds, whether it is tax exemptions, state contributions or some other form of incentive, may be one of the main reasons for the lack of voluntary pension funds in this entity.

CONCLUSION

The pension system in Bosnia and Herzegovina faces a number of problems that affect the functioning of the mandatory state pension insurance, or the first pillar of pension insurance. Common problems of the region, including Bosnia and Herzegovina, relate to the constant decline in the population, the increase in the number of unemployed people, and the increase in the number of older people who need to use pension and disability insurance services. Although both entity pension systems are based on intergenerational solidarity, sustainability is not possible given that one job covers one pension. Due to insufficient inflow of money into pension funds, both entity pension systems have switched to treasury operations. However, whatever the state undertakes in the field of parametric changes within the entity pension insurance cannot be enough to increase the pension income of citizens in old age. In order to ensure a higher pension for future pensioners without the burden falling on employers, one of the solutions is the formation of voluntary pension funds, or the formation of the third pillar of pension insurance.

Developed economies have long since switched to a pension financing system with a third pillar of pension insurance, with the aim of facilitating the functioning of the existing system. The reform of the pension system in the Republika Srpska has begun, given that this entity already has an established voluntary pension fund, which, in addition to contributing to the strengthening of the pension system, also affects the development of the domestic capital market and the attraction of new investors in various branches of the economy. Voluntary pension funds are generally among the largest institutional investors in capital markets, as they contribute to the creation of the primary and maintenance of the secondary market for government, local and corporate securities. The experiences of neighboring countries show that voluntary pension funds, together with banks, are the largest investors in government bonds.

In the entity of the Federation of BiH, the third pillar of pension insurance has not yet been established, that is, not a single voluntary pension fund has been registered. A possible reason for the failure to establish voluntary pension funds in this entity is a disincentive legal framework. Also, the lack of financial incentives for potential investors would to a certain extent limit the success of these funds' operations. If the entity authorities were to engage in amending certain legal regulations relevant to the establishment of the third pillar of pension

insurance, banks, insurance companies, other financial institutions, and all interested parties that meet the prescribed conditions would certainly be stimulated to establish voluntary pension funds. This way of reforming the pension system would help restore credibility to the pension system, influence the development of the capital market, and thus enable the strengthening of some of the characteristics of the transition such as: resilience, integration, green transition, governance, and competitiveness, which are key elements of successful and sustainable market economies.

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CRYPTO CURRENCIES: THE DIGITAL REVOLUTION OF THE MODERN FINANCIAL SYSTEM

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Summary

Cryptocurrencies are an innovative form of digital money based on decentralized blockchain technology. This paper explores the basic characteristics of cryptocurrencies, their development, functionality, advantages and challenges, as well as the impact they have on the global market, legislation and traditional financial systems. Special focus is placed on the most famous cryptocurrencies, such as Bitcoin and Ethereum, and on their technical and economic aspects. In addition, the perspective of their further development in the context of increasing digitization and the emergence of new forms of digital money, including CBDC (digital currencies of central banks), is considered. The research includes psychological, social and economic factors that shape the perception of cryptocurrencies among users, investors and regulatory authorities. The digital transformation of the financial sector, aided by the development of cryptocurrencies, is expected to have long-term implications for the way we understand money, value and trust in economic systems.

Keywords*: Cryptocurrencies, Bitcoin, Ethereum, blockchain, digital currency, decentralization, financial technology, regulation, digital economy, smart contracts*

1. NTRODUCTION

In the modern digital age, technology has an increasing influence on everyday life, including the financial sector. Cryptocurrencies, as a relatively new phenomenon, are becoming an increasingly important actor in the global economy. Their appearance has caused numerous discussions among economists, regulators and investors. Many consider them a revolutionary form of money that can change the way the financial world works. In this paper, we will focus on the basic concepts, history, technical background and economic significance of cryptocurrencies. We will also consider their impact on existing financial institutions and the challenges they face in terms of regulation. Cryptocurrencies are a symbol of digital freedom for many, while others see them as a threat to monetary stability. Regardless of the attitude, it is clear that their role in modern society is growing. Technological progress, the increasing accessibility of the Internet and the growing global demand for decentralized solutions contribute to their popularity. Although they are still not fully integrated into traditional financial flows, numerous indicators indicate that cryptocurrencies will play a key role in the future development of the digital economy. Considering this phenomenon requires a multi-faceted approach – technical, legal, economic, and sociological. The emergence of cryptocurrencies has led to changes in consumer and investor behavior, and raises new questions regarding responsibility, transparency, and trust. This paper aims to provide a comprehensive overview of the current state of and predict future trends in development and application crypto currency.

2. THE CONCEPT AND BASIC CHARACTERISTICS OF CRYPTOCURRENCY

Cryptocurrency is digital money that uses cryptographic methods to ensure the security of transactions. They function on the basis of blockchain technology, which enables transparency and irreversibility of transactions. One of the key features of cryptocurrencies is decentralization, which means that there is no central authority that issues them. In practice, this means that no government or central bank can directly control their emission. Bitcoin, as the first and most famous cryptocurrency, has shown how technology can replace institutions. Besides Bitcoin, there are thousands of other cryptocurrencies with different functions and goals. Ethereum, for example, allows the creation of smart contracts that are automatically executed when conditions are met. Cryptocurrencies can be used to buy goods and services, but also to invest and store value. Their value is determined on the basis of supply and demand, which makes them very volatile. Most currencies have a limited supply, making them resistant to inflation. Transactions are recorded on a public ledger that is accessible to everyone, which contributes to transparency. User anonymity is possible, but not complete, which causes ethnic and security dilemmas. Cryptocurrencies are often the target of hacker attacks, but at the same time they offer a high level of security through advanced algorithms. In some cases, the use of

cryptocurrencies enables access to financial services for people in countries with weak banking infrastructure. Accessibility, digital nature and global character make them extremely attractive for various forms of economic activities. However, due to their complexity and technical nature, understanding cryptocurrencies requires some prior knowledge and technical literacy.

3. DEVELOPMENT OF CRYPTOCURRENCY

The development of crypto-currencies begins with the appearance of Bitcoin in 2009. Bitcoin was created by Satoshi Nakamoto, a pseudonym for an unknown person or group. This currency is presented as an alternative to centralized financial systems. The motivation behind the creation of Bitcoin was the loss of trust in banks after the 2008 financial crisis. Bitcoin laid the foundation for decentralized digital currencies. After that, numerous other projects, known as "altcoins", appeared. Ethereum, launched in 2015, brought the concept of smart contracts. Ripple is focused on fast and cheap international transactions. Litecoin, Cardano, Polkadot and many other currencies seek to solve specific problems in the blockchain ecosystem. The cryptocurrency market has seen tremendous growth in the last decade. The value of the market reached hundreds of billions of dollars. Along with the development of infrastructure, cryptocurrency exchanges such as Binance and Coinbase are emerging. Also, more and more institutions and investors are entering this sector. A significant contribution to development was made by miners, who verify transactions and receive new tokens as a reward. Proof of Work technology has been replaced by more efficient solutions such as Proof of Stake. In addition to technical innovations, there is also a significant increase in institutional interest, as large firms such as Tesla, PayPal and JP Morgan are investing in digital currencies. Due to the growing interest, governments and regulators are beginning to develop laws related to digital currencies. In some countries they are treated as property, in others as a means of payment, and in some countries they are completely prohibited. The development of cryptocurrencies was not linear - it was accompanied by numerous crises, hacker attacks, regulatory changes and market instability. Nevertheless, despite all the challenges, the number of users and the level of investment is constantly growing, which indicates a stable trend of growth and adoption.

4. ADVANTAGES AND DISADVANTAGES OF CRYPTOCURRENCY

Cryptocurrencies, as a form of digital money, bring a number of advantages that have made them attractive to users, investors and developers around the world. One of the key advantages is decentralization - a system that does not depend on intermediaries, banks or state institutions. This enables a greater degree of financial freedom, especially in environments where the financial infrastructure is poorly developed or where there is mistrust towards institutions. Cryptocurrency transactions are often faster and cheaper compared to traditional bank transfers, especially when it comes to

international payments. Another advantage is transparency – all transactions are recorded on the blockchain and can be publicly verified, which reduces the risk of fraud. In addition, cryptocurrencies offer potential protection against inflation, as many have a predefined maximum amount that can be in circulation (eg Bitcoin). They also enable access to financial services for people who do not have open bank accounts, which contributes to inclusion in the global economy. Cryptocurrencies are also a tool for innovation – smart contracts, DeFi applications and NFT markets would not be possible without the basic infrastructure provided by blockchain technology. However, there are also significant drawbacks. The first is volatility – the prices of cryptocurrencies can fluctuate significantly in a short period of time, which makes it difficult to use them as a stable means of payment or store of value. The lack of regulation and oversight opens up space for illegal activities, including money laundering, terrorist financing and fraud schemes. The use of cryptocurrencies requires technical knowledge that is not available to all users, which can limit their wider application. Also, mining - especially with currencies that use the Proof of Work algorithm - has an extremely negative impact on the environment due to high energy consumption. Another challenge is legal uncertainty: in many countries there is no clear legal framework for the use of cryptocurrencies, which creates risks for both users and investors. Without adequate consumer protection, users are often left without funds in case of loss of access data or fraud. Finally, the lack of a central institution means that there is no refund in the event of a mistake, which imposes additional responsibility on users. Despite these shortcomings, the advantages that cryptocurrencies offer - especially in the context of technological development, economic inclusion and global connectivity - make them an important part of the future financial infrastructure. In the following chapters, we will consider how states and regulatory authorities treat this phenomenon and what are the challenges in its institutionalization.

5. REGULATORY CHALLENGES AND PERSPECTIVES

The regulation of cryptocurrencies represents one of the most complex and important issues of the modern digital age. Since cryptocurrencies operate outside the traditional banking system, many countries are still looking for an appropriate legal framework that would enable their legal use while preventing abuse. Regulatory challenges relate to several dimensions: the legal definition of cryptocurrencies, taxation, the fight against money laundering, investor protection and the stability of the financial system. In the European Union, through the proposed MiCA (Markets in Crypto-Assets) regulation, efforts are being made to establish a single legal framework for all members. The goal is to provide legal certainty and encourage innovation, while at the same time protecting users. Similarly, the United States recognizes the importance of regulation, but has not yet enacted a unified law at the federal level – regulation is fragmented and

depends on the federal state. China, on the other hand, has taken a stricter approach, banning the mining and trading of cryptocurrencies to protect its financial system and prepare the ground for the introduction of its own digital currency (e-CNY).

In Bosnia and Herzegovina, the regulation of crypto currencies is still in its infancy. There is no special law governing their use, and the Central Bank of Bosnia and Herzegovina has repeatedly emphasized that cryptocurrencies are not an official means of payment. Nevertheless, the interest of citizens and investors is growing, and some legal entities and individuals are already trading cryptocurrencies via international platforms. This legal gap creates uncertainty and makes it difficult for the wider use of cryptocurrencies in the domestic economic system. One of the basic challenges is user identification. Since many crypto transactions are anonymous, it is difficult to detect criminal activity. This is why international organizations, such as the FATF (Financial Action Task Force), insist on introducing KYC (Know Your Customer) and AML (Anti Money Laundering) measures for all crypto exchanges. These measures aim to bring crypto markets on par with the standards that apply to traditional financial institutions. Despite the challenges, more and more countries are recognizing the importance of developing a regulatory framework that does not stifle innovation. The perspective is to establish clear rules of the game, which will enable the safe and responsible use of cryptocurrencies. It is necessary to find a balance between the freedom of the market and the protection of the public interest. Also, cooperation between countries becomes crucial because the crypto market is global and not bound by borders. In the future, greater harmonization of laws is expected, as well as the development of international standards for digital assets.

6. IMPACT ON FINANCIAL SYSTEMS

The emergence and spread of cryptocurrencies significantly affects traditional financial systems, causing their transformation and rethinking of existing business models. One of the main challenges posed by cryptocurrencies is reducing the role of intermediaries, such as banks and other financial institutions. More and more frequently, transactions are carried out directly between users, without the need for central authorities, thus changing the basic architecture of the payment system. Cryptocurrencies enable cheaper, faster and more accessible financial services, which is especially important for underdeveloped countries and rural areas where access to banks is limited. In this way, they contribute to financial inclusion and democratization of access to capital. Also, with the emergence of decentralized financial services (DeFi), users can independently place capital, take loans, invest and save without the participation of traditional banks. This changes the role of banks from intermediaries to potential partners or competitors in a decentralized environment. In addition, crypto markets open the door to new forms of financial instruments and innovations, such as

tokenization of assets, which enables the sharing of ownership of real estate, works of art, and even intellectual property. Traditional banks are increasingly introducing their own digital services and exploring the possibilities of using blockchain technology to respond to new market needs. However, this influence is not exclusively positive. The instability and unpredictability of the crypto market pose a risk to the wider financial environment. In the event that a large number of institutions or citizens invest in cryptocurrencies without sufficient understanding of the risks, serious consequences for financial stability may occur. Another challenge is the integration of cryptocurrencies into existing capital control, taxation and reporting systems, where many countries have not yet developed efficient mechanisms. Central banks also recognize this challenge, and are increasingly considering and developing their own digital currencies (CBDC - Central Bank Digital Currency), in order to maintain monetary sovereignty and enable more transparent monitoring of money flows. These digital currencies could represent a balance between the security of centralized systems and the flexibility of decentralized solutions. The impact of cryptocurrencies on monetary policy is also reflected in the possibility of bypassing traditional control mechanisms, such as interest rates or fiscal measures. Ultimately, cryptocurrencies do not completely replace traditional financial systems, but they undoubtedly change them and adapt them to the new digital reality. Financial institutions that recognize and adapt to these changes will have a comparative advantage in the modern global economic system. The future is likely to bring coexistence models, where cryptocurrencies and traditional systems work side by side, using each other's strengths to improve services and strengthen security.

7. THE FUTURE OF CRYPTOCURRENCY

The future of cryptocurrencies will be shaped by a number of interconnected factors, including technological innovations, global regulations, changes in user behavior, and macroeconomic trends. As the digital economy expands and more and more aspects of life move into the digital sphere, the role of cryptocurrencies also gains importance. Their presence is no longer limited to investment flows, but increasingly become a means of payment, a financing instrument and a part of everyday financial services. Technological advances play a key role in shaping the future of cryptocurrencies. Further optimization of blockchain technology, reduction of energy consumption by switching to more environmentally friendly consensus mechanisms such as Proof of Stake, as well as the development of multi-layer networks (Layer 2) that enable scalability and lower transaction costs are foreseen. Also, more and more work is being done on interoperability between different blockchain networks, which could enable their wider use on a global level. On the other hand, regulation will play a decisive role. Countries that manage to develop a balanced legal framework - which supports innovation, but at the same time protects users and the economic system - will have an advantage in

positioning on the global market. More intensive cooperation between regulators at the international level is expected, as well as the definition of standards for investor protection, prevention of abuses and tax treatment of digital assets. The presence of Central Bank Digital Currencies (CBDC) is expected to grow in the market, which may lead to a redefinition of the relationship between decentralized cryptocurrencies and government money. In this context, three parallel trends are possible: competition between CBDC and cryptocurrencies, their complementary use or integration of technologies. Also, the role of cryptocurrencies in the global financial system will be further emphasized through the development of decentralized finance (DeFi), tokenization of real assets (real estate, art, property) and the growing number of digital services available via blockchain. These processes contribute to the democratization of access to capital and enable greater inclusion of individuals in the global economy.

In the future, we can expect a deeper integration of cryptocurrencies into everyday life - through digital wallets, cards linked to crypto accounts, as well as growing acceptance by retail chains and service industries. Young, digitally literate users will lead this change because they are more open to new technologies and alternative forms of financial management. In conclusion, the future of cryptocurrencies promises accelerated technological development and the expansion of their application, but it will not be without challenges. The key issue will be the ability of the system to enable the inclusive, safe and sustainable use of cryptocurrencies, while preserving the fundamental principles of decentralization and financial freedom.

CONCLUSION

Cryptocurrencies represent one of the most complex and dynamic phenomena of the contemporary digital era. Their development and expansion have a profound impact on the global economic order, causing changes that go beyond the framework of the financial sector. Through this work, the key dimensions of crypto-currencies are analyzed: Technical basis, historical development, strengths and weaknesses, regulatory challenges, as well as their impact on financial systems and wider society. All of the above points to the fact that the world is at a turning point in the way we think about money, trust and the economy.

On the one hand, cryptocurrencies offer enormous opportunities - improving efficiency, reducing costs, strengthening financial inclusion and promoting transparency. On the other hand, they face numerous challenges: volatility, energy unsustainability, lack of regulation and security risks. The key issue for the future of cryptocurrencies will not only be technological, but also institutional, legal and ethical.

The success of this phenomenon will depend on the ability of the international community, regulatory authorities and the private sector to find a balance between the freedom of innovation and the need for security and stability. Cooperation, education and the gradual introduction of new models of financial control could provide a long-term

sustainable system in which cryptocurrencies play a complementary but significant role.

Although it is difficult to predict with certainty the ultimate reach of the influence of cryptocurrencies, one thing is certain - their presence can no longer be ignored. They are no longer an experiment or a passing trend, but have become a permanent segment of the contemporary digital landscape. It is therefore essential that we approach them with understanding, caution and vision.

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STABILIZATION OF SLOPE INSTABILITY: APPLIED METHODS FOR LANDSLIDE REMEDIATION

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Abstract

Slope instability and landslides are natural processes of great importance for modeling modern relief. Landslides occur as a result of a complex interaction between geological, geomorphological, hydrological and climatic factors, but also due to various forms of human activity. According to the definition of Cruden (1991), "a landslide is the movement of a mass of rock, debris or soil down a slope, which includes all types of gravitational movements - from landslides and overturning, to rotational and translational landslides, as well as loose material flows". These phenomena are especially pronounced in terrains with pronounced slopes, complex geological structure, high hydrological activity and low vegetation coverage. In addition, inadequate urbanization, deforestation, poorly planned construction activities and transport infrastructure often destabilize the natural balance of slopes, encouraging landslides. The consequences of landslides can be catastrophic — damage to infrastructure, endangering the safety of the population, and degrading the environment. For this reason, understanding the causes and mechanisms of landslides, as well as the application of effective geotechnical methods for their remediation, are a key part of engineering practice and sustainable spatial planning. This paper aims to present modern geotechnical approaches to slope stabilization through a review of landslide remediation methods and an analysis of their application in real conditions.

Keywords: *slope, slide, landslide*
JEL classification: *Q25, Q28, L11*

1. INTRODUCTION

The soil or rock mass in the area of natural slopes and artificial slopes is in equilibrium as long as the shear strength within the slope is greater than the shear stresses. When these equilibrium conditions are violated, the slope is destabilized, which can lead to its movement, failure and sliding. shear. Therefore, when the soil surface is not horizontal, a component of the force of gravity appears that tends to move the soil mass downwards, as shown in Figure 1. The sliding will stop when the shape of the slope changes so much that the change in stress re-establishes equilibrium, or if the influences that caused the disturbances (groundwater level, current pressure, etc.) cease to act. The long-term effect of weathering factors and changes in meteorological conditions in geological periods cause changes in stresses and material properties in the surface layer of greater or lesser thickness, all of which reduces the shear strength. [2]

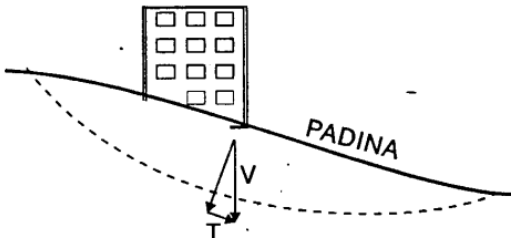

Figure 1. Slope [1]

Based on the above, it can be concluded that a landslide is the movement of soil or rock material caused by a failure within the boundaries of the moving mass. Under the influence of gravity and additional loads, shear stresses arise in the soil, which cause movement down the slope. The speed of this movement can vary significantly - from very slow creep, to sudden and destructive rapid sliding.Therefore, it is important to understand the basic elements of a landslide:

sliding surface– the surface along which a mass of soil or rock moves down a slope.
sliding block– a mass of soil or rock that moves.
breakdown zone- the place where there is cracking or breaking of material within the soil or rocks, which allows the movement of the sliding block.
foot– the lower, front part of the sliding block, which is often compressed and deformed due to the pressure of the mass above

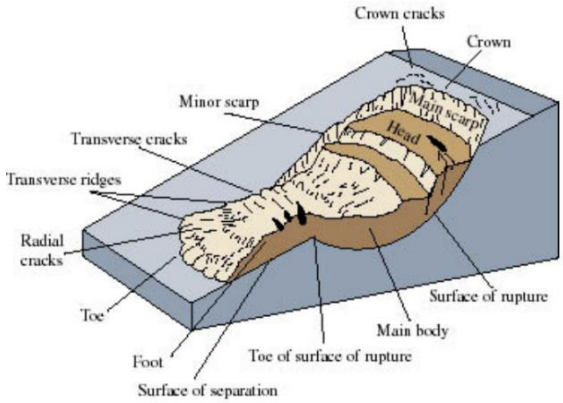

Figure 2. Landslide elements [5]

2. LANDSLIDES – DEFINITION, ELEMENTS, CAUSES OF OCCURRENCE

In nature, landslides occur due to long-term climatic influences, such as heavy and prolonged rainfall, which increase the water content in the soil, reducing its internal strength. Water penetrates into the cracks and pores of the soil, increases the pore pressure and weakens the bond between particles, making the soil significantly more susceptible to sliding. In addition, changes in groundwater levels and seasonal freezing and thawing further contribute to the mechanical instability of soil layers. In addition to natural factors, human activity has a significant impact on the occurrence of landslides. Irrational deforestation, excessive land use, uncontrolled earthworks and the construction of infrastructure on unstable terrain often contribute to the destabilization of slopes. When the natural plant cover is removed, the soil remains unprotected, and its layers become more exposed to erosion and atmospheric influences. Also, improperly designed roads, cuts and embankments can cause changes in the distribution of stresses within the slope, which can be enough to trigger the sliding process. Earthquakes, which abruptly change the stress state within the soil, pose a particular risk. Vibrations due to earthquakes can disrupt the already weakened structure of the slope, especially if it was previously saturated with water. In such cases, the soil loses its load-bearing capacity and there is an immediate sliding of large masses, which often has catastrophic consequences. Finally, the long-term influence of time should not be neglected either. During geological periods, as a result of the continuous action of natural processes such as wear and tear of rock material, the surface layers of the soil gradually lose their mechanical properties. Although these changes take place slowly and imperceptibly, their cumulative effect over decades or even centuries can lead to a decrease in slope stability. At the moment when the balance is disturbed, there is a sudden movement of the ground, which can result in serious consequences.

2.1. Classification of landslides

The formation of a landslide causes changes in the relief, the internal structure of a slope or artificial slope, the position and shape of the terrain surface or the sliding surface along which the moving mass moves. There are several classifications of landslides, which are described in more detail below.

Division of landslides depending on the direction of development of the sliding process:

- delapsive - landslides in which the sliding process develops from bottom to top
- detrusive - landslides where the sliding process develops from top to bottom

Classification of landslides according to the geological environment in which the landslide forms:

- consequential landslides - occur on slopes where there are already predispositions for their formation.
- sequential landslides - occur in homogeneous, non-layered rock masses, where the sliding surface is mostly circular-cylindrical and does not follow the rock layers.
- insequential landslides - occur in heterogeneous, layered rock masses where the sliding surface intersects multiple layers of different properties

Classification of landslides according to the depth of the sliding surface	Clasification of landslides according to the amount of mass moved
❖ surface (> 1m)	❖ small (up to a few thousand m^3)
❖ shallow (1 – 5 m)	❖ medium (up to several tens of thousands m^3)
❖ deep (5 – 20 m)	❖ large (up to several hundreds of thousands m^3)
❖ very deep (> 20 m)	❖ very large (up to several millions of m^3)

Table 1. Classification of landslides based on the depth of the sliding surface and the volume of displaced material.

According to the movement mechanism, there are five types of sliding:

fall-separation of mass from steep slopes on the surface, on which there is little or no shearing, but free fall of material, overturning or rolling occurs;
topple - rotation (forward) of a separate mass around an axis located at its base or near its base;
slide - movement of a more or less coherent mass along one or more well-defined sliding surfaces (failure surface);
spread - the main way of movement is the lateral spreading of blocks, resulting in the formation of shear or tension cracks,
flow - various movements with significant variations in speed and water content, and are manifested as spatially continuous deformation [4]
rotational landslides - characterized by a curved, concave sliding surface, where the soil mass rotates around an axis
translational landslides - a mass of soil or rock slides along an almost flat or slightly inclined sliding surface, often in layered rock formations

3. LANDSLIDES REMEDY METHODS

Stabilization of an existing landslide or prevention of a potential landslide is done with the aim of reducing the forces that trigger the slide, that is, by increasing the resistance forces of the soil or rock mass. For

good remediation, it is necessary to carry out thorough engineering-geological investigations of landslides that provide certain data and help to develop a remediation project, i.e. form calculation models, in order to know the level of danger of the area of the building located on a moving slope or on a slope that can be affected by sliding. At the same time, the critical sliding surfaces in the restored state are not always the same ones that were critical in the restored state. The best results in the rehabilitation of landslides are achieved by using a combination of different types of rehabilitation measures that must ensure the maximum effect in stabilizing the slope by implementing the simplest and least demanding rehabilitation measure. Landslide rehabilitation measures are classified into four basic groups: drainage, modification of slope geometry, support structures, internal reinforcement of the slope

3.1.Drainage

Buoyancy, pore pressure and the hydrodynamic action of groundwater are the most common causes of slope instability and landslide initiation. Therefore, drainage is one of the most effective and commonly applied remediation measures.

Drainage can be implemented in practice in three basic ways:

- surface drainage,
- dug drains,
- drilled pipe drains.

3.1.1.Surface drainage

The design of drainage cuts must be such as to ensure their permanent and safe functioning.When designing, care should be taken that the filtration flow of water towards the drain must not cause gradual erosion of the soil from the contact zone between the drainage layer and the surrounding soil, as this could lead to clogging of the drainage system. The drain fill must be designed in accordance with filter rules, whereby the permeability of the drainage material should be at least ten times greater than the permeability of the surrounding soil. The granulation of the drainage material must be carefully matched to the characteristics of the adjacent soil in order to avoid migration of fine particles. At the lower end of the drain, the minimum cross-section must be sufficient to accommodate the entire expected water flow. In practice, the geometry of the cross-section will most often not require a width greater than that technically necessary for the construction, which is usually between 60 and 80 cm. In situations where the drain passes through inhomogeneous material, especially if it includes layers with higher permeability, it is recommended to increase the capacity of the drain, because a greater inflow of water can be expected from these layers, at least occasionally. Placing pipes along the bottom of the drainage channel is an effective way of increasing its ability to drain water. When using pipes made of materials that naturally allow water to pass through, such as highly porous ceramic materials, it is recommended to lay them in a layer of sand to improve the flow. If the pipe material is not sufficiently permeable - which is often the case with baked clay, concrete or asbestos pipes - they must be additionally perforated, i.e. drill holes that allow water to

be absorbed from the surrounding soil. When installing such pipes, it is important to ensure that the joints between the segments are precisely made, with a minimum distance, so that water can enter the system without hindrance.

3.1.2. Trenched drains

Dug up dogwoodsare basically rectangular or trapezoidal trenches dug in the groundwater table. Their main function is to intercept water moving through the soil and direct it towards a specific recipient, most often an open channel, recipient or collector. A perforated drainage pipe or a pipe made of porous material is usually laid at the bottom of the trench, whose role is to collect water and transport it out of the critical area. The pipe is then lined with gravel or crushed stone, which allows the water to flow freely towards the pipe. To prevent the system from clogging with fine soil particles, a geotextile material is placed around the drainage layer, which serves as a filter. The dimensions of the drains are determined depending on the amount of groundwater and soil characteristics, but most often the depth is between 1.5 and 3 meters, while the width ranges between 0.6 and 1 meter.

3.1.3. Drilled pipe drains

Drilled pipe drains are a modern method of underground drainage, which is used in cases where the construction of classic dug drains is not possible or technically impractical. This method is used to lower the groundwater level in deeper soil layers, as well as to increase the stability of slopes and landslide zones. The basic principle is based on drilling horizontal or slightly inclined channels into the soil, into which are then installed

perforated plastic pipes(most often PVC or PEHD). The pipes are used to collect water from the ground and safely drain it away from the affected area. During installation, the space around the pipe can be additionally filled with gravel or filter materials to improve permeability and prevent clogging.

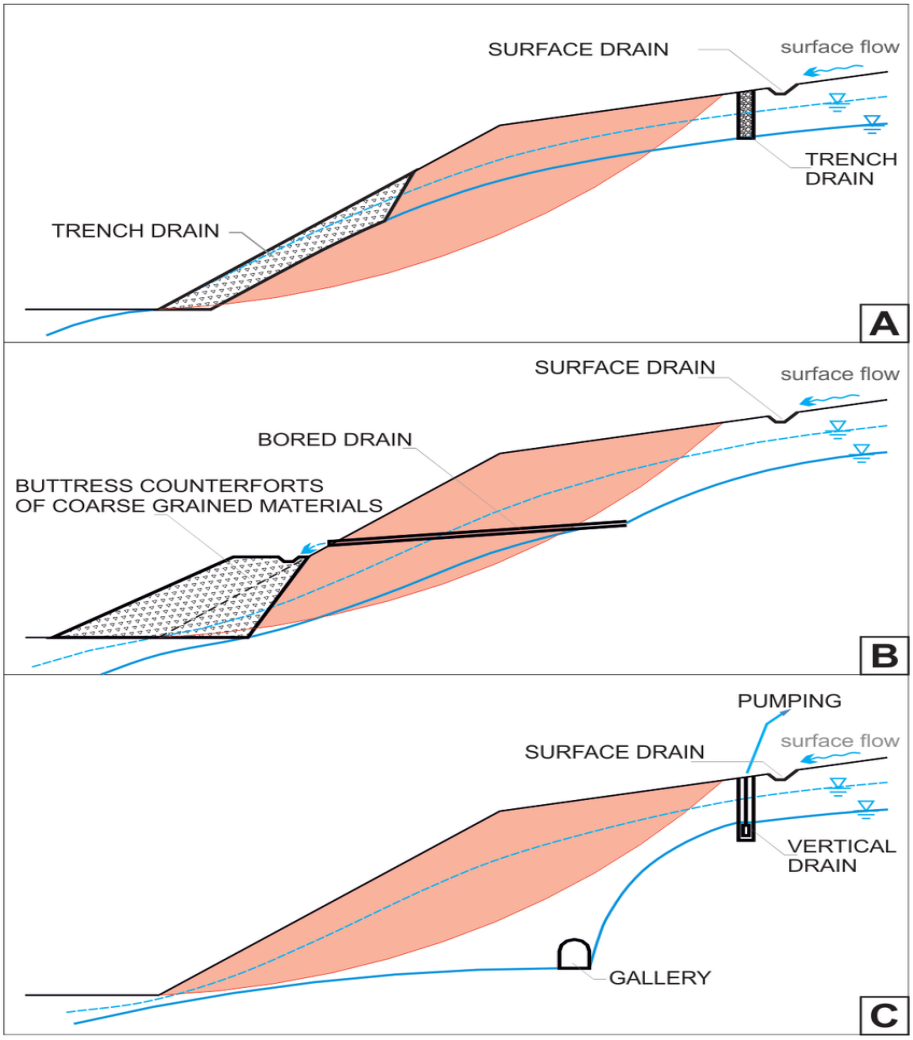

Figure 3. Stabilization of the slope by drainage: (A) Drainage using a combination of surface and trench drains; (B) Drainage using a combination of surface and drilled drains and buttresses (top walls) made of coarse-grained material; (C) Drainage using a combination of surface and vertical drains and a drainage gallery. [8]

3.2. Modification of slope geometry

This method is based on an engineering approach to reshaping the natural configuration of the terrain in order to reduce the forces that cause sliding and increase the stability of the soil mass. The most common form of geometry modification involves reducing the slope slope. By removing excess material from the upper part of the slope (cutting the slope), the weight of the soil acting on the sliding surface is reduced, which directly reduces the forces that cause the mass to move. This intervention is often combined with embankment at the foot of the slope, where the so-called counterweight (stabilization embankment) is built, which increases the soil's resistance to sliding. In certain cases, slope terracing is also used, whereby the slope is formed in a series of

horizontal or slightly inclined plateaus. This method not only increases stability, but also allows for better control of surface runoff, and can serve as preparation for urbanization, roads or agricultural cultivation. It is important to note that the change in geometry must be based on a detailed geotechnical analysis, which includes stability testing, determination of safety factors, as well as calculations of sliding surfaces. Improper or excessive intervention can lead to additional instability, especially in stratified or saturated terrains. That is why this measure is often performed in combination with drainage systems (flat, drilled or vertical drains), which reduce pore pressures in the soil and additionally increase the safety of the slope. Support structures, such as gabion walls, gravity walls or reinforced concrete elements, are also often used.

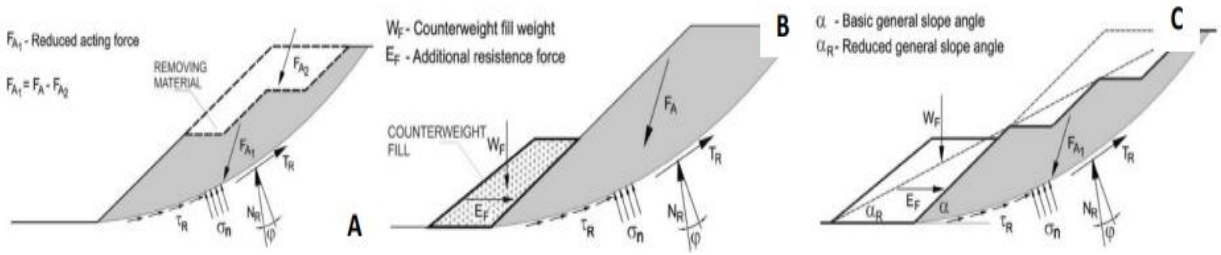

Figure 4. Removing material from the area that triggers the landslide (with possible replacement with lighter material) (A), adding material to the area that maintains stability (counterweight in the form of berms or embankments) (B), reducing the overall slope slope (C). [7]

3.3. Retaining structures

Retaining structures are walls of massive or segmented, permanent or temporary constructions that support uneven natural or filled soil, in such a way that the surface behind the wall is at a higher elevation than in front of the wall. [4] Retaining structures that are built on the lower edge of the moving mass can significantly contribute to the stabilization of landslides. There are different types of retaining walls, and their choice depends on the characteristics of the soil, the height of the slope and the loads to which the soil is subjected. The simplest are gravity walls, which achieve stability by their own weight. They are usually made of concrete or natural stone and are ideal for lower slopes. Their large mass allows them to easily resist soil pressures, but they also require a significant amount of material and space. Therefore, a gravity retaining wall takes on the horizontal or oblique pressure of the fill, and the weight of the wall directs it so that the resultant passes through the base of the foundation to the soil. In situations where walls of greater height are required or when the soil exerts significantly greater pressure, reinforced concrete walls are used. They are thinner and more elegant, but the key to their

stability is a quality base and often additional anchoring in the ground. Due to its strength, reinforced concrete walls are often used in urban areas where building space may be limited. Gabion walls are a modern and environmentally friendly alternative. They consist of wire baskets filled with stones, which gives them flexibility and allows water to pass through, thus reducing hydrostatic pressure. These walls are particularly suitable for less steep slopes and natural environments, where speed and simplicity of execution are important. For the most difficult conditions, such as deep and active landslides, more complex structures such as piled and anchored walls are used. These systems, deeply embedded in the ground, additionally ensure the stability and reliability of the renovation, even though they are much more demanding and expensive to perform. An essential part of the renovation is the proper solution for soil drainage behind the wall, because the accumulation of water can significantly increase the pressure and threaten the stability of the entire structure. That is why drainage layers, perforated pipes and geotextile materials are installed that efficiently drain excess water.

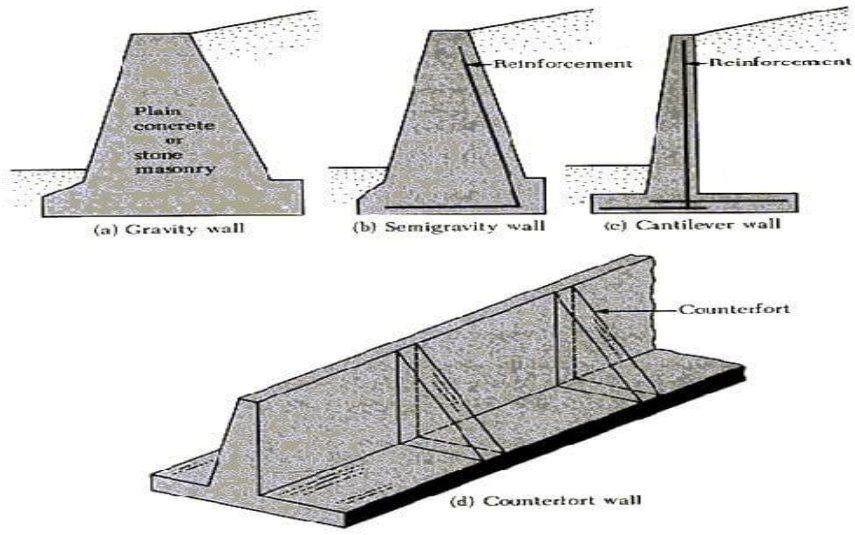

Figure 5. Types of retaining walls [6]

3.4. Internal reinforcement of the slope

Internal slope reinforcement involves the integration of various materials and technologies within the soil mass itself, thereby increasing its resistance to forces that can cause landslides. One of the most common techniques is soil reinforcement using geosynthetic materials – such as geotextiles, geogrids and geocomposites. These materials are placed in layers and act by increasing friction between soil layers, thereby reducing the possibility of movement. In addition to geosynthetics, the soil drilling method is also used, which involves placing steel rods in pre-drilled holes in the slope. These rods are then reinforced with cement injection material, forming a kind of "reinforcement" within the soil. This method is often used to stabilize existing slopes, especially when widening roads or building structures in mountainous areas. Internal reinforcement is often combined with surface protection, such as shotcrete, drainage systems and greening. This also allows for the control of surface water that can contribute to erosion and soil destabilization.

CONCLUSION

The issue of landslides in engineering practice requires a serious and systematic approach, as it represents one of the most common and dangerous phenomena related to terrain stability. The movement of soil mass along a slip surface is the result of a complex interaction between terrain structure, hydrogeological conditions, and external influences—whether natural or caused by human activity.Understanding the mechanisms of sliding, as well as accurately identifying all risk factors, forms the basis for selecting appropriate remediation methods. Whether it involves reducing pore water pressure through drainage systems, modifying slope geometry, constructing retaining structures, or internally reinforcing the soil mass—each intervention must be tailored to the specific field conditions. No solution is universal, but a combination of multiple approaches can achieve long-term slope stability.Ultimately, effective landslide management does not only mean responding after a problem occurs, but also ensuring timely prevention—through proper construction planning, preservation of natural vegetation, and control of impacts on the soil. Prevention is always more cost-effective, safer, and more sustainable than post-failure remediation.

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AI IN EDUCATION

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Abstract

Artificial intelligence (AI) is becoming more present in many aspects of society, and education is no exception. AI-based technologies are already being used to improve teaching practices, adapt content to student needs, and assist teachers with a range of administrative resources. Its applications are changing conventional learning patterns and offering new paths for unique learning experiences and the digital transformation of education. This paper reviews the AI tools currently available in education, shows how they are presented, outlines the outcomes they create for students and their teachers, and considers future development paths available in the form of intelligent tutors, adaptive learning, and automated assessments. This paper explores the benefits, obstacles, and ethical complications of introducing AI into education systems. The aim of the paper is to provide a general overview of the possibilities of AI in education and to offer a path for its future responsible and useful practices.

Keywords**:** *artificial intelligence, AI tools, future of education, personalized learning, intelligent tutors*

JEL classification**:** *I21, O33*

INTRODUCTION

Over the past few years, artificial intelligence (AI) has seen great progress and is increasingly being integrated into various aspects of everyday life, including education. AI already offers opportunities for individualized learning, automatic assessment, virtual assistants and adaptation of educational content to each student according to their abilities and pace of progress. However, as technology advances, an important question arises: What does the future hold for the application of artificial intelligence in education? In the following text, concrete examples of the use of AI tools in classrooms and online environments will be presented, together with the advantages that this approach brings. These advantages include more efficient acquisition of knowledge and better access to education for all students. Special attention will be focused on expert assessments of the future of artificial intelligence in education, which includes personalized teachers and smart analysis of student progress. Also, problems that education systems may face will be analyzed, including ethical dilemmas, privacy issues, and potential dependence on technology. The purpose of this paper is to provide an overview of the role of artificial intelligence in education, both now and in the future. We also want to encourage thinking about ways in which technology can be used wisely to advance knowledge.

THE CONCEPT AND DEVELOPMENT OF ARTIFICIAL INTELLIGENCE

Artificial intelligence was constructed as a scientific field in direct connection with the establishment of computer science as a scientific and technical discipline. It began to develop seriously after the Second World War, and it only got its name in 1956. Alan Turing, John McCarthy, Marvin Minsky and Claude Shannon stand out as the founders of this field. They laid the theoretical and practical foundations that will enable the development of "intelligent" machines.[1]The basic principle of AI technology is machine learning, a process in which computer systems learn based on data. Machine learning can be divided into two main categories: supervised learning and unsupervised learning.

Supervised learning is a process in which a computer system is taught based on data that has been labeled with a goal. For example, a computer system can be trained based on a data set of images that are labeled with the name of the object in the image. In this case, the goal is for the computer system to learn to recognize objects in images.

Unsupervised learning is a process in which a computer system is taught based on unlabeled data. For example, a computer system can be trained on a dataset of images to find patterns in the images. In this case, the goal is for the computing system to learn to find common characteristics in images.[2]

[1] https://informatecdigital.com/hr/povijest-umjetne-inteligencije/ (visited 30.05.2025.)

[2] https://unidigital.hr/umjetna-inteligencija/(visited 30.05.2025.)

The development of artificial intelligence is based on so-called machine learning, i.e. neural networks, which enables such systems to have large amounts of knowledge, communicate with humans (natural language) or some other inanimate system, learn from experience, draw conclusions, adapt behavior, complex planning, etc., whereas, unlike humans' ability to perform various functions simultaneously, today's intelligent systems are still specialized for a narrower range of capabilities.[3]

There are different techniques and approaches in the development of artificial intelligence. Machine learning is one of the most commonly used techniques. It is based on algorithms that allow computers to learn from data and improve their performance independently. Deep learning is a branch of machine learning that uses neural networks with multiple layers to process and interpret complex data. Natural language processing enables computers to understand and generate human language, which is crucial for the development of intelligent assistants and translators.

The implementation of artificial intelligence is having a profound and pervasive impact on society. On the positive side, it can improve productivity, make better and faster decisions, streamline work processes, and provide personalized service. However, there are also a number of challenges and issues surrounding artificial intelligence. Ethical issues, such as privacy rights and data security, are becoming increasingly important. There are also concerns about the potential loss of jobs due to automation and the replacement of human labor by machines.

APPLICATION OF AI IN EDUCATION

Artificial intelligence is increasingly shaping the way knowledge is shared and acquired. Its use in educational institutions leads to more innovative learning processes, faster assessment, and a better understanding of the specific needs of each student. Below are some of the ways in which AI is being used in education.

PERSONALIZED LEARNING

Significant progress in the development of artificial intelligence (AI) is rapidly transforming many aspects of modern society, and the education system is no exception. Traditional teaching methods, which were previously considered universally applicable, are increasingly being replaced by approaches based on personalization, allowing each student an individualized learning experience. AI plays an important role in this process, primarily through the analysis of large amounts of educational data, which enables content and work methods to be adapted to each individual in accordance with their pace and abilities.[4].

AI-based technologies enable the generation of educational materials adapted to the knowledge and needs of students, and even the analysis of students' emotional states using tools such as webcams and sentiment analysis software. Using advanced algorithms, it is possible to timely

[3] https://www.enciklopedija.hr/clanak/umjetna-inteligencija(visited 30.05.2025.)

[4]https://www.forbes.com/councils/forbestechcouncil/2024/07/22/personalized-learning-and-ai-revolutionizing-education/(visited: 31.05.2025.)

recognize weaknesses in knowledge, predict learning outcomes, and identify students who are at risk of school failure. Based on this, the system can recommend individualized learning paths, which simultaneously increases the quality of teaching and the efficiency of the educational process[5]Students with more advanced knowledge can receive more demanding content, which positively affects their motivation and engagement.

In addition, AI tools allow educators to better respond to the different learning styles, abilities and needs of students. Since the educational needs of students are extremely diverse, traditional methods are often not sufficient to achieve optimal results. With the help of adaptive learning systems and intelligent tutors, teachers can adapt the content, rhythm and approach to each student individually[6]. This not only increases the efficiency of teaching, but also enables greater independence and engagement of students in their own education[7].

However, this form of education does not come without challenges. Personalization relies on the collection of large amounts of data about students, which raises issues of privacy and ethical use of data. Also, there is a risk of algorithmic bias, and the possibility that technology, if not properly implemented, will further deepen existing digital and social inequalities.[8]. Unequal access to technology and the Internet can limit the benefits that AI offers in education, especially in poorer or remote regions. This is precisely why experts emphasize the need for clear ethical guidelines, as well as for the active involvement of all relevant actors in the creation of a fair and inclusive education system.[9].

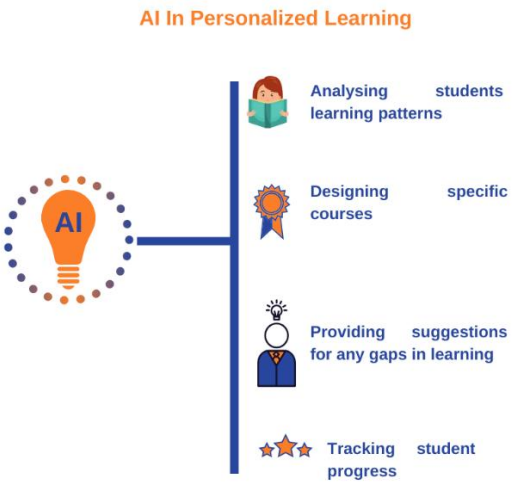

Figure 1. AI in personalized learning
Source:https://www.matellio.com/blog/ai-powered-tutoring-system-development/(accessed: 31.05.2025.)

INTELLIGENT LEARNING SYSTEMS

Intelligent Instructional Systems (ITS) are an advanced form of computer-assisted learning that uses artificial intelligence to provide individualized and adaptive education. Unlike earlier static systems (such as CBT and CAI), ITS focuses on the needs of each student individually – it analyzes their responses, knowledge and

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[9]Ibid.

learning style, and dynamically adapts content and approach based on this.[10]

ITS consists of three models: the expert model (which contains subject knowledge), the student model (which monitors what the student knows and needs to learn) and the pedagogical model (which decides how the material will be presented). Through these components, ITSs function as virtual tutors – guiding students through the material, offering additional explanations and exercises when needed, and providing detailed feedback on the accuracy of answers.[11]

One of the biggest advantages of ITS is their ability to effectively respond to the challenge of diversity in classrooms - especially when it comes to students of different abilities, backgrounds or languages. ITS can help each student progress at their own pace, enabling better quality and fairer teaching without additional burden on teachers. Research shows that students who use ITS often learn the material faster, show better results and more efficiently apply the acquired knowledge in practice. Examples like LISP Tutor and Smithtown demonstrate the measurable benefits of ITS in real-world educational environments – whether it's higher test scores or a reduction in the time it takes to master complex concepts.[12]

Although ITS does not replace the complete classroom experience, it can successfully complement and enhance traditional methods, especially in aspects such as homework, test preparation, and individual support for students.

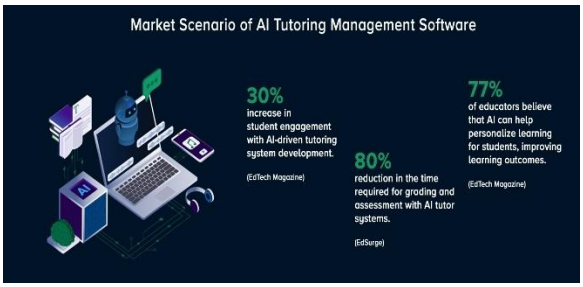

Figure 2. Effectiveness of the AI tutor system in education
Source:[https://www.matellio.com/blog/ai-powered-tutoring-system-development/](visited: 31.05.2025.)

LEARNING ANALYTICS

Learning analytics in digital education is the process of collecting, measuring, analyzing, and interpreting data about students and their interactions with digital educational content with the aim of improving learning and teaching.[13] Through analytics, student progress is monitored, those at risk of failure are identified, learning is personalized by adapting content and activities to the needs of each individual, educational methods are evaluated to determine what works and what doesn't, and student engagement is improved by understanding their behavior and motivation. Traditionally, analytics are mostly implemented through LMS systems

[10] https://www.ebsco.com/research-starters/education/intelligent-tutoring-systems(visited: 31.05.2025.)
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[12] https://www.ebsco.com/research-starters/education/intelligent-tutoring-systems(visited: 31.05.2025.)

[13]T.K Vashisth, B. Kumar, S. Chaudhary, K. Krishan Sharma (2024) AI-driven learning analytics for personalized feedback and assessment in higher education

such as Moodle or BlackBoard that collect basic data, but face challenges such as huge amounts of data, lack of integration, privacy and ethical issues, and lack of expertise in data interpretation.[14] Introducing artificial intelligence into learning analytics enables faster and deeper data analysis, pattern identification, predictive analytics to identify at-risk students and adapt content in real time, as well as automated reporting that unifies data from multiple sources.[15] However, the use of AI also brings risks such as non-transparency of algorithms, excessive reliance on technology while neglecting the human factor, bias if data is inadequate, and increased need for data security. There are tools like Moodle Analytics, Dropout Detective and Tableau that help with these processes.[16] All in all, learning analytics supported by artificial intelligence can transform education into a more efficient and personalized experience, but it requires careful management, human oversight and an ethical approach.

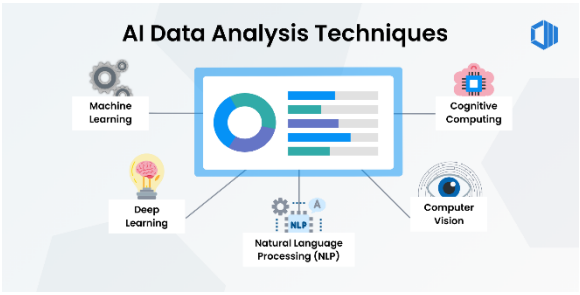

Figure 3.*AI approaches in data processing and analysis*
Source:[*https://www.proserveit.com/blog/ai-data-analysis-benefits-and-tools*](https://www.proserveit.com/blog/ai-data-analysis-benefits-and-tools)*(*visited*: 31.05.2025.)*

ADVANTAGES OF USING AI IN EDUCATION

AI in education refers to the use of artificial intelligence technology to enhance the learning experience. This includes tools and applications that can perform tasks such as personalized instruction, automated assessment, and data analysis to improve educational outcomes. One of the most significant benefits of AI in education is the ability to adapt learning. The traditional education system often does not take into account the individual needs of students. Each student has their own learning style, pace, and abilities, and AI can help tailor instructional content to those specific needs.

Some of the advantages of AI are:

AI is transforming education by personalizing learning and automating administrative tasks.

Chatbots and adaptive teaching systems enhance the educational experience by providing individualized support.

Ethical challenges include academic integrity and bias in AI algorithms.

Universities are using AI for administrative management and improving the learning experience.

AI is revolutionizing the way teachers solve routine tasks. AI-based systems can identify common mistakes and provide instant feedback, freeing teachers to focus on more creative, high-impact tasks. Advanced

[14] https://www.edsurge.com/news/2024-12-06-how-are-new-ai-tools-changing-learning-analytics(visited: 31.05.2025.)

[15] https://www.digitallearninginstitute.com/blog/ai-driven-evolution-in-learning-analytics-for-digital-education(visited: 31.05.2025.)

[16]Ibid.

algorithms can analyze student performance to identify areas for improvement, allowing teachers to personalize instruction based on each student's needs and learning styles.

AI also makes it easier to automate tasks like marking tests and providing instant feedback, optimizing teachers' time for active teaching and student engagement.

AI enables easily accessible resources for all students, regardless of their location or economic status. Many online competitions and platforms use AI to optimize content, allowing students to learn whenever and wherever they want.[17]

By automating routine tasks, teachers have more time to focus on quality teaching and student support. This can result in improved educational quality and greater teacher satisfaction.

AI systems can analyze large amounts of data, helping schools identify patterns in learning. This can include predicting the risk of failure, allowing for similar approaches and timely intervention.

An example of a successful application of AI in education is Duolingo, a popular language learning platform that uses AI to adapt lessons to the user's progress. This application offers fun and interactive learning methods, using technology to motivate users to continue learning. Coursera also offers online courses in various fields and uses AI to analyze the success of its students. This platform allows students to take control of their education and learn at their own pace. Carnegie Learning uses AI in its mathematics learning platform. This system is designed to adapt the teaching content to the needs of students, allowing them to focus on areas that they need additional help. It is also worth mentioning the artificial intelligence created by OpenAI: ChatGPT. It is a chatbot or chat robot that has become popular due to the questions that users usually ask the program, which responds based on the information it has in its database. Chatbots and adaptive teaching systems, such as AutoTutor and ALEKS, act as personalized digital tutors. These systems can handle student queries, offer personalized support and guidance, and adapt to individual learning needs, thus complementing traditional teaching.

In higher education, AI is being used to improve administrative and enrollment management, assist in the teaching and assessment process, and offer predictive analytics to further personalize the educational experience for students. However, its implementation must carefully consider ethical and privacy aspects.

CHALLENGES AND ETHICAL ISSUES OF ARTIFICIAL INTELLIGENCE IN EDUCATION

Artificial intelligence (AI) opens up numerous possibilities for improving education – from personalized learning and task automation to the creation of more dynamic and interactive educational experiences. Nevertheless, with all the advantages, the application of artificial

[17] https://elektronikaupraksi.com/ai-umjetna-inteligencija/ai-za-obrazovanje/(visited 31.05.2025.)

intelligence in the educational environment brings with it numerous challenges and ethical issues that must not be ignored.

1. Privacy and data security

Artificial intelligence systems in education rely on the collection and processing of large amounts of data about students, teachers and educational processes. This data often includes sensitive information such as academic results, behavior, attendance, emotional reactions and even biometric records. The question arises - who has access to this data, how is it stored and in what way can it be (mis)used?

Examples of data breaches, such as the hacker attack on the ProctorU platform, where the personal data of hundreds of thousands of students were compromised, point to the real risks of inadequate privacy protection.[18]In addition, there is a risk of unethical exploitation of data for marketing, commercial or research purposes without the knowledge and consent of the user.

2. Feeling of constant surveillance

Continuous digital surveillance through AI systems can lead to changes in student behavior. If they know they are constantly being monitored, students may feel uncomfortable, lose trust in the education system, and avoid expressing their honest opinions.[19]Such an environment is not conducive to a healthy and free exchange of ideas.

3. Equality and the digital divide

AI has the potential to make education more accessible – especially for students with disabilities or those in remote communities. However, unequal access to technology, the Internet and digital devices can further deepen existing educational inequalities.[20]Students from less developed backgrounds may remain excluded from the benefits that AI brings.

4. Bias and transparency

AI systems are not neutral - their effectiveness depends on the data they are trained on. If this data contains biases, the AI may inadvertently favor certain groups of students. In addition, many AI tools function as "black boxes",[21]which means that it is not clear to the users how they arrive at certain recommendations or decisions. The lack of transparency makes it difficult to check and possibly challenge those decisions.

6. Regulation, responsibility and free work

The use of tools like ChatGPT raises additional questions – who is responsible for the accuracy of the information generated by AI? How aware are students that their interaction with the system can serve as "free labor" for training algorithms? Experts recommend caution: avoid requiring students to open accounts, encourage the use of alternative email

[18] https://edly.io/blog/artificial-intelligence-in-education-and-privacy-concerns/ (visited: 31.05.2025.)
[19]Ibid.

[20] https://www.enrollify.org/blog/ethical-considerations-for-ai-use-in-education(visited: 31.05.2025.)

[21] https://guides.lib.jmu.edu/AI-in-education/ethics(visited: 31.05.2025.)

addresses and above all – always read the privacy policy of the tool being used.[22]

THE FUTURE OF AI IN THE EDUCATION SECTOR

Looking into the future of artificial intelligence is both exciting and dizzying. Advances in areas such as reinforcement learning, quantum computing and neurotechnology promise to push AI to new frontiers.

What trends and opportunities can we expect in the future of artificial intelligence?

1. Artificial General Intelligence: The search for systems that can match or surpass human intelligence across a wide range of tasks.

2. Brain-computer interface: The ability to connect our brains directly to artificial intelligence systems, improving our cognitive abilities.

3. Collaborative artificial intelligence: systems designed to work in harmony with humans, enhancing our abilities rather than replacing us.

4. Explainable artificial intelligence: developing systems that are not only efficient, but can explain their thinking in a way that is understandable to humans.

5. Sustainable Artificial Intelligence: Creating more energy-efficient algorithms and hardware to reduce the environmental impact of AI.

AI technology has the potential to transform many aspects of our lives. For example, AI can be used to improve healthcare, education and business. However, it is important to be aware of the potential risks associated with AI technology and to ensure that AI is used in a safe and ethical manner. AI technology is a powerful tool that has the potential to improve our lives in many ways. It is important to be aware of the potential risks associated with AI technology and to ensure that AI is used in a safe and ethical manner.

Artificial intelligence is no longer just part of science fiction – it has become a reality that changes the way we work and live. Today, it plays a key role in many aspects of life, from industry and healthcare to education and entertainment.

AI is transforming education by personalizing learning, automating tasks like marking tests and providing instant feedback. This allows teachers to focus on more interactive and creative teaching, while AI systems identify and support each student's areas of improvement.

The future of AI in education

The future of AI in education looks promising. Technological advances will likely bring even more sophisticated tools to help shape the education system.

CONCLUSION

Artificial intelligence (AI) has come a long way from humble beginnings to becoming one of the most influential technologies of our time.

[22]Ibid.

AI offers incredible opportunities for improving education. Its application can significantly transform learning and teaching, making them more efficient, accessible, and adaptable. While there are challenges that need to be addressed, the potential for AI to transform the education system is enormous.

As technology continues to evolve, it is important that educational institutions, teachers and students remain open to the innovations that AI offers, while also being mindful of privacy and ethical issues. Ultimately, the successful integration of AI into the education system can contribute to creating better educational experiences for all.

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UNDERSTANDING THE VERSATILE IMPACTS OF AI ON COMPETENCY DEVELOPMENT

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Summary

Artificial Intelligence (AI) has caused significant changes and important developments have been made in accessibility by customising learning. This paper discusses AI's facilitating and destructive roles in developing competencies. While AI-supported tools promote personalised learning, real-time feedback and interdisciplinary cooperation, they also bring challenges like decreasing intrinsic motivation, dissolving the natural learning process by causing overreliance and sabotaging competency development. This study emphasises the importance of the usage of AI as more of a supportive tool while using it in developing human competencies. For this reason, supporting holistic approaches that combine the efficiency provided by AI and human skills, promoting autonomy and engagement, and a lifelong learning culture is suggested. It is emphasised that individuals can demonstrate a more dynamic and balanced competency development while preparing for future needs, by taking these suggestions into consideration and utilizing the AI's potential at the highest level.

Keywords: *artificial intelligence, competency, learning, development, intrinsic motivation.*

JEL classification*: O33, J24, L86, D83*

1. INTRODUCTION

1.1. Background and Context

The advent of AI has caused significant changes in learning and professional development. Since the first applications in automation and data processing, now AI has become a multipurpose tool enabling personalisation, cooperation and promotion of competency development between industries (Mena-Guacas vd., 2023). This technological revolution has not only transformed the traditional learning environments but also redefined the nature of business dynamics. As an example, today AI plays a critical role in decision-making and enables the processing of complex databanks efficiently and unprecedentedly (Chen, 2024).

Even though AI clearly contributes to efficiency and accessibility, it also brings critical challenges to competency development. As long as organisations and individuals adopt AI-supported solutions, it is identified that there is an increasing need to understand the effect of AI on basic competencies like critical thinking, problem-solving and emotional intelligence (Mary & Niese, 2022). These changes highlight the urgency of adopting learning systems and workforce training programmes to meet the demands of an AI-driven future.

1.2. Problem Statement

Despite the transformative potential of AI, there are various problems in developing the competencies. One of the most urgent problems is the risk of overreliance in AI systems which decreases the intrinsic motivation and independent problem-solving capacity (Babashashi et al., 2024). Also, the usage of AI in learning environments creates an illusion that users generally perceive themselves as more competent than they are. Thus this situation can prevent long-term competency development and adaptability which are critical for dynamic, complex and unpredictable business scenarios (Xiao et al., 2024).

Another challenge is based on the accessibility of AI tools. While these technologies offer more democratised learning opportunities, inequalities in accessing AI-based platforms may worsen the current inequalities already exist. Communities with limited resources may be also excluded from resources to integrate those tools effectively and so the gap between socioeconomic groups may increase (Chen, 2024).

1.3. Objectives and Scope

This study aims to identify the bilateral role of AI in both the facilitating and destruction of competency development. It also aims to provide a balanced perspective on the effects of AI on learning and workforce training by investigating positive contributions such as advanced accessibility, personalisation and interdisciplinary learning besides the limitations of AI. This analysis is specifically important considering the ongoing discussions on the ethical and practical dimensions of AI integration (Mena-Guacas et al., 2023).

The scope of this study includes an in-depth examination of current literature and case studies to determine the trends and challenges that emerged in AI-oriented

competency development. Also, strategies are also mentioned to promote a balanced approach that highlights the strength of AI while addressing the shortcomings.

1.4. Methodology

The methodology of this study is based on a comprehensive literature review consisting of peer-reviewed papers, conference proceedings and academic publishings. The resources are selected according to their suitability, accessibility and contributions to understanding the effects of AI in competency development. In the study, thematic analysis is used to identify the recurring patterns and insights in various areas including work, learning, organisational behaviour and adopting technology. This methodological approach enables understanding the concpet in a holistic way by integrating the perspectives of academic and industrial stakeholders. The study synthesises the insights and aims to present suggestions for policy-makers, individuals and organisations confused about AI integration.

2. THEORETICAL FRAMEWORK

2.1. Competency Development in the Digital Era

In today's rapidly changing digital world, competency development is the keystone of personal and professional development. Generally, competency is defined as the combination of knowledge, skills, attitudes and behaviours that enables individuals to perform effectively (Woodruffe, 1993). The definition of competency is expanded today, including essential qualifications like digital literacy, adaptability and critical thinking which support individuals to deal with technological developments.

The digital era offers unique opportunities to develop competencies. E-learning platforms, virtual reality simulations and real-time feedback algorithms have created a significant revolution in individual skill development methods. As an example, personalised learning tools increase engagement and persistence by providing the ability for students to ensure specific learning goals and experiences (Salas, Tannenbaum, Kraiger & Smith-Jentsch, 2022). Furthermore, these tools close the gap between socioeconomic limitations by democratising accessibility.

But these opportunities also bring challenges. Overreliance on technology for learning activities can cause superficial engagement in which individuals passively consume information instead of critically analysing it. Also, the rapid evaluation of technology requires continuous development of new skills and the individuals may become disinterested from a point. This situation has now become apparent in areas in which automation avoids traditional learning styles and rapidly changes the work requirements (Park, Fritz & Jex, 2011).

From this perspective, a balanced approach is a must to overcome those challenges. Digital tools need to be used as facilitators instead of basic learning tools. Promoting tools which prioritise intrinsic motivation will provide more sustainable learning and development. For instance, organisations can build a holistic development ecosystem which supports long-term growth by applying hybrid models that combine digital tools with mentorship.

2.2. Self-Determination Theory

Self-Determination Theory (SDT) is a psychological framework which comprehensively investigates human motivation, personality development and psychological well-being. The theory, developed by Edward L. Daci and Richard M. Ryan in the 1980s, emphasises the role of intrinsic motivation and fulfilment of basic psychological needs in fostering optimal functioning and personal development (Deci & Ryan, 1985, p.229). The central of this theory is the understanding that human is focused on growth in nature and seek environments which support their psychological needs. While fulfilled needs contribute to increased motivation and well-being, disappointments decrease functioning and can cause distress.

SDT defines three basic psychological needs: autonomy, competency and relatedness. Autonomy is the sense of control over our own actions and decisions (Gagné & Deci, 2005). Autonomy refers to the sense in which a person feels strong, free from external control, and it reflects the desire to act aligned with the authentic self. On the other hand, competency refers to the need of feeling effective and capable while experiencing the challenges in one's environment. Relatedness encompasses the human drive to connect with others in meaningful ways, fostering a sense of belonging and care (Deci & Ryan, 2000). Together those needs are considered essential and universal to promote personal development and protect psychological integrity regardless of culture and individual differences. Satisfying those needs provides a basis for understanding the motivational sustainability SDT defines.

According to SDT, motivation exists on a spectrum ranging from intrinsic to extrinsic. While intrinsic motivation arises when activities are inherently enjoyable and interesting, external pressures and rewards lead to extrinsic motivation. However, all the extrinsic motivations are not the same, because SDT defines subcategories which change the internalisation degree of the extrinsic motives. When individuals are motivated by intrinsic or well-internalised extrinsic factors, they possibly tend to be more engaged, more creative and more persistent. This underlines the practical outcomes of the theory (Ryan & Deci, 2000).

This understanding of motivation has important applications in various areas including education, health, workplace and sports. For instance, in education, it is shown that environments supporting the autonomy, competency and relatedness of students promote intrinsic motivation and increase academic performance and satisfaction (Niemiec & Ryan, 2009). Likewise, healthcare service interventions based on SDT principles focus on increasing the adherence of the patients to medication regimes by considering these basic psychological needs. They promote patient satisfaction and better health outcomes by doing this (Ng et al., 2012). These examples demonstrate the versatility of SDT in discussing the challenges in the real world.

Furthermore, workplaces that adopt leadership styles supporting autonomy in the guidance of SDT generally report higher levels of employee and work satisfaction, and performance and lower levels of burnout (Deci, Olafsen & Ryan, 2017). Similarly in sports, fulfilling the autonomy,

competency and relatedness needs of sportives can increase general well-being (Vallerand, 2007). These findings emphasise the interdisciplinary interest of SDT by demonstrating how promoting supporting environments can cause better results in different concepts.

Even though it has strengths, SDT was criticised for its practicalibility in different cultural contexts. Some researchers discussed how cultural differences affected the emergence of those psychological needs (Chirkov vd., 2003). This situation raised the problem of how autonomy, competency and relatedness listed in SDT can be supported or compelled, and how they can be improved in modern-day digital and virtual environments.

While SDT emphasises the potential of well-designed learning environments, the rise of AI brings challenges to those psychological needs. Badly designed AI systems can prevent autonomy by offering single-track learning opportunities which limit personal choices. Similarly, feedback generated by AI tools can not be personal sometimes and it could decrease the sense of competence. Furthermore, relatedness can be blocked regarding the sense of isolation learners experience because AI-supported environments have no human interaction (Hutmacher & Appel, 2023). To address these challenges, designing SDT-adopted AI systems is critical. Understanding the importance of the relationship between SDT and AI and creating a suitable integration can turn AI into a strong tool to support intrinsic motivation and effective competency development.

2.3. Destructive Effects of AI

The concept of destruction defines generally unpredictable changes that challenge current systems and processes. In the context of competency development, AI presents a sharp double-edged spear. While it offers innovative learning and skill development solutions, it also brings complexities which destroys traditional paradigms (Brynjolfsson & McAfee, 2014, p. 165-172).

AI-supported tools created a revolution in learning and education by providing personalised learning experiences and real-time insights related to performance. For instance, adaptable learning platforms analyse personal progress and lead learners to consider their skill gaps effectively by offering unique resources (Smith & Anderson, 2020). These tools can also offer measurable learning and development programmes which can easily be accessible and low-cost.

However, there are disadvantages to the nature of AI. One of the biggest concerns is the “tech-dependency” phenomenon that causes overreliance on automation, it destroys the need for problem-solving and critical thinking of individuals. For example, automatic decision-making processes can cause a decrease in the analytical thinking skills of individuals if they are so used to making the automation perform the cognitive tasks (Ford, 2015). The tech-dependency effect causes long-term risks, especially in competency development in areas where adaptation and innovation are required.

Psychological effects turns the destructive effects of AI into a more complex situation.

Rapid integration of AI technologies generally cause a sense of uncertainty and concern among learners and professionals. As Noble mentioned in her book "*Algorithms of Oppression: How Search Engines Reinforce Racism"* (2018), the phenomenon known as "technologic disruption anxiety" may weaken the motivation and limit learning outcomes. In addition, ethical concers like algorithmic biases results in questions about the fairness and comprehensiveness of AI-based learning tools.

Another challenge about AI is its destruction potential on intrinsic motivation. When learners trust in AI so much, they may loose the instinct of exploring and solving the problems independently. This challenge has an utmost importance in specifically from the perspective of which success is required for creativity and critical thinking. Research shows that overreliance on AI can cause a decrease in self-competence and worsen competency development challenges (Hutmacher & Appel, 2023).

To eliminate such challenges, a balanced approach in AI integration is essential. Organizations and trainers needs to adopt human-centric design principles which prioritise learners' needs and well-being. For instance, AI systems need to be designed to complete the humanistic skills by promoting active and critical engagement, instead of replacing them. Also promoting digital flexibility such as adopting technological developments easily and the ability to lead these changes can support individuals develop themselves in such destructive environments. As a result, while AI offers a transformative potential in competency development, its destructive effects must be assessed correctly and a sensible integration must be suggested.

3. EFFECTS OF AI APPLICATIONS ON COMPETENCY DEVELOPMENT

3.1. Positive Contributions of AI

It is widely recognised that AI is a revolutionary reality of today in competency development by increasing the accessibility, efficiency and personalisation in education and professional development. AI-supported tools such as adaptable learning platforms provide unique learning experiences in accordance with learner's specific needs. Adaptable algorithms are able to offer customised resources for individual performance monitorization and development, thus engagement and quality of information saved to increase the performance may efficiently be developed (Mena-Guacas et al., 2023). Also, AI-based virtual simulations enable experimental learning in technical areas, especially health and engineering (Mady & Niese, 2022).

Additionally, AI is able to develop cooperation in competency development linking learners globally to each other through digital tools promoting teamwork and critical thinking. Platforms which facilitate group projects and peer conversations promote a more interactive and interesting learning environment (Mena-Guacas et al., 2023). Also, AI enables trainers to provide more highly valued development content with its scoring and automatised repeating task-assigning capability (Tenório & Romeike, 2023). The latest developments in AI-supported

language models allow individuals to communicate written and verbally with real-time feedback and support them improve language and professional skills (Chen, 2024). Such capabilities promote democracy in academic and corporate environments for those who seek equal development opportunities. AI, also, supports interdisciplinary competency development by integrating resources from different areas. For instance, AI systems can offer interdisciplinary learning ways which combine technical and social sciences, and prepare individuals for versatile roles in today's dynamic environments (Babashahi et al., 2024). From all these perspectives, AI contributes to competency development by providing adaptable, cooperative and effective learning solutions which prepare individuals for modern-day challenges.

3.2. Negative Effects of AI on Intrinsic Motivation

While AI offers important benefits, it causes challenges for intrinsic motivation. Over-trusting in AI tools can create a comfort zone that dissuades individuals from active engagement in problem-solving and critical thinking. For instance, overreliance on AI-produced solutions can decrease the sense of struggling with challenging tasks by destroying an individual's self-competency (Chen, 2024). In addition, AI-supported personalised learning environments may lead individuals to an unreal expertise illusion. As a result of this, learners can perceive themselves as more competent than real and so the intrinsic desire to develop themselves can be decreased. This dynamic can cause apathy in competency development and depression (Babashahi et al., 2024).

Furthermore, when AI automatises feedback and decision-making, it brings inefficiency risks to human mentorship and guidance. Lack of human interaction can cause a feeling of lost in learners and it harms human motivation and engagement (Xiao et al., 2024). To address these challenges, AI systems should be designed to promote active engagement and push users to apply the information independently before directly trusting in the automatic support (Mady & Niese, 2022). Also, hybrid learning models combining the training activities of both AI and human leadership can provide a balance between technological efficiency and personally designed mentorship.

3.3. Psychological Effects of AI

AI is able to affect psychological well-being by affecting autonomy, competency and cognitive flexibility. If the autonomous decision-making tools are over-prescriptive, it can weaken the sense of control of individuals which may lead to decreased satisfaction and engagement (Chen, 2024). In this context, while feedback methodologies of AI systems increase the sense of trust, over-trusting in automatic assessments can strip away the learners from the opportunities to experiencing real progress in their expertise areas. Such reliance may result in destruction of an individual's long-term competency development (Xiao et al., 2024). Also, AI systems designed to offer structured and predictable solutions can prevent creative and out of the box thinking. Such rigidity can limit specific abilities which have a significant place in today's dynamics on skills for individuals to adopt in novel and complex scenarios (Fulmer & Zhai, 2024).

Promoting human-AI cooperation via human-centric designs and flexible systems can overcome such psychological effects and support multifaceted competency development (Mena-Guacas et al., 2023). Also, adding experimental feedback methods into AI-based learning environments can support learners to internalise progress and adapt to challenges effectively.

3.4. Inferences on Skill Gaps

AI dramatically affects the skill gaps by redefining basic competencies like decision-making, critical thinking and flexibility. Automatic systems can decrease the need to deeply deal with analytical tasks for individuals by simplifying complex processes (Babashahi et al., 2024). In this respect, over-trusting in and overuse of insights generated by AI can prevent the capacity of individuals to question possibilities and explore alternative solutions (Mady & Niese, 2022). Also, the comfort provided by AI-based tools can weaken the potential capacity to struggle with daily challenges and manage those challenges effectively (Xiao et al., 2024)

The effect of AI on skill gaps extends over from accessing the development opportunities to equalities. Individuals from communities with opportunity limitations can face barriers to accessing AI-based tools and this can worsen the inequalities (Chen, 2024). To address eliminating those inequalities, policymakers and organizations should prioritise the fair distribution of AI resources and provide affordable developmental opportunities. In addition, AI systems should be integrated into human-centric frameworks which emphasise independent problem-solving and reflecting practices. Development programmes should compel the users' competencies and include opportunities to engage the practical and real-world scenarios that promote individual growth (Mady & Niese, 2022). As a result, even though AI has significant potential to transform competency development positively, it also has challenges that need to be considered from a reflective and practical perspective. Stakeholders can optimise its effect on skill development by balancing AI's advantages on active learning and critical thinking with promoting strategies.

4. RECOMMENDATIONS

4.1. Integrative Approaches to AI in Competency Development

Positioning AI as a supportive tool instead of a substitute has critical importance in optimising the effect of competency development. AI must be a subsidiary tool for human efforts, develop cognitive and practical skills, but still not be replaced all. AI systems can be designed to work with professionals and decision-making processes can be undertaken by humans while AI provides real-time data analysis and insights. This incorporator approach enables the protection of critical thinking and reasoning and also the development of them (Chen, 2024).

Training institutions and workplaces can adopt hybrid learning models which combine AI tools and traditional learning methods. Such kinds of models benefit from the efficiency of AI's content creation types by promoting a balanced learning environment while human leadership and mentorship continue (Mady & Niese,

2022). Also, user-centric AI design principles in which learners have control over AI-based learning types ensure individuals actively participate in the competency development journey (Mena-Guacas et al., 2023).

4.2. Promotion of Intrinsic Motivation

Maintaining autonomy and engagement in AI-based environments requires goal-focused strategies. One of the most effective approaches is to integrate gamefied learning components in AI platforms. Features like challenges, rewards and progress monitorisation can make learning more interesting and they can encourage individuals to follow their goals actively instead of trusting in AI passively (Xiao et al., 2024).

Promoting autonomy consists of designing AI systems which offer options and adaptability in learning experiences to users. From this perspective, a feature that allows learners to identify their own goals, choose the learning style they prefer and access various resources can be added to AI-based learning platforms. Such flexibility not only protects autonomy but also increases motivation by adapting self-choices with learning experiences (Chen, 2024). Also, AI features based on promoting peer interaction can maintain engagement as it is a community. Discussion forums, team projects and AI-supported peer feedback systems contend with the potential sense of isolation in AI-based environments by ensuring human interaction is the basic part of the learning process (Mena-Guacas et al.,2023).

4.3. Balancing the Agility and Competency

Holistic skill development in AI-based environments requires a balanced framework which prioritises both agility and competency. Rapid technological changes require adaptability, but it should not be at risk of developing basic competencies like critical thinking, flexibility and reasoning (Babashahi et al. 2024). Organizations can adopt competency frameworks which combine permanent competencies with agility-focused competencies like problem-solving and digital literacy to ensure the balance. Development programmes should include scenario-based learning methods in which participants discuss complex and real-world issues that require both agility and critical thinking (Chen, 2024). Interdisciplinary approaches that combine technical skills with emotional intelligence and cultural characteristics are also critical. For example, AI applications used in global workplaces should include intercultural training programmes to prepare individuals for various cooperative initiations (Xiao et al., 2024).

Promoting a continuous learning culture is required to protect the balance. AI needs to be positioned as a life-long learning provider with systems offering personalised suggestions for skill development or redevelopment based on industry trends (Mady & Niese, 2022). Such an approach ensures individuals equip themselves with agility and competence in adapting to future challenges.

CONCLUSION

AI came out as a transformer in competency development. It reshaped the development approaches and professional paradigms. While it results in enabling the promotion of personalising learning and interdisciplinary cooperation, it also has challenging results such as decreasing intrinsic motivation and widening skill gaps. Adaptable learning platforms, real-time feedback mechanisms and the capacity to democratise the learning opportunities of AI redefined how individuals gain skills. AI tools enable learners to reach their learning goals more effectively by offering personalised experiences which meet their different learning needs.

Despite those benefits, AI's transformative strength also brings challenges. Overreliance on AI systems can cause a decrease in the critical thinking and problem-solving competencies of individuals. Also, the illusion of expertise promoted by AI-based platforms may blind the long-term development capacity and intrinsic motivation. In addition, inequalities in accessing AI technologies worsen development inequalities and turn disadvantaged groups more disadvantageous.

From this perspective, a balanced and incorporating approach should be applied to benefit from AI's potential to eliminate the disadvantages. Policymakers, trainers and industry leaders should cooperate to design systems promoting active learning and critical participation. Hybrid models combining AI-resulted efficiency and human mentorship may protect the basic factors of traditional development models while increasing adaptability. Also, promoting a lifelong learning culture has significant importance due to rapid technological developments. AI systems should support continuous competence development by offering personalised suggestions to enable upskilling aligned with the developing industry demands. In addition, understanding the psychological effects of AI on autonomy and cognitive flexibility requires human-centric designs promoting reflecting practices and empowering users.

From all these perspectives, it is considered AI offers unique opportunities for competence development, but it needs to be taken into consideration carefully. Stakeholders may uncover completely AI's sustainable transformative potential on learning and professional development by prioritising equality, promoting intrinsic motivation and emphasising holistic competence development.

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