Evolution of development and implementation of technological innovations in the activities of public libraries in Ukraine

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Abstract. The study of the evolution of development and implementation of technological innovations in the activities of Ukrainian public libraries is relevant in view of the growing role of information and knowledge in society, changing user needs, and the need to increase the competitiveness of libraries. The purpose of the study is to analyse the stages of introducing technological innovations into the work of libraries and the impact of new digital technologies on the services provided by libraries. The study used such methods as analysis, generalisation, explanation, and classification. A review of methods and stages of technological innovations was conducted, and articles by contemporary scientists and researchers who dealt with the issues of library technological innovations were analysed. The impact and prospects of the latest technologies in the work of libraries were investigated. The introduction of technologies raises several ethical issues, such as data privacy, algorithm bias, and the impact on freedom of speech. Technological progress opens up great opportunities for libraries. Artificial intelligence can automate routine tasks, improve information retrieval, and personalise services for users. Virtual and augmented reality will allow the creation of interactive educational and cultural programs, conducting virtual tours of libraries and museums. Blockchain can provide secure and transparent data management, as well as protect copyrights. Technological progress has expanded access to information resources beyond the physical walls of the library. E-books, online databases, and digital archives have made vast collections remotely accessible, especially valuable in geographically dispersed regions. Modern trends in the implementation of technological innovations in the activities of Ukrainian public libraries include the use of artificial intelligence, virtual and augmented reality, and blockchain. This research aims to help Ukrainian libraries successfully implement technological innovations to better serve their users and meet the needs of society in the digital age

Keywords: information technologies; web services; electronic resources; library innovations; blockchain; Internet of Things; artificial intelligence

Introduction

The world is changing rapidly, and Ukrainian public libraries are not staying behind. Their traditional role as repositories of books is transforming in the era of digital technologies. The implementation of innovations is becoming a key factor in their successful development and survival in the modern information environment.

Ukrainian libraries are implementing various digital initiatives to meet the needs of modern users. These include the creation of electronic catalogues, digital libraries, online resources, and platforms for distance learning. Such innovations not only facilitate access to information but also promote reading among young people and adults.

Research on this topic is relevant as it can help libraries adapt to the new needs of users by offering them access to digital resources and online services, becoming active participants in public life, providing access to information, education, and innovations, and preserving cultural heritage by using digital technologies for digitising, archiving, and sharing collections.

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The problems of implementing modern information technologies in library operations have been studied by many scholars. This issue encompasses a broad spectrum of challenges that libraries face on the path to digital transformation. Scientific findings regarding the use of modern information and communication technologies in library operations and their significance for the functioning of libraries have been made by scholars such as O. Onyshchenko (2021). The author investigated the use of IT in library activities and its significance for the functioning of libraries in the information society. The researcher concluded that IT provides libraries with new opportunities to serve users, improve access to information, and expand the range of services. K.S. Horbach (2022) analysed the digital transformation of libraries. The author argues that digitalisation is a key factor in the development of libraries in the 21st century. It allows libraries not only to store and disseminate knowledge but also to do so more efficiently, accessibly, and conveniently for modern users.

Y.V. Chashka (2022) also explored the innovative activities of libraries in the 21st century. The author paid attention to the role of innovations in the development of new services and products of libraries, as well as in improving their image and reputation. The regulatory framework governing innovative activities and the main achievements of innovative activities of libraries, specifically in the field of management were also studied by the author. L.O. Malanchuk & Y.V. Lishchuk (2023) studied digitalisation as an effective method of communication for modern libraries. The authors argue that digital communication channels allow libraries to better interact with users, offer them new services, and expand their audience. S. Khrushch (2022) explored the innovative media space of modern libraries. The author analysed new forms of library work with information and users that have emerged through the use of IT. Researcher V. Medvedeva (2015) analysed the evolution of library activities under the influence of innovative technologies in her study. The author considered ways to improve innovative technologies in library science and identified the main problems that arise in the process of organising modern data exchange. Authors V.I. Lyashenko & O.S. Vyshnevsky (2018) in their monograph conducted a more comprehensive study of the trends in the development of the digital economy, which influences the development of business models used in the digital environment. They emphasised that the development of the digital economy in Ukraine is closely related to the increasing volume of use of digital platforms. The authors also noted that a promising digital platform is blockchain technology, which continues to develop actively in 2024.

The study aims to analyse the impact of new technologies on the services provided by libraries and to assess the impact of new technologies on the behaviour of library users.

The scientific novelty lies in expanding the understanding of the need for further technological innovations in Ukrainian public libraries by analysing the prospects of such innovations and reviewing examples of the use of the latest technologies in the work of libraries abroad.

Materials and Methods

For the research on the evolution of the development and implementation of technological innovations in the activities of Ukrainian public libraries, historical analysis methods were used, including the study of scientific articles by such authors as K.S. Horbach (2022), Y.V. Chashka (2022) and L.O. Malanchuk & Y.V. Lishchuk (2023), and materials describing the development of libraries and the introduction of technologies. Data from "Innovative activities in libraries" (2022) and the "Ukrainian library encyclopedia of National parliament of Ukraine named after Yaroslav the Wise" (2024) was analysed, which allowed the identification of key stages of innovation implementation and their impact on library work. Legislative and regulatory acts were analysed, including Order of the Cabinet of Ministers of Ukraine No. 219-r "On Approval of the Strategy for the Development of Library Services for the Period up to 2025 'Qualitative Changes in Libraries for Sustainable Development of Ukraine'" (2016), Law of Ukraine No. 32/95-BP "On Libraries and Librarianship" (2022). The Development Strategy of the Vernadsky National Library of Ukraine until 2025 (2024), the Development Plan of the Kyiv City Library Network for 2021-2025, and the National Program for the Development of Library Affairs for 2021-2025 were studied. The analysis of library modernisation programs allowed for assessing government policy and support for the implementation of technological innovations.

Analysis of the content of library websites, social media, publications, blogs, and other electronic resources allowed us to research how libraries use digital platforms for communication and innovation implementation. For example, the Vernadsky National Library of Ukraine actively uses its website and social media to inform about new acquisitions, events, and scientific research. This provides access to information for a wider range of users and promotes the library.

The case method, or the analysis of individual cases of technology implementation in specific libraries, enabled the selection and examination of successful examples and challenges faced by libraries. For example, some libraries implement electronic catalogues and automation systems, which simplify the process of searching and reserving books. Other libraries create virtual tours and interactive exhibitions, which attract younger generations and make libraries more appealing.

The comparative analysis of technology implementation in libraries in Ukraine with those in other countries allowed for the identification of international trends and best practices that can be adapted

in Ukraine. For example, in EU countries, libraries actively use augmented reality technologies to create interactive educational programs. Such practices can be useful for Ukrainian libraries that seek to attract more users and expand their capabilities. Thus, the use of digital platforms and the latest technologies in libraries contributes to their development and increases the accessibility of information for the general public. The implementation of successful international practices can help Ukrainian libraries become more modern and attractive to users.

Results and Discussion

Innovation and technological innovation are the driving forces of progress that constantly change the world. They lead to the emergence of new products, services, processes, and ideas that improve lives and open up new opportunities. Innovation is the process of implementing new ideas. This can include developing new products, services, processes, or even new ways of thinking. Innovations can be both incremental and radical. Incremental innovations make small improvements to existing products or services, while radical innovations lead to the creation of something

entirely new (Karuk, 2018). Technological innovations have led to 21st-century society viewing the processes of creating, preserving, and disseminating knowledge, information, and other cultural values as strategies for development and conditions for dynamic changes in libraries. It is worth noting the definition of the term "library innovation" in the Ukrainian Library Encyclopedia (ULE), which emphasises not only the implementation of non-standard ideas and methods but also the creation and application of new information services in library practice that have modern qualities and approaches (Ukrainian Library Encyclopedia, 2024).

Technological innovations can be both "hard" and "soft". "Hard" innovations involve the development of new technological products, such as smartphones or computers, while "soft" innovations involve the development of new ways to use existing technologies, such as new business models or programs. Some innovations are driven by socioeconomic changes, including an ageing population, urbanisation, unemployment, and increasing migration (Hromnytska, 2016). The entire range of library innovations can be considered in several aspects (Table 1).

Table 1. Aspects of library innovations

Technological	Functional-content	Communicative-social
Focused on the implementation of new information technologies in the formation of the document-resource base of libraries and the system of library-information services for users	Aimed at expanding the content range of library activities	Related to the role and place of the library in society

Source: developed by the author based on research Y.O. Khimich (2012)

Innovative activity is one of the priority areas of library work, the purpose of which is to search for, evaluate, develop, and implement library innovations (Bezruchko,

2014). The main stages of the development and implementation of technological innovations in the activities of public libraries in Ukraine are defined in Table 2.

Table 2. Stages of development and implementation of technological innovations in the activities of public libraries in Ukraine

1990s - 2000s	2000s - 2010s	2010s - 2020s	2020s
Formation of the necessary infrastructure to ensure access to information via the Internet, with websites primarily used for reading (receiving) information rather than posting and promoting it. The first personal computers appeared, used for automating library processes such as cataloguing and book tracking. The first electronic catalogues were created, making information search easier for users. Online resources, such as e-books and journals, began to be used	Users became active participants in creating and accumulating data. Libraries gained access to the Internet, opening new opportunities for providing information services. Library websites emerged, becoming the primary source of information for users. Digitisation of library holdings began, making access to information more convenient	The era of social networks and messaging apps. Libraries began using social networks to communicate with users and promote their services. Online communities of librarians emerged as a platform for sharing experiences and knowledge. Libraries started using online tools to provide new services, such as virtual reference and online courses	This period involves the development of what is known as the neural network, where communication between people, animals, and things is conducted based on neurocommunication principles, artificial intelligence, and the Internet of Everything (people, things, data, processes, etc.). Libraries are using artificial intelligence to automate library processes and enhance information retrieval. Virtual and augmented reality emerge, opening new possibilities for providing information services

Source: developed by the author based on research V.I. Lyashenko & O.S. Vyshnevsky (2018) and K.S. Horbach (2022)

The main goal of all innovations in traditional library work is to provide efficient, high-quality, and comfortable service to readers. In line with this goal, traditional library funding and electronic funding have a close interrelationship and complement each other to provide high-level library and information services. Libraries with internet access use full-text databases and information resources to select, order, and collect documents for library holdings (Innovative activities in libraries, 2022).

Libraries are supplemented by electronic versions of publications, systematic and regulatory documents, and a collection of non-authorial scanned publications from library holdings. Using information systems, librarians can create their own information products to help readers navigate the information and educational space. The Internet opens up numerous opportunities for librarians to improve the level of service and popularise books through electronic resources. Among such tools are library blogs and social media, which have a significant impact on its popularisation and advertising in the international information space of the Internet. To ensure that electronic resources are as effective as possible and meet user needs, various modern innovative approaches are being applied in 2024 (Fig. 1).
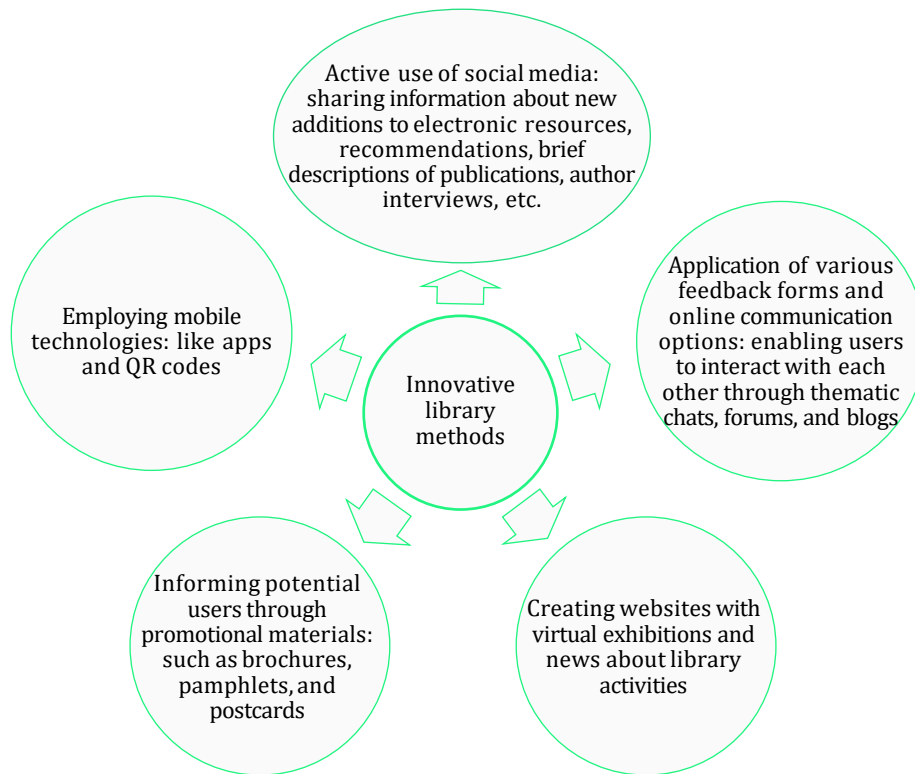

Figure 1. Innovative methods of libraries

Source: developed by the author based on materials O. Litvak (2022)

Websites, blogs, web services, and social media can become the most powerful tools for promoting reading and popularising information, positively influencing the development of reading skills. Modern technologies possess significant potential for promoting books and stimulating interest in reading. They can be effectively used in both group and individual interactions with library visitors. The choice of an optimal strategy for popularising literature depends on the librarian's practical skills, broad knowledge, professional training, and ability to engage and retain the audience's attention. This allows the librarian's work to be more effective, for example, through the use of library media lessons, media games based on the content of books, the introduction of multimedia presentations into every mass event, conducting library quests, flash mobs, virtual tours of unusual museums and libraries around the world, and organising library weekends.

Among the innovative web services offered by libraries, British Whichbook stands out. It assists users in selecting books based on various criteria such as emotional tone, protagonist description, plot, or setting. The system automatically generates millions of combinations and recommends books that best match each reader's preferences. The service also provides themed lists, searches by author and book title, and the ability to find works similar to those already read.

Whichbook offers links to library catalogues for ordering books and indicates the possibility of purchasing on Amazon with a reward for Whichbook for each purchase. Readers can also email information about books (Whichbook, 2024).

Ukrainian libraries are fundamental institutions that shape the country's cultural, scientific, educational, and informational infrastructure. They play a crucial role in enhancing the information and linguistic literacy of society, as well as in the patriotic, legal, and environmental education of citizens. Additionally, libraries contribute to fostering a deep interest in national history and culture, promoting the expansion of knowledge and understanding of these important aspects. They play a key role in the formation of a reading and thinking nation, providing free access to knowledge, cultural heritage of Ukraine and the world, and actively supporting educational activities (Lyashenko & Vyshnevsky, 2018).

Internet centres in libraries are one way to ensure free access to knowledge. They are structural units that provide users with access to the Internet, implement projects and targeted programs, and provide access to scientific and journal publications. Internet centre specialists work to form the information culture of users, teaching them to search for the necessary information and helping them communicate on the Internet. All Internet centres have educational programs that help users of all ages adapt to the information environment. Virtual and practical classes help to satisfy the

educational, recreational, and professional interests of organisers of reading for teenagers and young people (Bashun *et al.*, 2016).

The activities of the Internet centre have become an integral part of library services, helping users browse online information resources, supporting educational activities, and developing intellect and creativity. Internet resources are unlimited and very dynamic: new materials appear, addresses change, or resources disappear. Thus, traditional forms of bibliographic work are supplemented by modern library technologies, such as web bibliographic indexes, lists, and multimedia presentations.

Access to and analysis of Internet resources distinguishes libraries from Internet cafes, transforming them into information intermediaries and navigators (Maryina, 2018). The Internet centre also strives to develop its own resources to support the learning process, self-improvement, and leisure. When forming holdings, conducting book exhibitions, mass events, and preparing scenes, specific websites are selected on the Internet.

Serving readers using internet centre resources has become a standard library service. Internet centers have expanded the range of services, offering assistance with online searching and web navigation, using complex search queries, accessing full-text electronic databases, and the ability to print and save selected information on electronic media. However, it is important to note that since the 2020s, libraries in Ukraine have taken steps to address these issues (Fig. 2).
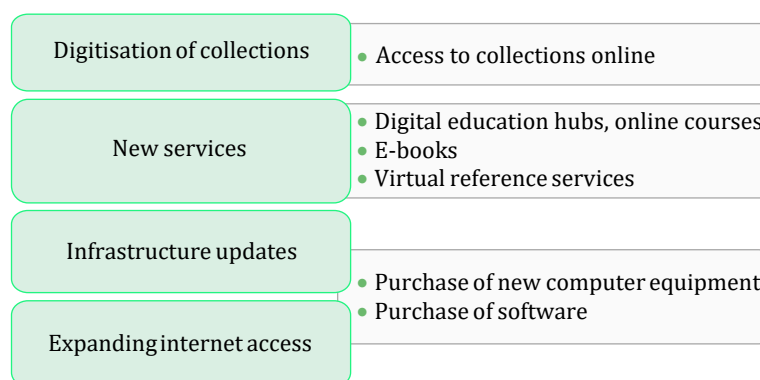

Figure 2. Major technological transformations of Ukrainian libraries in the 2020s
Source: developed by the author based on S.G. Klochok (2013)

Libraries are actively exploring cutting-edge technologies such as artificial intelligence and machine learning to personalise search, tailor content, and automate repetitive tasks (Onipko & Kozoriz, 2020). Virtual reality programs are being tested to create immersive learning environments, while open access initiatives promote the dissemination of research findings.

New technologies, particularly artificial intelligence, promise personalised learning experiences and automated content control (Medvedeva, 2015). Big

data analytics help to understand user needs, allowing libraries to customise services and predict research trends. Blockchain, which enables secure data storage, can revolutionise knowledge sharing and collaboration. The Internet of Things, consisting of a network of interconnected devices, can optimise resource management and create a dynamic learning environment (Isaenko, 2011).

Artificial intelligence (AI) assistants offer personalised learning methods tailored to individual needs. AI

algorithms can automatically analyse vast collections, identifying relevant information with high accuracy, saving librarians time and ensuring that users find the knowledge they need (Artificial intelligence in public libraries: Our civic mission, 2019).

Since 2018, Cambridge Public Library has been using AI in several projects, the first of which were "The Laughing Room" and Alterspace (Young, 2019). "The Laughing Room" was an interactive art installation where a comedic AI comedian reacted with laughter based on what visitors said. This exhibit aimed to make people think about how AI and surveillance affect their lives. Alterspace was an interactive exhibit where an AI-powered room responded with lighting, colour, and sound based on the visitor's preferences. This exhibit explored the concept of AI personalising the library experience (Fig. 3).
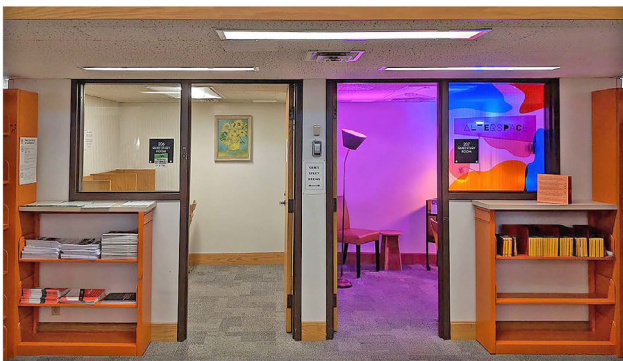

Figure 3. Alterspace – a room that automatically adjusts colour, lighting and sound to the user
Source: based on L. Young (2019)

The results of installing artificial intelligence in the Cambridge Public Library sparked conversations about the impact of AI and surveillance on human life, causing people to simultaneously feel happy and uncomfortable. A further discussion titled "Is AI Laughing at Us?" was held to delve deeper into these issues. The AI-powered room that adapted to visitors' preferences resonated with the idea of libraries as spaces that cater to individual needs. The exhibit was popular among visitors, including children.

Blockchain, as a secure registry technology, can revolutionise data sharing and collaboration. A platform where research results are stored on a blockchain ensures their authenticity and immutability, as well as facilitating transparent access and tracking of citations. The Internet of Things (IoT), which can include sensors embedded in books and shelves, provides real-time data on usage patterns, optimises resource allocation, and recommends relevant materials. Sensors in the physical space can create an energy-efficient and comfortable environment by adjusting lighting and temperature based on the number of people. Interactive exhibits based on the IoT can transform libraries into engaging learning spaces, sparking curiosity and igniting imagination (Massis, 2016). An example of such foreign experience can be seen in the study of IoT implementation in university libraries in Pakistan. This study showed that university libraries in Pakistan have implemented IoT-based devices, including smart air conditioners, automatic fire alarms, smart hand sanitisers, and smart security doors. In addition, university libraries used IoT elements, including automatic notification of checkout, registration of reading materials, self-checkout and self-registration system, user card recognition, and the use of Radio Frequency Identification (RFID) tags for security purposes. The main problems in the implementation of IoT applications were the identified lack of a well-networked and integrated environment, budget problems, lack of policy and strategic planning, and lack of technical personnel (Asim *et al.*, 2022).

Big Data analytics allows libraries to predict research trends, anticipate needs, and tailor services accordingly (Syniavin, 2024). Libraries can identify underserved communities through data analysis, enabling them to target outreach efforts and address the digital divide. However, with these opportunities come challenges. Data privacy, ethical considerations in algorithm development, and ensuring equitable access to technology are key issues: balancing the benefits of data analysis with user privacy remains critically important. Libraries need robust data security measures and transparent policies to earn user trust; artificial intelligence algorithms require careful development and monitoring to avoid bias and ensure fair access to information and resources; implementing these technologies requires significant investments in infrastructure and expertise.

To overcome resource shortages, Ukrainian libraries are actively engaged in project and fundraising activities, establishing partnerships, particularly with public organisations, and seeking support from international funds and foreign colleagues (Vernadsky National Library of Ukraine, 2024). Among other things, international book exchange (document exchange) is one of the forms of cultural and scientific cooperation in Ukrainian libraries, used to replenish library and information resources of libraries (Kot, 2015).

Despite the listed problems, the potential benefits of new technologies are significant. By thoughtfully and responsibly approaching innovations, public libraries in Ukraine can position themselves as important elements in the future, in research and science.

Conclusions

Technology has significantly influenced the implementation of innovations in libraries, offering new opportunities for both librarians and the public. As a result of the study, the main stages of development and implementation of technological innovations in the activities of Ukrainian public libraries were identified,

starting from the computerisation of libraries in the 1990s, namely: Computerisation of libraries (1990-2000); Development of the Internet (2000-2010); Use of social media (2010-2020); Implementation of new technologies (2020s).

Despite significant progress, challenges remain. There is still unequal access to technology, especially in rural areas. Cybersecurity threats and the need for in-depth digital literacy training require constant attention. It is important to consider the unique challenges and opportunities associated with the ongoing war in Ukraine. Studying its impact on the implementation and use of technology is crucial for understanding the resilience and adaptability of libraries in difficult times. In addition, it is necessary to recognise the diversity of Ukrainian libraries, which includes regional variations, urban and rural contexts, as well as different types, such as academic, public, and specialised libraries.

Ukrainian libraries are undergoing an exciting period of transformation due to rapid technological development. Research on this topic should delve deeper into the impact of the war on libraries. It would be interesting to explore how libraries have adapted and used technology to support communities during the conflict. Bridging the digital divide remains a critical task. Research should identify how to ensure equal access to technology in all regions and for all segments of the population. At the same time, increasing cybersecurity for libraries is an urgent need.

The future of libraries is closely tied to innovation. Exploring the potential of artificial intelligence, virtual reality, and other emerging technologies can open new horizons for library services. However, it is important to consider the diversity of libraries. From academic and public to specialised and rural – each type of library has unique needs. Research should help develop technology implementation strategies that take this diversity into account. Learning from international experience is also crucial. Studies should compare how other countries integrate technologies into libraries so that Ukraine can borrow and adapt best practices.

Furthermore, ethical aspects cannot be neglected. Research should help libraries develop clear standards regarding data privacy, algorithmic bias, and the protection of freedom of speech in the digital environment. Future research perspectives include a deeper exploration of how the war has affected access to libraries, the use of technology, and user behaviour; an analysis of how libraries have adapted their services and resources to support communities during the conflict; and research into best practices for library cybersecurity, taking into account the specific risks associated with war.

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Conflict of Interest
None.

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Еволюція розвитку та впровадження технологічних інновацій у діяльність публічних бібліотек України

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Анотація. Дослідження еволюції розвитку та впровадження технологічних інновацій у діяльність публічних бібліотек України є актуальним з огляду на зростання ролі інформації та знань у суспільстві, зміну потреб користувачів та необхідність підвищення конкурентоспроможності бібліотек. Мета роботи – проаналізувати етапи введення технологічних інновацій у роботу бібліотек та вплив нових цифрових технологій на послуги, що надаються бібліотеками. У дослідженні були використані такі методи як аналіз, узагальнення, пояснення та класифікація. Було зроблено огляд методів та етапів технологічних інновацій, опрацьовано роботи сучасних вчених та дослідників що займалися питаннями бібліотечних технологічних інновацій, досліджено вплив та перспективи новітніх технологій у роботі бібліотек. Впровадження технологій порушує низку етичних питань, таких як конфіденційність даних, упередженість алгоритмів та вплив на свободу слова. Технологічний прогрес відкриває перед бібліотеками великі можливості. Штучний інтелект може автоматизувати рутинні завдання, покращити пошук інформації та персоналізувати послуги для користувачів. Віртуальна та доповнена реальність дозволять створювати інтерактивні освітні та культурні програми, проводити віртуальні екскурсії бібліотеками та музеями. Блокчейн може забезпечити безпечне та прозоре управління даними, а також захистити авторські права. Технологічний прогрес розширив доступ до інформаційних ресурсів за межі фізичних стін бібліотеки. Електронні книги, онлайн-бази даних і цифрові архіви зробили величезні колекції доступними дистанційно, особливо цінними в географічно рознесених регіонах. До сучасних тенденцій впровадження технологічних інновацій у діяльність публічних бібліотек України належать використання штучного інтелекту, віртуальної та доповненої реальності, блокчейн. Дослідження має допомогти українським бібліотекам успішно впроваджувати технологічні інновації, щоб краще обслуговувати своїх користувачів та відповідати потребам суспільства в цифрову епоху

Ключові слова: інформаційні технології; веб-сервіси; електронні ресурси; бібліотечні інновації; блокчейн; інтернет речей; штучний інтелект

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