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Libraries, Digital Culture and Sustainable Development: The Synergy of Knowledge and Technology

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ABSTRACT:
This article explores the integration of digital culture technologies into library operations in the context of advancing the goals of sustainable development. It emphasizes that, in the digital era, libraries are no longer merely repositories of books — they are evolving into digital and educational hubs aimed at bridging the digital divide in society. This transformation calls for a deeper understanding of how digital culture is reshaping the roles and functions of libraries. Digital technologies enable libraries to ensure equitable access to knowledge, aligning with the Sustainable Development Goals (SDGs). The fusion of traditional and digital library services opens new avenues for educational innovation, cultural heritage preservation, scientific advancement and communication. The adoption of digital culture in library practices fosters the democratization of knowledge through open access to books, scholarly research and archives. Developing digital competencies among both librarians and users helps to reduce information inequality and enhances information security. The presence of digital culture in library activities is also transforming models of information consumption — traditional reading is increasingly complemented by multimedia content, virtual reality, interactive learning platforms, creating virtual spaces for dialogue, learning and collaboration. The article also highlights the importance of the environmental dimensions of digital transformation in libraries, noting that libraries can play a vital role in promoting ecological awareness and adopting "green" technologies in information resource management.

Keywords: digital culture, sustainable development, libraries, library digitalization, digital technologies, information literacy, intercultural communication, digital competencies, digital library services

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1. Introduction

In today's context, the development of digital technologies has not only accelerated the flow of information but has also created new modes of informational existence for humanity, leading to the emergence of a new type of culture — digital culture, which encompasses the use of technologies for the creation, preservation and dissemination of knowledge. Traditionally, librarians were seen as custodians of knowledge, responsible for managing physical collections of books and assisting users in locating information. However, with the advancement of digital technologies, their role has evolved. Librarians now act as information curators, technology experts and educators. They help users navigate digital environments and develop both information and digital literacy.

Under these conditions, the functional purpose of libraries is expanding globally. Libraries are no longer merely book repositories — they are transforming into educational, informational and social hubs that promote sustainable development by ensuring access to information, fostering social inclusion, and supporting environmental initiatives. However, this transformation is not without challenges, particularly in developing regions. Limited financial resources, outdated infrastructure, and shortages in qualified staff significantly constrain the ability of libraries in these areas to implement digital services effectively.

A detailed analysis of these resource limitations is crucial for understanding the practical obstacles to fostering digital culture in under-resourced communities. Budget constraints often hinder investments in digital tools, internet connectivity, and staff training. In many rural or economically disadvantaged areas, libraries operate with minimal support and must rely on external aid or partnerships to modernize their services. These conditions create disparities in digital access and literacy, undermining efforts toward inclusive and sustainable development. Addressing these gaps requires not only technological investment but also policy support and international cooperation to build resilient, future-ready library systems.

2. Literature Review

The theoretical foundation of this study is based on scholarly publications dedicated to the role of digital culture in today's information and communication processes. In particular, the article by J. Haider and O. Sundin examines how digital culture influences information literacy, especially in the context of trust and doubt when interacting with information (Haider & Sundin, 2022).

The publication "Digital Culture: The Changing Dynamics" considers digital culture as a complex and multifaceted phenomenon resulting from the integration of digital technologies into the realms of culture and the arts. This phenomenon encompasses various aspects of the convergence of cultures, media and information technologies, shaping new forms of communication and creativity. Information and communication technologies provide new opportunities for global interaction and networked connectivity, challenging traditional understandings of culture and expanding it into the realm of digital culture. Thus, culture today is understood as an open and dynamic process based on

interactive communication, rather than as a closed system composed of discrete cultural elements (Cvjetićanin, 2008).

In the current context, digital culture is becoming a leading factor influencing socio-professional mobility, significantly altering behavioral models of the modern generation. Under the influence of digital technology development, traditional cultural domains are being transformed, leading to shifts in societal worldviews and a reevaluation of values (Karpenko & Namestnik, 2018).

To better understand the essence of the research problem, publications discussing how the spread of digital technologies has led to a radical departure from previous modes of cultural transmission were also significant. These works emphasize that digital culture encompasses social behaviors and norms present in human societies, as well as knowledge, beliefs, art, law, customs, abilities and habits of individuals within these groups (Giannini & Bowen, 2019; Lomachinskyi, 2023; Busco et al., 2023).

The publication by S. Panda focuses on the prospects for integrating advanced digital technologies such as artificial intelligence, virtual and augmented reality and data analytics to enhance knowledge management practices (Panda, 2022).

Digital culture is reshaping all aspects of human activity, as virtual reality affects and transforms both groups and individual members of each community. In this context, one of the most critical issues is identifying the positive and negative impacts of digital technologies on the development of civilization — particularly the weakening of individual agency and the growing manipulative potential of digital culture (Wang & Dolska, 2023).

The Covid-19 pandemic served as a catalyst for the transformation of libraries, prompting rapid adaptation and the implementation of innovative service delivery approaches. The authors analyze how academic libraries adjusted their services during the pandemic, the challenges they faced, the new roles they assumed and which communication tools proved most effective (Ashiq et al., 2022).

The study by M. Deja, D. Rak and B. Bel emphasizes the importance of information literacy as a key element in the successful digital transformation of academic institutions and libraries. The article explores how to conceptualize, assess and enhance library readiness for digital transformation through the lens of information literacy (Deja et al., 2021).

The article by A. Leguina, S. Mihelj and J. Downey investigates the role of public libraries in accumulating cultural and digital capital, as well as their potential to reduce social inequality through digitalization. The authors stress that in the context of digitalization, libraries are not only repositories of knowledge but also centers for the development of digital skills essential for modern society (Leguina et al., 2021).

K. Thiruppathi's article provides an analysis of the transformation of librarians' roles in the contemporary digital environment. The author emphasizes that the digital era requires librarians to be flexible, willing to learn and adaptable to new realities. They must rethink their professional identity to remain relevant and effective within an ever-changing information landscape (Thiruppathi, 2024).

The importance of digital literacy and its effectiveness in achieving self-sufficiency in professional activities is emphasized in the article by O. Diseiye, S. Ejiro Ukubeyinje, B. Oladokun and V. Kakwagh (Diseiye et al., 2024).

The article by G. Farid, N. Warraich and S. Iftikhar provides a systematic review of practices and policies for managing digital information security in academic libraries. The authors highlight major challenges in library digitalization and draw attention to budget constraints and the lack of librarian preparedness for adopting new technologies (Farid et al., 2023).

The integration of artificial intelligence into the library field is addressed in articles by J. Hodonu-Wusu, who discusses ethical standards in implementing AI in libraries (Hodonu-Wusu, 2024); and A. Hussain, who examines potential benefits, challenges and ethical considerations of such implementation (Hussain, 2023).

The analysis of the literature base shows that digitalization and global environmental, social and economic challenges are creating new demands for library operations, highlighting the need to expand digital culture practices as a prerequisite for sustainable development.

3. Methodology

To investigate the stated problem, a system of theoretical research methods was applied. A systems approach made it possible to examine digital culture in libraries as a holistic system comprising technical, organizational, social and communication components, and facilitated the analysis of interactions among library staff, users, and digital resources. The cultural studies approach enabled an understanding of how digitalization influences the preservation and transmission of cultural heritage. The structural-functional method contributed to the examination of how digital technologies are transforming the functions of libraries. The use of comparative analysis made it possible to compare different models of digital culture in libraries.

Among the empirical methods employed, a survey was conducted: the research took place in March 2025 and involved students of humanities specialties from Borys Grinchenko Kyiv Metropolitan University, Bila Tserkva National Agrarian University and Bila Tserkva Humanitarian and Pedagogical College. A total of 87 undergraduate students from the first to fourth year participated in the study. The sample included young people from all regions of Ukraine. The average age of the respondents was 19 years. All participants were informed about the purpose of the research and the anonymity of their responses and voluntarily agreed to take part in the survey.

However, a limitation of the study arises from the specificity of the sample, which focuses exclusively on Ukrainian humanities students. This narrow scope may not fully capture the diversity of user needs, levels of technological competence, or perceptions of digital library services across various academic disciplines or cultural contexts.

Expanding the demographic coverage in future studies would enhance the generalizability of the findings and provide a broader, more inclusive perspective on how digital library services are experienced and valued in different educational and regional environments.

The diagnostic phase was based on a written questionnaire completed via Google Forms (original content design). Both quantitative and qualitative analytical methods were used to process the data. The diagnostic information obtained was interpreted and summarized during the final stage of the research.

4. Results and Discussion

In the context of rapid development within the digital age, libraries are no longer limited to the function of storing printed materials. They are undergoing transformation into multifunctional educational, informational and social hubs. Libraries actively contribute to sustainable development by expanding access to information, democratizing knowledge through open access mechanisms and fostering digital culture and education, thereby helping to bridge information inequality. Digital culture plays a particularly significant role in this process. In its broadest sense, it can be defined as a system of norms and behavioral rules guiding individuals in their interaction with information and communication technologies.

The study of digital culture encompasses not only the analysis of technological phenomena — emerging from the evolution of modern information technologies such as internet communication, virtual games and computer graphics — but also the exploration of transformations within the cultural space. Furthermore, it involves examining changes in thinking patterns related to the development of new digital competencies.

In contemporary scholarly discourse, the interpretation of the digital culture phenomenon spans a wide spectrum — from viewing digital technologies as tools for representing cultural heritage (libraries, museums, historical landmarks, etc.) to conceptualizing digital culture as a qualitatively new socio-anthropological reality that transcends information and communication technologies alone (Yatsenko, 2022).

Accordingly, the term "digital culture" may carry various meanings depending on the context of its application. In the professional sphere, it refers to an individual's ability to effectively utilize digital knowledge, skills and competencies. In the realm of everyday communication, digital culture is understood as a synthesis of the digital environment with traditional approaches to cultural norms and behavioral patterns (Karpenko & Namestnik, 2018).

Overall, it can be asserted that the concept of digital culture underscores the dynamic nature of cultural change and the recognition that digital technologies have become an integral part of human life. The impact of digital technologies on culture is evident in the digitization of traditional cultural heritage and the emergence, alongside classical values, of new markers of digital society. These include the ideology of digital transformation, the concept of "Industry 4.0", the development of intelligent interaction between humans and technology and a growing emphasis on rationality, functionality, efficiency, and mobility.

Digital culture within the library environment can be examined on three levels: individual, group and societal. At the individual level, one distinguishes between the digital culture of users, formed on the basis of digital competencies, and the digital culture of library professionals (Lomachynskyi, 2023). The group level of digital culture within libraries encompasses organizational, legal and security foundations that enable the effective functioning of library institutions. The societal level involves national initiatives related to the digitization of the book heritage and efforts aimed at enhancing the digital competencies of the general population.

The European Digital Competence Framework for Citizens, known as DigComp, serves as a tool designed to support the development of digital skills among the population. The European Union has recognized digital literacy (or digital competence) as one of the eight

key competencies essential for active participation in society and professional realization. In 2016, the EU introduced an updated model — DigComp 2.0, which consists of five core areas of competence:

- Information and data literacy,
- Communication and collaboration through digital technologies,
- Digital content creation, modification, and optimization,
- Safety, including personal data protection and privacy in digital environments,
- Problem-solving skills related to the use of digital technologies.

Thus, acquiring digital culture involves developing digital literacy as one of the core technological competencies. This, in turn, requires a clarification of the relationship between digital literacy and the concept of information literacy.

While DigComp offers a robust and structured approach widely adopted in Europe, other international models also provide valuable perspectives on digital competence. For example, the American framework developed by ISTE (International Society for Technology in Education) emphasizes creativity, critical thinking, and digital citizenship in educational contexts. Meanwhile, Australia's "Digital Literacy Skills Framework" integrates employability-focused skills across various learning environments.

Comparing such models highlights regional priorities — such as a stronger focus on ethics and well-being in Nordic countries or entrepreneurial competencies in North America — and can help libraries adapt their training programs to the specific needs of their communities. Incorporating multiple frameworks not only enhances the inclusivity and cultural sensitivity of digital literacy initiatives but also enables global library practices to become more flexible and locally relevant.

Currently, within the academic community, there is no unified consensus regarding the definitions and boundaries of the terms information competence and digital competence. R. Vuorikari and colleagues interpret digital competence broadly, incorporating aspects such as information literacy, communication and collaboration, media literacy, digital content creation (including programming), safety (e.g., digital well-being and cybersecurity), intellectual property issues, problem-solving and critical thinking (Vuorikari et al., 2016).

Information literacy, by contrast, implies the application of digital skills in a more narrowly defined context, focusing on the effective use of information and communication technologies. It includes a combination of technical, cognitive and social abilities required to complete tasks and solve problems in a digital environment.

Digital competencies encompass the ability to access, filter, evaluate, create, program and disseminate digital content. In other words, they represent a set of specific skills and knowledge essential for the efficient retrieval, processing and management of information in digital formats.

In today's dynamic information environment, library professionals play a crucial role in ensuring access to digital resources, critically evaluating them and facilitating their effective use by both individuals and communities.Digital literacy is considered a key competency for modern librarians, vital for adapting to the evolving ways of acquiring, disseminating and utilizing information.

According to the study by D. Oguche and co-authors, the core competencies required for library staff include technological skills such as computer use, barcode technology, database creation and maintenance, and the development and management of web resources. In addition, information retrieval skills, managerial competencies (including financial literacy, human resource management and coordination across library departments), and communication skills are also essential, as librarians act as intermediaries between users and information resources or providers. The importance of digital security competencies is also emphasized (Oguche et al., 2017).

In a broader sense, digital competencies constitute a multidimensional concept encompassing data and information literacy, communication and collaboration, media literacy, digital content creation, online safety, and the application of critical thinking and innovation in working with digital technologies and tools. In the context of library work, digital competencies go beyond mastering ICT tools and involve fostering responsible digital behavior. This includes ethical, secure and conscious use and dissemination of information, along with the development of creative and innovative approaches to using digital media in educational, professional and social processes (Martzoukou, 2021).

The key characteristics of developed digital competence for librarians include the ability to effectively use, filter, evaluate, create, program and disseminate digital content. Important aspects also involve managing and protecting information, digital content, data and digital identities, as well as the ability to work with software, digital devices, and AI. The concept of digital security includes managing one's digital identity to promote responsible and critical interaction in digital spaces. The notion of digital identity in this context has two main interpretations: one involves the protection of personal data such as email accounts or other digital services; the other refers to self-perception and behavior in virtual environments, including social networks.

In the context of active implementation of digital technologies, the process of library digitalization becomes particularly significant. The main advantages of library digitalization include:

- Fast and convenient access to information resources from any location at any time with an internet connection;
- Efficient interaction with digital documents, including search, sorting, saving, retrieval and other functions;
- Optimization of physical space by transitioning resources to electronic formats;
- Expansion of library service offerings;
- Improved quality of user service through enhanced accessibility and usability of resources;
- Growth in the number of remote users, which enhances the library's prestige;
- Broader open access to digitized rare and valuable editions from scientific library collections.

As noted by S. Berezhna and O. Korobkina, library activity in the digitalization era is grounded in key principles: preserving and ensuring access to traditional information sources, such as printed materials and scholarly periodicals, with the integration of digital technologies; and the development and provision of access to electronic resources, both

original and sourced from national and international information systems (Berezhna & Korobkina, 2023).

Accordingly, digital culture in libraries can be defined as a set of digital practices, technologies, skills and principles that enable the effective use of information resources, the provision of digital services, and the support of users' information literacy.

Digital literacy is a crucial factor in ensuring the effective professional activity of library specialists in a digital environment. It supports the implementation of modern information technologies, increases professional autonomy and optimizes library services to meet the needs of contemporary users. According to Diseiye et al. (2024), key recommendations for library professionals include: continuous professional development and training; investment in digital marketing, e-commerce and content creation; and the development of strategies aimed at overcoming barriers to digitalization.

The group of authors (Leguina et al., 2021) identifies four main categories of library users: traditional users, accounting for 27.5% of all visitors, use library services exclusively to access printed materials; active users (19.3%) engage in a variety of library events and make use of a wide range of services, including digital resources. The group of family users includes families who visit libraries together with their children to participate in specialized programs and activities. A separate category comprises users who primarily visit libraries to access computers and the Internet, due to limited availability of such resources at home. Therefore, the authors emphasize the need to adapt library services to the specific needs of each identified user group. In particular, for those interested in technological access, it is important to implement programs aimed at developing digital competencies.

The digital era presents not only significant challenges for librarians, but also promising opportunities. By using digital asset management systems and metadata standards, librarians can enhance access to digital resources. Digital tools allow librarians to efficiently organize, catalog and maintain these resources, ensuring their long-term usability. Virtual reference services, chatbots and video tutorials enable librarians to provide timely support and information literacy instruction in virtual environments. Librarians can also collaborate with educators to integrate information literacy into online learning platforms, thereby improving users' digital literacy skills and fostering critical thinking (Thiruppathi, 2024).

The emergence of AI-based tools in library services, such as conversational agents and recommendation systems, introduces both practical innovations and complex ethical considerations. These technologies have the potential to significantly reshape user experiences by offering personalized assistance, streamlining information retrieval, and expanding access for users with disabilities or language barriers. However, questions arise regarding algorithmic bias, data privacy, and the transparency of automated decisions, all of which can affect users' trust in digital services.

Moreover, as AI begins to mediate interactions previously handled by librarians, there is a growing need to redefine professional roles. Will librarians act as supervisors of AI systems, ethical stewards, or digital literacy mentors? Understanding how these roles evolve is essential for developing inclusive and accountable library environments. Future research should therefore examine the implications of AI-driven services on information access, equity, and decision-making in libraries, particularly in relation to the preservation of human-centered values and professional integrity.

In a context of information overload, library professionals serve as navigators in the digital space, helping users to search for, critically evaluate and effectively use relevant resources. This role requires not only technical knowledge but also the development of social-communication and cognitive skills, including critical thinking, adaptability and effective communication.

Promising directions for enhancing librarians' information competencies as knowledge managers include the implementation of comprehensive educational initiatives that develop technological skills related to the digitalization of information, working with electronic resources, information and cyber security, as well as the formation of an information-legal culture. Effective professional development methods in this context include the organization of library schools, short-term advanced training courses, seminars and scientific conferences (Lomachynskyi, 2023).

In the context of global challenges of the modern information era, the Ministry of Digital Transformation of Ukraine has initiated a digital transformation project for libraries and the book publishing sector ("e-Book"). This project includes the implementation of an automated library and information system, the creation of the Ukrainian Digital Library, the automation of document submission processes for grant support and the development of an electronic catalog containing information about available publications on the national market.

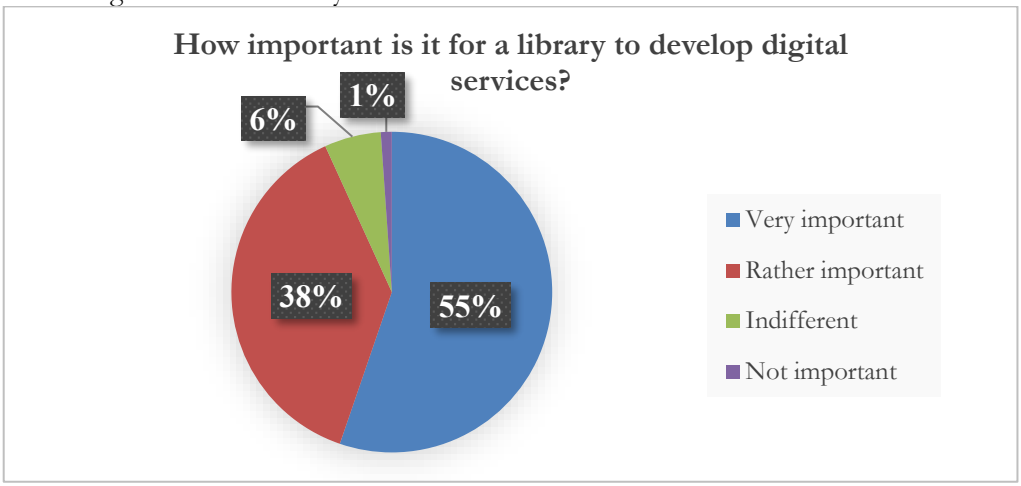
Accordingly, the development of the library sector entails the formation of a secure and protected information environment aimed at minimizing cyber threats to knowledge-based resources and users' personal data. The shift from an analog to a digital model of library operation in Ukraine reflects an evolution from local information systems to the formation of a unified global media space (Lomachynskyi, 2023).

In particular, for the effective integration of AI into library activities, it is necessary to implement educational programs for librarians that introduce them to the potential opportunities and risks of these technologies. An important step is the development of normative and ethical standards for the use of artificial intelligence in libraries, ensuring adherence to principles of transparency, fairness and accountability in the process of digital transformation (Hussain, 2023).

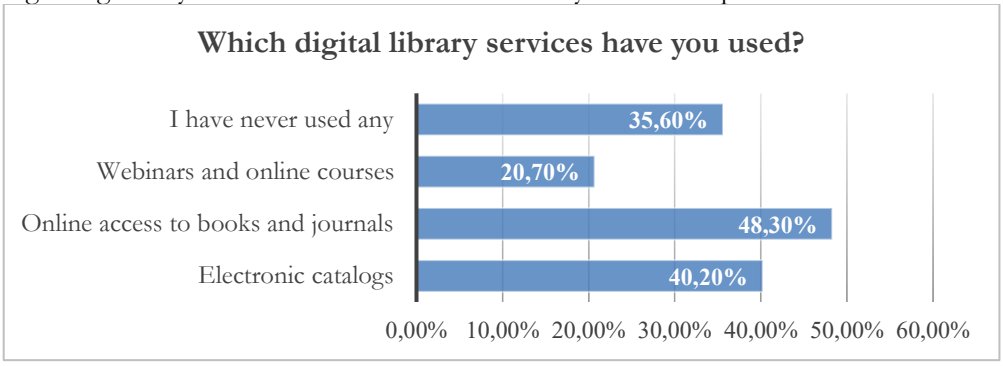
The empirical basis of our study is a survey conducted among students of Ukrainian educational institutions, aimed at identifying the level of development of digital services in Ukrainian libraries as a prerequisite for ensuring sustainable societal development.

The age profile of the respondents — a generation born into the digital age, necessitating a distinct categorization of their characteristics as library users. We argue that the digital generation, as a reader category, exhibits specific traits that manifest in various aspects of their information behavior. The information and communication aspect is characterized by high speed in searching for and processing information. The technological aspect underscores the intensive integration of technology into information-related activities, as digital readers demonstrate readiness to apply modern digital tools in academic work, independent learning and leisure. The psychological aspect reveals features of digital readers' cognitive behavior — for example, a preference for visualized data and concise information presentation. The social aspect reflects interaction patterns in online environments: digital readers tend to express their thoughts and views openly online and actively participate in communication via social media and online communities.

Digital culture in libraries involves the use of digital tools for library collection management (electronic catalogs, repositories, databases); providing access to electronic resources (e-books, journals, multimedia materials); and creating virtual spaces for discussion, learning, and communication. More than half of the respondents (55%) are confident in the importance of developing digital services in library work, while 38% consider these services to be fairly important. This indicates a high level of public demand for the digitalization of library activities.

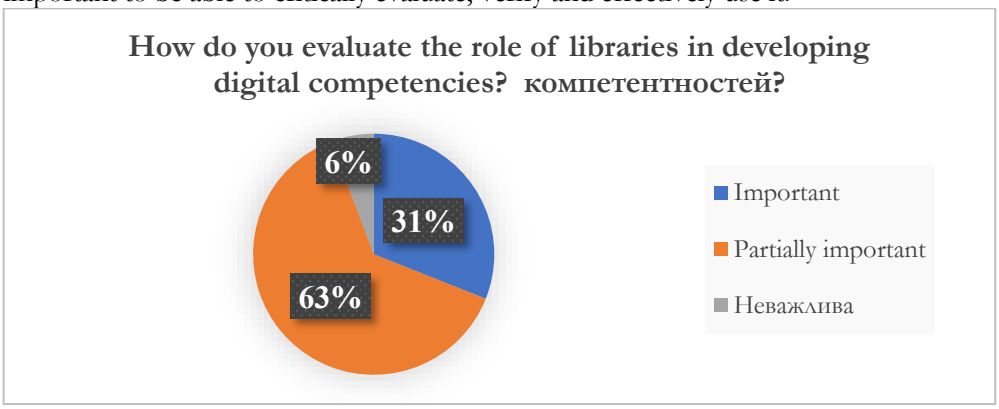


Among the digital services, the most in-demand among respondents were online access to books, journals and electronic catalogs. However, one-third of the respondents had never used any digital library services, which indicates both a low level of information awareness regarding library services and insufficient efforts by libraries to promote their activities.

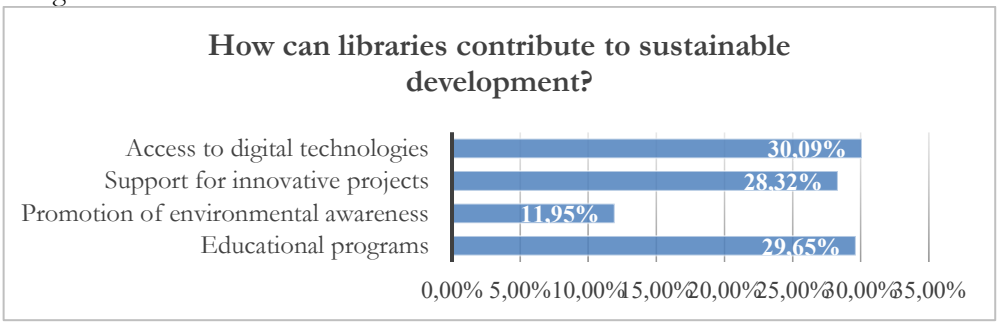


The development of digital culture in libraries involves the acquisition of digital competencies by both librarians and users. Among the respondents, one-third (31%) expressed confidence in the importance of the library's role in fostering digital competencies, 63% considered this role to be partially important, and 6% viewed it as unimportant. In our opinion, this distribution reflects the respondents' personal experiences with the development of their digital skills facilitated by librarians, and underscores the need for libraries to significantly enhance their efforts in this area. In

today's world, it is not enough to simply have access to information — it is equally important to be able to critically evaluate, verify and effectively use it.

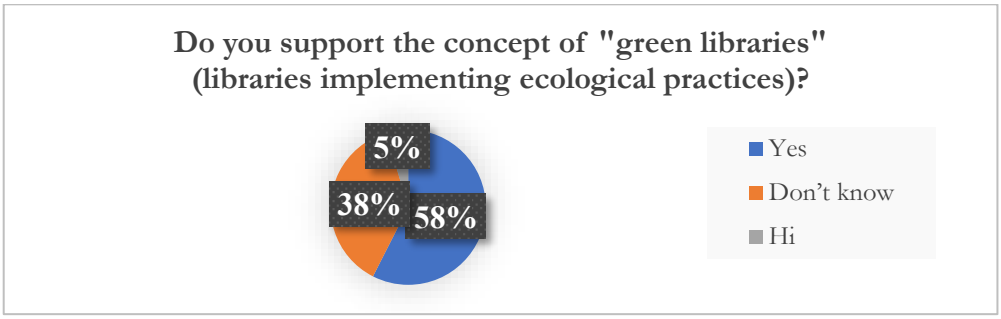


Digital technologies enable libraries to ensure equitable access to knowledge, aligning with the UN Sustainable Development Goals (which include quality education, reducing inequalities, fostering innovation, among others). Among the respondents, educational and informational-digital programs offered by libraries were the most popular. At the same time, library initiatives aimed at promoting environmental awareness did not receive due recognition.

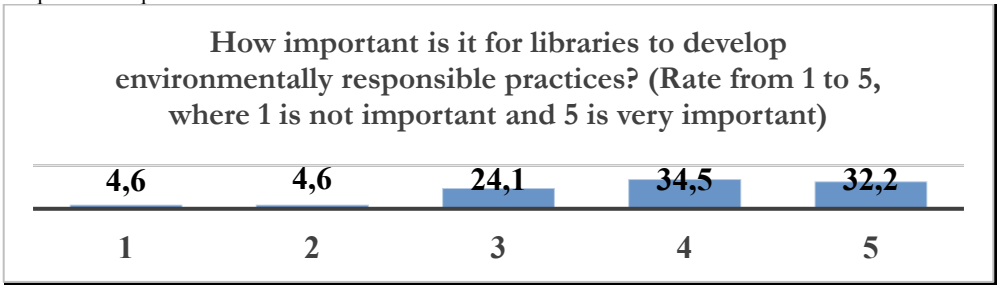


At the same time, the environmental aspects of digital transformation are also essential for sustainable development. The overwhelming majority of respondents (58%) believe that libraries can contribute to raising environmental awareness and promote the development of "green" technologies in the management of information resources.

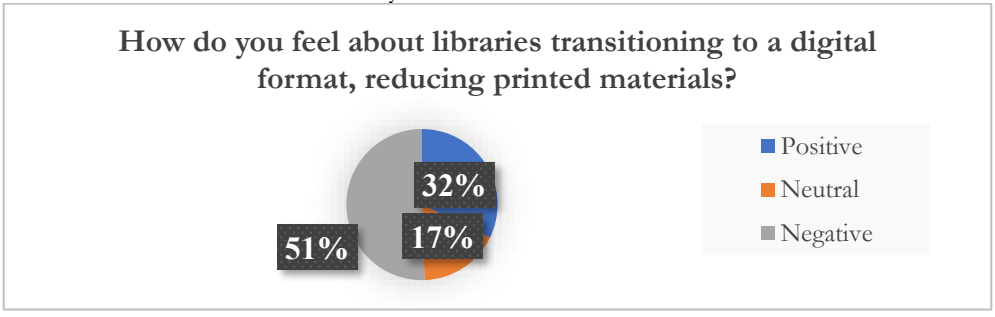
In practice, this includes reducing paper consumption through digital lending, minimizing energy use via server virtualization, and encouraging electronic communication instead of printed materials. Some libraries also track savings in electricity and materials to monitor their environmental impact more effectively. These actions demonstrate how digital tools can directly support ecological goals.



It is worth noting that the concept of "green libraries" is gaining popularity in Ukraine, directing libraries' activities towards supporting sustainable development and environmental education. Among the examples of libraries and initiatives actively implementing this concept, the "Green Libraries" movement in Ukraine, initiated by the charitable foundation "Library Country" and the Ukrainian Library Association (https://ula.org.ua), can be highlighted. This movement encourages libraries to share their experiences in ecological activities and implement sustainable development principles. The survey confirmed the importance for respondents of libraries adopting environmentally responsible practices.



The overwhelming majority of respondents (60%) understand that the digitalization of libraries is an important step towards sustainable development, as it reduces the environmental impact (by decreasing paper consumption and promoting energy savings), expands access to knowledge, ensuring accessibility and inclusivity, and contributes to environmental education in society.



The transition to digital formats allows libraries to use their spaces more effectively, for example, by creating community hubs, learning spaces, or eco-friendly areas. 99% of respondents are confident in the need to develop libraries as open spaces for collaboration and learning, as augmented reality, artificial intelligence, virtual reading rooms, and digital

archives are part of innovative technologies that are transforming modern libraries and creating prospects for the future.

5. Conclusions

The digitalization of libraries helps preserve cultural heritage by reducing the need for physical media and contributes to the democratization of knowledge through open access to books, scientific research, and archives. Modern librarians manage electronic resources, educate users on digital literacy, implement cutting-edge technologies such as artificial intelligence and data analysis, and ensure access to digital collections. They also play a key role in supporting digital inclusion, ensuring equal access to information for all members of society.

Digital culture in libraries is viewed as a set of digital practices, technologies, skills and principles that ensure the effective use of information resources, the provision of digital services, and the support of users' information literacy. The digital culture of libraries facilitates their transformation into modern information hubs that meet the needs of society in the digital age. The development of digital culture in libraries contributes to sustainable development and creates conditions for a future where knowledge is accessible, resources are used efficiently and society becomes more environmentally conscious.

The challenges of globalization make it necessary to transform libraries into open educational and cultural spaces that help bridge the digital divide, promote social equality and integrate technologies (augmented reality, artificial intelligence, open data) into cultural and educational processes for sustainable development. The results of the research highlight the importance of accelerating the work of Ukrainian libraries in this direction.

To implement these goals practically, libraries can adopt strategic models that integrate sustainability principles into digital service design. For example, libraries may align their digital initiatives with the UN Sustainable Development Goals (SDGs), embedding environmental, social, and economic sustainability into project planning. This includes designing user interfaces that promote energy efficiency, offering remote services to reduce travel-related emissions, and developing inclusive platforms that consider the needs of marginalized communities.

Clear institutional guidelines, sustainability audits, and staff training programs can help operationalize these goals. Libraries that treat sustainability not as a separate initiative but

as a core element of digital transformation will be better positioned to serve as resilient and future-ready knowledge ecosystems.

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