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Enhancing Mathematics Education Research through Technology, Open Access Initiatives, and Library Support: A Sustainable Development Perspective

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Abstract
This paper examines how technology and libraries play a critical role in influencing scholarly publications in mathematics education, promoting open-access initiatives, and promoting sustainable development. Academic discourse is anchored by scholarly publications, which serve to spread information and promote intellectual progress in particular fields. Open access initiatives, enabled by technology and libraries, democratize access to scholarly content worldwide, promoting innovation, accelerating the distribution of research discoveries, and elevating public involvement. Furthermore, the incorporation of sustainable practices in libraries is consistent with the values of social justice, economic feasibility, and environmental stewardship. Technology is a revolutionary enabler that makes scholarly resources more accessible beyond geographical boundaries, promotes digital repositories, and supports creative approaches to information distribution. Through the exploration of the interconnected realms of scholarly publications, open access initiatives, sustainability, libraries, and technology, this paper underscores their crucial roles in shaping academia and society, laying the groundwork for a more inclusive, accessible and sustainable information landscape. The study suggested among others that Libraries should prioritize investments in robust digital infrastructure, ensuring seamless access to online resources, open-access platforms, and digital repositories. Upgrading technological systems and expanding bandwidth capabilities will facilitate broader access to scholarly publications.

Keywords: Libraries, Technology, Scholarly Publication, Open Access, Sustainability

Introduction

Over the years, a transformative shift has occurred in the dissemination of scholarly information. Traditional publishing models grapple with challenges related to access, affordability, and the speed of dissemination. The escalating costs of journal subscriptions and the restrictive nature of traditional publishing models have, in turn, restricted access to scholarly knowledge. In response to these limitations, open-access initiatives have emerged. Open Access strives to make scholarly information freely accessible to the global community, fostering knowledge dissemination and collaboration. In recent years, open-access scholarly publications have garnered significant attention as a means to enhance the accessibility and sustainability of academic research. Libraries and technology play pivotal roles in supporting open-access initiatives and ensuring the long-term viability of scholarly publications in the open-access model.

Libraries have traditionally served as gateways to information, providing access to a wide range of resources, including scholarly publications. Libraries have embraced the open-access movement by actively supporting open-access publishing platforms and initiatives. They collaborate with researchers, institutions, and publishers to promote open-access policies, advocate for sustainable funding models, and provide guidance on publishing in open-access journals. Libraries also offer institutional repositories to host and preserve open-access scholarly publications, ensuring their long-term availability and accessibility.

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Technology plays a crucial role in facilitating the dissemination and sustainability of open-access scholarly publications. Digital platforms and tools enable efficient and cost-effective publishing processes, such as online submission systems, peer review management systems, and digital archiving solutions. Technology also enables innovative models of scholarly communication, such as preprint servers and open-access mega journals, which promote rapid dissemination and interdisciplinary collaboration. Moreover, technology supports the discovery and access of open-access publications. Libraries utilize advanced search engines, metadata standards, and discovery tools to enhance the discoverability of open-access content. They also employ digital preservation strategies to ensure the long-term accessibility and integrity of digital publications.

The sustainability of open-access scholarly publications is a critical concern. While open access offers numerous benefits, it requires sustainable funding models to support the costs of publishing, peer review, and infrastructure. Libraries play a crucial role in advocating for and implementing sustainable open-access models, such as library-led publishing initiatives, institutional memberships, and consortia agreements. Given the evolving landscape of scholarly publishing and the increasing importance of open access, it is essential to examine the specific roles libraries and technology play in supporting open-access scholarly publications for sustainability. This paper aims to explore the contributions of technological tools and libraries in promoting open-access initiatives and the challenges and opportunities for ensuring the long-term sustainability of open-access scholarly publications. In understanding the roles of libraries and technology in open-access publishing, stakeholders can make informed decisions and implement strategies to foster a sustainable and inclusive scholarly communication ecosystem.

Scholarly Publications

The term scholarly usually describes a source that has undergone "peer review," a rigorous editing and review procedure carried out by experts in the field to ensure its validity and quality. (The Libraries, 2023). Publication of research findings is typically regarded as what is meant by scholarly publication. Stated differently, it refers to the documented findings of investigators who have expanded their understanding of their field by the use of scientific ideas and techniques. Journal articles, research reports, conference papers, and books are the most common publication formats. Publishing is essential in the information life cycle by enabling scholars to share their research, allowing others to see, comment on, and expand upon it, thereby enhancing knowledge. It also advances a scholar's reputation within their field, which is crucial for securing funding and employment. Accreditation bodies regularly demand scholars to remain active in their fields and publishing is the key way to demonstrative active engagement (University Library, 2020; National University Library, 2023).

A scholarly publication is, therefore, research-based, peer-reviewed authoritative content with extensive argument-supporting citations and references written by researchers using specialized field-appropriate language for problem-solving or knowledge advancement. The Libraries (2023) further disclosed the characteristics of scholarly journals, suggesting that the credentials of the authors of a scholarly academic article should be provided and that they should be affiliated with a university or other research institute. The article should be found in a library database, Google Scholar, and it must be peer-reviewed. The content should be persuasive, and the author should neither include misleading information nor exclude relevant information. It should include references and not be less than 10 pages. A scholarly article usually consists of multiple sections, each of which fulfils a distinct function and adds to the overall comprehension and organization of the presented research. The particular components could differ slightly based on the requirements of the journal. However, a scholarly article generally includes the sections below. Additional sections (eg, acknowledgement, appendices, author biography, or supplementary materials) may be included depending on the guidelines or specific requirements of the journal.

- **Title**: The title provides a brief description of the content of the article, aimed at capturing the attention of the reader, and the main aim of the study. An empirical article should have both independent and dependent variables. A well-organized topic forms the cornerstone around which the entire research project is constructed. It clearly defines the context and delimitation of the research, providing readers and researchers with guidance and clarity.
- **Abstract**: The abstract is a concise summary of the entire article, usually around 150-250 words. It conveys the main aim of the study, provides a brief of the methodology adopted, key findings, conclusion and a recommendation.

- **Introduction**: The introduction provides the background information, specifies the research problem, and presents the main aim and objectives of the study. The introduction offers a logical flow of events and a systematic presentation of thoughts, setting the tone and context of the entire study. A well-written introduction provides readers with confidence and clarity by acting as a road map through the research terrain. The review of related literature is often integrated discussing existing research on the topic and identifying the gaps that the present study aims to plug.
- **Methodology or Materials and Methods**: The procedures, research methods or techniques adopted in the study are detailed in this section. Information about the design, sample and sampling techniques, instrumentation, materials, data collection methods, and data analysis procedure.
- **Results**: The findings obtained from the research methods are presented in the results section. It includes data, statistics, tables graphs or other visuals illustrating and supporting the results of the study. The results are presented factually and objectively without interpretations.
- **Discussion**: In the discussion sections, the results are interpreted and analyzed by the authors, linking them to the research question or hypothesis. The authors usually compare their findings with existing literature, explain their significance, address the study's limitations and propose implications or areas for future research.
- **Conclusion**: The main findings of the study are summarized in the conclusion. The significance of the research is reiterated. The practical applications or implications of the findings may be suggested. It may also offer recommendations for further research based on the findings.
- **References**: The reference includes complete citations for all sources referenced or cited within the article. A specific citation style (e.g. APA, MLA or Chicago) is followed and provides readers with information to locate the cited sources.

Table 1: Problems and Prospects of Scholarly Publication Challenges

SN	Challenges of Scholarly Publications	The way forward
1	Insecurity and Industrial Actions:	Implement remote work solutions during crises to ensure research continuity
2	Perception of Research by Policymakers:	Conduct workshops to showcase research value for policymaking
3	Poor Writing Skills for Grants	Offer writing skill workshops for grant proposals
4	Publish or Perish Pressure	Encourage quality over quantity in scholarly publications
5	Patent and Commercialization	Establish tech transfer offices for research outcome commercialization
6	Lack of Policy Framework	Advocate for national policies supporting research
7	Secrecy	Promote transparency and open collaboration among researchers
8	Inadequate Advocacy for OAI	Conduct awareness campaigns for Open Access Initiatives
9	Research Misconduct	Enforce ethical guidelines and educate researchers on misconduct prevention
10	Weak Research and Data Analysis	Provide training in research methodologies and data analysis techniques

Source: Adapted from Okwelle (2022).

Libraries Promoting Scholarly Publications

Libraries play a pivotal role in advancing scholarly publications by offering an array of crucial services and resources. One key function of libraries is providing extensive access to scholarly databases, journals, and repositories, acting as gateways for researchers to access essential literature necessary for their publications. These resources empower researchers to explore a vast array of academic work, enabling them to build upon existing knowledge and contribute to their respective fields. In addition to granting access to resources, libraries offer publication support services. They conduct workshops and guide publication strategies, manuscript formatting, and citation styles, equipping researchers with the necessary skills to prepare their work effectively for publication. This guidance ensures that research output meets the standards required for successful dissemination in scholarly circles. Moreover, libraries champion Open

Access initiatives by actively supporting institutional repositories and advocating for broader accessibility to scholarly content. They assist researchers in depositing their work into these repositories, ensuring that publications are freely available to a wider audience. This advocacy for Open Access aligns with the ethos of sharing knowledge freely and promotes a more inclusive dissemination of scholarly work. Libraries also serve as hubs for fostering research collaboration. Through forums, conferences, and networking events, they provide platforms for researchers to interact, share their work, and forge potential collaborations for future publications. These collaborative spaces nurture a culture of knowledge exchange and interdisciplinary engagement among researchers.

Furthermore, libraries conduct information literacy programs aimed at enhancing researchers' skills in navigating the publishing landscape. Workshops focused on research methodologies, citation practices, and ethical considerations in scholarly publishing empower researchers with the information literacy skills necessary to navigate the complex world of academic publishing confidently. Lastly, libraries acknowledge and showcase researchers' published work through exhibitions, newsletters, or online platforms. By recognizing and promoting researchers' contributions within the academic community, libraries encourage further engagement, creating a cycle that fosters the dissemination of knowledge and encourages scholarly endeavours.

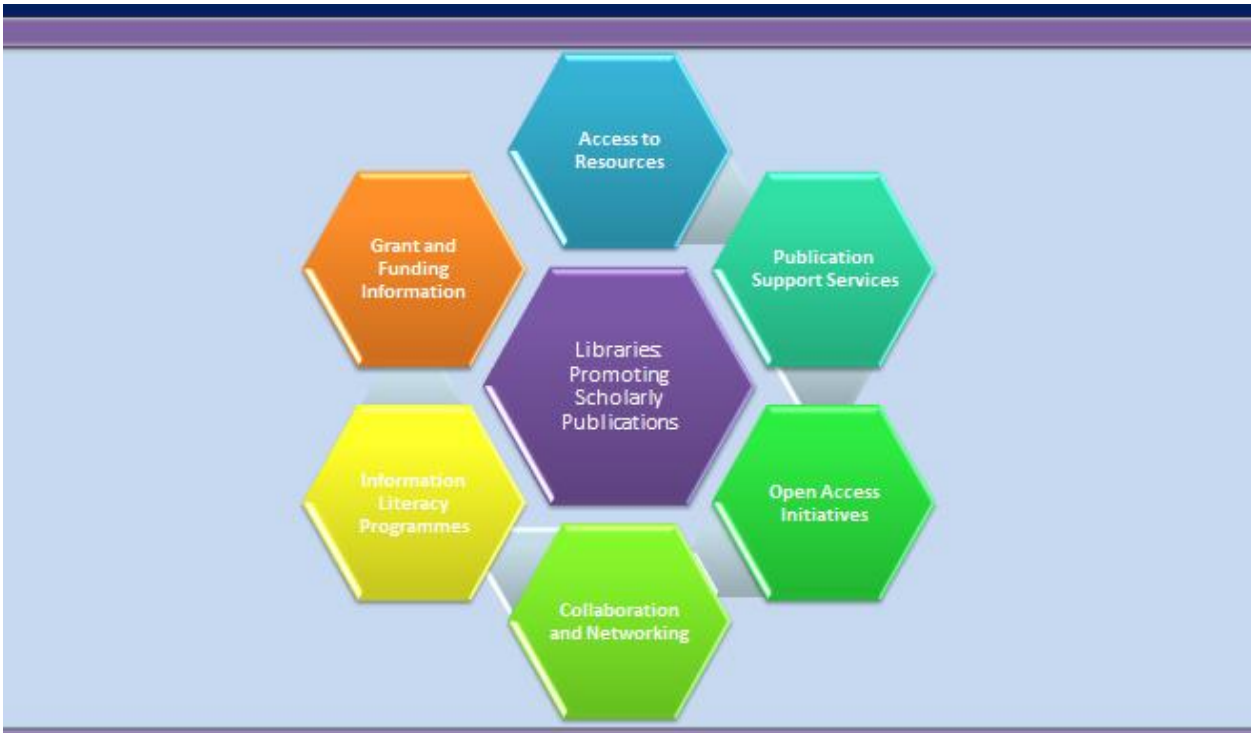

Fig. 1: Libraries: Promoting Scholarly Publications

Technology Promoting Scholarly Publications

Libraries have embraced technology as a catalyst for advancing scholarly publications, employing various digital strategies to support researchers and enhance accessibility to academic resources. Leveraging digital library platforms stands as a cornerstone in this endeavour, offering users seamless and round-the-clock access to an extensive collection of scholarly materials. These platforms transcend physical limitations, providing remote access to digital resources and accommodating users' diverse schedules. Moreover, libraries actively champion Open Access initiatives by spearheading the establishment and maintenance of institutional repositories. They facilitate researchers in depositing their work into these repositories, advocating for wider accessibility to scholarly content. Through such initiatives, libraries uphold the principle of Open Access, ensuring the dissemination of knowledge without restrictions or financial barriers. Utilizing technology for electronic resource management enables libraries to curate and provide access to a diverse array of scholarly journals, databases, and e-books. This digitized approach augments the research

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process, granting users access to a rich repository of academic resources essential for their scholarly pursuits. Libraries equipped with technological capabilities also offer invaluable research data services. They provide support in data management, including guidance on curation, preservation, and visualization tools. Such services aid researchers in bolstering their publications with robust data analysis, contributing to the credibility and depth of their scholarly work.

In addition, technology enables libraries to offer virtual reference services and support. Through online consultations, workshops, and virtual assistance, libraries assist researchers in publication strategies, citation management, and effective literature searches. This virtual engagement provides researchers with tailored guidance irrespective of their location, fostering a collaborative and supportive environment. Libraries further extend their role by providing technology training and support to researchers. Conducting training sessions on digital tools, citation management software, and publication platforms equips researchers with the requisite skills to navigate the evolving landscape of scholarly publishing. These initiatives empower researchers with the necessary technological proficiency to optimize their scholarly output and engagement.

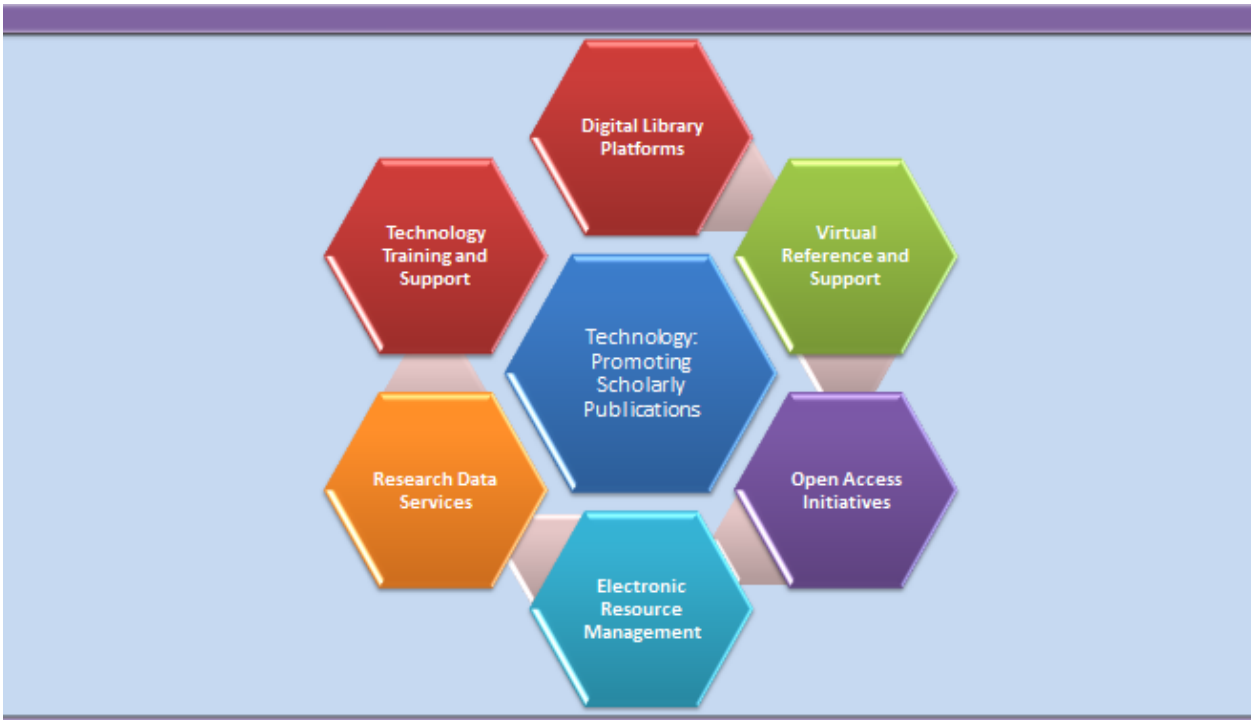

Fig. 2 Technology: Promoting Scholarly Publications

Open Access Initiatives

The Budapest Open Access Initiative (2002) defines open access as unrestricted public internet access to scientific material, mainly peer-reviewed journal articles, without any technical, financial, or legal impediments. These articles may be read, downloaded, copied, distributed, printed, searched, linked to, and used for legitimate purposes by users. The fundamental idea is to eliminate obstacles related to cost and authorization so that academic publications can be accessed with few limitations on their use and correct author attribution is preserved. To attain open access to scholarly journal literature, the Budapest Open Access Initiative (BOAI) recommended self-archiving and the establishment of open-access journals. Therefore, Open access refers to the unrestricted availability of scholarly research and academic publications online, allowing anyone to access, download, and sometimes reuse and redistribute these materials without legal or financial barriers.

Self-archiving is the practice where authors make their articles freely available in digital form on the internet. These articles could either be preprints (draft versions of an article not yet peer-reviewed) or post-prints (final published

versions or updated preprints reflecting changes made during peer review). Digital materials, or e-prints encompassing digital preprints, postprints, and other scholarly materials, including conference presentations can be self-archived. The strategies for self-achieving e-prints are personal websites, disciplinary archives, and institutional repositories. An author may use multiple self-archiving options for wider visibility. Harnad (2005) referred to self-archiving as the green road to open access. In this Green Open Access model, the authors publish articles in subscription-based journals but also self-archive a version of the article in an open repository, (like institutional repositories). This model allows readers to access the authors' accepted manuscripts or preprints without paywalls.

Open Access Journals are scholarly, quality-controlled, digital, freely available, and may allow authors to retain copyrights. The Directory of Open Access Journals (DOAJ) catalogues numerous open-access journals based on stated criteria. However, there are disputes on whether open-access journals must utilize peer review or specific licenses reflecting differing views on defining open access (Bailey, 2006). Harnad (2005) referred to Open Access Journals as the Gold road to open access. In this Gold Open Access model, the authors' published articles in open-access journals are freely made available immediately upon publication. The cost of publication is covered by the article processing charges paid by the authors, their institutions or funding agencies.

The Budapest Open Access Initiative (BOAI) also referred to as Open Access Initiatives (OAI) was established during a meeting in Budapest, Hungary in December 2001 by the Open Society Institute. It focuses on advocating for facilitating the widespread online availability of scientific journals without cost access or restrictions (Solomon, 2007). The OAI has several benefits, including increased visibility and citation-propelled impact, promotion of collaboration among researchers globally, public accessibility, and fostering of innovations. The OAI has been supported by governments, funding agencies, research institutions, and academic publishers to promote the dissemination of knowledge and accelerate scientific progress. Many universities and research institutions now have open-access policies requiring their researchers to make their scholarly publications accessible, contributing to the growth of freely available scholarly content.

In leveraging their resources, expertise and technological skills, libraries actively contribute to the advancement of open access, ensuring equitable access to scholarly publications and providing a culture of knowledge sharing and dissemination. Some of the ways the libraries and technology promote open access initiatives are as follows:

- **Providing Access to Open Access Resources**: Access to databases, journals, and open-access repositories is made easier by libraries. They make scholarly materials freely available to users by curating them and providing advice on how to use them.
- **Supporting Institutional Repositories**: Institutional repositories are created and maintained by libraries, providing a means for scholars to self-archive their works and enhancing the visibility and use of academic outputs.
- **Technology Infrastructure**: To ensure the sustainability and long-term availability of resources available for public access, libraries invest in technology infrastructure for the protection and management of digital collections.
- **Advocacy and Collaboration**: To promote open access within academic communities, libraries encourage researchers, scholars, and organizations to adopt and put into practice open-access policies. They collaborate to advance open-access policies and programmes with publishers, funding organizations, and academic associations.
- **Technological Innovations**: Libraries investigate and make use of novel technology, like digital repositories, text and data mining tools, and open-source publishing platforms, that promote the growth of open access.
- **Collaborative Partnerships**: Libraries collaborate with other institutions, consortia, and organizations to share resources, advance open-access programmes, and promote open-access principles globally.
- **Educational Workshop and Support**: To educate researchers on open-access publishing, copyright issues and repository use, libraries conduct training workshops and consultations. This fosters the provision of guidance on compliance with open-access mandates and policies.

Sustainable Development

Sustainable development refers to an advancement mode which ensures that current requirements are met without jeopardizing the ability of future generations to meet their own needs. It entails striking a balance between social

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advancement, environmental protection (ecological preservation), and economic growth (financial). The realization that unrestrained economic growth might result in resource depletion, social inequality, and environmental degradation, all of which pose threats to the welfare of present and future generations, led to the development of this idea in the late 20th century. Therefore, sustainable development aims to proffer solutions that reconcile economic development with environmental protection and social well-being. This includes implementing policies and practices that promote sustainable agriculture, renewable energy, conservation of natural resources, efficient resource use, waste reduction, fair labour practices and inclusive economic growth. The key principles of sustainable development are environmental stewardship, inter-generational equity, economic development, and social equity and inclusion. The United Nations' Sustainable Development Goals (SDGs) outline a set of 17 global goals adopted by member states to address various goals, including poverty, inequity, climate change, and clean energy among others, by 20230. These goals serve as a framework to guide efforts towards a more sustainable future for all.

Sustainable Development in the field of Library and Information Science (LIS) is relatively novel. However, in recent times the worth of sustainable development in libraries has increased in its space (Khalid, 2021). Therefore, sustainable development of libraries is the integration of environmentally conscious economically feasible and socially equitable practices within the library operations and services. The libraries can uphold the key principles of sustainable development in the following ways:

Environmental Stewardship: The libraries place a high priority on environmental stewardship by implementing Green Initiatives, Digitization, and Green Buildings. Green Initiatives can be achieved by using energy-efficient systems, utilizing renewable resources and adopting sustainable practices in library operations (e.g., energy-efficient lighting, waste reduction, and recycling programmes). The libraries increase digital collections and reduce reliance on physical materials to minimize paper use and conserve resources. They achieve green building by designing or retrofitting library buildings to meet eco-friendly standards, incorporating sustainable architecture, and utilizing green technologies for heating, cooling and lighting.

Inter-generational Equity: The libraries uphold inter-generational equity through Preservation and Access, and Education and Outreach. They ensure the preservation of knowledge for future generations by digitizing and archiving materials. Facilitating access to historical documents and resources to promote inter-generational transfer of knowledge. Programmes, workshops and events are organized to engage people of different ages, promoting learning and knowledge sharing among diverse age groups.

Economic Development: The libraries uphold the economic development principle of sustainable development through Open Access Initiatives, and Support for Infopreneurship. The libraries support open access initiatives and reduce barriers to information access. Open access initiatives and resources, including open educational resources, enhance accessibility to information for economically disadvantaged groups. They also provide resources for infopreneurship, offering workshops and assistance to local inforepreneurs, thereby fostering economic growth within the community.

Social Equity and Inclusion Initiatives: The libraries promote social equity and inclusion initiatives through Diversity in Collections, Accessibility and Community Engagement. They curate diverse collections that represent various cultures, languages, and perspectives. They also ensure accessibility by providing physical access, assistive technologies, and services for people with disabilities. Community engagement is a cornerstone, where libraries collaborate with diverse community groups, host inclusive events, and offer resources tailored to the needs of marginalized communities.

It has been shown that libraries support the key principles of sustainable development by upholding economic development, inter-generational equity, economic development, and social equity and inclusion. This implies that the libraries support sustainable development. However, it can also be further clarified using Ranganathan's Five Laws of Library Science, published in the year 1931. The laws provide guiding principles for the organization and management of libraries (Ranganathan, 1931). The laws are:

1. **Books are for use**: Stressing the need to make library materials available and accessible to meet the information needs of users.

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2. **Every reader, their book**: Emphasizing the idea of matching the right book to the right reader.
3. **Every book its reader:** Highlighting the importance of diverse collections that cater for the varied needs and preferences of users.
4. **Save the time of the reader**: Emphasizing the efficiency of the library services.
5. **The library is a growing organism**: Stressing the dynamic nature of libraries. It highlights the continued development and growth of the library collections, services and resources.

These five laws have been conceptualized by different authors showcasing different eras of technological development and the growth of the library. The examples of the modifications are in Table 2 below:

Table 2: Ranganathan's Five Laws and Its Conceptualization in Different Era

Law	Ranganathan (1931)	Kumbhar, B (nd).	Chhetri (2023).
1st	Books are for use	Digital Objects are for use	AI is for use.
2nd	Every reader, their book	Every user of his / her Digital Object	Every citizen his/her AI.
3rd	Every book its reader	Every Digital object It's user	Every AI is for citizen usage.
4th	Save the time of the reader:	Save the time of the user	AI saves the time of user
5th	The library is a growing organism	Digital Library is a growing Organism	AI Systems are constantly evolving

The evolution of Ranganathan's Five Laws of Library Science, as depicted in the table across different eras, signifies a significant transition in how libraries conceptualize their role in the ever-changing information landscape. Initially centred around books and readers, the adaptation of these laws to digital objects and artificial intelligence (AI) reflects the profound impact of technological advancements on library services. This evolution has broader implications for sustainable development. Embracing digital resources and AI technologies in libraries contributes to various facets of sustainability. Firstly, the shift towards digital materials reduces reliance on physical resources like paper, potentially lessening the environmental footprint associated with traditional library operations. Moreover, this transition aims to promote social equity and inclusion by broadening access to information and resources, catering to a more diverse audience. The incorporation of digital libraries and AI systems can bring about cost efficiencies and innovative service models, enhancing the economic sustainability of libraries. Furthermore, the constant evolution and integration of AI technologies position libraries to adapt to technological advancements, foster innovation, and meet evolving user needs.

Conclusion

The way that libraries have incorporated technology shows how they work together to advance open-access initiatives, support scholarly publishing in mathematics education, and support sustainable development. Their combined efforts increase the amount of information that is shared, make it easier for everyone to obtain information, and adopt sustainable habits. Technology and libraries work together as transformative forces to promote sustainability, diversity, and creativity in the academic environment.

Suggestions

1. Libraries should prioritize investments in robust digital infrastructure, ensuring seamless access to online resources, open-access platforms, and digital repositories. Upgrading technological systems and expanding bandwidth capabilities will facilitate broader access to scholarly publications.
2. Encourage institutions to adopt and promote open access policies. Libraries can collaborate with academic and research institutions to advocate for open-access publishing, encouraging researchers to self-archive their work in institutional repositories or open-access journals.
3. Embrace emerging technologies like artificial intelligence (AI), machine learning, and data analytics within library systems. These technologies can streamline information retrieval, enhance metadata analysis, and facilitate personalized access to scholarly content.
4. Foster partnerships among libraries, publishers, and research institutions to negotiate fair and sustainable open-access agreements. Collaborations can lead to innovative models that ensure the dissemination of scholarly work while sustaining the scholarly publishing ecosystem.

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5. Develop educational programmes to raise awareness among researchers, faculty, and students about the benefits of open-access publishing and sustainable practices. Workshops, seminars, and training sessions can empower individuals to embrace open-access initiatives and utilize library resources effectively.
6. Libraries can adopt eco-friendly practices by promoting digital collections, implementing energy-efficient technologies, and engaging in recycling and waste reduction programs. Green library initiatives contribute to environmental sustainability.

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