

ICT and Emerging Technologies for Indian Knowledge Systems in Education: A Framework-Oriented Approach

Aditi Srivastava
Student Scholar
National PG College
Lucknow University, India
aditisrivastava9944@gmail.com

Rinku Raheja
Assistant Professor
National PG College
Lucknow University, India
rinkuraheja.nationalpgcollege@npgc.in

Krishna Agarwal
Student Scholar
National PG College
Lucknow University, India
krishnaagarwal0193@gmail.com

Mahesh Kumar Tiwari
Assistant Professor
National PG College
Lucknow University, India
maheshtiwari.nationalpgcollege@npgc.in

Abstract— Indian Knowledge System is the ancient India's vast wisdom spreading its roots along different domains including arts, science, philosophy, astronomy, music, dance, mathematics, architecture, yoga, medicine (Ayurveda) and education. It is passed from one generation to another having its roots in Vedas, Upanishads and ancient texts and various manuscripts. The National Education Policy (NEP 2020) besides transforming the traditional 10 + 2 education system to a 5 + 3 + 3 + 4 education pattern, highlights the importance of integration of traditional knowledge into modern education systems. In this context, the technology plays a crucial role and bridges the gap between the traditional knowledge system and modern education. The advancement in Information and Communication Technology (ICT) presents new opportunities to digitally preserve the ancient knowledge and present the knowledge in an easy to understand and more interactive fashion. The paper examines how digitization and ICT tools integration can support the preservation of indigenous knowledge and modern display of ancient knowledge. The paper explores the digital tools, online learning platforms, multimedia tools, role of artificial intelligence, cloud computing, augmented reality and virtual reality. The study briefly discusses the role of scalable software infrastructures and how a Java based system can be effectively build in support of secure and interoperable education platform. Further, challenges relating to language diversity, authenticity, ethical considerations are analyzed. The paper concludes that aligning technology with the indigenous education system can effectively sow the seeds for the better future of students.

Keywords— Indian Knowledge System (IKS), Indigenous Knowledge, Information and Communication Technology (ICT), Digital Preservation, Java-Based Educational Platforms.

I. INTRODUCTION

Indigenous knowledge is a treasure of cultural values, sustainable practices, and community-based learning that has been accumulated over hundreds of years. This indigenous knowledge has its roots in many fields, like yoga, ayurveda, art, astronomy, math, and education. This knowledge was passed down orally through gurukul systems and written down in manuscripts that kept the knowledge very

contextually and community-based. However, the manuscripts are destroyed with the passage of time; thus, these traditional methods of passing down knowledge have been disrupted by the rapid technological advancements and globalization.

The current education system is heavily dependent on digital technology to improve teaching and learning practices. This technological revolution presents a great opportunity to preserve and integrate indigenous knowledge into the structured education system. The digitization of knowledge through ICT support makes it possible to record, preserve, and share this knowledge across generations and geographical locations without the degradation of knowledge.

II. INDIAN KNOWLEDGE SYSTEM: AN OVERVIEW

The ancient Indian scriptures have been a rich source of information for exhaustive and intricate theories and practices called the Indian Knowledge Tradition, which includes several fields of study such as Philosophy, Mathematics, Art, Craft, Music, Dance, etc. The Indian Knowledge System has been designed to give students the ability to acquire the skills and knowledge required for professional success (in their respective fields) and to develop themselves into well-rounded, socially responsible members of society through the use of ethical values and spiritualism, self-discipline, and personal growth. Through the Indian Knowledge System, Students learn to think critically and make better decisions using the process of Guru-Shishya Parampara/Teacher-Student Relationship to establish a meaningful connection with their Gurus/Teachers. In addition to academics, the Indian Knowledge System supports Children's social, physical, mental, and creative growth through Holistic Development, as defined in the NEP 2020 framework. In order to succeed in today's increasingly globalized and digitalized world, a Multidisciplinary Approach must be implemented by integrating Traditional Methods of Learning, the Digital Marketplace, and Project-Based Learning.

III. ROLE OF TECHNOLOGY IN BRIDGING TRADITIONAL AND MODERN EDUCATION

Technology plays an essential role in preserving and connecting the traditional knowledge of ancient India with today's educational system. New technologies have enabled researchers, teachers, and students from all over the world to access rare manuscripts, palm leaves, and sacred texts through digital format in order to preserve these unique forms of knowledge while making them available. Web and mobile apps have made knowledge of Indian disciplines like Yoga, Ayurveda, Philosophy, and Mathematics much more accessible and engaging for everyone via multimedia education, discussion forums, independent study opportunities, and increased availability. Emerging technologies such as Artificial Intelligence, Augmented Reality, and Virtual Reality provide unparalleled opportunities for many learners through immersive, hands-on experiences that help bring to life many aspects of Ancient Gurukuls, Astronomical Studies, and Architectural Wonders.

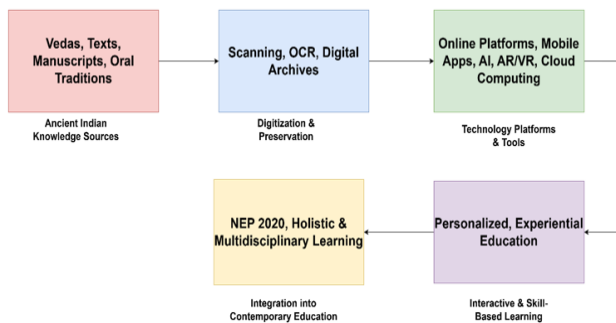


Fig. 1: Technology-Enabled Promotion of Indigenous Knowledge

Technology plays an essential role in preserving and connecting the traditional knowledge of ancient India with today's educational system. New technologies have enabled researchers, teachers, and students from all over the world to access rare manuscripts, palm leaves, and sacred texts through digital format in order to preserve these unique forms of knowledge while making them available. Web and mobile apps have made knowledge of Indian disciplines like Yoga, Ayurveda, Philosophy, and Mathematics much more accessible and engaging for everyone via multimedia education, discussion forums, independent study opportunities, and increased availability. Emerging technologies such as Artificial Intelligence, Augmented Reality, and Virtual Reality provide unparalleled opportunities for many learners through immersive, hands-on experiences that help bring to life many aspects of Ancient Gurukuls, Astronomical Studies, and Architectural Wonders knowledge.

IV. DIGITIZATION AND ICT FOR PRESERVATION OF INDIGENOUS KNOWLEDGE

Technology plays an essential role in preserving and connecting the traditional knowledge of ancient India with today's educational system. New technologies have enabled researchers, teachers, and students from all over the world to access rare manuscripts, palm leaves, and sacred texts through digital format in order to preserve these unique forms

of knowledge while making them available. Web and mobile apps have made knowledge of Indian disciplines like Yoga, Ayurveda, Philosophy, and Mathematics much more accessible and engaging for everyone via multimedia education, discussion forums, independent study opportunities, and increased availability. Emerging technologies such as Artificial Intelligence, Augmented Reality, and Virtual Reality provide unparalleled opportunities for many learners through immersive, hands-on experiences that help bring to life many aspects of Ancient Gurukuls, Astronomical Studies, and Architectural Wonders.

The digital distribution of India's Knowledge Traditions raises questions of Preservation and Authenticity. Technology needs to be used to preserve and protect the Culture of India through appropriate representation, utilization and sustainability. Today's advanced digitization technologies including high-resolution scanning, OCR and Metadata annotation allow access to Manuscripts for Academic use, while preserving them from deterioration. Recent advancements in digital technology enable us to preserve Ancient Manuscripts in digital format without causing deterioration of the manuscript physically. Digital Life Archives and repositories provide a means for organized storage, indexing and retrieval of resources for Indian Knowledge. Digital Life Archives provide a means for documenting scholarly citations for the documentation of Indian Knowledge, as well as for enabling organized distribution of Indian Knowledge.

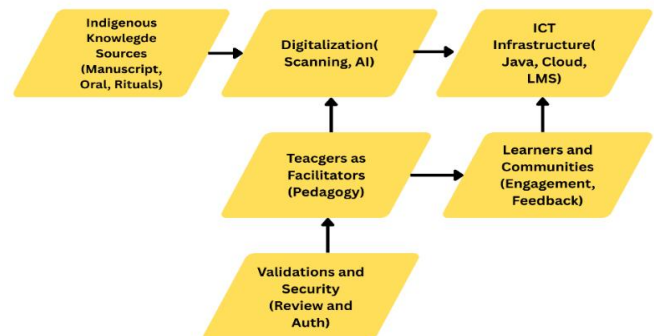


Fig. 2. ICT-Driven Indigenous Knowledge Education Framework

V. DIGITAL TOOLS AND ONLINE LEARNING PLATFORMS FOR IKS

This section of the paper represents various examples demonstrating how emerging technological developments/digital platforms enhance opportunities for people to be able to practice using technology to promote Indian Knowledge Traditions (IKTs) via contemporary educational environments. It highlights the ways in which traditional Indian knowledge is being preserved, distributed and incorporated within the modern education systems, according to the aims of NEP 2020

A. The SWAYAM Platform – Promoting Indian Knowledge Systems

The SWAYAM (Study Webs of Active Learning for Young Aspiring Minds) Platform is a Massive Open Online Course (MOOC) initiative launched by the Government of India. SWAYAM has facilitated the democratization of education

through its MOOC platform, SWAYAM, which provides Learners of all backgrounds access to the knowledge and skills found in many traditional Indian knowledge systems - Yoga, Philosophy, Sanskrit language, Ayurveda, Indian Mathematics, and Ethical Values; among many others - offered by prestigious institutions, including IITs, Central Universities, and National Institutes of Ayurveda. Through video lecture presentations, Reading Materials, Forums, Self-Assessment Quizzes, and Certification Options on each Course, the SWAYAM platform provides the means by which to transfer the knowledge through a structured

academic approach, to a wide audience of people coming from various geographic and socio-economic backgrounds. The SWAYAM platform was designed as a Multilingual MOOC to create opportunities for people to use their own native languages, as recommended under the National Education Policy (NEP) 2020, which aims to make it easier for all people, regardless of location or location of their institution, to obtain an education.

Currently, SWAYAM provides the means to close the gap between traditional forms of Knowledge and Modern Methods of Education.

TABLE 1: CASE STUDIES OF TECHNOLOGY ENABLED IKS PROMOTION

Case Study	Technology Used	IKS Domain	Educational Level	Key Outcomes
SWAYAM Platform	MOOC, LMS, Cloud	Philosophy, Yoga, Sanskrit	Higher Education	Wide accessibility, structured learning
NDLI	Digital Archiving, Metadata	Manuscripts, Texts	All levels	Preservation, authenticated access
AR/VR Applications	AR, VR	History, Architecture	School and Higher Education	Immersive learning

B. AR/VR (Augmented Reality and Virtual Reality) for Cultural and Historical Learning

Many startups and educational institutions in India are exploring the potential of AR and VR in recreating ancient Indian learning environments (Gurukuls), ancient universities such as Nalanda and Takshashila, as well as monuments like temples and observatories.

Immersive learning experiences allow students to experience the complete configuration of past educational environments, astronomical instruments, and methods of construction. The ability to learn in an interactive way helps students think about and understand history and culture better than they otherwise would. The use of AR/VR technologies in education supports the experiential and multidisciplinary approach stated in NEP 2020 and provides a strong means of preserving and revitalizing India's Knowledge Traditions.

C. National Digital Library of India (NDLI) for Preservation and Access

The NDLI (National Digital Library of India) is an extensive digital library that will collect, store, and distribute educational materials digitally. The very large collection of resources related to India's Knowledge System includes digitized manuscripts, classical works, valuable manuscripts, and research papers concerning India's knowledge system, culture, philosophy, and science. NDLI supports advanced searching, tagging of metadata, and supports multiple languages, so resources can be easily located and used for research or study. Long-term preservation of NDLI's materials will be performed through digital archives to protect ancient & rare documents from physical degradation. The institution also supports educators, researchers, and students by providing written materials that have been authenticated and verified for credibility and scholarly integrity concerning the Knowledge Traditions of India.

VI. EMERGING TECHNOLOGIES IN IKS EDUCATION

A. Artificial Intelligence in Education

Artificial Intelligence (AI) provides personalized learning experiences for students, based upon a student's learning abilities, learning habits, and ability to retain information. From an Indigenous Knowledge System (IKS) perspective, this type of personalization enables students to actively engage with culturally-based educational content in a meaningful way that is representative of their culture and context. In this instance, AI not only allows for personalization of learning but also assists students in overcoming language barriers associated with ancient texts via language processing.

B. Cloud Computing for Knowledge Preservation

The manuscripts written on palm leaves or barks of trees decay with the time leading to loss of knowledge. Thus, it becomes a necessity to preserve the indigenous knowledge materials including manuscripts, oral histories, and visual records. The cloud computing, one of the most commonly used ICT tools plays a key role here. Cloud based storage systems not only ensure the long-term availability and global accessibility but also enhances scalability and reliability. The controlled access mechanism ensures that sensitive cultural knowledge is protected from reuse. Further, to ensure scalability, security and efficient resource management of these knowledge repositories and educational platforms at the enterprise level, Java based architecture is commonly used for backend systems.

C. Augmented Reality and Virtual Reality in Learning

ICT promotes the enhancement of learning in an interactive media-rich environment by providing opportunities for students of today to learn about indigenous ways in a manner that is more user-friendly. New emerging technologies like Augmented Reality (AR) allow for the

layering of digital objects on top of the physical environment and Virtual Reality (VR) allows for the creation of an immersive virtual environment; therefore, both AR and VR will improve experiential learning and correlate closely to the ways in which indigenous people teach.

TABLE 2: EMERGING ICT TECHNOLOGIES AND THEIR ROLE IN INDIGENOUS KNOWLEDGE DIGITIZATION

ICT Technology	Role in Indigenous Knowledge Education
Cloud Computing	Long-term storage, scalability, global accessibility, and data reliability
Artificial Intelligence	Personalized learning, intelligent tutoring, content recommendation, language translation
Augmented Reality (AR)	Visualization of cultural artifacts, rituals, architecture, and historical practices
Virtual Reality (VR)	Immersive learning experiences replicating Gurukul systems and heritage environments
Data Analytics	Monitoring learner engagement, performance assessment, and learning outcomes
Multimedia Tools	Audio, video, animations, and digital storytelling for enhanced engagement

VII. SCALABLE SOFTWARE INFRASTRUCTURE FOR INDIGENOUS EDUCATION

The framework designed for Indigenous Knowledge Education using ICT will be a cohesive, expandable, and adaptable ecosystem that provides ethical safeguards, secure forms of distribution, and effective teaching/learning strategies using the incorporation of Indigenous Knowledge

into the existing system. Inter-related variables include sources of Indigenous Knowledge, digital conversion tools, ICT infrastructure, teachers as facilitators, learners, and community, as well as perpetual validation and security mechanisms.

The foundation of the proposed framework is found in the Indigenous Knowledge Sources; manuscripts, palm leaf books, traditional agricultural practices, myths, ancient holy books, folk cures, oral and aural traditions, and rituals. To maintain the integrity, meaning, and authenticity of these culturally specific and contextually based sources of knowledge, they will be digitized (converted) into standardized electronic data using high-quality scanning equipment, audio/visual recording tools, transcription equipment, and metadata tagging; for use as an archived source of Indigenous Knowledge.

When considering the overall structure of the future of information and communication technology (ICT), its next level will include many different types of media that can be found in repositories all over the world. Some examples of these types of media are: audio, video, documents, any platform for learning that can be used in a multimedia format, mobile apps, and web apps. This technology is referred to as "content intelligence technology." This type of technology will allow the person using it to personalize their experience by having the content delivered in their own language or receiving suggestions about the best way to present the information to them.

As part of that framework, teachers' role is to guide or facilitate student learning and to be cultural brokers, guaranteeing that the digital content they are using meets educational best practices, is culturally appropriate and relevant, and meets the school curriculum.

Indigenous activists, learners, and Indigenous doers or groups have an active role in providing feedback and confirming knowledge to validate and support the construction of knowledge and know-how by giving it the context and true essence of the knowledge being created.

Through a framework that incorporates continuous validation and security methods, it promotes the integrity, trust, and sustainability within the development, creation, and distribution of knowledge.

To validate knowledge from the point of view of sources used, methods include: verifying expertise in validating knowledge, validating knowledge from within a community, maintaining version control, using cryptography to secure knowledge, restricting access to sensitive knowledge, and maintaining audit trails to ensure that there will be no unauthorized access or interpretation of sensitive knowledge that may lead to misuse.

A. Java as a Scalable Platform for Indigenous Knowledge Digitization

Java has been selected as the primary technology to develop the backend infrastructure for this proposed framework because it is platform-independent, scalable, secure, and robust enough to be used in an enterprise environment. There are a number of Java-based frameworks that can be used to design modular systems that can easily integrate digital repositories, learning management systems, AI services, and cloud platforms. For instance, the Spring Boot framework

allows developers to design modular systems that can easily integrate digital repositories, learning management systems, AI services, and cloud platforms. Using Java's secure access control features, such as authentication, authorization, and encryption libraries, it is relatively easy to develop an effective access control system (for example, Indigenous knowledge preservation) and safeguard the data of Indigenous users/customers.

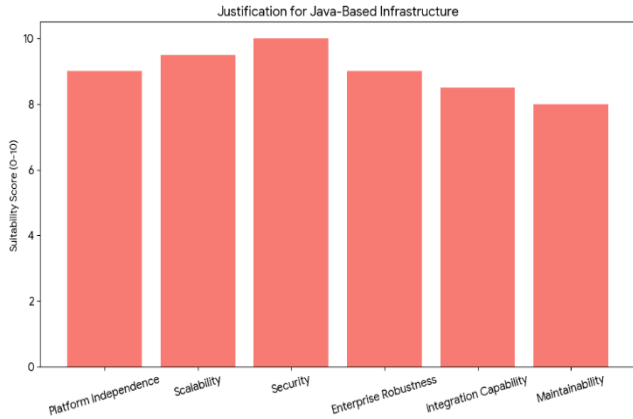


Fig. 3. Justification Graph for Java-Based Platform

Moreover, Java allows developers to design high-performance distributed systems and microservices, making it ideal for managing a large number of users accessing systems, distributing multimedia content to users, and analytics. Moreover, the interoperability features of Java with a number of databases, cloud platform, and AI tools will ensure long-term sustainability and adaptability for the proposed framework. In summary, Java will offer a trustworthy technology platform for developing a secure, scalable, and interoperable ICT-driven ecosystem for Indigenous Knowledge.

TABLE 3: JUSTIFICATION FOR USING JAVA IN THE PROPOSED FRAMEWORK

Criterion	Relevance of Java
Platform Independence	The concept of byte code in Java makes it platform independent i.e. the application can run on any operating system or device
Scalability	The scalability features of Java i.e. a support for large number of users and huge volume of data makes it relevant for digital repositories
Security	The spring framework provides built-in security features such as authentication, authorization, encryption libraries, and secure APIs
Enterprise Robustness	Java is one of the most popular languages used in enterprise level applications to ensure robustness and reliability
Integration Capability	Java can easily integrate with multiple databases, AI models, cloud services and web technologies required for ICT-driven educational systems
Maintainability	The modular architecture supported by Java enables easy maintenance and debugging with a long-term sustainability

VIII. CHALLENGES IN DIGITIZING INDIAN KNOWLEDGE SYSTEMS

Digitizing Indigenous Knowledge is a positive change for education, but still encounters many problems. For instance, rural individuals face a lack of access to digital infrastructure, inhibiting their ability to gain an education and access educational materials. The large number of languages used to document Indigenous Knowledge is also a challenge to accurately translating and interpreting Indigenous Knowledge from original sources such as manuscripts. In addition, digitizing Indigenous Knowledge must have the proper security and privacy measures in place to limit misinterpretations of knowledge and provide the validation of knowledge transferred via digital means.

TABLE 4: CHALLENGES AND MITIGATION STRATEGIES IN ICT-DRIVEN INDIGENOUS KNOWLEDGE DIGITIZATION

Challenge Area	Description	Mitigation Strategies
Digital Divide	Inadequate access of digital technologies particularly in remote areas	Promotion of mobile-based learning solutions, and increased government and institutional support
Linguistic Diversity	Challenges in the interpretation of indigenous and regional languages	Use of AI-supported translation tools, and involvement of language scholars and cultural experts
Data Security and Privacy	Threats related to unauthorized access, data misuse, and cyberattacks on culturally sensitive information	Implementation of role-based access, cryptographic algorithms and cybersecurity practices
Cultural Misrepresentation	Risk of decontextualization or distortion of indigenous practices during digital documentation	Community-based validation and expert review processes
Teacher Readiness	Insufficient digital literacy among educators	Faculty Development Programs (FDPs), and ICT skill enhancement workshops
Resistance to Technology Adoption	Reluctance among some educators and institutions to adopt digital platforms and technologies	Awareness and orientation programs with a user-friendly design
Ethical and Legal Concerns	Weak intellectual property protection	Establishment of ethical governance frameworks

IX. CONCLUSION

This study highlights how new technologies can assist in revitalizing and keeping alive the existing Indian Knowledge Systems (IKS). The benefit of combining new and immersive learning technologies with IKS has demonstrated how traditional methods of transmitting knowledge can be modernized while still retaining their integrity. However, we cannot achieve this goal if we do not address critical issues such as differing languages, unequal access to technology, how we validate knowledge, and ethics surrounding the use of technology in education. To realize this opportunity, we need to build validation tools for IKS, promote multilingual learning platforms, and develop comprehensive learning technologies that empower learners.

A multilingual and multimedia technology platform is needed that meets the needs of diverse learners. Java based educational software infrastructure will promote the digitization of indigenous knowledge system by the preservation of digital repositories in a more secured manner along with scalability.

Technology-based IKS Education has the potential to transform education globally through innovative technology solutions. The successful implementation of digitization of indigenous knowledge is not a self-dependent task but needs the active participation of teachers. The teachers must be equipped with the digital tools and ICT fundamentals along with cultural knowledge. The integration of cultural knowledge and ICT knowledge of educators will give birth to a better future of learners and in turn the better future of country. The idea is not to replace the traditional wisdom but to redesign the old patterns of study in a modern fashion.

REFERENCES

- [1] Aithal, P. S., & Aithal, S. (2019). Innovation in education through emerging technologies. *International Journal of Scientific Research and Modern Education*, 4(2), 23–30.
- [2] Bhat, A. H., & Ahmad, S. (2020). Digital learning in higher education: Opportunities and challenges. *International Journal of Educational Technology*, 5(1), 45–53.
- [3] Bhattacharya, S. (2018). Indian education systems and knowledge traditions. *Journal of Indian Philosophy*, 46(3), 389–402.
- [4] Bhushan, S. (2022). Integrating Indian knowledge systems in higher education. *University News*, 60(12), 18–25.
- [5] Chandrasekhar, C. P., & Ghosh, J. (2015). Information and communication technologies and education in India. *Economic and Political Weekly*, 50(6), 12–15.
- [6] Chatterjee, S., & Chakraborty, S. (2021). Artificial intelligence and education: Indian perspectives. *Education and Information Technologies*, 26(4), 4567–4585.
- [7] Davis, N., & Rose, R. (2007). Professional development for virtual schooling. *Journal of In-Service Education*, 33(4), 461–476.
- [8] Deshpande, S. (2020). Reviving ancient Indian education system. *Indian Journal of Educational Studies*, 57(2), 101–112.
- [9] Dey, S., & Mukherjee, A. (2022). Digital preservation of Indian manuscripts. *Journal of Cultural Heritage Management*, 8(1), 55–67.
- [10] Government of India, Ministry of Education. (2020). *National Education Policy 2020*. Government of India.
- [11] Goyal, M., & Singh, R. (2021). Blended learning models in Indian higher education. *International Journal of Learning and Teaching*, 13(3), 203–212.
- [12] Gupta, A., & Sharma, S. (2019). Role of ICT in Indian education. *International Journal of Computer Applications*, 178(7), 25–30.
- [13] Harsh, M., & Suresh, M. (2020). Cloud computing in education. *Procedia Computer Science*, 172, 798–805.
- [14] Iyengar, R. (2018). Education as the practice of freedom in India. *Comparative Education Review*, 62(2), 233–250.
- [15] Joshi, K. (2017). Knowledge traditions and Indian culture. *Indian Historical Review*, 44(1), 90–105.
- [16] Kaur, G. (2020). Digital divide in Indian education. *Journal of Social Sciences*, 12(4), 211–219.
- [17] Kumar, A., & Rani, S. (2021). Gamification in education: A review. *Education and Information Technologies*, 26(2), 1815–1835.
- [18] Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017–1054.
- [19] Mohanty, S. (2021). Indian knowledge systems: Policy and practice. *Higher Education for the Future*, 8(1), 34–49.
- [20] Mukherjee, S., & Dutta, P. (2020). AR and VR in education. *International Journal of Educational Technology*, 7(2), 88–97.