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Evolution of Open Educational Resources in the Artificial Intelligence Age

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Abstract

Open Educational Resources (OER) have emerged as a transformative movement in global education, aiming to democratize knowledge by providing free, openly licensed learning materials that can be accessed, reused, and adapted by educators and learners worldwide. The concept of OER was formally recognized in the early 2000s through international initiatives led by organizations such as UNESCO, which defined OER as educational resources released under open licenses that permit free access, modification, and redistribution. The evolution of Open Educational Resources (OER) in India reflects a dynamic progression from foundational digital repositories to AI-augmented, adaptive ecosystems that address the nation's unique challenges of scale, multilingualism, and equity. Globally inspired by the 2001 MIT OpenCourseWare movement and the 2002 UNESCO coined term "OER". India's journey began in earnest with early 2000s initiatives such as the National Program on Technology Enhanced Learning (NPTEL, 2003), the National Repository of Open Educational Resources (NROER), OSCAR, and SHAKSHAT under the National Mission on Education through ICT. This paper examines the evolution of Open Educational Resources in the Artificial Intelligence age. It highlights key milestones, technological advancements, policy frameworks, and emerging trends that shape the contemporary OER landscape. The study also discusses the opportunities and challenges associated with integrating AI into OER development, emphasizing the need for ethical practices, quality assurance, and sustainable open education ecosystems.

Keywords: Open Educational Resources (OER), Artificial Intelligence (AI), Generative Artificial Intelligence (GAI), Open Pedagogy, Open Educational Practices (OEP), AI Literacy

1. Introduction

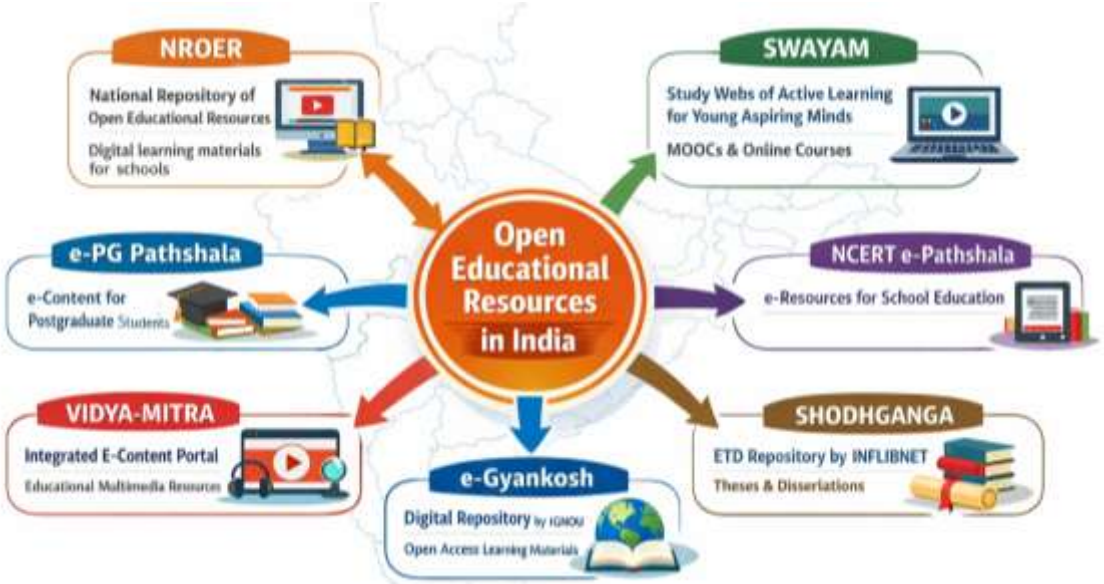
Artificial intelligence (AI) is widely recognized as a pivotal technology shaping both the present and the future. It is 'transforming our world' (United Nations, 2024, p. 7). Generative artificial intelligence (AI), leveraging

advanced data processing and pattern-recognition capabilities, presents significant opportunities to develop, personalize, and curate OER content while improving its accessibility across diverse learner and regional contexts. It is an opportunity to student productivity and creativity in the context of open pedagogy and non-disposable assignments (Wiley and Hilton 2018). The primary aim of this article is to explore the impact of Open Educational Resources in the AI Age and use of Open Educational Resources.

The evolution of Open Educational Resources (OER) has been one of the most transformative developments in education over the past two decades. Open Educational Resources defined as teaching, learning, and research materials that reside in the public domain or are released under open licenses (such as Creative Commons) enable free access, use, adaptation, and sharing. This movement began gaining momentum in the early 2000s with initiatives like MIT's OpenCourseWare (2001) and UNESCO's promotion of OER, driven by goals of reducing educational inequality, lowering costs for students, and fostering global collaboration. By the 2010s and early 2020s, OER had matured into a robust ecosystem repositories like OER Commons, MERLOT, and institutional presses grew; adoption increased in higher education and research demonstrated impacts on student success, retention, and equity. The COVID-19 pandemic accelerated this shift by highlighting the need for flexible, digital, and cost-free materials in remote and hybrid learning environments.

The arrival of generative artificial intelligence (GenAI) since late 2022 particularly tools like ChatGPT, subsequent large language models, and multimodal systems has ushered in what many describe as the "AI Age" for education. This marks a profound new phase in OER's evolution, shifting from static, human-authored resources toward dynamic, intelligent, and hyper-personalized ones.

Key aspects of this transformation include dramatically lower barriers to creation and adaptation GenAI tools enable rapid generation of drafts for textbooks, quizzes, exercises, lesson plans, and ancillary materials. Educators can now remix and customize OER in minutes rather than months, addressing one of the longstanding challenges the time and effort required for revision/remixing. This has the potential to explode the volume, diversity, and relevance of available OER, especially for niche subjects or underrepresented contexts. Personalization at scale AI integrates with OER to create adaptive learning paths, recommend resources based on performance and preferences, generate real-time feedback, and even produce interactive or conversational elements (e.g., AI tutors drawing from open content). Platforms increasingly combine OER with AI for tailored experiences, moving beyond one-size-fits-all textbooks toward living, responsive materials.



This fusion of openness and intelligence holds immense promise for democratizing high-quality, adaptive education worldwide, while demanding continued vigilance to preserve the core values of equity, transparency, and human-centered learning that have defined OER from the beginning.

Open Educational Resources (OER) in India provide free, high-quality, and openly licensed digital learning materials to enhance access and equity in education, ranging from school (K-12) to higher education. Key initiatives include the National Repository of Open Educational Resources (NROER), SWAYAM, NPTEL, and the National Digital Library of India.

NROER (National Repository of Open Educational Resources): A major government initiative offering e-books, audio, videos, and interactive modules for school education across multiple languages.

SWAYAM: An indigenous platform providing Massive Open Online Courses (MOOCs) covering school and higher education, enabling self-paced learning.

NPTEL (National Programme on Technology Enhanced Learning): Joint venture by IITs/IISc offering free online engineering and science courses.

e-PG Pathshala: An initiative by the MHRD (now Ministry of Education) providing high-quality, curriculum-based, interactive e-content for postgraduate subjects.

e-GyanKosh: A national digital repository managed by IGNOU, housing over 1,25,000 self-learning materials.

Shodhganga (INFLIBNET Centre): A repository of Indian Electronic Theses and Dissertations, allowing open access to full-text, Ph.D. and M.Phil. Research.

Vidya-Mitra: A web-based interface called "Vidya-mitra an Integrated e-Content Portal" for all e-content projects, developed/funded under the National Mission of Education through ICT. There are more than 50 projects on e-content under NME-ICT which are developed/being developed in various subject disciplines (science, arts, engineering, social science, etc) through various Indian institutes/universities/colleges.

2. Literature Review

The digital era accelerated OER's formalization. Coined in 2002, OER was defined by the Organization for Economic Co-operation and Development (OECD) in 2007 as adjustable digital assets without usage restrictions. UNESCO's 2012 Paris OER Declaration and 2022 definition emphasized public domain materials for adaptation and redistribution. Key milestones include the 2019 UNESCO OER Recommendation, adopted by 193 member states to align with the 2030 Sustainable Development Goals, and funding from the William and Flora Hewlett Foundation for projects like OpenLearn and ISKME. The digital era accelerated OER's formalization. Coined in 2002, OER was defined by the Organisation for Economic Co-operation and Development (OECD) in 2007 as adjustable digital assets without usage restrictions. UNESCO's 2012 Paris OER Declaration and 2022 definition emphasized public domain materials for adaptation and redistribution. Key milestones include the 2019 UNESCO OER Recommendation, adopted by 193 member states to align with the 2030 Sustainable Development Goals, and funding from the William and Flora Hewlett Foundation for projects like OpenLearn and ISKME.

The most prominent learning scenarios in education are face-to-face classroom instruction, online learning and blended learning (Singh et al., 2021). The core educational principles of Open Educational Resources (OER) are embodied in the '5R' framework retain, reuse, revise, remix, and redistribute which are legally enabled through Creative Commons licensing (Wiley, 2015). The scope of open education now extends far beyond open resources to include structural changes in pedagogy, the learning experience, and evaluation techniques (Cronin, 2017). It is asserted that GenAI is now involved in reshaping how content is generated, copyright is understood, and customized learning is enacted, thus posing difficulties to the static concept of OEP (Bozkurt, 2023). In the context of education, openness is a dynamic and multifaceted concept (Baker, 2017) involving aspects such as accessibility, flexibility, equity, collaboration, agency, democratization, social justice, transparency and the removal of barriers (Zawacki-Richter et al., 2020).

3. Evolution of OER (Historical Analysis)

Evolution of OER: From Static Content to Digital Ecosystems

The **evolution of Open Educational Resources (OER)** reflects broader shifts in technology, pedagogy, and access to knowledge. OER defined as teaching, learning, and research materials in any medium that reside in the

public domain or are released under open licenses permitting no-cost access, use, adaptation, and redistribution began as largely static, shareable digital content but has matured into interconnected **digital ecosystems** that support dynamic, collaborative, and inclusive education.

Early Phase: Static Content and Repositories

Late 1990s-Early 2010s OER originated from ideas of open knowledge sharing, drawing parallels with open-source software. In 1994 the concept of reusable "learning objects" emerged, laying groundwork for modular digital materials. From 1999-2002 MIT's OpenCourseWare (OCW) launched in 2002 making full course materials freely available online. This marked the formal birth of large-scale OER, focusing on static resources like lecture notes, syllabi, videos, and readings. Early 2000 initiatives like Connexions (now OpenStax CNX) and repositories (e.g., MERLOT) emphasized discoverable, downloadable static content PDFs, slides, and videos licensed under Creative Commons for reuse.

During this period, OER were primarily static fixed documents or media in repositories, aimed at reducing costs and widening access. Challenges included fragmented discovery, limited metadata, and a focus on "one-way" sharing rather than interaction.

Transition Phase: Remixing, Collaboration, and Open Practices

Between 2010-2020 as awareness grew, the focus shifted from mere access to **reuse and adaptation** (the "5Rs" retain, reuse, revise, remix, redistribute). In this era saw rise of open textbooks (e.g., OpenStax) and platforms like OER Commons, which added authoring tools and curation. Emphasis on **Open Educational Practices (OEP)**: Educators and learners not just consuming but contributing-remixing materials, co-creating curricula, and integrating OER into pedagogy. Integration with MOOCs and online learning, where OER supported dynamic elements like interactive modules and community-driven updates. Barriers persisted, such as quality concerns, discoverability issues, and institutional resistance, but reports (e.g., from Hewlett Foundation) highlighted an emerging "ecosystem" with supply (creation), demand (adoption), and policy support.

Current Phase: Digital Ecosystems

In 2020-2026 by the mid of 2020 OER have evolved into **interconnected digital ecosystems** networks of platforms, tools, communities, and technologies enabling adaptive, collaborative, and AI-enhanced learning. Key developments are

Integrated platforms: OER commons hubs, micro sites, and collaborative tools foster "commons" mindsets, with features for curation, evaluation, and group sharing.

Dynamic and interactive content: Beyond static files, OER now incorporate simulations, adaptive elements, multimedia, and user-updated resources.

Open Educational Practices and pedagogy: OER-enabled approaches allow learners to revise materials, contribute knowledge, and engage in situated, collaborative learning.

Policy and global momentum: UNESCO's 2019 Recommendation on OER (reinforced by events like the 2024 Dubai Declaration) promotes OER as **digital public goods**, emphasizing inclusive access, AI integration, and sustainability.

AI and emerging tech integration: Generative AI supports personalized OER creation/adaptation, while ecosystems connect with LMS, analytics, and open infrastructures for seamless reuse.

In 2025-2026, trends show OER as part of broader digital learning shifts: cost savings, equity, and hybrid models. Adoption grows (e.g., rising faculty familiarity), with ecosystems addressing fragmentation through better aggregation, quality controls, and interoperability. This progression from isolated static resources to vibrant, participatory ecosystems transforms education by prioritizing affordability, inclusivity, and innovation in a knowledge society. As platforms evolve with AI and collaborative tools, OER continue to democratize high-quality education worldwide.

4. Role of Artificial Intelligence in OER in Indian Context

Open Educational Resources (OER) refer to freely accessible teaching, learning, and research materials that can be used, adapted, and shared under open licenses. In India, with its vast educational ecosystem serving over 260 million school students and 40 million in higher education integrating Artificial Intelligence (AI) into OER holds immense potential for personalization, scalability, and equity. AI enhances OER by enabling adaptive content creation, multilingual translation, automated assessments, and teacher support tools, aligning with the National Education Policy (NEP) 2020's emphasis on technology driven inclusive education.

Key Initiatives and Examples in India

Several governments, international, and private initiatives are pioneering AI-OER integration:

Commonwealth of Learning (COL) Pilot Project: In collaboration with the Central Board of Secondary Education (CBSE) and National Council of Educational Research and Training (NCERT), COL launched a national consultation in November 2024 to explore AI-powered OER for improved learning outcomes. A key pilot targets Grade 9 mathematics, using a Human-in-the-Loop (HITL) approach where teachers refine AI-generated content. COL's AI-integrated OER platform supports lesson planning, peer review, curriculum alignment, and adaptation of openly licensed materials, with over 50 educators trained in its use. This initiative draws from global pilots in Ghana and the Pacific, emphasizing equitable, adaptive resources.

DIKSHA and MindCraft Platforms: The government's DIKSHA platform, expanded during COVID-19, reached nearly two million households in states like Jharkhand and Rajasthan, delivering OER via basic mobiles and WhatsApp. AI enhancements include Natural Language Processing (NLP) for translating English textbooks into vernacular languages and generating voice-assisted explanations for tribal learners. MindCraft, an AI-powered OER tool, provides personalized content with visual cues and interactive problem-solving, supporting rural students and saving teachers 20-30% of planning time.

NEP 2020 and CBSE Curriculum Integration: NEP 2020 mandates AI education from Grades VI-XII, with CBSE partnering IBM for generative AI training and developing an AI Facilitator Handbook with Intel. AI tools suggest real-time OER supplements, multilingual quizzes, and adaptive lesson plans, bridging dialectal gaps in languages like Tamil and Hindi. The Indian Council of Secondary Education (CISCE) will introduce AI and robotics from 2025-26.

EY-Reported EdTech Trends: AI-driven platforms generate self-paced quizzes, dashboards for student weaknesses, and diverse content formats (e.g., videos, infographics) tailored to learning styles. Tools like Duolingo for Autism and Auticare (from India's Department of Science and Technology) use AI to adapt OER for special needs, promoting inclusive education.

OpenAI-ARISE Collaboration: In September 2025, OpenAI partnered with the Association for Reforms in Indian Schools and Education (ARISE) to train K-12 educators in AI for lesson planning and student engagement. While not explicitly OER focused, it emphasizes ethical AI to enhance pedagogy in diverse Indian contexts, aligning with broader OER adaptation efforts.

Artificial Intelligence (**AI**) plays a transformative and increasingly central role in **Open Educational Resources** (**OER**), which are freely accessible, openly licensed teaching, learning, and research materials that can be used, adapted, and shared.

AI enhances the creation, accessibility, personalization, and sustainability of OER, addressing long-standing barriers like time-intensive development, limited localization, and discoverability. As of 2026, generative AI tools (e.g., large language models) combined with OER principles are accelerating equitable education worldwide, as emphasized in initiatives like the **UNESCO Recommendation on OER** (2019) and the **Dubai Declaration on OER** (2024), which highlight integrating AI and emerging technologies for inclusive knowledge access.

5. Conceptual Model: AI-Driven OER Ecosystem

1. Content Generation and Co-Creation: AI dramatically speeds up OER development by generating high-quality drafts of textbooks, lessons, activities, practice problems, interactive elements, and ancillaries (e.g., quizzes, slides, summaries). Educators provide prompts, subject expertise, and refinements to ensure accuracy, pedagogical soundness, and alignment with learning objectives. This has enabled projects like rapid open textbook production (e.g., in months rather than years) and "generative OER" resources explicitly designed to spawn other OER.

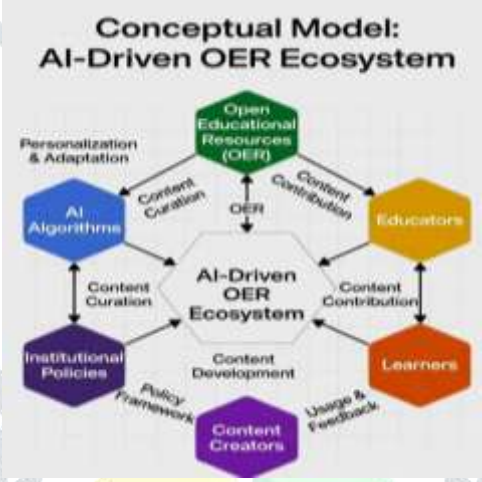
2. Curating, Discovering, and Recommending OER: AI tools search across repositories (e.g., OER Commons, Press books), evaluate relevance, translate materials, identify gaps, and recommend resources based on user needs, learner performance data, or course context. This improves discoverability and helps educators quickly assemble tailored collections.

3. Adaptation and Contextualization (Personalization & Localization): AI customizes existing OER by Adjusting reading levels or complexity. Localizing examples, cultural references or languages. Adding accessibility features (e.g., alt text, simplified explanations, support for colorblind users). Generating multiple

formats (text, audio, interactive) this supports diverse learners, including non-native speakers and underrepresented regions, advancing equity in STEM and other fields.

4. Updating and Maintaining OER: AI helps keep resources current by incorporating recent developments, revising outdated sections, or suggesting improvements - reducing the maintenance burden that often limits OER reuse.

5. Supporting AI Literacy through OER (Two-Way Relationship): OER are increasingly used to teach AI concepts and ethical use across K-12, higher education, and professional training (e.g., platforms like AI Campus). Conversely, AI-powered OER build broader AI literacy and competencies.



Benefits and Opportunities

Scalability: Rapid, low-cost production in resource-scarce contexts.

Equity: Broader access, multilingual support, culturally relevant materials.

Innovation: Interactive, adaptive, and personalized learning experiences.

Cost savings: Reduced textbook expenses and development time.

Challenges and Considerations: Ethical use (avoiding copyright infringement, bias in AI outputs). Quality control (AI "hallucinations," factual errors) human oversight remains essential. Transparency (disclosing AI use in OER creation). Sustainability (ensuring AI-enhanced OER remain openly licensed and editable). Institutions and systems (e.g., in the US, Mexico, and via UNESCO) have issued guidelines for responsible generative AI use in OER, emphasizing human-AI collaboration. Overall, AI is shifting OER from static repositories toward dynamic, intelligent ecosystems making education more inclusive, responsive, and innovative when guided by educators' expertise and open principles.

Here are the key benefits of AI-enabled OER

Rapid and Scalable Content Creation: Generative AI dramatically reduces the time and effort needed to produce high-quality educational materials. AI can automatically generate textbooks, lessons, worksheets, quizzes, summaries, flashcards, activities, and ancillaries (e.g., slide decks or podcasts) based on curriculum guidelines or learning objectives. This expands the overall availability of OER and makes it feasible to create resources for niche or underserved subjects.

Personalization and Adaptive Learning: AI analyzes learner data (performance, style, interests, and pace) to tailor OER experiences. It recommends relevant resources, adjusts difficulty levels, localizes examples, or generates customized content. This fosters more engaging, inclusive, and effective learning, helping diverse students including those with special needs achieve better outcomes.

Efficient Updating and Maintenance: AI keeps OER current by identifying gaps, inaccuracies, or outdated content and generating revisions based on new developments. This ensures materials remain relevant without requiring full manual rewrites, supporting long-term sustainability.

Enhanced Curation, Discovery, and Recommendation: AI-powered tools search across OER repositories, evaluate quality, translate materials, suggest the best fits for specific needs, and highlight missing elements. This makes it easier for educators and learners to find and adopt high-quality, context-appropriate resources.

Improved Accessibility and Inclusivity: AI generates alternative formats (e.g., audio versions, simplified text, and alt text for images), supports translations, and promotes equitable access. Combined with OER's zero-cost model, this reduces barriers related to geography, economics, language, or disability, aligning with goals like those in the UNESCO OER Recommendation.

Support for Educators and Innovative Practices: AI streamlines ancillary creation, proofreading, outlining, and administrative tasks, freeing instructors to focus on pedagogy, interaction, and student support. It enables modular, interactive formats (videos, exercises) and fosters innovative teaching while maintaining open licensing for collaboration and remixing.

Cost Reduction and Broader Impact: By lowering production barriers, AI amplifies OER's traditional advantages (affordability, student success gains, equity). It promotes scalable, high-quality education globally, potentially transforming access in resource-limited settings.

Overall, AI-enabled OER builds on the open movement's foundation of permission and agency (via open licenses) while leveraging AI's speed and intelligence. This creates more dynamic, interactive, and learner-

centered experiences though responsible use (e.g., verifying accuracy, addressing biases, ensuring ethical application) remains essential for maximizing these benefits.

6. Challenges and Ethical Concern

AI's opacity and data intensity raise profound ethical issues in OER, threatening core principles like equity and transparency. Unlike traditional OER, AI-generated resources can perpetuate biases from training data, amplifying inequalities for underrepresented groups. UNESCO's AI in Education guidelines stresses human-centered approaches to mitigate these.

Major concerns include:

Algorithmic Bias and Equity: AI inherits societal prejudices, leading to culturally misaligned or discriminatory content. This undermines OER's inclusivity goals, especially for diverse learners (e.g., indigenous or disabled communities). Mitigation requires diverse datasets and human oversight.

Privacy and Data Governance: GenAI collects vast user data without consent, risking violations of GDPR/CCPA. In OER, this includes learner performance metrics used for personalization, vulnerable to inference attacks. Ethical development demands transparent, self-hosted open-source models.

Plagiarism and Authorship: AI blurs lines of originality; generated content can't be authored ethically, complicating attribution in openly licensed works. Detection tools fail, eroding academic integrity. Recommendations include disclosing AI use and applying CC0 licenses for low-human-input outputs.

Overreliance and Human Agency: Excessive dependence on AI may stifle critical thinking and pedagogical innovation, conflicting with OEP's emphasis on reflection and collaboration. Broader risks involve misinformation and security threats like prompt injections.

The Dubai Declaration advocates ROAM-X principles (Rights, Openness, Accessibility, etc.) to embed ethics, urging block chain for attribution and green AI practices.

7. Future Directions: Toward AI-Empowered Open Ecosystems

Looking ahead, OER/OEP in the AI age will pivot to "clever ecosystems" prioritizing human-AI symbiosis, equity, and innovation. Key directions include:

Frameworks and Competencies: Adopt the AI-empowered Open TPACK Framework (2026), which embeds AI as core infrastructure across content, pedagogy, technology, and openness. This enables "smart instructional

design" where teachers co-pilot AI for personalized OER adaptation. Professional development should focus on AI literacy, bias evaluation, and ethical prompting.

Policy and Standards: Update OER guidelines (e.g., UNESCO's 2019 Recommendation) for AI, incorporating machine-readable licenses, block chain for attribution, and impact metrics. Promote open-source AI models for transparency and interoperability.

Inclusive and Sustainable Practices: Leverage Universal Design for Learning (UDL) with AI for "accessible-first" resources, including localization via diverse datasets. Fund green AI (e.g., efficient models) and multi-stakeholder networks for shared metadata and research.

Innovative Applications: Scale AI tutors and companions in public education, as in OpenAI's school tools (2026) for safe adoption. Decentralized platforms like OpenLedger could create "Open Courseras" where creators own AI-enhanced content.

Global Solidarity: Foster international cooperation for curricula on AI ethics and knowledge exchange, ensuring OER evolves into resilient, culturally relevant systems.

By 2030, with 40% of job skills AI-disrupted, these directions position OER as a cornerstone for equitable Education 4.0 human-led, AI-augmented, and truly open. As Dr. David Wiley notes, AI could solve long-standing OER challenges like Benjamin Franklin's vision of universal access, through conversational, adaptive experiences.

8. Conclusion

The integration of **Open Educational Resources (OER)** into the **AI age** represents one of the most transformative shifts in education since the open movement began over two decades ago. As generative AI reshapes how content is created, personalized, adapted, and delivered, OER rooted in principles of openness, sharing, affordability, and collaboration face both existential challenges and unprecedented opportunities.

In the AI age, OER have evolved from fixed open artifacts to living, generative ecosystems that promise unprecedented personalization and accessibility but only if quality, ethics, and human agency are prioritized. As Bozkurt (2023) observes, GenAI reconfigures openness into a “new front,” while Wiley (2024) and OECD (2026) underscore the need for deliberate design. By integrating lessons from 25 above years of OER advocacy with responsible GenAI practices, education can become more inclusive, efficient, and innovative. Ongoing collaboration among researchers, policymakers, and practitioners guided by frameworks like UNESCO’s Dubai Declaration will determine whether this evolution fulfills its democratic potential.

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