Integrating New Technologies into Teaching and Learning is a timely and comprehensive book that examines how emerging digital technologies are reshaping the higher education landscape. It was developed within the framework of the CBOL (Online Cross-Border University Library) project, a cross-border initiative between Romania and the Republic of Moldova designed to ensure equitable access to high-quality digital educational resources.

The book explores both conceptual frameworks and practical applications of technology in education. It addresses the digitization of libraries, artificial intelligence in assessment and tutoring, learning analytics for monitoring student progress, and the integration of virtual and augmented reality in technical and medical training. Additional chapters analyze gamification strategies, the use of IoT laboratories, and the development of hybrid online learning platforms. Each section combines theoretical insights with case studies and reflective exercises, making the material suitable for academic courses, professional development, and policy discussions.

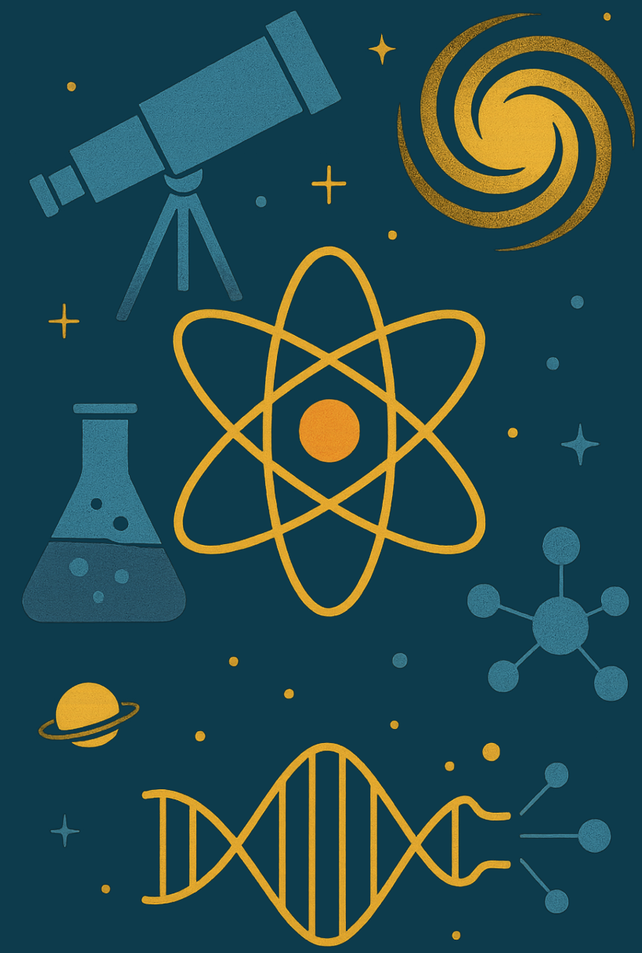
A distinctive feature of the work is its critical perspective on challenges and limitations. It does not merely advocate for technological adoption but carefully examines issues such as costs, infrastructure gaps, staff training, and the ethical implications of data use in education. By doing so, the book emphasizes that the digital transformation of higher education is not only a technical process but also a profound pedagogical and institutional shift.

Ultimately, this work positions technology as a catalyst for student-centered, interactive, and inclusive education. It argues that digital innovation, when strategically integrated, can foster creativity, interdisciplinary collaboration, and lifelong learning, preparing graduates for the dynamic demands of the knowledge economy and the digital society.

TURKUAZ
Kongre Eğitim Yayıncılık

INTEGRATING NEW TECHNOLOGIES INTO TEACHING AND LEARNING
Silvius STANCIU

# INTEGRATING NEW TECHNOLOGIES INTO TEACHING AND LEARNING



Silvius STANCIU

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# INTEGRATING NEW TECHNOLOGIES INTO TEACHING AND LEARNING

**Silvius STANCIU**

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# TABLE OF CONTENTS

**“Online Cross-Border University Library for Equitable Access to High-Quality Educational Services ROMD00388 – CBOL.”**

**SILVIUS STANCIU**

# INTEGRATING NEW TECHNOLOGIES INTO TEACHING AND LEARNING

The material was developed as documentation for teaching the training programme “Integrating New Technologies into Teaching and Learning”, carried out within the project “Online Cross-Border University Library for Equitable Access to High-Quality Educational Services ROMD00388 – CBOL”.

This course support material was prepared with the assistance of artificial intelligence technologies (ChatGPT – OpenAI), with the author assuming the role of editor, critical reviewer, and content adapter.

The material reflects a combination of automatically generated resources and personal expertise, integrated for educational purposes.

**Galati**

**2025**

# Declaration of Originality and AI Use

I, the undersigned, Stanciu Silvius, author of the work entitled “Integrating New Technologies into Teaching and Learning”, hereby declare the following:

The work is the result of my own documentation, writing, and content organization, carried out for educational and scientific purposes.

In the preparation process, I used generative artificial intelligence tools (particularly ChatGPT – OpenAI) strictly as technological support for drafting, structuring, and formulating texts.

The AI-generated content was critically reviewed, supplemented, and adapted by the author to meet academic and curricular requirements.

All external sources of information used are cited and listed in the references, in accordance with APA standards (7th edition).

The material does not constitute plagiarism, and the author assumes full responsibility for the accuracy, originality, and use of the content.

This work represents a course support material intended exclusively for educational activities and does not aim to replace individual research or the critical teaching–learning process.

Date: August 24, 2025

# INTRODUCTION

Technological transformations over the past two decades have radically redefined the way higher education is conceived and delivered. The development of information and communication technologies (ICT) has enabled the transition from traditional, teacher-centred models of direct instruction to flexible and interactive models in which the student becomes the main actor of his or her own learning process. The COVID-19 pandemic significantly accelerated this process, demonstrating that digitalization is no longer an option but an essential condition for the continuity and quality of education (Bond et al., 2021).

Currently, digital platforms, Learning Management Systems (Moodle, Canvas, Blackboard), hybrid solutions (Google Classroom, Microsoft Teams), and interactive tools (Nearpod, Wizer.me, Desmos, Woot Math) have radically changed the educational landscape. They provide unlimited access to resources, facilitate collaborative learning, and enable the personalization of education, adapting content to the pace and needs of individual students (Henderson et al., 2017).

At the same time, the integration of emerging technologies such as artificial intelligence, learning analytics, augmented reality, and IoT laboratories is transforming the classroom into an intelligent ecosystem where human–machine interaction generates authentic and interdisciplinary learning experiences (Zawacki-Richter et al., 2019).

However, this shift also requires methodological adaptation: moving from teacher-centered instruction to student-centered learning, emphasizing critical and collaborative thinking, and ensuring equitable access to resources, including for students with special needs. At the same time, new challenges emerge—from high costs and the need for adequate infrastructure to ethical and data security risks.

Thus, the integration of digital technologies in higher education is not merely a modernization of teaching tools but a paradigm shift. The new approach requires a rethinking of curricular strategies, the role of the teacher, and the way students' competences are assessed, in order to train graduates capable of meeting the dynamics of the labor market and the challenges of the digital society.

**Structure of the Book**

This work is structured to provide a comprehensive overview of the potential, limitations, and applicability of digital platforms in the university environment:

Chapter 1 presents the CBOL project (Online Cross-Border University Library), a concrete example of a European cross-border initiative supporting equitable access to digital educational resources for Romania and the Republic of Moldova. The project has a demonstrative value, showing how external funding can support the modernization of university infrastructure and the creation of common platforms for learning, research, and academic cooperation.

Chapter 2 addresses previous cross-border collaboration models of "Dunărea de Jos" University of Galați (UDJG), such as the PROSANA project. It illustrates the experience gained in managing international projects and how best practices in the field of health can be transferred and adapted to the digitalization of education.

Chapter 3 analyzes the role of partner institutions, particularly universities and university libraries in Galați and Chișinău, which become central actors in the knowledge ecosystem. It highlights the existing infrastructure, collections, and platforms already in use, as well as their potential to support a digitalized and equitable educational process.

Chapter 4 focuses on other digital platforms useful in the educational process, such as Liveworksheets, Wizer.me, Woot Math, Desmos, Nearpod, and FlexiQuiz. Each platform is described in terms of functionalities, examples of university use, and pedagogical benefits, with emphasis on their practical value for teaching, assessment, and student engagement.

The CBOL project – Online Cross-Border University Library for Equitable Access to High-Quality Educational Services (ROMD00388) illustrates how ICT can be implemented in a cross-border framework, supporting free access to information and digital resources. The common platform developed by the partner universities of Galați and Chișinău meets both the objectives of modernizing the educational process and those of European integration, strengthening academic cooperation and reducing digital gaps between states.

CBOL thus becomes a good practice example, showing how projects funded under Interreg NEXT Romania–Republic of Moldova can support digital education, preparing universities and students for the challenges of the knowledge-based society.

# 1. PROJECT "ONLINE CROSS-BORDER UNIVERSITY LIBRARY FOR EQUITABLE ACCESS TO HIGH-QUALITY EDUCATION SERVICES ROMD00388 – CBOL"

The CBOL project – Online Cross-Border University Library for Equitable Access to High-Quality Educational Services – represents a concrete example of European cross-border cooperation in the field of education, funded through the Interreg NEXT Romania–Republic of Moldova 2021–2027 Programme.

The total value of the project is €331,481.72, of which €298,333.54 comes from non-reimbursable European Union funds, while €33,148.18 represents the co-financing provided by the two universities. These financial resources are directed towards the development of digital infrastructure, the acquisition of equipment, and the creation of a joint educational platform for Romania and the Republic of Moldova.

## 1.1. Interreg NEXT Romania–Republic of Moldova 2021–2027 Programme (ROMD)

**Context and Rationale**

The main objectives of the Interreg 2021–2027 Programme focus on promoting cross-border, transnational, and interregional cooperation in Europe. This includes strengthening collaborative governance, ensuring safety and security, and supporting the transition towards a green and digital economy (Interreg NEXT Romania–Republic of Moldova, n.d.).

**General Objectives of Interreg 2021–2027**

**Strengthening collaborative governance:** Improving cooperation between regions and Member States by supporting dialogue and the exchange of best practices**.**

**Promoting cross-border cooperation:** Funding projects aimed at addressing common problems across borders, such as transport, environment, or health.

**Supporting the green and digital transition**: Investments in clean energy, circular economy, sustainable urban mobility, and digitalization.

**Increasing resilience**: Supporting adaptation to climate change and risk management.

**Improving social inclusion**: Implementing the European Pillar of Social Rights, with emphasis on employment, education, and poverty reduction.

**Sustainable territorial development**: Promoting the integrated development of territories, including rural and urban areas, through local initiatives.

**Key aspects of Interreg 2021–2027:**

**Four components:** cross-border cooperation, transnational cooperation, interregional cooperation, and cooperation in outermost regions.

**Investment priorities:** focused on innovation, green transition, connectivity, social inclusion, and better governance.

**European funds:** supporting Interreg objectives through the European Regional Development Fund (ERDF), the European Social Fund Plus (ESF+), the Cohesion Fund, and the European Maritime and Fisheries Fund (EMFAF).

**Interreg NEXT Romania–Republic of Moldova 2021–2027**

Interreg NEXT Romania–Republic of Moldova 2021–2027 is a cross-border cooperation programme financed by the European Union through the Neighbourhood, Development and International Cooperation Instrument (NDICI–Global Europe) and co-financed by the participating states.

**Total budget allocated**: approximately €85.9 million

**EU contribution (non-reimbursable):** about €77.3 million (European Commission, 2022; Interreg NEXT Romania–Rep. Moldova, n.d.)

The programme aims at the integrated development of the Romania–Republic of Moldova border regions, supporting joint projects designed to reduce economic and social disparities, strengthen infrastructure, and foster collaboration between communities, universities, local authorities, and the business sector.

Furthermore, studies highlight cross-border challenges from the citizens' perspective, including the need for legislative harmonization for effective implementation and the need for modern administrative and technological resources (Profiroiu, Nastacă & Brișcariu, 2025).

**Eligible Area**

The programme covers territories located in the proximity of the border:

- **Romania** – the counties of Botoșani, Iași, Vaslui, Galați.
- **Republic of Moldova** – the entire national territory is eligible for partnerships.

This delimitation reflects both the interest in promoting direct cooperation between border communities and in involving actors from across the Republic of Moldova in partnerships with Romanian institutions.

**Specific Objectives and Funding Axes**

The programme is aligned with the EU Cohesion Policy and the Policy Objectives (PO) defined for 2021–2027. Interreg NEXT Romania–Republic of Moldova provides funding for projects in fields such as education, climate change, culture, tourism, good governance, and emergency management.

- **Priority 1: Green Communities**
- **Priority 2: Social Development across Borders**
- **Priority 3: Cross-Border Cooperation**

**Main funding axes in the 2021–2027 call for projects:**

- **Education** – support for academic cooperation, vocational training, and equal access to digital education.
- **Climate change and adaptation** – biodiversity protection, natural risk management (floods, droughts, etc.), and cross-border resilience.
- **Health and social inclusion** – improved medical services, access for vulnerable groups, and cooperation in social and healthcare fields.

- **Culture and tourism** – enhancing cultural heritage, developing sustainable tourism, and fostering social inclusion through culture.
- **Governance and cross-border security** – strengthening institutional capacity, administrative cooperation, and border management.

*Additional related domains mentioned in official documents:*

- **Environment and green infrastructure** – development of green communities and sustainable management of natural resources.

**Eligible Beneficiaries**

- **Universities and research institutes** – for education, academic cooperation, innovation, and digitalization projects.
- **Local and regional public authorities** – for social infrastructure, health, environment, and administrative cooperation projects.
- **NGOs and community development associations** – for social, cultural, inclusion, or tourism projects.
- **Chambers of commerce, clusters, SMEs** – particularly in innovation, local development, and transfer of best practices (generally in partnership with public or academic institutions) (Euro-Access, 2025; Turșie, 2022).

**Types of Projects Financed**:

- **Major projects** – €40,317,100 (investments in educational, medical, cultural, and environmental infrastructure).
- **Small Scale Projects (SSP)** – €19,446,936 (max. €300,000/project), focused on academic mobility, training, and joint events.
- **Integrated projects** – complex partnerships with direct impact on communities.

**Programme Budget**

- **Total EU funds allocated (2021–2027):** ~€77 million
- **National and local co-financing**: up to 10–15%, depending on the type of beneficiary.
- Allocation is made through competitive project calls, launched by the Managing Authority (Ministry of Development, Public Works and Administration – Romania), with the support of the Joint Technical Secretariat.

**Relevance for the Academic and University Environment**

For universities, the Interreg NEXT ROMD programme offers the opportunity to:

- develop sustainable cross-border partnerships,
- implement digital educational platforms,
- improve access to modern educational resources,
- support the mobility and joint training of students and academic staff,
- contribute to knowledge and technology transfer within the cross-border area.

## 1.2. Previous Cross-Border Projects of UDJG Implemented by the Project Team

### 1.2.1. PROSANA – Proactive Health Without Borders

**The PROSANA Project – "Proactive Health Without Borders" (Code 2SOFT/4.1/104),** implemented between 2020 and 2022, was funded through the **Romania–Republic of Moldova Joint Operational Programme 2014–2020**, under the **European Neighbourhood Instrument** ("Dunărea de Jos" University of Galați, n.d.-c).

**The total value of the grant** was €219,981.30, of which €197,131.30 came from European funding, while **€22,850.00** represented co-financing from the partner universities ("Dunărea de Jos" University of Galați, n.d.-a).

**Partnership and Coordination**

The project was coordinated by **"Dunărea de Jos" University of Galați**, as lead partner, in collaboration with **"Bogdan Petriceicu Hașdeu" State University of Cahul, Republic of Moldova,** as partner ("Dunărea de Jos" University of Galați, n.d.-c). Coordination was ensured by **Professor Silvius Stanciu, PhD (Economics), PhD (Engineering), Habilitated Doctoral Advisor,** project manager from Galați, together with the partner team from the Republic of Moldova.

**Objectives and Main Activities**

The main objective of the project was to equip the university buildings and student dormitories of both institutions with 85 defibrillators ("Bogdan Petriceicu Hașdeu" State University of Cahul, 2021).

Another important objective was the selection and training of target groups (TGs):

- **TG A**: 30 employees,
- **TG B**: 600 teaching staff and students,
- **TG C**: 40 participants (high school teachers and students),
- **TG D**: 120 participants in dissemination events ("Dunărea de Jos" University of Galați, n.d.-a).

The project also included training activities, such as first aid courses, conducted through the Department of Continuing Education and Technology Transfer of UDJG ("Dunărea de Jos" University of Galați, n.d.-d).

**Impact and Relevance**

The PROSANA project enhanced the capacity of partner institutions in the field of proactive health and emergency response through technological equipment, development of digital tools (mobile application), training, and dissemination. The initiative represents an innovative cross-border approach, connecting universities, local authorities, and regional communities, and was successfully implemented by both institutions.

Through its educational activities and equipment, the PROSANA project contributed to strengthening a culture of prevention and rapid response in emergency situations. The equipping of university spaces with defibrillators represents the first initiative of its kind in both Romania

and the Republic of Moldova, opening a pioneering path for the health of cross-border academic communities.

## 1.3. Partners of the ROMD00388 – CBOL Project

### 1.3.1. "Dunărea de Jos" University of Galați (UDJG), Romania

**"Dunărea de Jos" University of Galați (UDJG)** is one of the most important higher education institutions in southeastern Romania.

Founded in 1948, UDJG has a strong tradition in research and innovation, with numerous international projects and strategic partnerships. The university has an extensive network consisting of 15 faculties, an extension in Buzău, 35 research centers, a Technology Transfer Center (CTT UGAL), and a modern teaching and research infrastructure.

UDJG is among the first universities in Romania to have developed educational programs with partner universities from the Republic of Moldova (since 2000). At present, active cooperation partnerships are maintained with universities in Cahul, Comrat, Taraclia, and Chișinău. UDJG also initiated the development of academic educational programs with universities in Ukraine, but the outbreak of the war of aggression by Russia has limited these initiatives.

The university's academic staff comprises approximately 1,000 teaching and research members, of whom over 80% hold a PhD, with a significant number being doctoral supervisors in advanced fields. UDJG manages 4,000 employment contracts, and its annual budget is estimated at around €60 million (Viața Liberă, 2023). Each year, approximately 12,500 students are enrolled, alongside about 3,000 trainees participating in various training programs (other than bachelor's, master's, or doctoral studies).

In the field of scientific research, UDJG has relevant experience in implementing both international and national projects. In recent years, the university has carried out over 100 research and international cooperation projects, with total managed funds amounting to tens of millions of euros, financed through programs such as Horizon Europe, Erasmus+, Interreg, PNCDI, or structural funds.

This combination of faculty expertise, research infrastructure, and experience in managing external funds makes UDJG a reliable strategic partner in cross-border and international cooperation projects. Through this project, UDJG strengthens its role as a regional hub of knowledge and innovation, supporting the integration of digital educational resources into teaching and research processes.

### 1.3.2. "Dunărea de Jos" University of Galați Library

The **Library of "Dunărea de Jos" University of Galați (UDJG Library)** is an essential documentation and information center for the local, regional, and national academic community. The library represents the fundamental infrastructure that supports the educational process, scientific research, innovation, and the continuous professional training of students, teaching staff, and researchers.

Being integrated into the university's structure, the library plays the role of providing access to high-quality information, fostering the development of information literacy skills, and strengthening the institution's profile within the academic environment ("Dunărea de Jos" University of Galați, n.d.-a).

Since its establishment, the library has offered core services such as book lending, consultation of materials in reading rooms, and the organization of collections according to the Universal Decimal Classification. The library's branches are distributed across faculties and respond to the specific requirements of their educational programs. These services support the teaching process by providing fundamental and specialized works necessary for individual study and seminar or laboratory activities ("Dunărea de Jos" University of Galați, n.d.-c).

The library is also involved in educational activities by organizing training programs and sessions for students and doctoral candidates, aimed at developing skills in database use, managing bibliographic sources, and respecting academic ethics.

The institution has responded to the dynamics of the academic environment by integrating modern information technologies. The electronic catalog, based on the **Koha system**, allows quick searches of printed and electronic resources, as well as access to information from partner digital libraries ("Dunărea de Jos" University of Galați, n.d.-b). The **"Ask the Librarian"** service facilitates direct communication between users and librarians, offering real-time answers and personalised solutions.

Another major tool is **UGAL Index**, a platform that integrates the online catalog, the digital repository, and the university's scientific journals, transforming the library into a comprehensive information hub. Through it, students and researchers can access a wide range of resources from a single interface, thus optimizing the process of searching for and using information.

"Dunărea de Jos" University of Galați, as a member of **the Anelis Plus Consortium** (Association of Universities, Research-Development Institutes, and Central University Libraries of Romania), benefits from online access to scientific databases. This service was acquired within the project *"Access to Scientific Literature and Open Access Publishing",* under PNCDI IV – Programme 5.10 Science and Society, Project type Access to Scientific Literature. Access is available either through intranet (IP-based) or remotely (via mobile access accounts created on e-nformation and Info-edu, for Cambridge journals).

***ARTHRA Digital Repository***

ARTHRA is the institutional digital repository managed by the UDJG Library, with the objective of disseminating peer-reviewed academic works such as doctoral theses, scientific articles, and research reports. It contributes to the visibility of scientific results, promotes open access, and supports international transparency policies in research ("Dunărea de Jos" University of Galați, n.d.-c). ARTHRA complies with international interoperability standards (OAI-PMH), which facilitates international indexing.

***Open Journal Systems (OJS)***

In addition to the ARTHRA platform, the library also supports the management of scientific journals through Open Journal Systems (OJS), an international open-source software used for the complete management of the editorial process.

Through OJS, the university's journals benefit from a standardized framework for peer review, article management, and open-access publishing, thus contributing to the increased international scientific visibility of UDJG ("Dunărea de Jos" University of Galați, n.d.-d).

**Collection Size and Infrastructure**

According to official reports, the library holds a collection of 357,329 volumes, of which 53,127 are in open access.

The network includes five branches, 14 databases accessible to users, and 264 study spaces for both individual and group work (Library of "Dunărea de Jos" University of Galați, n.d.).

The collections cover diverse fields—exact sciences, engineering, medicine, social sciences, arts, and humanities—and include books, journals, technical standards, electronic publications, audio-visual materials, and digital educational resources.

The library publishes annual information guides and thematic resources, supporting users in their learning and research processes.

In addition, modern facilities provide multimedia rooms with internet access and computers dedicated to documentation.

**Modernization and Recent Investments**

The modernization process reached a peak in 2023, with the inauguration of a renovated space at the Gării Street location, within the courtyard of the Faculty of Economics and Business Administration, through an investment of €1.5 million.

Two reading rooms were equipped with touchscreen systems for consulting the electronic catalog, while part of the old collection (over 60,000 outdated volumes) was decommissioned to make room for current works and digital resources (Spânu, 2023).

The library is part of the Anelis Plus consortium, which provides users with access to international databases, journals, and reference e-books. This strengthens its integration into the global academic circuit and supports the competitiveness of university research.

The library is not only a provider of resources but also a strategic partner in education and research. Through its development strategy, the UDJG Library aims to:

- adapt its collections and services to current academic needs;
- ensure the continuous training of librarians to respond to technological and social changes;
- promote open access and digital culture;
- strengthen the role of the library as a hub of knowledge for the academic community and the regional society ("Dunărea de Jos" University of Galați, n.d.-c).

The Library of "Dunărea de Jos" University of Galați stands out as a model of continuous transformation and adaptation. With an impressive collection of resources, modern infrastructure, advanced digital tools, and policies oriented towards openness and collaboration, the UDJG Library is not only a space for accessing information but also a catalyst for academic and scientific progress.

### 1.3.3. Ion Creangă State Pedagogical University of Chișinău (UPSC), Republic of Moldova

Founded in 1940, the Ion Creangă State Pedagogical University of Chișinău (UPSC) is one of the most prestigious higher education institutions in the Republic of Moldova, playing a fundamental role in the training of teachers, specialists in educational sciences, and experts in the cultural and social fields.

Over time, UPSC has consolidated its academic profile, being recognized for its contributions in pedagogy, psychology, arts, philology, and social sciences.

The university comprises eight faculties (Visual Arts and Design; Philology and History; Foreign Languages and Literatures; Psychology and Special Psychopedagogy; Educational Sciences; Physics, Mathematics and Information Technologies; Biology and Chemistry; Geography), as well as several research centers and teaching laboratories (Future Classroom, Continuing Education and Leadership, Polygraphic Publishing Center, Career Guidance and Counseling Center, Institute for Research, Innovation, and Technology Transfer). These research centers provide a modern academic and scientific framework that supports both the initial and continuing training of teachers, as well as the development of interdisciplinary programs for national and international cooperation.

Research and innovation at UPSC are aligned with the five strategic priorities of research and innovation for 2021–2025: Health; Sustainable Agriculture; Food Security and Food Safety; Environment and Climate Change, Societal Challenges; Economic Competitiveness and Innovative Technologies.

The teaching staff of UPSC consists of about 300 members (professors, associate professors, lecturers, and assistants), supported by researchers and experts in the field of education. The university hosts a community of approximately 8,000 students, enrolled in bachelor's, master's, and doctoral programs.

UPSC has gained significant experience in implementing international projects, including Erasmus+, Tempus, Horizon Europe, and more recently, cross-border projects under the Interreg Romania–Republic of Moldova programs.

The institution benefits from an academic infrastructure adapted to current requirements, with modernized classrooms, research laboratories, and digital learning platforms.

The research funds attracted and managed by the university in recent years have enabled the expansion of study programs and the strengthening of scientific activities. This experience confirms UPSC's capacity to act as an active and reliable partner in cross-border projects, contributing to innovation, exchange of best practices, and the development of a joint academic community in the Romania–Republic of Moldova border region.

### 1.3.4. The Scientific Library of the Ion Creangă State Pedagogical University of Chișinău

The Scientific Library of the Ion Creangă State Pedagogical University of Chișinău (UPSC Library) serves as the main documentation and information center supporting the institution's teaching and research activities. Its mission is to support the educational process and

the scientific development of faculty and students by ensuring permanent access to diverse and up-to-date information resources (Ion Creangă State Pedagogical University, n.d.-a).

Founded together with the university in 1940, the library has evolved from a traditional book repository into a modern center for educational and scientific resources. Its role has expanded from supporting teaching activities to strengthening research and innovation, becoming a strategic partner for the academic community.

The library also functions as a **Departmental Library Center,** providing methodological coordination for the libraries of pedagogical institutions in the Central and Southern regions of the Republic of Moldova. Thus, its impact goes beyond the boundaries of the university, assuming an important regional role (Ion Creangă State Pedagogical University, n.d.-a).

**Platforms and Services:**

The library manages essential platforms such as:

- **PRIMO** – the integrated catalog of partner libraries in the Republic of Moldova and third countries,
- **Electronic Library**, which brings together digital collections,
- **Institutional Digital Repository**, which ensures the archiving and dissemination of scientific works in open access (Ion Creangă State Pedagogical University, n.d.-b; Ion Creangă State Pedagogical University, n.d.-c).

The library offers services such as lending, consultation in reading rooms, access to international databases, reference services, and bibliographic counseling. Through its electronic platform, users can access academic resources from anywhere, ensuring the continuity of documentation and research.

An important aspect of the library's activities is its involvement in the development of students' and teachers' digital and information literacy skills. Through courses and training sessions, such as the Information Culture module taught to first-year students, users learn how to search, evaluate, and correctly use information sources, navigate electronic catalogs and databases, and prepare citations and bibliographic references in accordance with international standards (Schërlet & Susarenco, 2022).

**Documentary Heritage and Collections**

The documentary heritage of the UPSC Scientific Library is vast and diversified. As of January 1, 2022, it comprised 649,278 document units (copies) corresponding to 10,226 distinct titles (Ion Creangă State Pedagogical University, n.d.-d). The collection's distribution reflects a balance between teaching and research needs: 43% educational publications, 37% scientific publications, and 20% fiction (Ion Creangă State Pedagogical University, n.d.-d).

In the academic year 2021–2022, the collections were supplemented with 1,579 new items, including 1,217 books, 294 periodicals, 58 abstracts, and 10 dissertations (Ion Creangă State Pedagogical University, 2022). These acquisitions reflect the institution's constant effort to maintain the relevance of its collections and to meet the needs of the academic community.

**Projects and Collaborations**

The UPSC Library participates in national and international projects, such as Tempus MISISQ and programs coordinated by European library networks, which aim to modernize

services and integrate them into global information flows. Through these partnerships, the library contributes to the digitization of resources and the enhancement of the academic visibility of the Republic of Moldova.

The UPSC Scientific Library is not merely a storage space for resources, but an educational and scientific hub integrated into the national and international academic ecosystem. Its rich heritage, combined with digitization initiatives, the development of information literacy skills, and participation in international projects, makes it a strategic actor in contemporary higher education.

**Academic Collaboration**

From an educational perspective, the two universities collaborate by organizing joint bachelor's and master's programs.

The project "Online Cross-Border University Library for Equitable Access to High-Quality Education Services ROMD00388 – CBOL" is the first EU-funded initiative jointly implemented by the two institutions, also incorporating some research components.

## 1.4. Budget Allocation of the ROMD 00388 Project

The total project budget amounts to €331,481.72, of which 90% represents European Union grant funding and 10% the co-financing provided by the two partner universities (Table 1.1).

**Table 1.1 Budget Allocation of the ROMD 00388 Project**

| Component | Amount (€) | Details |
|---|---|---|
| **Total Project** | 331,481.72 | 10% Co-financing, 90% EU grant funding |
| **UDJG – Galați** | 261,903.90 | 79% of the total budget |
| **UPSC – Chișinău** | 69,577.82 | 21% of the total budget |
| **Equipment and Infrastructure** | 176,400 | Scanners, servers, PCs, digital boards |
| **Human Resources (Staff)** | 86,080 | Project team: librarians, technicians, experts |
| **External Services and Consultancy** | 37,900 | Software development, legal consultancy |
| **Logistics, Communication, and Visibility** | remaining | Conferences, promotion, multimedia materials |

*Source: ROMD 00388 Project Proposal (2024)*

## 1.5. Objectives and Key Activities Planned within the ROMD 00388 Project

The objectives and activities of the project have been designed to ensure both the modernization of the educational infrastructure and the creation of a sustainable cross-border academic framework that promotes digitalization, inclusion, and innovation. The following key directions have been identified:

- Digitization of university collections and creation of a multilingual platform (Romanian, English, Russian).
- Development and equipment of two modern educational centers (Galați, Chișinău).
- Complementary activities: training sessions, forums, camps, and joint studies.
- Launch and public promotion of the platform to both academic and general audiences.

**Expected Impact**

The expected outcomes of the project highlight its direct contribution to the modernization of education and the strengthening of cross-border academic cooperation:

- Approximately 15,000 direct beneficiaries (students, teaching staff, researchers) from the two institutions.
- Universal access to digital educational resources for citizens of Romania, the Republic of Moldova, and the EU.
- Modernization of the educational process and reduction of the digital divide.
- Strengthening of cross-border academic identity and cooperation.

**Applied Topics and Reflection Exercises for Students**

To enhance the educational value of the project, a series of applied themes and reflection exercises have been proposed for students and teaching staff, aimed at stimulating critical thinking, creativity, and practical application of concepts:

**The Role of External Funding and Partnerships**

- Partnership management in cross-border projects: distribution of responsibilities, resources, and effective communication channels.
- Possible risks in project implementation: administrative overload, procedural differences, linguistic or technical barriers.

**Digitization and Prioritization**

- Practical simulation: designing a digitization plan for a university collection (selection criteria: scientific value, usage frequency, physical condition).
- Reflection: how can libraries with limited resources prioritize the digitization process?

**Inclusion and Equal Access**

- Case study: identifying barriers to digital education for students in rural or vulnerable areas.

- Applied project: designing a hybrid educational module (online + offline) aimed at reducing digital gaps.

**Multilingualism and Academic Cooperation**

- Creation of a small multilingual digital library (Romanian, English, Russian) using open-access resources.
- Reflection: what role does multilingualism play in strengthening cross-border academic cooperation?

**Interoperability and Digital Integration**

- Exercise: integrating a local digital catalogue into an international hub (e.g., Europeana, ARTHRA).
- Discussion: which international standards (OAI-PMH, Dublin Core) are essential for interoperability?

**Ethics, Security, and Intellectual Property**

- Applied study: protection of personal data and copyright in university digital libraries.
- Reflection: how can a balance be ensured between open access and respect for intellectual property rights?

**Academic and Societal Impact**

- Exercise: proposing indicators to measure the impact of the CBOL project (number of users, resources accessed, collaborations generated).
- Discussion: how can digital libraries function as hubs of knowledge and regional innovation?

**Good Practices and European Models**

- Comparative analysis between CBOL and other Interreg digital library projects in the European area (e.g., Poland–Lithuania).
- Reflection: which lessons can be transferred and adapted for Romania and the Republic of Moldova?

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# 2. DIGITIZATION OF LIBRARIES – NATIONAL AND INTERNATIONAL PERSPECTIVES

## 2.1. General Aspects of Library Digitization

Library digitization constitutes an essential process in the information society era, driven by the need for rapid access to resources, preservation of cultural heritage, and the adaptation of information institutions to new technologies (Borgman, 2007).

The application of digitization in libraries primarily refers to the process of converting physical materials into digital formats, a process that brings numerous benefits such as increased access to resources, improved preservation of materials, and better space management. However, digitization projects also raise significant challenges related to funding, staffing, copyright issues, and technical infrastructure.

Currently, libraries are no longer merely physical storage spaces for books but have become digital hubs that facilitate open access, interoperability, and the global exchange of knowledge (IFLA, 2019).

According to Shashikala & Nachiappan (2021), digitization in libraries is a normal phenomenon, specific to the revolution of contemporary society. This involves converting traditional materials—books, manuscripts, images, audio, and video materials—into digital formats accessible online.

The digitization process began in the 1980s, with the introduction of computers into library activities, initially limited to bibliographic databases but later extended to complete collections (Shashikala & Nachiappan, 2021). The authors highlight benefits such as increased and faster access to information, the possibility for multiple users to consult the same materials simultaneously, preservation of fragile documents, and improved physical space management.

In addition, digitization supports education and research through the creation of repositories, digital libraries, virtual exhibitions, and multimedia collections (Fabunmi et al., 2009; Pandey & Misra, 2014).

As in other studies, significant challenges are also mentioned: high infrastructure costs, legal aspects (particularly copyright issues), the selection of materials to be digitized, and risks associated with the limited lifespan of storage media (Outbelu & Ume, 2015; Saini, 2017).

Furthermore, digital libraries cannot fully reproduce the reading experience offered by traditional libraries, and users sometimes face difficulties in managing the ever-growing volume of digital data.

In conclusion, digitization is an indispensable endeavor for 21st-century libraries, serving both as a preservation strategy and as a means of democratizing access to information. However, its success depends on sustainable funding, staff training, and the adoption of coherent policies for managing digital resources (Shashikala & Nachiappan, 2021).

**Digitization for Document Preservation and Conservation**

According to the American Library Association (ALA, 2014), digitization for preservation is a concept derived from the traditional field of conservation and analogy preservation.

In the 1990s, many fragile books and newspapers were microfilmed with financial support from the National Endowment for the Humanities and other grant schemes, the aim being to preserve informational content and make it accessible without further damaging the originals.

However, access remained restricted to specialized researchers.

Later, an intermediate stage was introduced, in which recommended practice included microfilming for preservation and digitization for access.

Today, although debates continue, digitization has become an accepted method for all forms of preservation reformatting. The "digitization for preservation" policy was officially adopted by the Association of Research Libraries in July 2004.

Digitization for preservation itself generates digital materials that must also be preserved, which in turn implies the need for digital preservation (Caplan, 2008).

ALA has adopted several resolutions establishing principles and policies in the field of library digitization, such as:

- Principles for digitized content (ALA, 2007);
- Resolution on the digitization of U.S. government documents (ALA, 2014);
- Adoption of digital preservation definitions and the revised preservation policy (ALA, 2009).

## 2.2. Benefits Associated with Library Digitization

The digitization of library collections is associated with multiple advantages for both institutions and users:

**Easier access** to documents: knowledge, from anywhere and for anyone connected to the Internet: Digitization makes library materials accessible to a wider public, regardless of location, allowing simultaneous access for multiple users (Smith, 2021).

- **Improved preservation of fragile documents**: Digital copies contribute to preserving fragile or rare materials, reducing the need for handling original copies (Borgman, 2003).
- **Better management of library space**: Digitization frees valuable space within libraries, reducing the need for large-scale physical storage (Jeanneney, 2007).
- **Reduced costs associated with preservation and storage**: In the long term, digitization can generate savings by lowering storage and maintenance costs for physical materials (Chen & Lin, 2017).
- **New services available to library subscribers:** Digitization enables libraries to offer innovative services, such as online research tools and digital exhibitions, thereby expanding their impact and visibility (UNESCO, 2022).

## 2.3. Challenges Associated with Library Digitization

Digitizing library collections offers undeniable advantages, but it also presents a series of complex challenges related to resources, technology, and sustainability.

These obstacles must be carefully addressed to ensure that digitization initiatives achieve their objectives and provide long-term benefits:

- **Funding for digitization**: The digitization of extensive collections requires significant investment in equipment, staff, and maintenance (Crăciun, 2021).
- **Qualified personnel**: Digital preservation demands specialized skills in IT, data analysis, and digital archiving, which often implies hiring or training additional staff (Stoica & Bodea, 2020).
- **Copyright and intellectual property rights**: Complying with copyright legislation is often complex, especially in the case of materials with unclear legal status or multiple rights holders (Jeanneney, 2007).
- **Technical infrastructure**: Libraries need a robust infrastructure—high-speed internet, servers, and appropriate software—to effectively support digital collections (IFLA, 2019).
- **Quality control**: Maintaining high-quality digital copies requires careful attention to scanning resolution, file formats, and associated metadata (Smith, 2021).
- **Long-term preservation**: Ensuring the future accessibility and usability of digital materials involves planning for data migration, preventing format obsolescence, and implementing reliable storage solutions (UNESCO, 2022).

In conclusion, overcoming these challenges requires sustainable funding models, continuous staff training, strong legal and technical frameworks, and strategic planning to guarantee that digitization projects contribute effectively to knowledge preservation and equitable access.

## 2.4. Approaches to the Digitization of Library Collections

The process of library digitization involves a set of technologies and methods designed both to preserve documentary heritage and to facilitate open access to resources for the academic community and the wider public.

Among the most relevant examples are:

- **Book and document scanning**: the conversion of printed volumes, rare manuscripts, and historical archives into standardized digital formats (PDF, TIFF). This activity not only preserves fragile documents but also enables rapid and simultaneous access for an unlimited number of users. In addition, digitized materials can be integrated into electronic catalogues and educational platforms (European Commission, 2020).
- **Digitization of photographs and artifacts**: through high-resolution scanning and 3D imaging technologies, libraries create faithful digital copies of historical photographs, maps, cartographic charts, and cultural artifacts. These resources are essential for researchers, who can analyse details without physically handling fragile objects, thereby reducing the risk of deterioration.

- **Creation of digital repositories**: modern libraries develop institutional repositories that enable the archiving, management, and dissemination of digital collections. These include doctoral theses, scientific articles, research reports, and teaching materials. Repositories enhance the international visibility of institutions and support open access policies (European Commission, 2020).
- **Development of online exhibitions**: using multimedia technologies and interactive interfaces, libraries can organize virtual exhibitions showcasing their digital collections. These offer users the possibility to explore cultural and scientific heritage remotely, transforming the library into an expanded educational space in the virtual environment.
- **Implementation of digital libraries**: establishing fully integrated libraries that provide access to a wide range of electronic resources—books, journals, databases, technical standards, and multimedia materials—alongside digital services such as advanced search, online referencing, and mobile access. Such libraries represent an effective solution for adapting institutions to the digital age and for democratizing access to knowledge (Bărbulescu, 2019).

In conclusion, library digitization is not merely the conversion of physical materials into electronic files, but the creation of an integrated informational ecosystem focused on accessibility, preservation, and educational innovation.

## 2.5. Regional and International Library Digitization Initiatives

Major digitization programs have redefined the role of libraries and public access to knowledge. In the following section, the most significant regional and international initiatives will be briefly presented.

### 2.5.1. Google Books

**https://books.google.com**

Through the establishment of Google Books, more than 25 million volumes have been scanned, making it one of the largest digitization projects worldwide. The initiative generated both enthusiasm and controversy, particularly concerning copyright issues (Jeanneney, 2007).


The Google Books platform, developed by Google, provides access to a vast collection of digital books sourced from libraries and publishers around the world (Google Books, n.d.; ALLEA, 2011).

Its functionality lies in scanning volumes and making digital versions publicly available with varying levels of access: full access for public domain works and limited previews for copyrighted materials.

Access regulation is ensured through partnerships with publishers and authors, who define the restrictions governing how content is displayed and used (Google Books, n.d.).

Copyright management is carried out through several mechanisms:

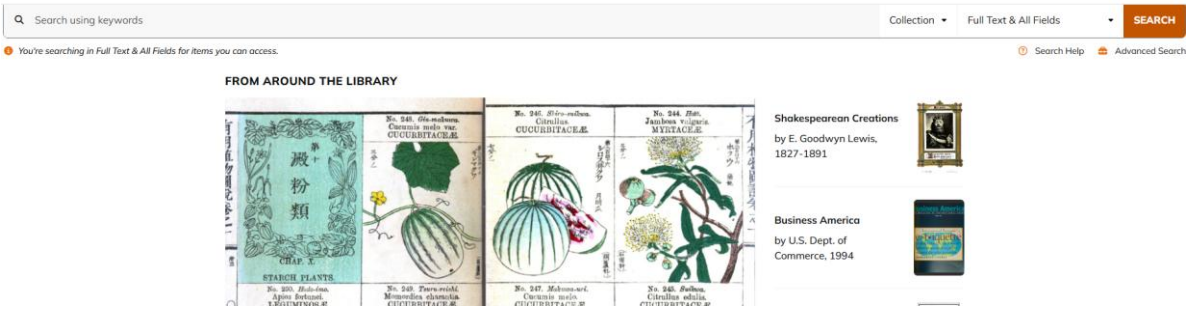
- **Partnerships with libraries and publishers**, which establish the terms of digitization and dissemination.

- **Access restrictions**, which allow consultation of only selected pages or sections in the case of copyrighted works.
- **Content control by authors and publishers**, who may decide how their works are displayed on the platform.
- **Payment and commercialization schemes**, through which Google ensures compensation for publishers and authors when books are purchased by users.

The case of Google Books illustrates both the opportunities and challenges of large-scale digitization: while it democratizes access to knowledge at an unprecedented scale, it also raises complex legal, ethical, and economic questions that continue to shape global debates on digital libraries.

## 2.5.2. HathiTrust

**https://www.hathitrust.org**




HathiTrust Digital Library – Millions of Books Online is a large-scale academic initiative launched in 2008 by the University of Michigan and Indiana University, which quickly expanded into an international consortium of more than 200 member institutions, primarily universities and research libraries in the United States, Canada, and Europe (HathiTrust, n.d.). The digital collection currently brings together over 17 million volumes (books, periodicals, government documents), many of which originate from the Google Books project, as well as from the independent digitization programs of partner libraries.

Full access is granted for works in the public domain, while copyrighted publications can be consulted either partially or only through the advanced text search function. This approach balances respect for copyright with the need for broad academic access.

A distinctive feature of HathiTrust is the HathiTrust Research Center (HTRC), which provides researchers with advanced digital text analysis tools (text and data mining), enabling large-scale quantitative studies of scientific and cultural literature. In addition, HathiTrust ensures long-term digital preservation through strict archiving and interoperability policies, making it a model for digital libraries worldwide.

By the size of its collections and the range of its tools, HathiTrust is now considered one of the largest and most significant academic digital libraries, supporting both open access and digital humanities research.

Main sources of funding for the digital library include:

- **Membership contributions** – more than 200 university and research libraries (primarily from the US and Canada, but also Europe) pay annual fees, with amounts depending on

the size of the institution and level of involvement (founding members pay more, others contribute proportionally).

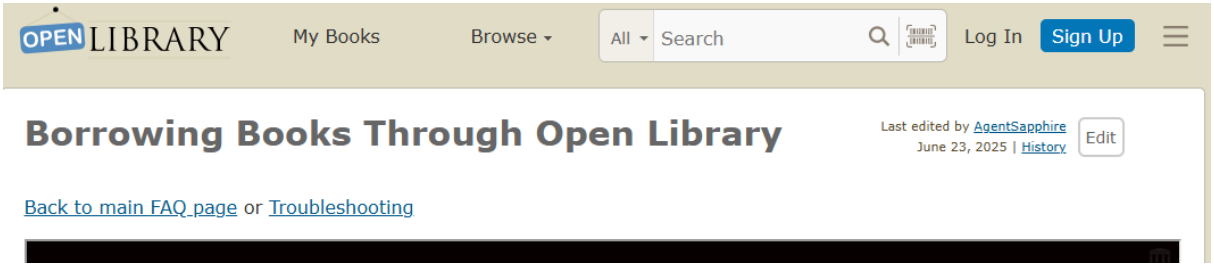
- **Entry fees** – new institutions wishing to join HathiTrust pay an initiation fee, designed to cover administrative costs and integration of their collections into the archive.
- **External projects and grants** – occasionally, HathiTrust receives support for research and development initiatives (e.g., for the HathiTrust Research Center, text-mining tools).
- **Shared infrastructure** – storage and administrative costs are distributed among consortium members, ensuring relatively stable and sustainable funding.

Unlike other digital libraries that depend on individual donations, HathiTrust operates on a cooperative, self-sustaining academic model.

This cooperative model makes HathiTrust not only a repository of millions of digitized works but also a symbol of international academic collaboration, demonstrating how shared resources and collective governance can secure sustainable access to knowledge and long-term preservation of cultural and scientific heritage.

### 2.5.3. Internet Archive and Open Library

**https://openlibrary.org/subjects/internet_archive**




Founded in 1996, the Internet Archive is a non-profit organization whose mission is to preserve and provide universal access to knowledge. Best known for its Wayback Machine service—which allows users to access billions of archived web pages over time—the institution plays a crucial role in safeguarding the digital memory of humanity (Internet Archive, n.d.).

Beyond web archiving, the Internet Archive hosts massive collections of books, periodicals, audio files, video recordings, software, and images, making it one of the most comprehensive digital libraries worldwide.

A major sub-project is Open Library, which aims to create "one web page for every book ever published." This initiative functions as a universal bibliographic catalogue, offering both bibliographic descriptions and digital access where possible.

An innovative feature is the Controlled Digital Lending (CDL) model, which allows users to borrow copyrighted works online under conditions like traditional library lending—the number of digital copies available corresponds to the number of physical copies owned by the archive. This approach provides a balanced solution between copyright compliance and the democratization of access to knowledge.

The significance of the Internet Archive goes far beyond technical achievements. It is widely recognized as a global cultural and educational hub, supporting research, distance learning, and the preservation of digital heritage. Collaborations with university libraries and

cultural organizations around the world further strengthen its status as one of the most influential initiatives for digitalization and open access to knowledge.

**Wayback Machine – Scope and Usage**

The Wayback Machine, the central sub-project of the Internet Archive, contains over 800 billion archived web pages (as of 2023–2024) and is widely used as a source of information verification in academic research, journalism, and legal proceedings.

The Internet Archive collaborates with more than 1,000 libraries and cultural institutions worldwide, including leading university libraries (e.g., the Library of Congress, the Smithsonian Institution, and several European state and university libraries), thereby expanding its collections and academic legitimacy.

Through its digitization and open-access programs, the Internet Archive has become an essential tool for academic communities in countries with limited access to costly educational resources, contributing significantly to reducing the global digital divide.

Currently, the Internet Archive hosts:

- more than 38 million digitized books and texts,
- around 14 million audio recordings,
- over 9 million video materials,
- millions of images and historical software (including video games and classic programs).

The Internet Archive is also an active player in the global debate on copyright and open access. Its Controlled Digital Lending (CDL) model has triggered lawsuits with major publishers, yet the organization has strengthened its reputation as a pioneer of free access to knowledge.

**Funding Sources**

As a non-profit organization, the Internet Archive relies on a diverse funding model, including:

- **Individual donations** – one of its main revenue streams. The platform frequently runs online fundraising campaigns, where users contribute small amounts (typically between $5 and $50).
- **Grants and institutional funding** – support from international foundations and organizations (e.g., the Mellon Foundation, the National Endowment for the Humanities, the Knight Foundation) for specific projects related to digitization, preservation, or research.
- **Partnerships with libraries and universities** – institutions collaborating with the Internet Archive may contribute financially to cover the costs of digitization, infrastructure, and archive maintenance.
- **Service revenues** – certain specialized services (e.g., professional scanning, institutional web archiving, dedicated hosting) are offered for a fee, especially to university libraries and public archives.
- **Volunteering and in-kind resources** – a significant portion of activities (digitization, proofreading, cataloguing) is carried out by volunteers, substantially reducing operational expenses.

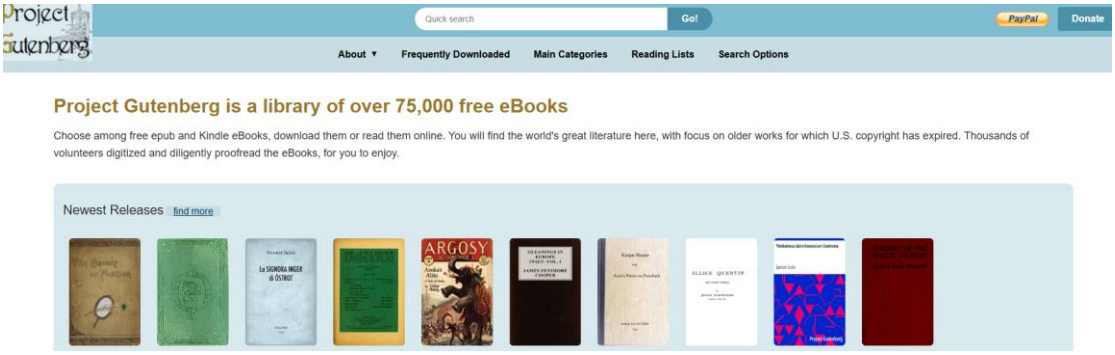
Legally, the **Internet Archive** is registered as a non-profit organization in the United States, which allows it to receive tax-deductible donations.

In comparison with **Google Books**, which primarily operates through publisher agreements and commercial models, and **HathiTrust**, which relies on academic consortia and membership-based sustainability, the **Internet Archive** stands out for its strong emphasis on open access, preservation of digital memory, and inclusiveness.

While **Google Books** focuses on large-scale digitization and **HathiTrust** prioritizes academic collaboration and controlled access, the Internet Archive positions itself as a global cultural common, ensuring universal access to knowledge regardless of geographic or financial barriers.

## 2.5.4. Project Gutenberg – free e-books

**https://www.gutenberg.org**




Initiated in 1971 by Michael S. Hart, Project Gutenberg is the world's oldest and longest-running book digitization project, founded on the principles of volunteerism and open access to knowledge (Project Gutenberg, n.d.). Considered a pioneer in the field of digital libraries, the project began with the digitization of the United States Declaration of Independence, setting a global precedent for the democratization of access to literature.

Today, Project Gutenberg provides free access to more than 70,000 titles available online, focusing primarily on works in the public domain. Unlike large-scale initiatives such as Google Books, which aim to create a universal repository of publications, Project Gutenberg concentrates on classical literature and expired copyright works, making it especially relevant for the humanities and the preservation of cultural heritage.

A defining feature of the project is its volunteer-driven structure. Volunteers worldwide contribute to the digitization, proofreading, and dissemination of texts, ensuring continuous development and expansion of the collection. Furthermore, Project Gutenberg promotes the use of accessible and user-friendly formats (EPUB, Kindle, HTML, plain text), facilitating reading across a wide range of devices.

From a cultural and educational standpoint, Project Gutenberg is more than a repository of digitized texts—it is a symbol of free access to knowledge, frequently cited as an inspiration for other large-scale digital library projects worldwide.

Its funding model is markedly different from that of Internet Archive or HathiTrust, relying almost exclusively on donations and volunteer contributions:

- **Individual donations** – the main source of funding, covering technical infrastructure (servers, hosting) and minimal administrative costs.
- **Occasional grants and sponsorships** – sporadic support from foundations or cultural organizations, without being a stable source of funding.
- **Volunteer work** – thousands of volunteers contribute to digitization, proofreading, technical development, and database maintenance, drastically reducing personnel costs.
- **Partnerships with non-profit initiatives** – collaborations with platforms such as Distributed Proofreaders ensure a steady flow of digitized works without commercial expenses.

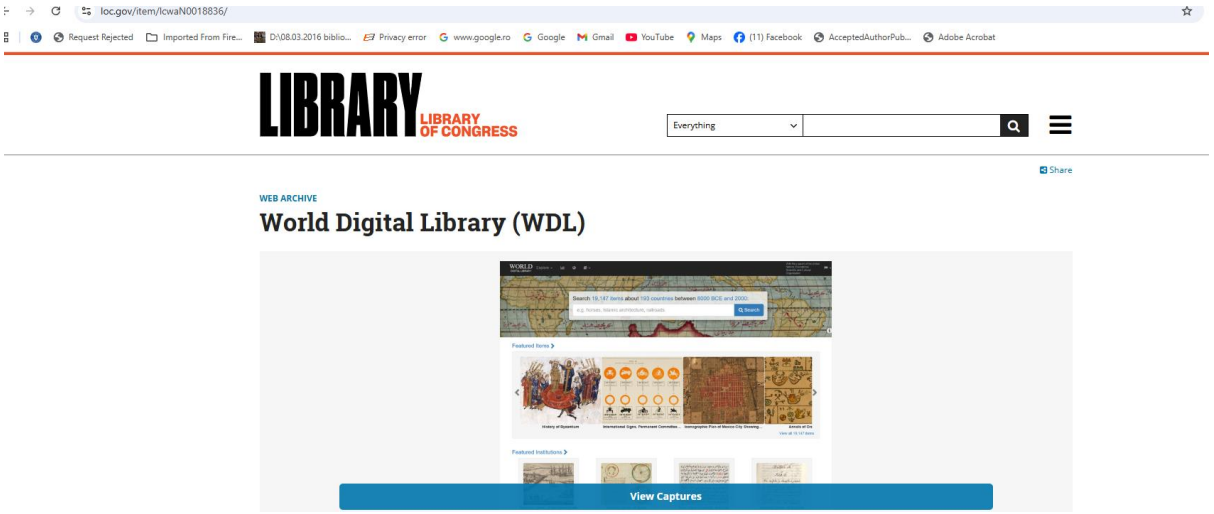
In comparative perspective, **Google Books** represents a large-scale, commercially driven digitization initiative that balances open access with copyright restrictions through publisher agreements; **HathiTrust** reflects an academic consortium model, ensuring long-term preservation and research-oriented tools such as text mining; and Internet Archive combines universal web archiving and multimedia digitization, supported by donations, grants, and partnerships. By contrast, **Project Gutenberg** stands out for its volunteer-based, low-cost structure, focusing on public domain works and prioritizing accessibility over comprehensiveness.

Together, these initiatives illustrate the diversity of strategies—commercial, institutional, non-profit, and volunteer-based—through which digital libraries are redefining access to knowledge at a global scale.

Unlike **HathiTrust** (based on institutional membership fees) or **Internet Archive** (supported by grants and service-based income), **Project Gutenberg** remains almost entirely volunteer-based, with a minimalist financial structure that explains both its longevity and its non-commercial character.

## 2.5.5. World Digital Library (WDL)

**https://unesdoc.unesco.org/ark:/48223/pf0000181091**




The World Digital Library (WDL) was officially launched on April 21, 2009, at UNESCO headquarters in Paris, as a joint project between UNESCO and the Library of Congress. The idea originated with James H. Billington, Librarian of Congress, who proposed the creation of a global platform designed to make the "cultural treasures of the world" freely and multilingual accessible to the public (Billington, 2009).

The WDL hosts millions of digital files, including unique manuscripts, rare books and first editions, historical maps, photographs, films, sound recordings, and official documents of historical value. Its collections come from more than 190 countries and are available through seven interface languages (Arabic, Chinese, English, French, Portuguese, Russian, and Spanish). This multilingualism transformed the WDL into a truly global platform, in contrast to Google Books, which is more centred on Anglophone content (UNESCO, 2009).

Although the number of books available in WDL is smaller compared to Google Books, the collection emphasizes cultural heritage and equitable access to knowledge, supporting education and intercultural dialogue. The library features medieval Arabic manuscripts, Chinese imperial documents, Latin American chronicles, and rare African collections, thus offering a cultural geography of the world within a single digital space (Cobb, 2010).

An essential aspect is its funding model.

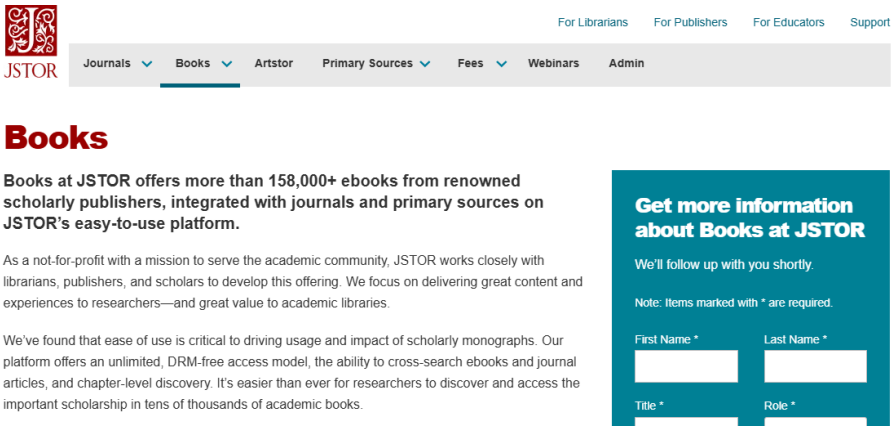
The platform's development and maintenance have been supported through an extended partnership: the Library of Congress ensured coordination and technical infrastructure, UNESCO provided international legitimacy, while private companies and foundations—such as Google, Qatar Foundation, Carnegie Corporation of New York, and Microsoft—contributed through grants and sponsorships (Kelly, 2012). In addition, many national libraries and archives participated by supplying digital content and logistical support, thereby reducing central costs.

Today, the WDL is widely used as an educational resource in schools and universities, as a source for historical research, and as a tool of cultural diplomacy.

Through international collaboration, the platform has demonstrated that digitization can serve not only technological or commercial functions but also a geopolitical role, strengthening cooperation among states and cultural institutions (Kelly, 2012).

## 2.5.6. JSTOR Books

**https://about.jstor.org/librarians/books**




Initially developed as a digital archive of academic journals, JSTOR was created in 1995 by the Andrew W. Mellon Foundation to address the storage crisis and the high costs associated with preserving scientific publications. The expansion into e-books through the Books at JSTOR program, officially launched in 2012, was a natural evolution, as researchers increasingly needed integrated access to both journal articles and academic monographs (Schonfeld, 2012).

Today, the collection exceeds 158,000 e-books provided by prestigious academic publishers such as Princeton University Press, Yale University Press, MIT Press, and Cambridge University Press (JSTOR, 2023). This significant growth has consolidated JSTOR's position as one of the most important digital platforms for the global academic community.

The platform's main features include:

- **Integration with JSTOR journals**: users can seamlessly navigate between articles and book chapters, supporting interdisciplinary research.
- **DRM-free access**: JSTOR offers an unlimited access model without DRM restrictions, facilitating use within academic libraries.
- **Chapter-level search and discovery**: advanced search functions enable fast retrieval of relevant information.
- **Flexible access models**: books are available through institutional licenses (universities, libraries), individual purchases, and, in some cases, open access programs (Schonfeld, 2013; Ithaka, 2020).

**Funding and sustainability.**

Unlike fully free initiatives such as Project Gutenberg or Internet Archive, JSTOR is sustained through a mixed model:

- institutional subscriptions paid by libraries and universities;
- individual purchases of digital titles;
- grants and partnerships supporting the development of open access collections (Ithaka, 2020).

Educational impact. Books at JSTOR is widely used by top universities across the United States, Europe, and Asia, playing a major role in supporting teaching, research, and access to high-quality academic monographs. Compared with Google Books—focused on volume and universal access—JSTOR emphasizes academic rigor and scientific continuity (JSTOR, 2023).

While Google Books remains the initiative with the greatest global reach, non-state projects such as HathiTrust, Internet Archive, and Project Gutenberg demonstrate viable alternatives with different models of access and governance.

These highlight non-profit principles, academic partnerships, and public-domain content, in contrast to Google's hybrid commercial approach.

Table 2.1 provides a comparative overview of the most significant digital library initiatives worldwide, highlighting their scope, access models, funding mechanisms, and distinctive features. This synthesis illustrates the diversity of approaches—from commercial to non-profit models—and their collective impact on global knowledge accessibility.

**Table 2.1 Comparative Overview of Major Digital Library Initiatives**

| Initiative/ Project | Year Established | Size of Collection | Access Model | Funding Model | Distinctive Features |
|---|---|---|---|---|---|
| **Google Books** | 2004 | >25 million volumes | Public domain: full access; Copyrighted: limited previews | Commercial model with publisher/author agreements | Largest scanning initiative; partnership with publishers & libraries; copyright controversies |
| **HathiTrust Digital Library** | 2008 | >17 million volumes (books, journals, gov. docs.) | Full access for public domain; restricted or search-only for copyrighted works | Membership fees, entry fees, shared infrastructure, grants | Strong academic consortium (>200 institutions); advanced text mining tools (HTRC); long-term digital preservation |
| **Internet Archive (incl. *Wayback Machine* & *Open Library*)** | 1996 | >38 million books, 14M audio files, 9M videos, billions of web pages | Controlled Digital Lending (CDL), open access for public domain | Donations, grants, institutional partnerships, fee-based services | Wayback Machine: 800+ billion web pages; global cultural & educational hub; CDL model under legal debates |
| **Project Gutenberg** | 1971 | >70,000 titles (mainly classics & public domain) | Free, open access | Donations, occasional grants, volunteer work | First digital library; volunteer-driven; focus on classic literature; accessible formats (EPUB, HTML, TXT) |
| **World Digital Library (WDL)** | 2009 | Millions of heritage items (manuscripts, maps, rare books, audiovisuals) | Free, multilingual access (7 interface languages) | UNESCO, Library of Congress, private sponsors (Google, Microsoft, Qatar Foundation, etc.) | Focus on cultural heritage; intercultural dialogue; diplomatic and educational mission |
| **JSTOR – Books at JSTOR** | 2012 (as book program) | >158,000 academic e-books | Institutional licenses, individual purchases, partial open access | Subscriptions, purchases, grants, partnerships | Academic rigor; DRM-free; integration with JSTOR journals; chapter-level search |

*Source: Author's own documentation*

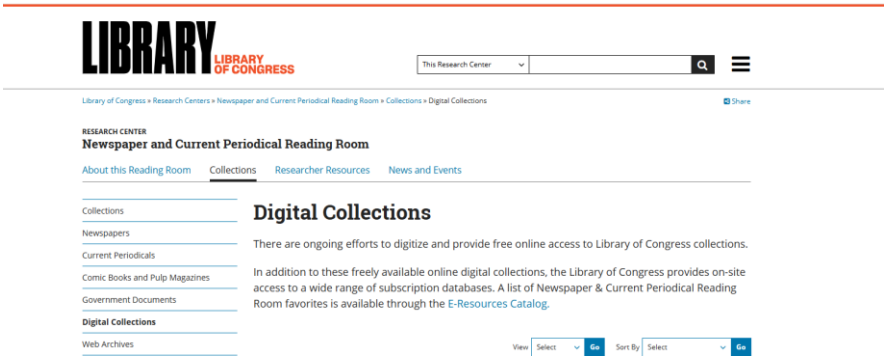
## 2.6. Federal and Regional Digital Library Projects

### 2.6.1. Projects Implemented in the United States of America

In the United States of America (USA), several nationwide digital library initiatives have been developed. At the federal level, there is no single "National Online Library" in the traditional European sense (such as the Romanian National Digital Library).

Instead, large-scale digital platforms have been established at national level, with the Library of Congress serving as the de facto national library.

- **Library of Congress Digital Collections** – The Library of Congress hosts a vast online section with millions of digitized documents, including rare books, manuscripts, maps, photographs, and audio-video recordings. Access: https://www.loc.gov/collections.
- https://www.loc.gov/research-centers/newspaper-and-current-periodical/collections/digital-collections/




The Library of Congress is de facto the national library of the United States, holding an extensive collection of approximately 173 million items, including books, manuscripts, maps, audio recordings, and photographs (The Library of Congress, n.d.).

Digital access is provided through the Discover and Digital Collections sections, where users can explore millions of items in multiple formats and languages.

In addition, specialized divisions, such as the Geography and Map Division, offer online access to over one million historical images—maps, atlases, and relevant cartographic data.

The Library of Congress also provides a dedicated digital portal for historical newspapers, Chronicling America, which has digitized millions of newspaper pages for broad public access.

- **National Digital Library Program** (NDLP) – Initiated by the Library of Congress, it has become the foundation for digital resources accessible to both the general public and researchers. Access: https://www.loc.gov/loc/lcib/0410/ndl.html

Launched in 1995, the National Digital Library Program (NDLP) aimed to develop an extensive digital library composed of digital reproductions of primary materials essential for American history and culture. Building on the success of the earlier American Memory pilot, the program was designed to provide direct access to digital collections without compromising fragile originals or restricting use to advanced researchers.

NDLP digitized a wide variety of materials, including books, manuscripts, photographs, maps, sound recordings, films, and searchable texts.

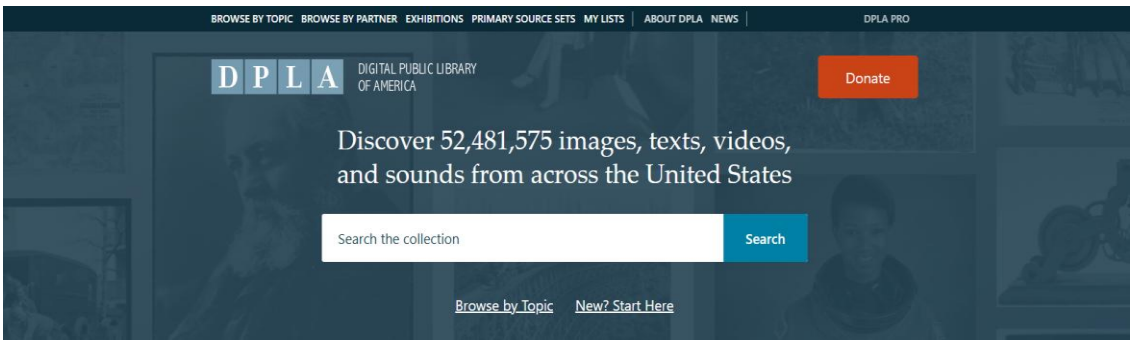
The formats used ranged from bitonal images (black-and-white scans) and color versions to TIFF and JPEG files, RealAudio for sound, QuickTime for video, and text formats such as SGML. The overarching objective was to make these materials accessible to a broad audience—researchers, educators, teachers, students, and the general public. To achieve this, NDLP developed and refined tools such as the Learning Page, the Today in History section, and dedicated resources for teachers and schools (Educators' Institute).

By the end of its first five-year cycle (in 2000), the program had successfully placed 5.6 million digital files online, drawn from 87 distinct collections. These collections were thematically grouped within the American Memory Historical Collections, which continue to expand to this day.

The NDLP was supported by both government funding and private contributions. Initially, the U.S. Congress and private sponsors invested significant resources in the project, enabling the launch of competitive grants for cultural institutions engaged in disseminating historical collections. By 2000, the program benefited from cumulative funding evaluated at tens of millions of dollars

- **Digital Public Library of America (DPLA)** – The Digital Public Library of America (DPLA) is a non-profit initiative launched in 2013 that functions as a de facto national digital library. Its database brings together more than 45 million documents from American libraries, archives, and museums. Access: https://dp.la,

At the digital level, DPLA can be regarded as the closest equivalent to a true 'national online library,' complementing the digital collections of the Library of Congress.




**The Digital Public Library of America (DPLA)** has the mission "to provide open, public, and comprehensive access to America's cultural and scientific heritage," thereby facilitating learning, personal growth, and contributions to a more diverse and functional society (Digital Public Library of America, n.d.). The concept was inspired by the model of traditional public libraries but transposed into an open and distributed digital network (Knight Foundation, 2013).

DPLA operates through a network of hubs (regional or institutional nodes) that collaborate in aggregating metadata and thumbnails of digital objects into a centralized repository. Users are provided with interfaces that allow searches by chronology, theme, location, and

format, as well as the ability to create and share personalised lists and to navigate resources via maps or timelines (Clark County Public Library, 2025; Cohen, 2014).

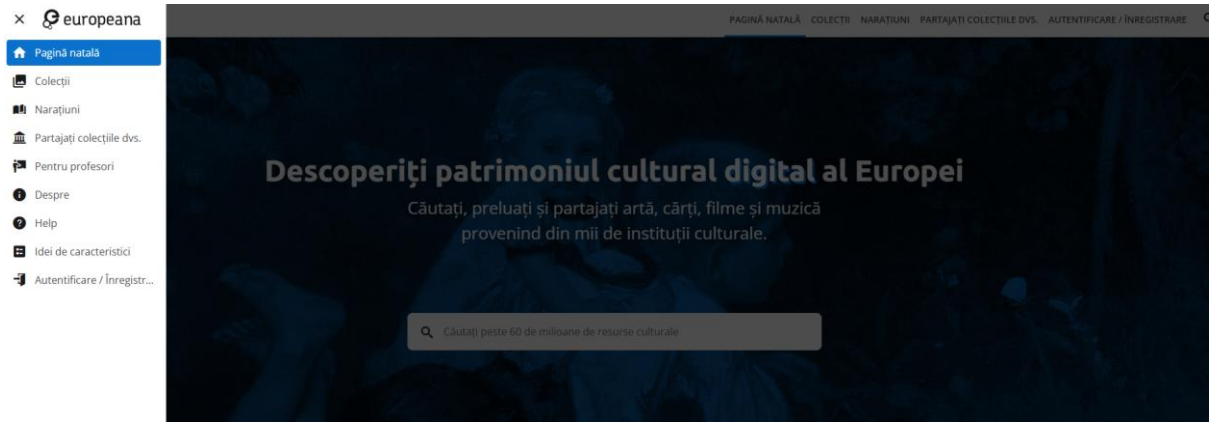
The project emerged around 2010 during a conference organized at Harvard, supported by the Berkman Center and major foundations such as Alfred P. Sloan, Knight, Arcadia, Soros, the National Endowment for the Humanities, and the Institute of Museum and Library Services (Knight Foundation, 2013; Darnton, 2013). Its official launch took place in 2013, with content contributed by prestigious institutions such as Harvard University, the New York Public Library, and the Smithsonian Institution (Darnton, 2013).

A distinctive feature of DPLA is its commitment to open access, with metadata published under a CC0 license, enabling broad reuse by developers and institutions. The availability of a robust Application Programming Interface (API) has facilitated the creation of educational, cultural, and tourism-oriented applications. Moreover, the integration of geocoded metadata allows resources to be visualized on interactive maps, generating dynamic research and learning experiences (Digital Public Library of America, n.d.; Cohen, 2014).

## 2.6.2. Online European Library *Europeana*

**https://www.europeana.eu**

In Europe, the *Europeana* project brings together more than 60 million digitized documents from over 3,500 cultural institutions, including libraries, museums, and archives (European Commission, 2020).




Launched in 2008 and supported by the European Commission, *Europeana* was designed to provide online access to Europe's cultural heritage.

The initiative emerged as a response to global projects such as Google Books, aiming to create a public, non-commercial, and collaborative alternative that reflects Europe's cultural diversity (European Commission, 2020; Europeana Foundation, 2018).

Europeana collaborates with thousands of libraries, museums, archives, and galleries from EU member states and beyond. At present, the platform provides access to more than 50 million digital objects, including millions of books, manuscripts, and rare documents, as well as paintings, photographs, maps, audiovisual materials, and 3D objects (Europeana Foundation, 2022).

Access to Europeana is free and open to the public. The materials can be used for educational, research, and creative innovation purposes, with many of them available under

Creative Commons licenses. **Europeana** also provides dedicated educational tools (Europeana Classroom) and resources for developing applications based on cultural big data (Europeana Pro, 2021).

**Europeana** has a significant impact in:

- **Preserving European cultural heritage** in a globally accessible digital format.
- **Education and research**, by integrating resources into academic and school platforms.
- **The creative industries**, offering reusable materials for digital art, design, and media productions (Nauta et al., 2017).

The main difference compared to Google Books is that Google Books is a private initiative with a predominantly commercial purpose, whereas Europeana is a public platform financed by the European Union (Table 2.2).

## 2.6.3. Comparative Analysis: Europeana vs. Google Books

The main differences between the two online digital libraries are summarized in Table 1.2.

**Table 2.2 – Comparative Analysis: Europeana vs. Google Books**

| Criterion | Europeana | Google Books |
|---|---|---|
| **Initiators** | European Union, supported by member states and cultural institutions | Google Inc. (private initiative, launched in 2004) |
| **Launch year** | 2008 | 2004 |
| **Institution type** | Public, non-profit platform funded by the European Union | Commercial project, market-oriented, under private control |
| **Partners** | National libraries, museums, archives, art galleries, some private partners | University and national libraries (limited partnerships), but with private control |
| **Collection size** | Over 50 million digital objects (books, manuscripts, maps, images, audio, video) (European Commission, 2020) | Over 25 million scanned volumes, mainly books (Jeanneney, 2007) |
| **Access** | Free and open access, emphasis on European cultural heritage | Partial free access; full texts only via purchase or licensing |
| **Orientation** | Cultural and educational; promoting European identity and open access | Commercial; expanding digital market and seeking informational dominance |
| **Controversies** | Copyright concerns regulated under EU legislation | Major lawsuits over copyright (e.g., Authors Guild v. Google) |
| **Strategic role** | European alternative to digital monopoly; cultural policy instrument | Global private digitization engine, profit-driven |

*Source: Own research*

Europeana focuses on Europe's diverse cultural heritage, not only on books, with the selection of materials carried out in collaboration with cultural institutions. Unlike Google Books, Europeana provides clear usage licenses and emphasizes interoperability and education. According to ALLEA, the platform was designed to ensure a balance between open access to knowledge and the protection of copyright, through an infrastructure coordinated by EU member states and supported by European copyright legislation (ALLEA, 2011, p. 8).

Moreover, Europeana is not just a digital collection but also a cultural policy instrument, serving to promote European identity and to support digital innovation in the cultural sector (ALLEA, 2011).

## 2.7. Digitized National Libraries

Digitized national libraries represent key institutional actors in the preservation and dissemination of cultural heritage in the digital age. Many national libraries have developed large-scale digitization programs, offering free public access to rare books, manuscripts, maps, newspapers, and other heritage documents through dedicated online platforms.

These initiatives reflect each country's commitment to safeguarding national identity while promoting open access to knowledge and supporting education and research.

In Asia, Japan and China have invested heavily in national digital libraries, considering digitization a cultural soft power strategy (Chen & Lin, 2017).

Thus, at the global level, digitization is seen not only as a technical solution but also as a strategic policy for education, culture, and diplomacy (UNESCO, 2022).

Most of these digitized national libraries are also part of international initiatives such as the World Digital Library or *Europeana*, which further strengthens the global visibility of their heritage. At the European level, the digital library *Europeana* integrates the collections of national libraries from EU Member States, creating a coordinated framework for information sharing (Figure 2.1).

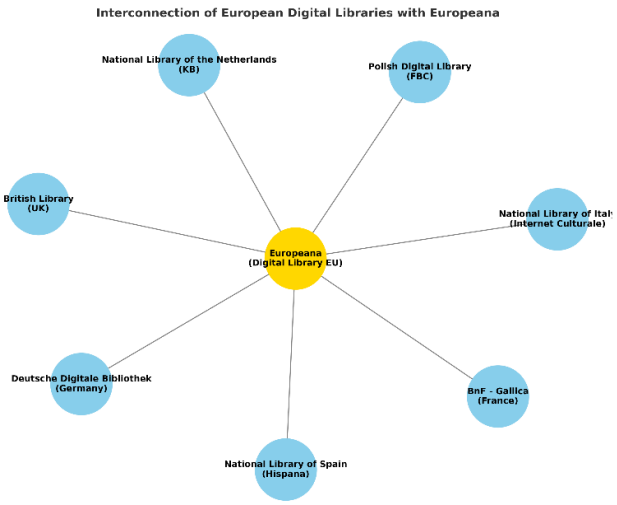



Figure 2.1 Europeana as a hub integrating national digital libraries across Europe

*Source: Generated by the author with AI*

## 2.7.1. British Library, Marea Britanie

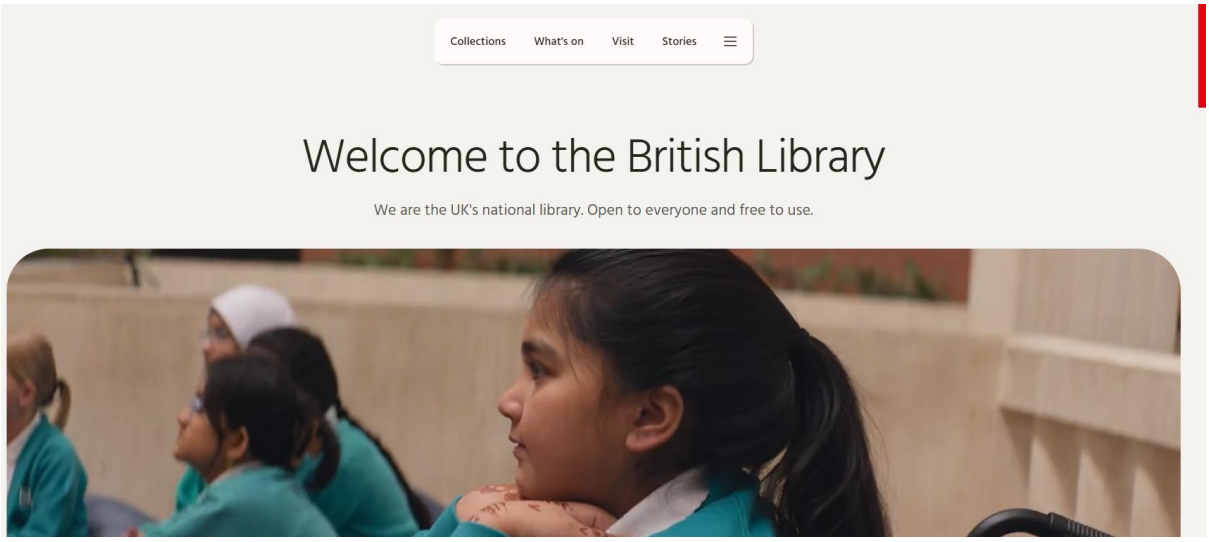
**https://www.bl.uk**

The British Library is one of the largest libraries in the world, with a heritage estimated at over 170 million items, including books, manuscripts, periodicals, maps, sound recordings, stamps, patents, and digital materials.

A significant part of these collections has already been digitized and made available to the public, strengthening the library's role as a European leader in cultural heritage digitization (British Library, n.d.-a).

**Major Digitization Projects**

Turning the Pages – an innovative project that enables online consultation of rare manuscripts in interactive 3D format, offering an immersive and accessible experience for both researchers and the public. Notable documents include Leonardo da Vinci's Codex Arundel and the Magna Carta (British Library, n.d.-b).




UK Web Archive – the national archive of the British internet, developed in collaboration with university libraries and heritage institutions. The project aims to preserve websites of historical and cultural relevance, reflecting transformations in British society in the digital age (British Library, n.d.-c).

British Newspaper Archive – an initiative through which millions of pages of historical press are digitized, in partnership with the British Newspaper Library and the company Findmypast. This has become one of the most important sources for historical and genealogical research (British Library, n.d.-d).

Digitisation of Sound Archives – a program dedicated to preserving and digitizing rare sound collections, including vinyl records, magnetic tapes, and historic discs, to prevent the degradation of analogy media (British Library, n.d.-e).

The British Library supports these activities through a combination of funding sources:

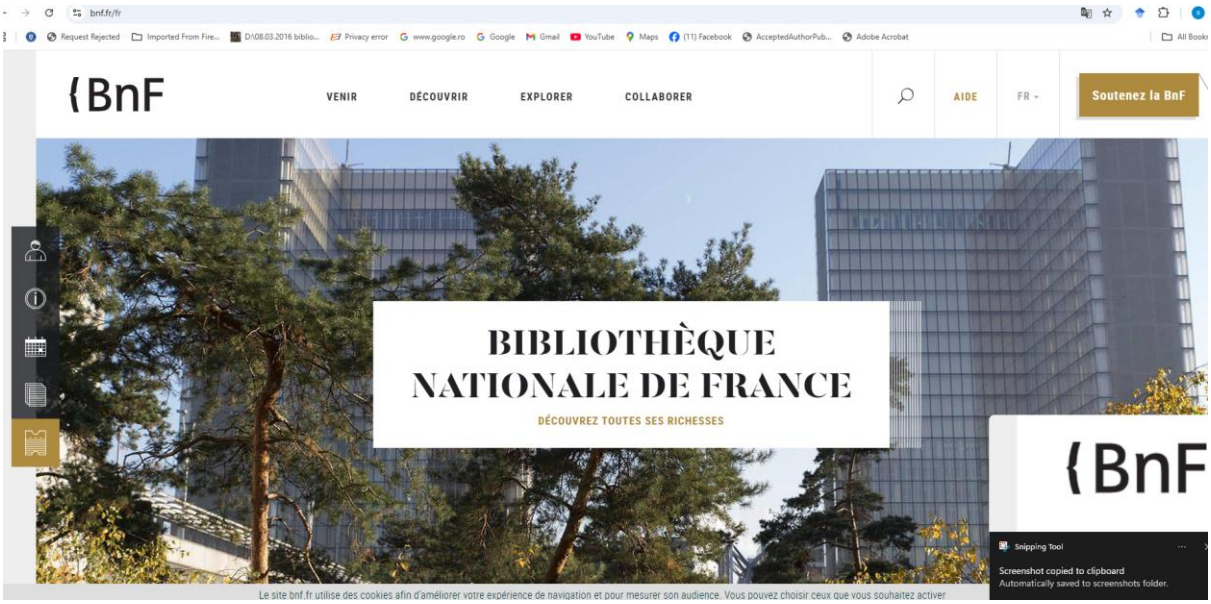
- Government budget allocated by the UK Department for Digital, Culture, Media and Sport;

- Sponsorships and philanthropic donations from organizations such as the Heritage Lottery Fund and the Wellcome Trust;
- Research and digitization grants, including European and international funding for collaborative projects (British Library, n.d.-a).

Through these initiatives, the British Library positions itself as a strategic actor in the digitization of world heritage, integrating into international projects such as Europeana and the World Digital Library, and providing a replicable model for preservation and open access to knowledge.

## 2.7.2. Bibliothèque nationale de France (BnF)

**(https://www.bnf.fr/fr).**




Bibliothèque nationale de France (BnF) is one of the largest and most prestigious national libraries in the world, with a heritage exceeding 40 million documents: books, journals, manuscripts, maps, photographs, musical scores, coins, medals, stamps, and audiovisual resources (BnF, n.d.-a).

The Gallica platform, launched in 2007, is one of the most significant initiatives for digitizing world cultural heritage. It provides free online access to over 10 million documents, covering an impressive diversity of resources: books, journals, historical newspapers, rare manuscripts, maps, scores, and images (BnF, n.d.-b). Unlike other digital libraries, Gallica is multilingual and has an accessible interface, addressing both researchers and the public.

**Major projects include:**

- **Digitization of French national heritage** – **Gallica** provides access to fundamental documents of French and European culture, such as medieval manuscripts or first editions of major writers (BnF, n.d.-c).
- **International cooperation** – **BnF** collaborates with libraries and cultural institutions worldwide, playing an active role in major projects such as **Europeana** and the **World Digital Library** (Kelly, 2012).
- **Advanced search and analysis tools** – **Gallica not only enables document access but also supports** downloads in multiple formats, integration into educational projects, and the use of metadata in digital applications.
- **Long-term digital preservation** – through its digitization centres and the **BnF DataLab program**, the library supports digital research and innovation in the field of digital humanities.

Funding sources for BnF's digitization activities include:

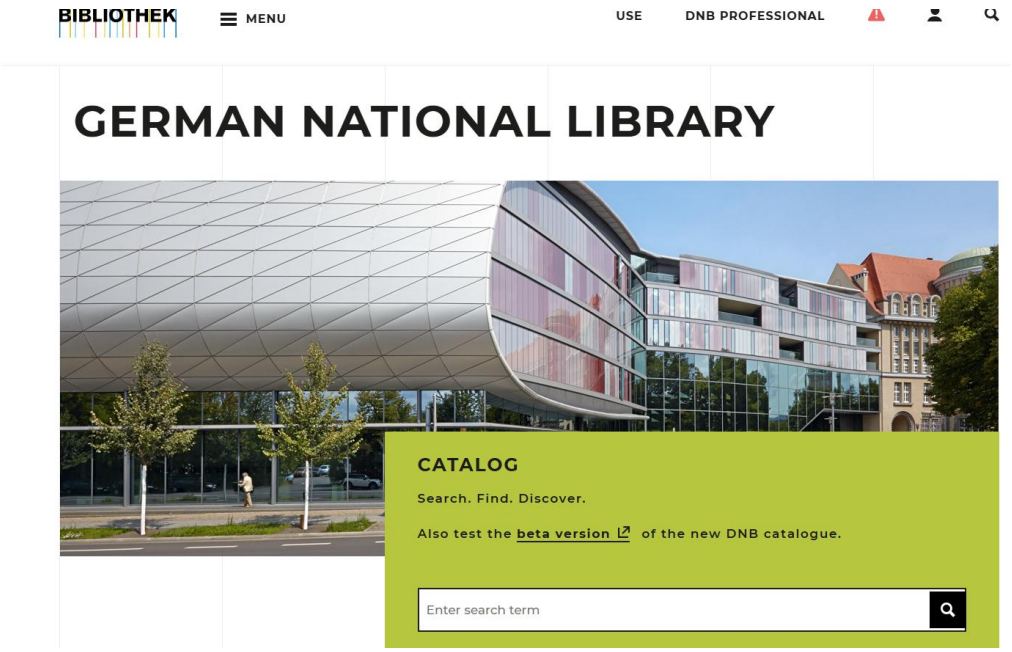
- The French state budget, via the Ministry of Culture;

- International partnerships, especially European projects (e.g., Europeana, Horizon Europe);
- Sponsorships and donations through cultural foundations and public-private partnerships (BnF, n.d.-a).

Through Gallica, the BnF preserves France's cultural heritage and makes it accessible globally. The platform is widely used in education, research, and cultural diplomacy, standing as a benchmark for digitization and the promotion of open access to knowledge.

## 2.7.3. Deutsche Nationalbibliothek, Germany

**https://www.dnb.de/DE/Home/home_node.html**




The Deutsche Nationalbibliothek (DNB), founded in 1912, has the mission of collecting, archiving, and making publicly available all printed and digital publications published in Germany, as well as foreign literature about Germany or in the German language.

Today, the DNB manages an impressive collection of tens of millions of documents, making it one of the largest national libraries in Europe (DNB, n.d.-a).

The Deutsche Digitale Bibliothek (DDB) is one of the most ambitious digital projects coordinated by the DNB.

Launched as a central platform for access to Germany's cultural heritage, the DDB integrates resources from more than 700 cultural institutions—including libraries, museums, archives, media collections, and research institutes—and offers access to over 42 million digital objects, including texts, images, films, audio recordings, and more. Through DNB's digital services, users can access books, manuscripts, artworks, videos, photographs, and historical documents, creating an open "portal of German culture" for the public (DNB, n.d.-b).

**Key features and impact**:

- **Integration with Europeana –** the DDB actively contributes to the European platform Europeana, enhancing the international visibility of German heritage.
- **Open access –** most resources are freely available, in line with European policies on open access to information.
- **Digital preservation –** the DNB carries out long-term digital archiving programs, including multimedia resources and electronic publications.
- **Support for research –** through advanced digital services, DDB and DNB provide essential infrastructure for research in the digital humanities.

The Deutsche Nationalbibliothek is funded by the federal budget of Germany and by contributions from the federal states (Länder), ensuring its stability and capacity to invest in modern digitization technologies and international cultural cooperation projects (DNB, n.d.-a).

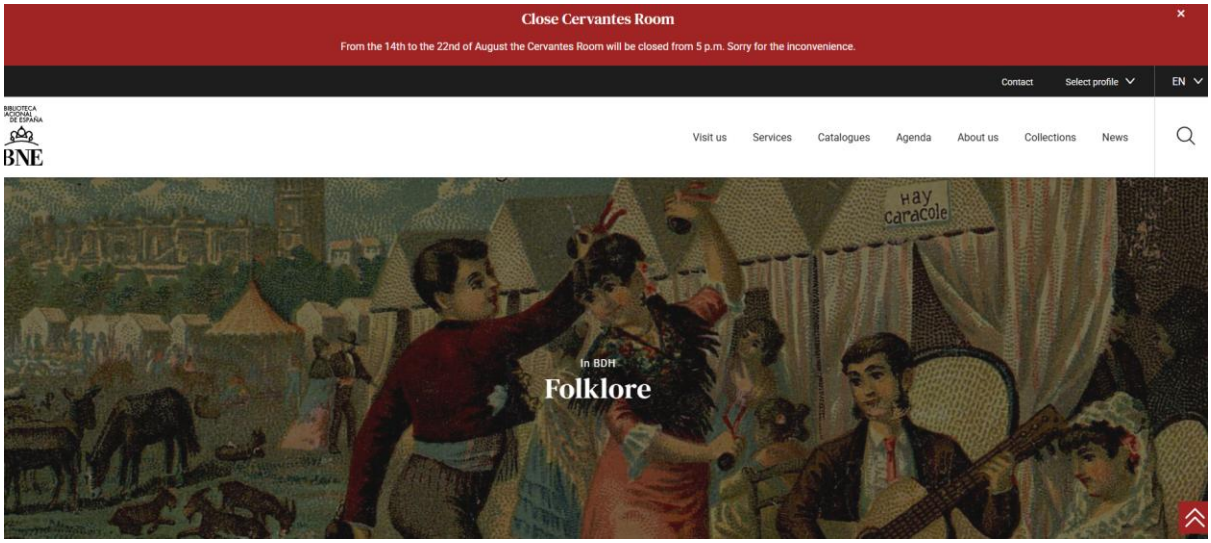
Additionally, some initiatives, such as the DDB, receive European support and benefit from institutional partnerships.

The DNB is not only a depository of German literature and culture but also a strong promoter of open access and cultural digitization, consolidating Germany's role as a European leader in digital lib.

## 2.7.4. Biblioteca Nacional de España (BNE), Spain

**https://www.bne.es/en**

The **Biblioteca Nacional de España (BNE)**, founded in 1712 by King Philip V, is one of Europe's most prestigious cultural institutions and the official depository of Spain's bibliographic heritage.




The library plays a fundamental role in preserving, cataloguing, and disseminating the country's editorial production and historical collections (BNE, n.d.).

A flagship initiative of the BNE is the Biblioteca Digital Hispánica (BDH), launched in 2008, which provides free and open access to hundreds of thousands of digitized documents, including:

- Medieval and modern manuscripts,
- Incunabula and rare editions,
- Historical maps and atlases,
- Music scores and collections,
- Photographs, posters, and iconographic materials.

**Collection size and growth:**

As of August 2023, the BDH offered open access to more than 250,000 digitized titles from BNE collections—books, manuscripts, scores, maps, photographs, and audiovisuals.

- According to Cambridge University Press & Assessment (2022–2023), the BDH included over 220,000 digitized objects, explicitly listing music scores and recordings.
- The Hemeroteca Digital, as part of BDH, provided access to around 2,500 journal and newspaper titles, totaling more than 70 million scanned historical pages.
- Earlier reports (2014) indicated approximately 60,000 works, covering manuscripts, incunabula, maps, scores, and sound recordings, illustrating the platform's rapid expansion.

The BDH is recognized internationally as a reference in heritage digitization, designed not only for public access but also to support academic research and education. With a multilingual interface, it allows advanced exploration of collections using standardized metadata and visualization tools.

Its importance extends beyond Spain: The Biblioteca Digital Hispánica has served as a model and inspiration for large-scale European platforms such as Europeana, reinforcing Spain's role in democratizing access to culture and knowledge (BNE, n.d.).

Funding: The BNE and BDH are primarily supported by Spain's Ministerio de Cultura y Deporte, complemented by European funds and international institutional partnerships. This combination ensures the continuity of digitization programs and the modernization of IT infrastructure required for long-term digital preservation.

In this way, the Biblioteca Nacional de España positions itself as a key node in the European network of digital libraries, actively contributing to the visibility and accessibility of universal cultural heritage. Through the BDH, the BNE has transformed its documentary heritage into a globally accessible resource, supporting research, education, and the preservation of cultural memory worldwide.

## 2.7.5. Internet Culturale, Italy

**https://www.internetculturale.it/**


The **Internet Culturale** portal is Italy's national platform for digital cultural heritage, launched by the Ministry of Culture together with the Central National Library of Florence. Its primary goal is to integrate and make accessible the digitized collections of Italian libraries and other cultural institutions (Internet Culturale, n.d.-a).

The platform hosts millions of digitized pages, including manuscripts, rare books, periodicals, photographs, and musical materials. It also provides thematic collections and integrated catalogues for both researchers and the public (Internet Culturale, n.d.-b).

Currently, **Internet Culturale offers access to more than 15 million digital objects**, including images, texts, films, musical documents, and associated metadata. While the exact figure is subject to updates, available data highlights its extensive coverage of Italy's digitized heritage across numerous collections and institutions.

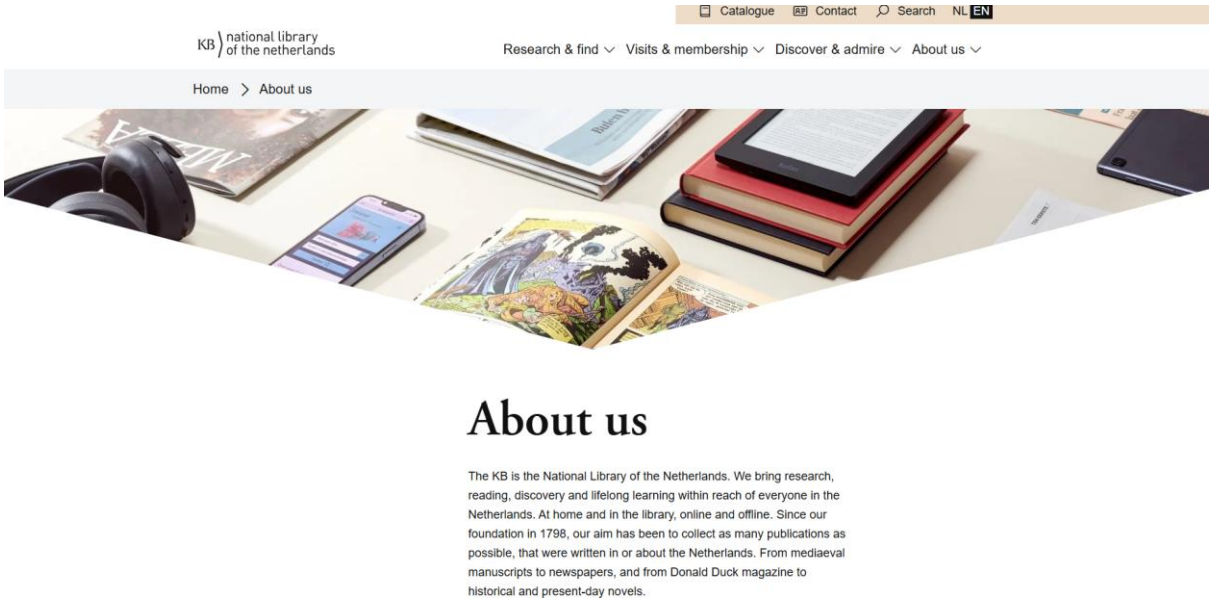
As a **major contributor to Europeana**, Internet Culturale supplies metadata and digital content from Italy, supporting the standardization of collection descriptions across Europe and fostering cooperation in joint cultural initiatives (Europeana, 2023).

**Funding**: The platform is primarily financed by the Italian government through the Ministry of Culture, with additional support from European digitization programs (e.g., *eContentplus*, *Horizon Europe*) and institutional partnerships (Ministero della Cultura, 2021).

Through its scale and interoperability, Internet Culturale has become one of the most advanced European digital platforms, offering access to a vast cultural heritage and strengthening Italy's role as a leader in digital preservation and cultural innovation.

## 2.7.6. Koninklijke Bibliotheek (KB), Necderlands

**https://www.kb.nl**




The Koninklijke Bibliotheek (KB), National Library of the Netherlands, plays a crucial role in preserving and digitizing Dutch cultural heritage. Since 1993, KB has coordinated national digitization programs, and since 2009 it has been a major contributor to Europeana (KB, n.d.-a).

Its digital collections include millions of pages from books, journals, newspapers, and manuscripts.

A flagship project is Delpher, which provides access to more than 120 million digitized pages, including a vast repository of Dutch historical newspapers. The platform integrates advanced search services and Optical Character Recognition (OCR), enabling precise and large-scale text analysis (KB, n.d.-b).

KB was one of the founding members of Europeana and remains actively engaged in European cooperation projects focused on standardization and open access to digital collections (Europeana, 2023).

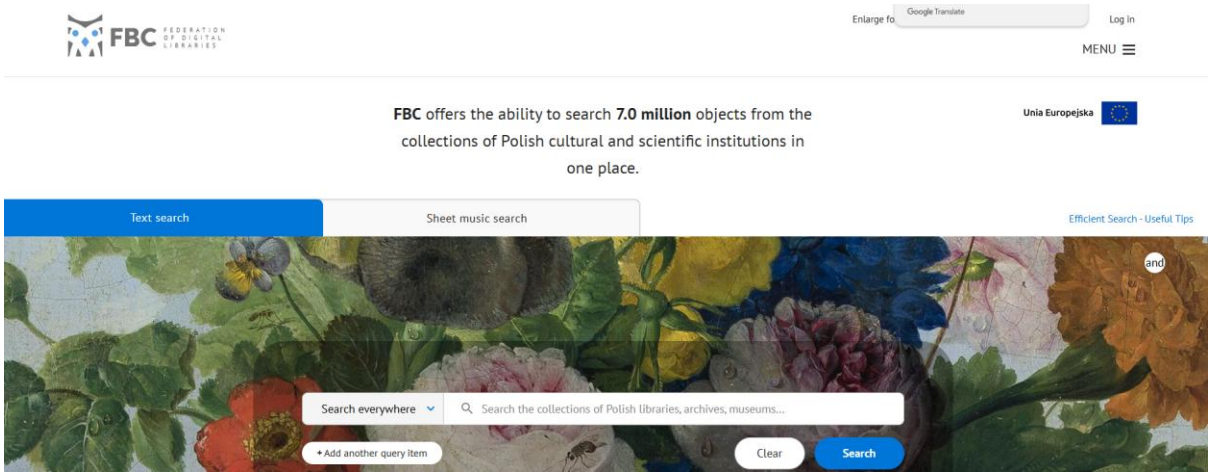
Funding: KB's digitization activities are financed primarily by the Dutch government through the Ministry of Education, Culture, and Science, supplemented by European grants and partnerships with private foundations and organizations (Koninklijke Bibliotheek, 2021).

Through its scope, technical innovation, and commitment to accessibility, KB is regarded as a model of best practice in integrated digitization and open access, recognized internationally for the scale and quality of its digital collections.

## 2.7.7. Federacja Bibliotek Cyfrowych (FBC), Poland

**https://fbc.pionier.net.pl/**

The Federacja Bibliotek Cyfrowych (FBC) – Polish Digital Libraries Federation is Poland's national infrastructure for integrating and providing access to the digital collections of libraries and cultural institutions.




Launched in 2007, FBC functions as a central access point for Poland's digital resources (FBC, n.d.-a).

The platform integrates more than 8 million digital objects—including books, journals, historical documents, manuscripts, and visual materials. It enables distributed search and provides standardized metadata for international reuse (FBC, n.d.-b).

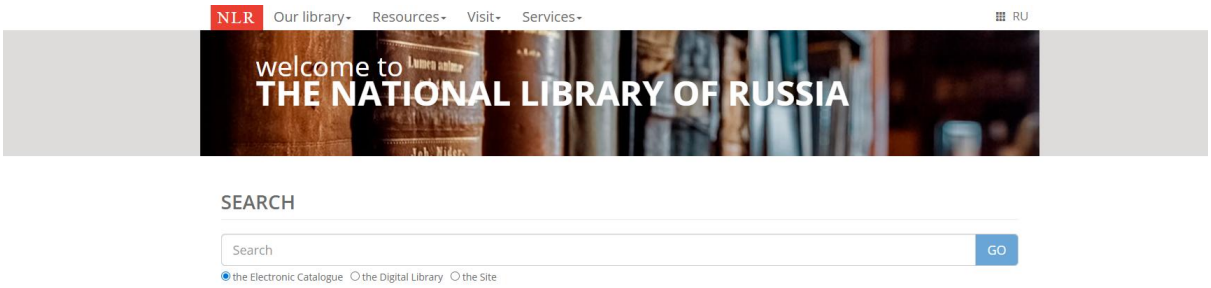
FBC is the main Polish contributor to Europeana, ensuring broad European visibility of Poland's digital heritage. It actively collaborates with international networks to promote open access and interoperability (Europeana, 2023).

**Funding:** The initiative is financed by the Polish Ministry of Science and Higher Education, supported by European Structural Funds and participating member institutions (FBC, 2020).

As a national cooperation model, FBC successfully integrates diverse resources and supports both research and education through open access to Poland's cultural and scholarly heritage.

## 2.7.8. Russian State Library (RSL), Russia

**https://nlr.ru/eng**




The Russian State Library (RSL), also known as the Lenin Library, is one of the largest libraries in the world and the largest in the Russian Federation. Founded in 1862, it has gradually become a national cultural and scientific landmark.

At present, its total collection exceeds 48.1 million items, including books, manuscripts, periodicals, cartographic documents, music scores, and audiovisual materials. Among these, approximately 3 million items are considered valuable or rare editions, reflecting both Russia's and the world's cultural and intellectual heritage (Russian State Library, n.d.).

A major step in the modernization of the institution was the implementation of the National Electronic Library (NEL) — a strategic project of the Russian government launched to facilitate public access to digital resources. As of November 2024, the NEL platform offered access to 5,752,597 electronic documents, of which around 94% were available in open access, making it one of the largest digitization initiatives of cultural and scientific heritage in Europe (National Electronic Library, 2024).

The Russian State Library plays a key role in promoting open access to information and supporting academic research. Its digital projects include not only text collections but also cartographic, musical, and audio materials, all integrated into a unified platform accessible to users worldwide. Moreover, NEL aims to create a unified framework for public and university libraries across the Russian Federation, facilitating interoperability and integrated access to resources (National Electronic Library, 2024).

Through these initiatives, the Russian State Library has evolved from being merely a repository of cultural heritage into a national digital hub, contributing to the international visibility of Russian resources and the democratization of knowledge. At the same time, the project aligns with global digitization demands, positioning Russia within the international network of major digital libraries.

## 2.7.9. National Library of China (NLC)


The **National Library of China (NLC),** located in Beijing, is one of the largest libraries in the world and the largest in Asia.

Founded in 1909, the institution has the mission of preserving China's cultural heritage, supporting education and research, and promoting international cultural exchanges (National Library of China [NLC], n.d.-a).

The NLC's total collection exceeds 41 million items, while its digital resources amount to more than 1,000 TB, with an annual growth of approximately 100 TB (NLC, n.d.-a).

The library holds one of the richest collections of classical Chinese manuscripts, including Confucian, Buddhist, and Daoist texts, imperial government documents, maps, and historical archives.

The Chinese Ancient Book Resources database contains approximately 105,000 digitized ancient books accessible to the public.

The digitization program has led to the creation of the China Digital Library, which provides online access to millions of documents, including rare editions, periodicals, manuscripts, historical newspapers, and audiovisual materials. In addition, the Chinese Ancient Books Digital Library is dedicated to ancient manuscripts and heritage documents (NLC, n.d.-b).

**Digitization projects**

- **China Digital Library** – a national platform with millions of documents available online.
- **Chinese Ancient Books Digital Library** – preserves and provides access to classical texts and ancient manuscripts.
- **National Digital Library Project** – supported by the central government, aiming to digitize major resources by 2030.

The library is financed primarily through the state budget of China, under the authority of the Ministry of Culture and Tourism. Funding covers infrastructure modernization, digitization projects, and the development of electronic platforms.

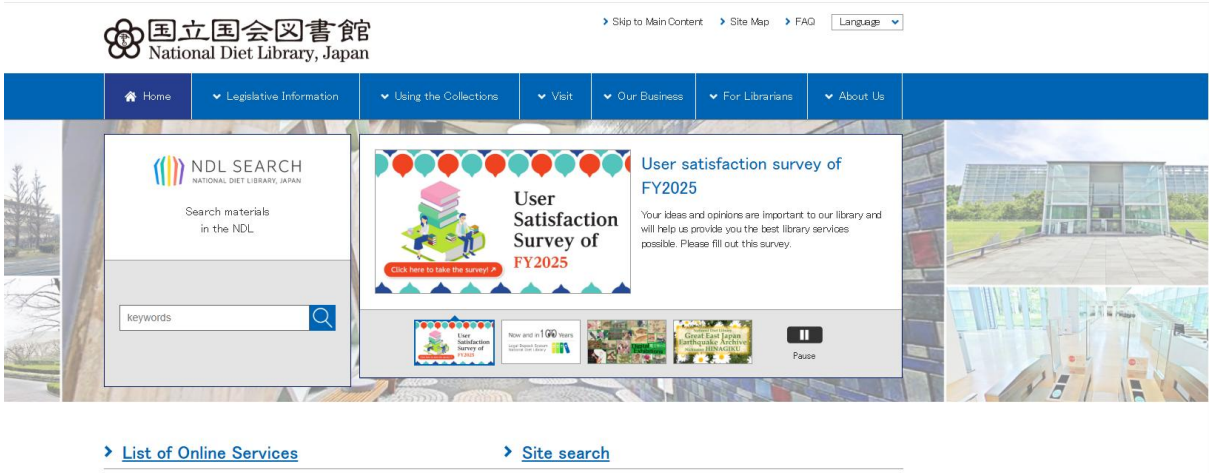
In addition to government support, the NLC benefits from partnerships with academic institutes and from UNESCO's support in international cooperation projects (NLC, n.d.-a; UNESCO, 2019).

The NLC has a major influence on the development of libraries and digitization in Asia. Through participation in international initiatives such as the World Digital Library (WDL) and IFLA, the NLC contributes to the global exchange of resources. Regionally, the library supports institutions in mainland China and collaborates with libraries in Hong Kong, Macao, and Taiwan. By digitizing classical Chinese collections, the NLC has become a central hub for Asian studies, supporting universities and research institutes worldwide.

The National Library of China is not only a conservation institution but also a regional and global leader in digitization. With its vast collection, solid government funding, and international partnerships, the NLC plays a strategic role in democratizing access to China's cultural heritage and integrating it into global information flows.

## 2.7.10. National Diet Library (NDL), Japan

**https://www.ndl.go.jp/en/**




The National Diet Library (NDL) of Japan was founded in 1948 to support parliamentary activity while also serving as the country's national library. Its mission is to collect, preserve, and disseminate national and international publications, making it the largest library in Japan (NDL, n.d.-a).

The institution manages three major facilities: the Tokyo Main Library (headquarters near the Parliament), Kansai-kan (Kyoto, specialized in digital collections and access to databases), and the International Library of Children's Literature (Tokyo, focused on children's literature). The NDL combines tradition with digital innovation, becoming a central hub of Japan's informational and cultural heritage.

The NDL's collections exceed 44 million materials (NDL, n.d.-a), including:

- Japanese books, journals, and newspapers,
- Government and legislative documents,
- Rare manuscripts and maps,
- Foreign publications and electronic resources.

**Digitization programs**

- NDL Digital Collections – more than 3.6 million digitized volumes, including manuscripts, Japanese incunabula, and rare editions.
- Web Archiving Project (WARP) – archives Japanese public web resources to safeguard the nation's digital memory.
- National Diet Library Online (NDL-OPAC) – a unified catalog integrating access to both physical and digital holdings.

**Digital platforms and services**

- NDL Digital Collections provide open access to public domain resources, while copyright-protected materials can be consulted on-site in reading rooms.
- Japan Search – a national integrated platform developed in cooperation with museums, archives, and libraries, allowing cross-institutional searches.
- WARP – one of the earliest webs archiving projects worldwide, initiated in 2002.

Educational services include training programs for researchers and support for the use of international databases.

**Funding sources**

The NDL is primarily funded through the Japanese government budget and operates under the authority of the National Diet (Parliament). Funding covers:

- Preservation and expansion of collections,
- Development of digital infrastructure (including Kansai-kan and WARP),
- Modernization of public services.

The NDL collaborates with international partners (e.g., UNESCO, IFLA) and participates in digitization projects supported by research grants and cultural cooperation initiatives (Yamamoto, 2019). It also coordinates university and public libraries in national digitization and resource-sharing projects. Programs like Japan Search directly support education, research, and the preservation of Japan's cultural heritage.

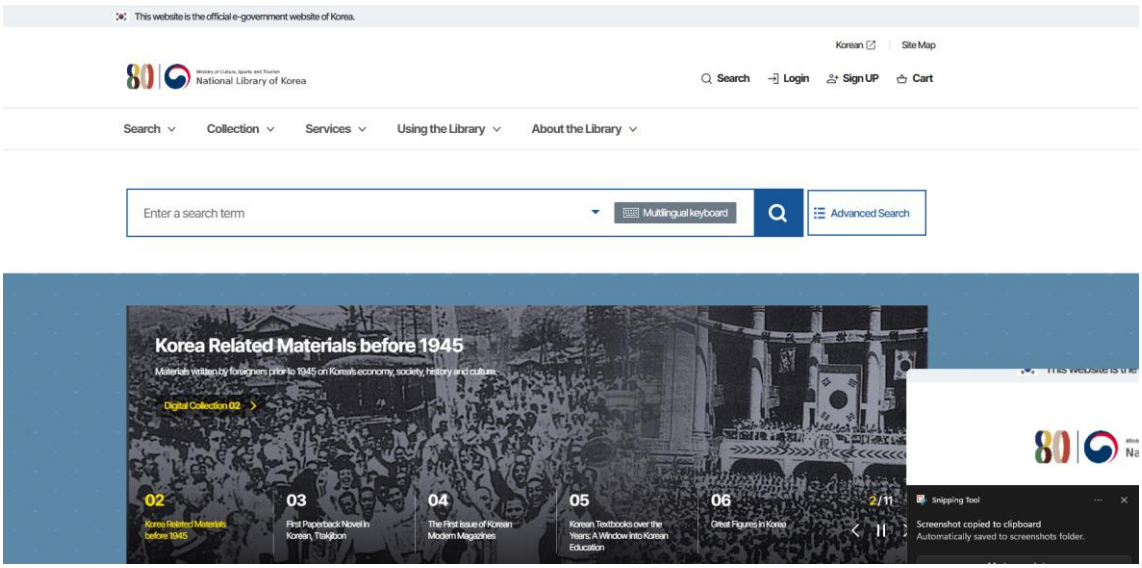
Globally, through participation in Europeana and the World Digital Library, the NDL contributes to the worldwide circulation of knowledge. Moreover, standardized bibliographic data exchange (MARC, DOI) facilitates integration into international networks.

The National Diet Library of Japan exemplifies the integration of tradition and digital transformation, managing one of the most extensive collections in Asia.

Through platforms such as NDL Digital Collections, WARP, and Japan Search, it has become a hub of innovation in archiving and open access. Supported by the Japanese government, the NDL has a significant impact both in the Asia-Pacific region and globally, consolidating Japan's role as a leader in digital preservation.

## 2.7.11. National Library of Korea (NLK/Dibrary)

**https://www.nl.go.kr/EN/main/index.do**




The National Library of Korea (NLK), founded in 1945 and headquartered in Seoul, is the primary library institution of the Republic of Korea. Its mission is to collect, preserve, and disseminate national and international publications, while also promoting digital literacy and free access to information.

An innovative component is the Digital Library of Korea (Dibrary), inaugurated in 2009 as the first facility of its kind in Asia, focused exclusively on digital services and collections (NLK, n.d.-a).

**Collections and digitization**

- **The total holdings** exceed 14 million printed volumes (NLK, n.d.-b). In terms of digitization:
- Over **264 million digital** resources are available via the NLK platform, including e-books, official documents, educational resources, and international databases (NLK, n.d.-a).
- The **National Newspaper Archive** comprises more than 381,000 pages from 99 publications, totalling over 8 million digitized articles accessible through the NLK portal (NLK, 2024).
- **Multimedia resources** include audio-video files, web archives, and academic collections.

**Digital platforms and services**

- Dibrary (Digital Library of Korea) – a digital hub with access to millions of resources, interactive services, virtual reality, and multimedia rooms.
- Korean Newspaper Archive – a platform dedicated to digitized newspapers.
- Korean History Digital Library – specialized in historical and heritage collections.
- International access – partnerships with IFLA, OCLC, and partial integration with Europeana and other global networks.

**Funding**

The NLK is primarily funded by the South Korean government through the Ministry of Culture, Sports and Tourism.

Funding priorities include:

- Modernization of digital infrastructure (including Dibrary),
- Preservation of cultural heritage and translation of resources,
- Educational programs and international projects.

Additionally, certain initiatives are supported by grants for digital innovation and cultural cooperation from international organizations (Kim, 2020).

**Regional and global roles**

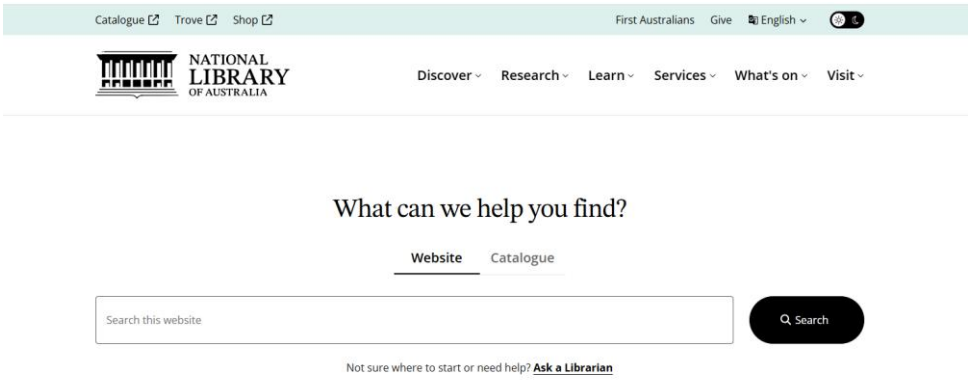
Regionally, the NLK functions as the central hub for South Korea's public and university libraries, ensuring equal digital access for students, faculty, and the public. Through Dibrary, it promotes a highly advanced digital culture, supporting distance education and technological innovation.

Globally, the library is an active partner in UNESCO and IFLA projects and participates in international cultural exchanges. The digitization of newspapers and historical collections contributes significantly to global research on East Asian history and culture.

The National Library of Korea represents a model of digital transformation in Asia by integrating a traditional national library with state-of-the-art digital infrastructure (Dibrary). State-funded and strengthened through international partnerships, the NLK has a strong impact on developing digital skills, ensuring equal access to knowledge, and preserving Korea's cultural heritage, thereby consolidating its role as a regional leader in library digitalization and innovation.

## 2.7.12. National Library of Australia (NLA) and the Trove Platform

**https://trove.nla.gov.au/**

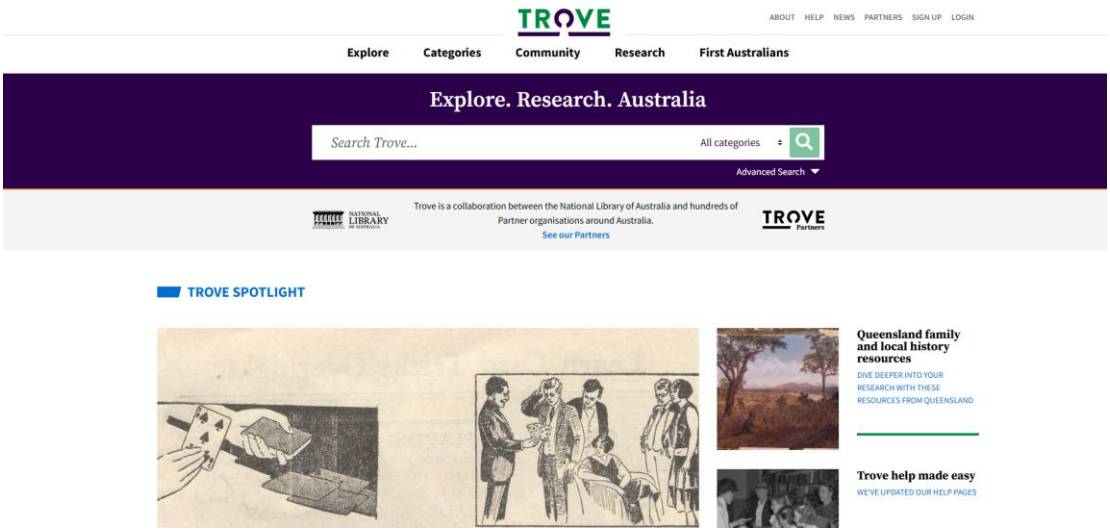



**The National Library of Australia (NLA),** founded in 1960, is the country's largest library institution. Its role is to collect, preserve, and disseminate the nation's documentary heritage, while also facilitating access to international resources for research and education (NLA, n.d.-a).

The library coordinates **Trove**, one of the largest digital platforms in the world, which integrates resources from Australian libraries, museums, archives, and universities.

**Trove** is often described as the "digital heart of Australia", providing access to tens of millions of documents, including the continent's historical press.

The total physical collections of the **NLA** exceed 10 million items, including books, manuscripts, maps, scores, photographs, and multimedia materials (NLA, n.d.-b).




In the digital environment, Trove provides:

- Over **6.5 billion indexed resources** (books, articles, photographs, audio-visual recordings, archived web pages),
- More than **25 million fully digitized pages** of Australian historical newspapers,
- Government archives, academic collections, and materials from Aboriginal and Torres Strait Islander heritage.

**Digital platforms and services associated with the NLA**

- **Trove** – the national discovery and access engine, integrating the collections of the NLA and thousands of partners (state libraries, museums, university archives).
- **Digitisation Program** – a large-scale program for digitizing historical newspapers and rare materials.
- **Australian Web Archive** – preservation of web resources, including government and cultural websites.
- **Educational resources** – teaching and learning materials for schools and universities.

**Funding sources**

The National Library of Australia and the Trove platform are primarily funded by the Australian federal government, through the Department of Communications and the Arts. In addition to public funding, Trove is supported by:

- **National grants** for digitisation,
- **Institutional partnerships** with state libraries and universities,
- **Private donations and sponsorships** (including crowdfunding campaigns for digitisation expansion).

In 2023, the Australian government allocated an additional **AUD 33.8 million** to modernize and sustain Trove, ensuring its long-term viability (Australian Government, 2023).

**Regional and global impact**

Regionally, **Trove** democratizes access to Australia's cultural heritage, providing essential resources for education, research, and national history preservation. It is a vital tool for Aboriginal and Torres Strait Islander communities, enabling access to and reclamation of documents related to their cultural heritage. Globally, the **NLA** and **Trove** are partners in the World Digital Library, IFLA, and other international digitisation initiatives.

**Trove** is frequently cited as a model for similar projects worldwide due to its large-scale integration of resources and open access approach.

The **National Library of Australia**, through **Trove**, has become an outstanding example of excellence in digitisation and open access to information. Supported by public funding and multiple partnerships, the NLA provides a unique global-scale digital infrastructure. Its impact is evident both nationally—through the integration of Australia's diverse heritage—and internationally, strengthening Australia's role as a leader in digital libraries.

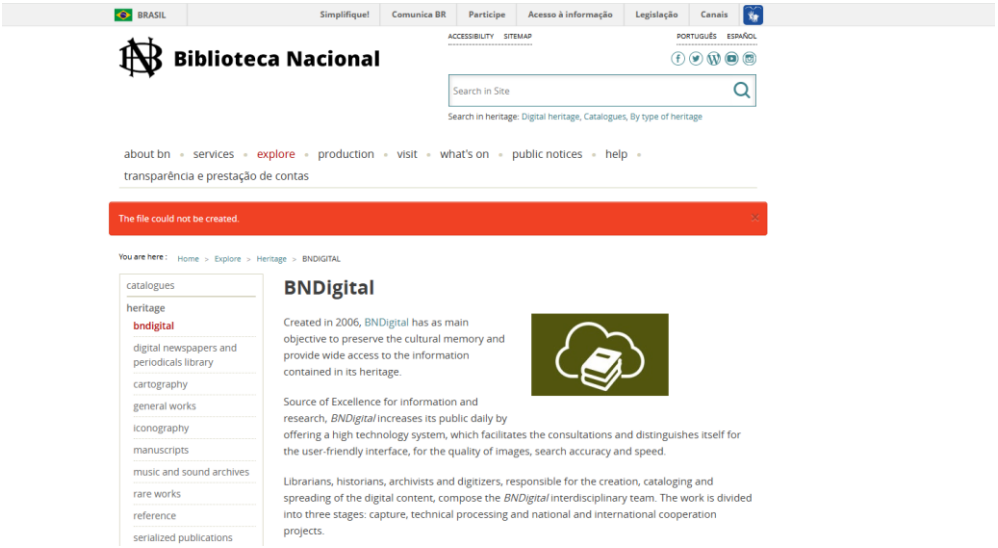
## 2.7.13. National Library of Brazil (Biblioteca Nacional do Brasil)

**https://antigo.bn.gov.br/en/explore/catalogues**

**The National Library of Brazil** (**Biblioteca Nacional do Brasil**), located in Rio de Janeiro, is the largest library in Latin America and one of the largest in the world.

Founded in 1810, the institution preserves an impressive documentary heritage, estimated at approximately 9 million items, including books, manuscripts, maps, periodicals, government documents, and iconographic materials (National Library of Brazil, n.d.-a).

The library's mission is to collect, preserve, and disseminate Brazil's cultural and scientific heritage, serving as a major reference point for academic research in the region.




While the physical collections comprise around 9 million units, digitisation has become a strategic priority.

The **Biblioteca Nacional Digital (BN Digital)** platform provides access to a significant portion of this heritage, including:

- The **Teresa Cristina Collection** with over 21,700 19th-century photographs, inscribed in UNESCO's Memory of the World program (National Library of Brazil, n.d.-b).
- **Rare manuscripts, incunabula, first editions, and historical maps**.
- **Digitised Brazilian newspapers and magazines**, essential for research on Brazil's social and political history.

Although consolidated data on the exact number of digitised objects is not available, the online collections are estimated to comprise hundreds of thousands of items, making BN Digital one of the most important digitisation initiatives in Latin America.

BN Digital serves as the library's main online platform, integrating textual, visual, and audiovisual resources.

**Key features**:

- **UNESCO-recognised collections** – support for the preservation and accessibility of globally significant Brazilian heritage.

- **International partnerships** – collaborations with networks such as IFLA and the World Digital Library, integrating Brazilian collections into the global knowledge ecosystem (UNESCO, 2010).

**Funding sources:**

- The National Library of Brazil is primarily funded by the **Federal Government of Brazil**, through the Ministry of Culture. Additional resources come from:
- **UNESCO** programmes for world heritage preservation,
- **International digitisation partnerships and research grants**,
- **Private sponsorships and donations**, especially for digitisation and restoration projects (UNESCO, 2010).

**Regional and global role:**

At the regional level, the National Library of Brazil acts as a central hub for academic research in Brazil and Latin America, ensuring free access to historical and cultural sources. Globally, through integration with platforms such as the World Digital Library, the library makes Brazil's cultural heritage widely accessible to the international scholarly community.

The National Library of Brazil stands as a representative example of a cultural institution that has successfully combined the preservation of physical heritage with digitisation and open access. Supported by governmental and international initiatives, BN Digital contributes to the democratisation of knowledge access and to the promotion of Brazilian cultural heritage worldwide.

### 2.7.14. Other Major Online Libraries in Latin America

Other notable institutions in **Latin America**, recognised for the quality and accessibility of their digital platforms, include:

- **Biblioteca Virtual de México** — offering approximately **12,450 digitised books**, along with documentary archives, photographs, and curated online exhibitions.
- **Biblioteca Virtual del Banco de la República (Colombia)** — part of the Luis Ángel Arango Library network, which provides a significant collection of digital resources, including texts, audio, video, and scholarly articles. The platform currently hosts around **80,000 digitised texts**, making it one of the most comprehensive digital libraries in the region.

## 2.8. Can ChatGPT Be Considered a Digital Library?

**ChatGPT cannot be considered a digital library,** because digitized libraries (e.g., Gallica, Europeana, World Digital Library) have a set of distinctive characteristics:

- they contain finite and clearly defined collections (books, manuscripts, maps, etc.);
- the documents come from institutional sources (national libraries, archives, museums);
- they are accompanied by metadata (author, title, year, edition, ISBN, DOI);
- they comply with a legal framework for copyright and heritage preservation.

By contrast, ChatGPT is an artificial intelligence model, not a repository of documents, which:

- does not hold its own collections but generates text based on linguistic patterns learned during training;
- does not guarantee access to original or digitized documents (books, articles, manuscripts);
- does not play an archival, bibliographic, or preservation role.

**Similarities and differences between ChatGPT and a digital library:**

- Both provide access to information in digital format, but digital libraries are official archives of authentic content, while ChatGPT is a probabilistic text generator, not a provider of original documents.
- Therefore, ChatGPT may be regarded as an **information assistant**, which can guide the user toward digital libraries or databases, but it should not be considered a digital library itself.

## 2.9. Library Digitization in Romania

In Romania, the first initiatives for library digitization were launched in the early 2000s, along with the development of IT infrastructure and the growing interest in integration into international networks of digital resources.

The National Library of Romania (BNR) initiated digitization programs for rare and heritage collections, later joining the European project Europeana, which aims to ensure unified access to cultural resources at a continental level (BNR, 2023).

The digitization programs carried out by the National Library of Romania focused on integrating rare and heritage collections into the European digital flow, through participation in Europeana, which provides unified access to cultural resources.

Currently, over 4,600 digital objects are available online, including old books, manuscripts, photographs, musical scores, and archival documents (National Library of Romania, 2023; Central University Library "Carol I", 2024). This initiative not only preserves cultural heritage but also facilitates research and education through free and open access to authentic resources (Europeana, 2025).

### 2.9.1. The National Digital Library of Romania (BDNR)

**https://bibnat.ro/biblioteca-digitala-nationala/**


A decisive step in the digitization process was the creation of the National Digital Library of Romania (BDNR), which provides online access to a wide range of resources: books, periodicals, manuscripts, official documents, and iconographic materials.

The platform enhances the international visibility of Romanian collections and contributes to the democratization of knowledge access, also ensuring interoperability with the Europeana portal (Bărbulescu, 2019).

The BDNR's digital collection includes diverse heritage materials such as:

- Historical archives (1,878 objects);
- Old Romanian books (316);
- Old foreign books (876);
- Manuscripts (448);
- Incunabula (153);
- Photographs (434);
- Drawings (51);
- Japanese prints (107);

- Ex-libris (90);
- Musical scores (146);
- Other documents (correspondence, reports, sketches, etc.) (193).

These objects are an integral part of Romania's effort to valorise cultural heritage at the European level, facilitating unified access and digital use within Europeana.

This strategic orientation aimed not only to preserve fragile documents but also to create a modern digital infrastructure capable of integrating Romanian heritage into global information flows.

Moreover, BDNR has become an essential infrastructure for researchers, professors, and students, by integrating valuable collections of old books, historical newspapers, and rare publications.

**The role of university libraries in digitizing information**

University libraries have played a crucial role in the digitization process, through the creation of institutional repositories and by participating in European projects.

Relevant examples include:

- Central University Library "Carol I" (Bucharest) – digitization of unique collections of periodicals and manuscripts, available via its own platforms (Stoica & Bodea, 2020).
- Central University Library "Mihai Eminescu" (Iași) – digitization initiatives for old books and involvement in international projects such as Europeana Local.
- Central University Library "Lucian Blaga" (Cluj-Napoca) – development of integrated digital databases with open access to academic publications.
- Central University Library "Eugen Todoran" (Timișoara) – platforms for archiving and disseminating scientific works produced at institutional level (Crăciun, 2021).

In addition, numerous Romanian university libraries have developed digital repositories based on open-source software, such as DSpace or EPrints, for archiving scientific articles, doctoral theses, and educational materials (IFLA, 2019).

**Challenges of digitization in Romania**

The digitization process in Romania is marked by several structural and operational obstacles:

- High costs for equipment, IT infrastructure, and specialized software (Smith, 2021).
- Copyright and licensing issues for protected materials, limiting access to certain collections (Jeanneney, 2007).
- Insufficient metadata standardization and limited interoperability between platforms, which hinders integration into international projects (IFLA, 2019).
- Lack of specialized human resources in digitization and digital preservation, especially in smaller libraries (Crăciun, 2021).

**Benefits of digitization**

Despite these challenges, digitization provides major advantages:

- Preservation of fragile cultural heritage, protecting rare documents from deterioration and ensuring their transmission to future generations (Borgman, 2003).

- Democratized access to information, including for disadvantaged communities and the diaspora, helping reduce educational inequalities (UNESCO, 2022).
- Integration of emerging technologies, such as artificial intelligence, machine learning, and OCR (Optical Character Recognition), which facilitate indexing, automated processing, and text searching (Chen & Lin, 2017).
- Alignment with European strategies in open science and cultural heritage digitization, supported by programs such as Horizon Europe or Digital Europe (European Commission, 2020).
- Creation of consortia and international partnerships, which can bring financial resources and expertise to accelerate digitization in Romania (IFLA, 2019).

**Conclusions**

The digitization of Romanian libraries is in a progressive development stage, marked by notable initiatives at the national and university level, but also by significant challenges for local public libraries. Integration into European projects, the use of emerging technologies, and the strengthening of digital infrastructure are essential directions for transforming Romanian libraries into modern digital hubs capable of providing universal and sustainable access to knowledge.

Digitization of libraries is an irreversible process, situated at the intersection of technology, culture, and education. Internationally, it is regarded as a strategic priority, and in Romania it represents a growing direction, requiring a coherent national strategy and sustainable funding.

**Practical Themes**

- **Digitization and the democratization of information access**

Impact on digital inclusion and reduction of the knowledge gap between developed and developing countries.

- **Copyright and digitization**

Comparative analysis of EU, US, and Asian regulations regarding copyright for digital resources.

- **Funding models for digital libraries**

Comparative study of public projects (e.g., *Europeana*), non-profit initiatives (e.g., *Internet Archive*, *Project Gutenberg*), and private projects (Google Books, JSTOR).

- **Digital libraries as instruments of soft power**

Examples: China and Japan use digital libraries to promote cultural heritage and international influence.

- **Emerging technologies in library digitization**

Artificial intelligence, augmented reality, advanced OCR, and digital twins for rare manuscripts.

- **Digital libraries and open education**

Their role in supporting open access, open science, and Open Educational Resources (OER).

- **Digital sustainability and long-term preservation**

Challenges related to file formats, data migration, and cloud archiving infrastructures.

- **Comparing national digital libraries in Eastern Europe**

Analysis of integration into Europeana and of national digitization strategies (e.g., Poland, Romania, Russia).

- **Digital libraries and cultural diplomacy**

Case study: World Digital Library and UNESCO's role.

- **Users of digital libraries**

Analysis of the information behaviour of students, researchers, and the public.

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# 3. NEW TECHNOLOGIES IN UNIVERSITY TEACHING

The integration of new technologies into the university teaching process represents a major opportunity for the transformation of higher education. Universities are becoming spaces of innovation, where traditional teaching methods are complemented by interactive and personalised digital tools, connected to the needs of the labour market.

Today's society is increasingly digitalized, and if technology is used in a balanced and creative way, it can generate major benefits that lead to undeniable results in the development of children, both cognitively and socio-emotionally, since technology is already part of the life of the current generation.

The integration of information and communication technologies into the teaching–learning–assessment process allows the new generation to acquire digital skills that can be applied in the study of each discipline. The aim is to create the conditions for effective teacher–student collaboration, ensuring quality education.

The use of information systems in student training presents a series of advantages:

- they allow a high level of individualization of the educational process, which can be programmed and applied to create different learning situations, regardless of learners' age;
- they enable the completion of training programs without time barriers;
- they provide modern and efficient ways of organizing the educational process;
- they make it possible to carry out a set of very important didactic operations related to evaluation and the development of students' creativity;
- they offer the possibility of questioning the learner and identifying gaps in the process of assimilating new content;
- they stimulate interest in novelty, reducing the risk of boredom;
- students learn at their own pace, without emotional pressure or behavioural disturbances caused by environmental factors.

New technologies represent an important step in teaching activity, as they complement traditional methods of teaching, learning, and assessment with modern approaches that meet the expectations of today's students. The integration of digital tools into the teaching–learning–assessment process, along with the development of information technologies, has become a real necessity across all disciplines, contributing to student-centered active learning, differentiated approaches, creativity, and critical thinking.

The pandemic accelerated the adoption of digital teaching platforms such as Zoom, Microsoft Teams, or Google Classroom, normalizing their use in the educational process. Even though many institutions have returned to face-to-face teaching, it is important for teachers to remain connected to new technological developments and to integrate them into their teaching activities.

The integration of emerging technologies should not be limited to IT-related disciplines but should extend to diverse fields such as health, civil engineering, or economics. Practical examples and collaborations with industry partners provide students with a concrete understanding of how these technologies are applied in real-world contexts.

Learning by doing activities—based on case studies, simulations, or collaborations with professionals—contribute to the development of critical perspectives and stimulate curiosity. Through direct contact with industry applications, students are better prepared to meet the demands of a constantly changing professional environment.

## 3.1. Emerging Technologies Used in Higher Education

**Artificial Intelligence (AI), Machine Learning, and Conversational Applications in Education**

**Artificial Intelligence (AI) and Machine Learning (ML)** are increasingly used in higher education and are regarded as catalysts for digital transformation in education. They enable the analysis of large volumes of educational data (learning analytics), the identification of learning patterns, and the personalization of the educational process (Zawacki-Richter et al., 2019). Through machine learning algorithms, educational platforms can adapt content to the knowledge level and learning pace of each student, thereby creating an adaptive and flexible learning environment.

Recent advances in ML have led to the emergence of generative digital tools such as ChatGPT, capable of producing software code, analyses, reflective essays, natural language summaries of complex documents, or sustaining open conversations, learning, and adapting over time (Kasneci et al., 2023).

These features make them an innovative educational resource, capable of providing personalised support to both students and faculty.

A major advantage of AI lies in its ability to support teachers' decision-making processes. Predictive analytics can identify at-risk students, highlight knowledge gaps, and suggest personalised intervention strategies (Siemens & Long, 2011). This allows teachers to focus on mentoring and the development of critical skills while leaving repetitive tasks to algorithms.

### 3.1.1. Educational Recommender Systems (ERS)

Recommender systems are AI applications that suggest personalised content to users based on an analysis of their interests, preferences, and past behaviors. In higher education, such systems are used to support learning by automatically selecting educational resources tailored to students' individual needs (Manouselis et al., 2011).

Instead of manually searching for learning materials, educational recommender systems (ERS) provide personalised suggestions such as:

- relevant scientific articles and books;
- online courses (MOOCs) suited to their level of knowledge;
- videos, simulations, and interactive virtual labs;
- study groups and learning communities.

**Types of recommendations used in education**:

- **Content-based** – suggest materials like those previously accessed (e.g., an article like one already read).

- **Collaborative** – recommend resources based on the behaviour of other students with similar learning profiles.
- **Hybrid** – combine both methods for more accurate and diverse results (Drachsler et al., 2015).

**Benefits in the academic context:**

- **Personalised learning**: each student receives resources adapted to their style and pace.
- **Reduction of information overload**: in the digital abundance era, ERS guide students toward relevant materials.
- **Increased engagement**: students are more motivated when recommended resources directly match their interests (Verbert et al., 2012).

**Challenges**

Despite all these advantages, the specialized literature emphasizes the possibility of certain risks such as

- algorithmic bias, which may limit the diversity of resources (Baker & Siemens, 2014);
- privacy issues, as these systems collect and analyze sensitive student data;
- overreliance on algorithms, which may reduce critical exploration and learner autonomy.

Therefore, recommender systems should be viewed as complementary tools, integrated within a responsible pedagogical framework under faculty supervision.

## 3.1.2. Conversational Applications and Educational Chatbots

A bot—short for robot—is a computer program (software application) that acts as an agent for a user or another program, simulating a human activity. Bots are commonly used to automate certain tasks, meaning they can operate without direct instructions from humans.

A chatbot is a specific type of bot that uses a chat interface to communicate with users, answering questions, providing advice, or offering support services. They are used in domains such as e-commerce, banking, insurance, healthcare, and beyond.

Chatbots are a form of artificial intelligence and use machine learning and algorithms to become more accurate and useful over time. They are virtual agents that simulate human conversation while automating various processes. They can be classified by purpose, interface, algorithm, access, and functional complexity.

In the university context, educational chatbots represent a concrete example of AI integration into teaching.

**They can be used for:**

- generating tests and worksheets, adapted to students' knowledge levels;
- course assistance, by providing rapid answers to clarification questions;
- stimulating creativity through activities that encourage critical thinking and academic reflection (Okonkwo & Ade-Ibijola, 2021).

Moreover, AI facilitates the creation of intelligent learning environments integrated with virtual reality, gamification, and the Internet of Things (IoT), transforming education into an interactive, competency-oriented experience (Luckin et al., 2016).

**Limitations and challenges:**

Despite the benefits, models such as ChatGPT may produce erroneous or fabricated information, requiring critical verification of their output. In this sense, the role of faculty remains essential, both in filtering and validating content and in integrating these tools into a responsible pedagogical framework (Selwyn, 2019).

The literature points out several ethical and pedagogical challenges:

- the risk of over-dependence on algorithms;
- data privacy concerns;
- algorithmic biases.

In the context of AI and ML, **biases** represent errors or distortions in the way algorithms make decisions or generate outputs, caused by:

- Biased training data – if the system is trained on incomplete, unbalanced, or discriminatory data, it reproduces those tendencies (e.g., better performance in English than Romanian due to data distribution).
- Implicit assumptions in algorithm design – programming choices may favor certain patterns or groups of users.
- User interaction – AI can learn from human input, which may amplify misinformation or discriminatory content.

Types of bias in AI:

- Selection bias – training data not representative of the population.
- Linguistic and cultural bias – AI models better reflect the cultural reality of regions where data originates (e.g., predominance of English).
- Cognitive bias – how users phrase prompts influences responses.
- Algorithmic bias – automated decisions favor certain outcomes over others.

**Applied example in education**

An AI system used for automated essay grading may favour writing styles like those in the training set and penalize alternative but valid or creative styles. Thus, scores may not reflect real competencies but only conformity with algorithmic pattern.

**Why it matters?**

In education, biases can lead to inequities among students (some advantaged, others disadvantaged), erroneous feedback that impacts motivation, and flawed decisions regarding admission, scholarships, or performance evaluation.

Therefore, researchers and educators stress that AI must be used critically and always complemented by human judgment (Selwyn, 2019; Zawacki-Richter et al., 2019).

**New Professions Created by AI**

A significant aspect of AI progress is the emergence of new professions, such as Prompt Engineer and Prompt Designer, reflecting the need to understand and optimize interactions with

conversational models (Mollick & Mollick, 2023). This phenomenon confirms that AI not only transforms the educational process but also reshapes the labour market and the competency profiles required of graduates.

**Types and Classifications of Educational Chatbots**

Chatbots are virtual agents capable of simulating human conversation and automating various processes (Trofymenko et al., 2022). Today, they are used in e-commerce, financial services, healthcare, education, and customer support.

By 2025, the most popular chatbots include ChatGPT, Claude, Google Gemini, Microsoft Copilot, Perplexity, and DeepSeek, each with competitive advantages such as integration into productivity suites or advanced conversational abilities (Rebelo, 2025; TechTarget, 2025).

In education, chatbots have begun to be integrated to support teaching, learning, and student services (Gao, 2025). They can provide instant feedback, answer frequently asked questions, and personalize students' learning paths (Bimpong, 2025).

Notable examples include the "All Day TA" at the University of Toronto, which answered more than 12,000 student questions in one semester at minimal costs (Business School, 2025).

**Performance comparisons** show that ChatGPT-4 and Microsoft Copilot outperform Google Gemini on standardized tests, but experts caution that these tools should be viewed as educational support, not primary sources of knowledge (Accuracy of ChatGPT, 2024).

Academic reviews present a dual perspective: on one hand, chatbots have high potential for increasing student motivation and engagement; on the other hand, there are risks of dependency, misinformation, and reduced critical thinking (McGrath, 2024; Huang, 2025). Thus, specialists stress the need to integrate these tools into regulated pedagogical frameworks with clear ethical guidelines (Torres, 2025).

Online traffic studies show that ChatGPT dominates global usage, followed by Grok (xAI), confirming the accelerated adoption of this type of technology (One Little Web, 2025).

Overall, **general-purpose chatbots** are seen as versatile and accessible tools but remain vulnerable to algorithmic biases and informational "hallucinations."

The main differentiating elements between general-purpose chatbots and educational chatbots are presented in Table 3.1.

**Table 3.1 Comparative Analysis of General-Purpose vs. Educational Chatbots**

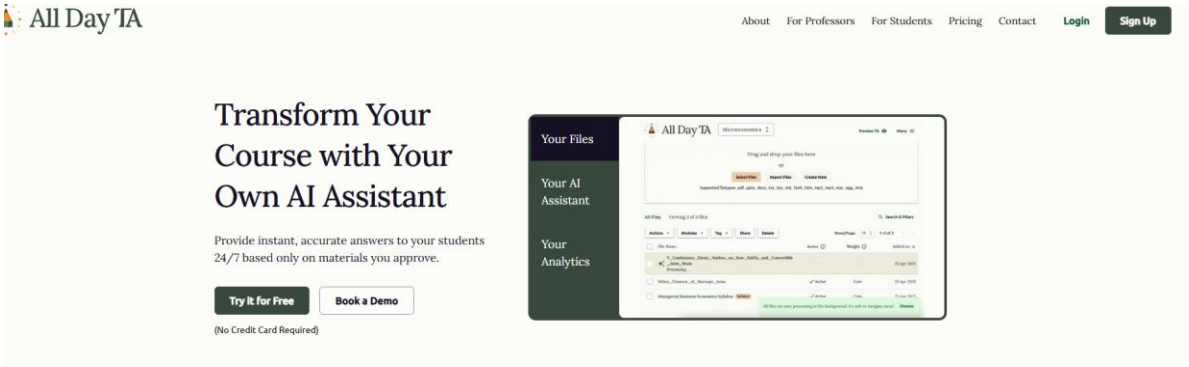
| Aspect | General-Purpose Chatbots | Educational Chatbots |
|---|---|---|
| **Usage** | Conversations, productivity, web search | Student support, assessments, educational access |
| **Main Models** | ChatGPT, Claude, Gemini, Copilot, Perplexity | ChatGPT-based, "All Day TA," custom platforms |
| **Key Advantages** | Speed, versatility, accessibility | Instant feedback, personalization, workload reduction |
| **Challenges / Risks** | Bias, misinformation, privacy issues | Overdependence, misplaced trust, academic integrity concerns |
| **Recommendation** | As a general support tool | As complementary support, under pedagogical supervision |

*Source: Own documentation*

## 3.1.3. Main Educational Chatbots

**All Day TA (University of Toronto)**

**https://alldayta.com/**




All Day TA is an innovative AI-powered teaching assistance platform developed by professors Kevin Bryan and Joshua Gans at the Rotman School of Management, University of Toronto. It aims to transform higher education by offering 24/7 personalised support based exclusively on instructor-approved content, reducing the gap between students' needs for help and the availability of educational resources (Rotman School of Management, 2024).

The project has been successfully piloted at prestigious universities such as MIT, Berkeley, Princeton, Chicago, UCLA, the University of Melbourne, and UNSW, with results showing a significant impact on student engagement and academic performance. One of the main reported benefits is the reduction of pressure on office hours and email volume, enabling faculty to focus their efforts on mentoring and personalised teaching (Rotman School of Management, 2024).

**Jill Watson (Georgia Institute of Technology)**

**https://dilab.gatech.edu/jill-watson/**


Built on IBM Watson, Jill Watson was one of the first well-known educational chatbots. Developed by the Design Intelligence Lab at Georgia Tech, Jill functioned as an AI-based virtual teaching assistant in an online e-learning forum, responding to students' questions without them initially realizing they were interacting with AI (Goel & Polepeddi, 2016).

It engages students in meaningful conversations about course materials, such as textbooks, using Retrieval Augmented Generation (RAG) techniques and integration with OpenAI's ChatGPT to improve response accuracy, reduce "hallucinations," and increase resilience against inappropriate content.

Inspired by the Community of Inquiry theoretical framework, Jill seeks to strengthen Teaching Presence, thereby enhancing Social Presence and Cognitive Presence in educational settings. The platform can be implemented across institutions as an LTI (Learning Tools Interoperability) tool for one-on-one conversations within university LMS platforms (e.g., Canvas, Blackboard) or in discussion forums (e.g., EdStem).

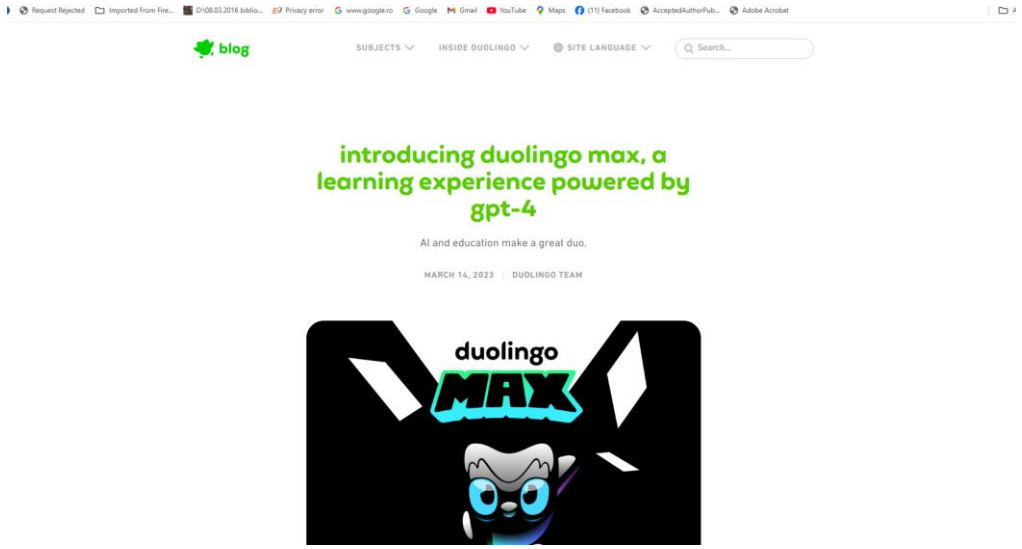
Research has shown that Jill Watson improves teaching presence, student grades, and academic retention rates. Current development directions include broader scalability, multimodal integration, and additional functionalities to support student learning.

**Duolingo Chatbot**

**https://blog.duolingo.com/duolingo-max/**

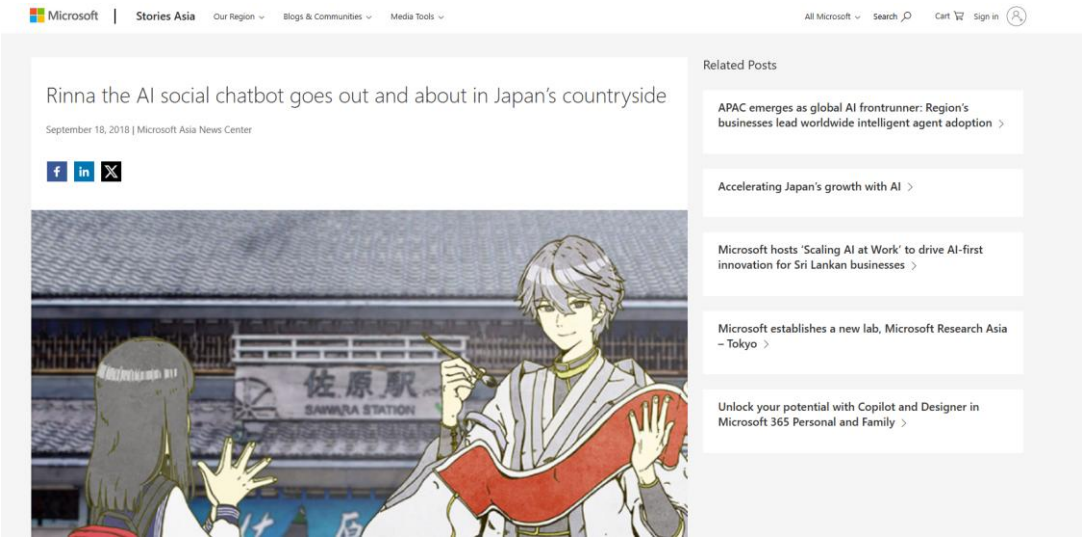
The Duolingo language-learning platform employs conversational bots to simulate interactive dialogues.

These chatbots support the development of linguistic skills through simulated conversations, instant feedback, and adaptation to user levels (Vesselinov & Grego, 2016).




**Rinna (Microsoft, Japonia)**

**https://news.microsoft.com/apac/2018/09/18/rinna-the-ai-social-chatbot-goes-out-and-about-in-japans-countryside/**




Rinna was experimentally used in Japan as an educational assistant, acting as a conversational mentor for students. Although not designed exclusively for academic use, it demonstrated AI's capacity to support personalised educational interactions (Fukuda, 2020).

Developed by Microsoft Japan, Rinna is a social chatbot with over 7 million users, mostly young people in major urban centres such as Tokyo. Launched in 2015, it stood out for its unique approach: unlike other AI assistants designed primarily to execute commands, Rinna functions as a conversational partner capable of engaging on an emotional level, making interactions more pleasant and engaging.

Recently, Microsoft launched the "Rinna Goes Local!" project in partnership with regional administrations and local organizations, aiming to extend the chatbot's appeal beyond major cities. The program uses smartphone-based games to raise awareness of different Japanese regions and promote local tourism through AI.

**Initiatives include:**

- "Rinna's Social Studies Tour" in Miyazaki, where users explore the region through interactive quizzes with prizes.
- "Rinna's Mystery Tour" in Katori, a narrative game with multiple-choice scenarios, local stamp routes, and sightseeing.
- "Rinna's Awesome Tour Map" in Kitakyushu, Gunma, Saga, and Amami, which analyzes user posts to promote lesser-known tourist attractions.

Through these initiatives, Rinna has consolidated its role as a cultural and social chatbot, contributing to youth engagement in local communities and the promotion of regional tourism through AI-driven innovation.

**ChatGPT EDU (OpenAI)**

Launched in 2025, ChatGPT EDU is an academic version of ChatGPT, designed for universities, with enhanced integration and data protection functions. It has been implemented at institutions such as Harvard Business School and the University of Pennsylvania, providing support in writing, problem-solving, and academic mentoring (Chatbots in the classroom, 2025).

ChatGPT EDU was specifically designed to meet higher education needs, incorporating advanced security and privacy protections, including compliance with international educational data regulations (e.g., GDPR).

A distinctive feature is its ability to integrate into campus digital infrastructure, connecting with LMS platforms, academic collaboration tools, and institutional applications (OpenAI, 2025). Universities can also customize settings, tailoring responses and conversational styles to specific courses and disciplines.

Already adopted at prestigious institutions, ChatGPT EDU is used for a variety of educational activities:

- assistance in writing essays and academic projects;
- problem-solving in mathematics, programming, and applied sciences;
- personalised academic mentoring;
- generation of learning resources adapted to individual student levels (Chatbots in the classroom, 2025).

Scholarly literature emphasizes that ChatGPT EDU helps reduce faculty administrative workload and supports large-scale personalised learning (Business schools ease their resistance to AI, 2025).

However, researchers warn that excessive reliance may hinder critical thinking and student autonomy. Thus, ChatGPT EDU is recommended as a complementary tool within a balanced pedagogical strategy (Selwyn, 2019).


**AI in Education – Guardrails and Ethical Use**

AI integration in education should be seen as an opportunity, not a threat. By using generative technologies responsibly, universities can prepare students for a society where interaction with AI will be ubiquitous, enhancing adaptability, critical thinking, and creativity.

Nevertheless, generative AI chatbots pose risks such as:

- misinformation ("hallucinations");
- reduced independent learning capacity;
- threats to academic integrity.

This highlights the need for **AI guardrails**—ethical safeguards, rules, and predefined system constraints designed to prevent misuse, severe errors, or harmful outcomes.

Examples of guardrails in educational chatbots include:

- Content filters → preventing AI from generating inappropriate or biased material.
- Limiting dependence → encouraging students to consult external sources rather than relying solely on AI responses.
- Privacy protections → safeguarding student data in compliance with regulations (e.g., GDPR).
- Transparency → AI clarifies its limitations and flags uncertainty in responses.
- Pedagogical frameworks → AI use must be supervised by educators within clear ethical guidelines (Torres, 2025).

Thus, guardrails are indispensable for ensuring that tools like ChatGPT EDU, All Day TA, or Jill Watson are not only effective but also safe in academic contexts.

Table 3.2 provides a comparative overview of the main educational chatbots, highlighting their year of development, key features, educational applications, and associated risks.

**Table 3.2 Comparative Overview of Main Educational Chatbots**

| Chatbot | Year / Developer | Main Features | Educational Use | Risks / Challenges |
|---|---|---|---|---|
| **All Day TA** | 2024 – University of Toronto (Bryan & Gans) | 24/7 AI teaching assistant, based on instructor-approved content | Personalised student support, reduced email/office-hour overload | Overreliance on system; requires integration into pedagogical framework |
| **Jill Watson** | 2016 – Georgia Tech (IBM Watson + Design Intelligence Lab) | Virtual TA using RAG + ChatGPT integration, supports *Community of Inquiry* model | Q&A in online courses, strengthens teaching/social/cognitive presence | Risk of inaccurate answers; scalability and multimodality challenges |
| **Duolingo Bot** | 2016 – Duolingo | Interactive language-learning dialogues, adaptive feedback | Supports language practice through simulated conversations | Limited to language learning; dependency on app-based model |
| **Rinna** | 2015 – Microsoft Japan | Social chatbot, emotional interaction, tourism gamification features | Experimental use as conversational mentor; cultural/educational engagement | Not academic by design; privacy issues; cultural bias |
| **ChatGPT EDU** | 2025 – OpenAI | Academic-grade AI, LMS integration, advanced data protection | Writing support, problem-solving, academic mentoring, personalised learning paths | Dependence risk, misinformation ("hallucinations"), academic integrity risks |

*Source: Own contributions*

## 3.1.4. Automated assessment of assignments (essays, multiple-choice tests)

Automated assessment represents one of the most applicable and efficient uses of Artificial Intelligence (AI) and Machine Learning (ML) in higher education. Through natural language processing algorithms and predictive models, digital systems can automatically grade multiple-choice tests and provide feedback on essays or written assignments, reducing the administrative burden on faculty and accelerating the feedback process (Shermis & Burstein, 2013).

One example is Automated Essay Scoring (AES) platforms, which use neural networks to analyze the structure, coherence, vocabulary, and argumentation of a text. Studies show that such systems can achieve a level of accuracy comparable to that of human instructors in evaluating standardized essays (Perelman, 2014). At the same time, multiple-choice tests benefit from immediate and objective grading, enabling students to receive instant results and allowing teachers to focus on mentoring and the development of critical thinking.

The benefits of automated assessment include:

- speed and scalability, particularly in large classes;
- immediate and personalised feedback that supports adaptive learning;
- reduced human subjectivity, ensuring greater consistency in grading (Wang et al., 2023).

However, there are also important limitations associated with the use of automated assessment. Systems may exhibit algorithmic biases, favouring certain writing styles or linguistic patterns, which raises issues of fairness and educational validity (Williamson et al., 2020). Furthermore, the evaluation of idea quality and creativity remains a major challenge, still requiring human intervention.

Thus, the specialized literature recommends using automated assessment as a complementary tool rather than a substitute for the teacher, with continuous supervision and adjustment of algorithms necessary to maintain pedagogical relevance and fairness in the evaluation process (Selwyn, 2019).

## 3.2. Virtual Reality (VR) and Augmented Reality (AR) in the University Teaching Process

**Virtual Reality (VR) and Augmented Reality (AR)** are emerging technologies that are transforming the way knowledge is transmitted and assimilated in higher education. They enable the creation of immersive, interactive, and personalised learning experiences, going beyond the limitations of traditional teaching materials (Radianti et al., 2020).

VR provides students with the possibility of being transported into a fully digital environment, where they can explore virtual laboratories, scientific simulations, or historical reconstructions. This type of experiential learning increases student engagement and motivation, facilitating the understanding of abstract concepts through visualization and direct interaction (Makransky & Mayer, 2022).

AR, on the other hand, overlays digital information onto the real world, enriching the educational experience without replacing the physical environment. In university classrooms, AR can be used to display 3D models of organs in medical courses, project molecular structures in chemistry, or demonstrate complex engineering processes (Akçayır & Akçayır, 2017).

**The integration of VR and AR in higher education can bring several benefits, such as**:

- active, student-centred learning through direct exploration and problem-solving.
- reducing geographical and economic barriers by enabling access to costly simulations without physical equipment;
- developing transversal skills, including critical thinking, collaboration, and creative problem-solving (Bailenson, 2018).

However, the specialized literature also highlights challenges such as high costs, technical difficulties, and the risk of cognitive overload in cases of excessive use (Radianti et al., 2020). For these reasons, VR and AR should be integrated into a well-structured pedagogical framework, serving as complementary tools rather than substitutes for traditional teaching.

### 3.2.1. Simulations for Technical and Medical Disciplines

The integration of Virtual Reality (VR) and Augmented Reality (AR) into university education has opened new opportunities for teaching and learning in technical and medical disciplines. These immersive technologies allow students to experience complex scenarios in a

safe and controlled environment, where they can practice practical skills without the risks associated with real-world situations (Radianti et al., 2020).

In the technical field, VR is used for engineering, architecture, and mechanics simulations, enabling students to visualize 3D projects, test virtual prototypes, and explore industrial processes. AR complements this process by overlaying digital information onto physical objects, thus facilitating the understanding of equipment functioning and technological processes (Bacca et al., 2014).

In medical education, VR and AR are applied in the training of future doctors and nurses through simulations of surgical interventions, 3D anatomy, and clinical scenarios. These environments allow repeated practice of procedures without endangering real patients and provide immediate feedback on accuracy and efficiency. Studies show that VR simulations increase knowledge retention and improve students' practical performance compared to traditional methods (Kyaw et al., 2019).

**Examples of applications**:

- **VR surgical simulations** (e.g., Osso VR) – enable resident physicians to train in safe and repeatable conditions.
- **Virtual engineering laboratories** – allow exploration of electrical circuits or complex mechanical systems in 3D.
- **AR anatomy (e.g., Microsoft HoloLens)** – projects anatomical structures directly into the classroom, facilitating collaborative learning.

**Advantages**:

- Experiential learning through immersion.
- Increased student motivation and engagement.
- Repeatability of scenarios and safe learning environments.

**Challenge**s:

- High costs of VR/AR equipment.
- The need to adapt university curricula.
- Possible health issues (e.g., visual fatigue, cybersickness).

Therefore, VR and AR represent valuable teaching tools for technical and medical disciplines; however, their effectiveness depends on integration into a well-defined pedagogical framework and on ensuring equitable access for all students.

## 3.2.2. Virtual Laboratories (VLs)

Virtual laboratories are interactive digital environments that allow students to conduct simulated scientific experiments using technologies such as Virtual Reality (VR), Augmented Reality (AR), and computer-based simulations.

They are particularly useful in situations where physical resources are limited, equipment is expensive, or real experiments involve high risks (Potkonjak et al., 2016).

In technical and engineering disciplines, virtual laboratories make it possible to simulate complex processes (e.g., fluid dynamics, thermodynamics, robotics) without requiring costly infrastructure. Students can explore abstract concepts through 3D visualizations and repeat

experiments an unlimited number of times, without the risk of damaging equipment (Heradio et al., 2016).

In medical and biotechnological fields, these laboratories provide opportunities to simulate chemical reactions, genetic experiments, or the handling of hazardous biological materials, avoiding the risks associated with high-security physical laboratories (Bonde et al., 2014).

**Examples of applications**:

- **PhET Interactive Simulations** – developed at the University of Colorado Boulder, it offers hundreds of interactive simulations for physics, chemistry, biology, and mathematics, and is widely used in both higher and secondary education (Perkins et al., 2006).
- **Labster** – an international platform of virtual laboratories that enables experimentation in molecular biology, chemistry, and engineering through interactive scenarios and immediate feedback; studies have shown that its use increases student motivation and performance (Bonde et al., 2014).
- **VirPharma** – a suite of simulations for testing pharmaceutical processes and chemical reactions at an industrial scale, used as both an educational and professional training tool (Potkonjak et al., 2016).

**Advantage**:

- Increased accessibility, regardless of location.
- Elimination of risks related to handling toxic substances or dangerous equipment.
- Lower costs compared to physical laboratories.
- Opportunities for self-directed and repetitive learning.

**Limitations:**

- Lack of tactile experience and direct hands-on manipulation.
- Requirement for advanced digital skills to use platforms effectively.
- Potential reduction of real practical skills if virtual laboratories are not complemented by hands-on training.

Thus, virtual laboratories represent an innovative and scalable alternative to traditional laboratories, but their maximum effectiveness is achieved when they are integrated into a blended curriculum that combines digital experimentation with direct practical experiences.

### 3.2.3. 3D Reconstructions for Architecture, Art, or History Specializations

3D reconstructions represent an innovative application of VR and AR technologies, used to digitally reproduce objects, buildings, archaeological sites, or works of art. They allow students and researchers to explore, analyse, and interact with cultural or architectural elements in ways that go beyond the physical limits of classrooms or museums (Addison, 2000).

In architecture, 3D reconstructions facilitate the study of complex forms and structures, offering the possibility to test different design scenarios and to analyse the behaviour of materials under simulated conditions. Students can "enter" a virtual building and explore its details without the need for a physical model (Boeykens, 2011).

In art and art history, these technologies are employed to reconstruct damaged or lost works and to enable interactive exploration. Museums have begun adopting augmented reality

to provide personalised visitor experiences, as in the case of the "Louvre AR" project, where users can visualize hidden details of masterpieces (Bekele et al., 2018).

In history and archaeology, digital reconstructions support heritage preservation and experiential learning. Relevant examples include the Rome Reborn project, which digitally recreates ancient Rome, or the 3D reconstruction of the Pompeii site, allowing students to virtually explore ancient buildings and streets (Frischer, 2008).

**Advantages**:

- Preservation and accessibility of cultural heritage.
- The possibility to visualize historical and architectural hypotheses interactively.
- Improved student engagement through immersive learning.

**Limitations**:

- High costs of 3D scanning and rendering technology.
- The need for interdisciplinary expertise (historians, architects, IT engineers).
- The risk of misinterpretation in the reconstruction process.

## 3.3. Online Learning Platforms and Advanced Learning Management Systems (LMS)

Learning Management Systems (LMS) have become the backbone infrastructure of modern higher education. Among the most widely used are Moodle, Canvas, and Blackboard, recognized for their ability to fully manage the educational process: course administration, assessment, resource distribution, and integration of AI tools (Aljawarneh, 2020).

At the same time, solutions such as Google Classroom and Microsoft Teams are increasingly used in universities due to their direct integration with productivity and collaboration ecosystems (Google Workspace and Microsoft 365).

These platforms enable fast communication, assignment management, and real-time collaboration, being considered accessible and flexible platforms for hybrid learning (Iftakhar, 2016; Raes et al., 2020).

**Essential functionalities of these platforms include**:

- AI integration → personalised recommendations, content generation, automated assessments.
- Progress monitoring → through learning analytics, instructors can identify learning patterns and dropout risks (Siemens & Long, 2011).
- Access to hybrid courses and digital micro-credentials → students can obtain badges and micro-credentials certifying specific skills that are valuable on the labor market (Pérez-Pérez et al., 2022).

### 3.3.1. Traditional and Hybrid LMS Platforms

In higher education, digital Learning Management System (LMS) platforms play a key role in the administration and delivery of courses. These can be divided into two main categories:

- **traditional LMS**
- **hybrid platforms**.

**Traditional LMS Platforms: Moodle, Canvas, and Blackboard**

**Moodle** is one of the most widely used open-source LMS platforms globally, valued for its flexibility and the active developer community behind it. It provides tools for course management, student assessment, resource management, and progress tracking through detailed reports (learning analytics) (Dougiamas & Taylor, 2003).

**Canvas**, developed by Instructure, is a modern cloud-based LMS that emphasizes an intuitive interface and integration with external applications through the Learning Tools Interoperability (LTI) standard. It is used in numerous top universities and is recognized for its adaptability to hybrid education and support for multimedia resources (Aljawarneh, 2020).

**Blackboard** is one of the oldest and most established LMS platforms, widely adopted in the United States and Europe. It is known for its robust structure, but also for a higher level of complexity in use. It provides advanced features for test administration, integration with digital libraries, and tools for distance education (Bradford et al., 2007).

**Hybrid Platforms: Google Classroom and Microsoft Teams**

**Google Classroom**, part of the Google Workspace for Education ecosystem, is widely used due to its accessibility and simplicity. It allows assignment distribution, real-time collaboration, and integration with applications such as Google Docs, Drive, and Meet. While it does not provide the full range of functionalities of a complete LMS, it proves extremely effective for hybrid and collaborative learning (Iftakhar, 2016).

**Microsoft Teams**, integrated within the Microsoft 365 suite, is increasingly used as an educational tool. Teams offers chat, video calls, file sharing, and integration with OneNote Class Notebook or Microsoft Forms, being perceived as a "digital hub" for teaching and learning (Raes et al., 2020).

Unlike a traditional LMS, Teams functions more as a teaching support system, but through the integration of educational extensions, it can fulfil part of the roles of traditional LMS platforms.

**Key differences between the two types of platforms**:

- **Traditional LMS** → comprehensive course management, structured design, advanced learning analytics.
- **Hybrid platforms** → easier to use, focused on collaboration and communication, integration with large productivity ecosystems (Google and Microsoft).

Table 3.3 presents a comparative analysis between traditional Learning Management Systems (LMS) and hybrid platforms, highlighting their core functions, advantages, limitations, and best use cases in higher education.

**Table 3.3 Comparative Analysis of Traditional vs. Hybrid LMS Platforms**

| Aspect | Traditional LMS (Moodle, Canvas, Blackboard) | Hybrid Platforms (Google Classroom, Microsoft Teams) |
|---|---|---|
| **Main Function** | Comprehensive course management, evaluation, learning analytics | Collaboration, communication, and integration with productivity ecosystems |
| **Examples** | Moodle, Canvas, Blackboard | Google Classroom, Microsoft Teams |
| **Strengths** | Robust structure, advanced assessment tools, scalability | User-friendly, accessible, real-time collaboration, integration with Docs/Drive/365 |
| **Limitations** | Higher complexity, requires training, heavier infrastructure needs | Limited advanced analytics, not a full LMS, dependent on external apps |
| **Best Use Case** | Formal higher education courses requiring rigorous structure and assessment | Hybrid and collaborative learning, flexible environments |

*Source: Author's own documentation*

## 3.3.2. Monitoring Student Progress through Learning Analytics

Learning analytics represents the process of collecting, measuring, analyzing, and reporting data about students and their educational environment, with the aim of understanding and optimizing learning and the contexts in which it occurs (Siemens & Long, 2011). Modern universities increasingly employ these tools to monitor progress, identify student difficulties, and support data-driven pedagogical decisions.

An example is provided by platforms such as Moodle Analytics or Canvas Learning Analytics, which can track student activity on the platform, time spent on materials, task completion rates, and forum engagement. This information enables instructors to identify at-risk students early and intervene with additional support (Ifenthaler & Yau, 2020).

Learning analytics also allows for the personalization of the educational path: algorithms can recommend supplementary resources based on past performance, suggest practice exercises, or highlight learning gaps (Ferguson, 2012). In this way, the educational process becomes more adaptive, fostering student-centered learning.

However, the literature highlights important ethical and privacy challenges. The data collected about students may include sensitive information, which requires adherence to strict standards of protection and transparency. Moreover, there is a risk that teachers or institutions may overemphasize the role of quantitative data while neglecting the qualitative aspects of learning (Slade & Prinsloo, 2013).

In conclusion, learning analytics is a powerful tool for monitoring progress and supporting learning, but its effectiveness depends on integration into a responsible and ethical pedagogical framework.

A notable example of the use of learning analytics in monitoring student progress is the Course Signals project developed at Purdue University (Arnold & Pistilli, 2012). The system

employs a predictive algorithm that analyses data on participation, midterm grades, and online activity to estimate the probability of student success or dropout.

The results are presented in an intuitive, traffic-light–like format:

- green – student on track, good progress;
- yellow – moderate risk, requires attention;
- red – high risk of failure or dropout.

Instructors and academic advisors can use this data to intervene quickly, offering personalised support through tutoring, supplementary resources, or counselling. Studies have shown that the use of the system increased pass rates and reduced university dropout, confirming the value of predictions based on learning analytics.

This example demonstrates how integrating progress monitoring technologies into education not only supports instructors' decision-making but also contributes to creating a more inclusive and adaptive educational environment.

### 3.3.3. Access to Hybrid Courses and Digital Micro-Credentials

Contemporary higher education is increasingly characterized by flexible teaching formats that combine traditional face-to-face components with online elements, in a model known as blended learning. This type of organization enables students to participate both in on-campus activities and in synchronous and asynchronous virtual sessions, thereby enhancing accessibility and personalization of the educational process (Raes et al., 2020).

At the same time, universities are increasingly adopting digital micro-credentials, through which students can obtain official recognition for acquiring specific competencies that complement traditional study programs. These certifications are often based on open badges and are portable, allowing integration into electronic portfolios or professional platforms such as LinkedIn (Pérez-Pérez et al., 2022).

Examples of implementation include:

- **edX MicroMasters** and **Coursera Specializations**, which provide micro-credentials recognized by universities and global companies;
- **Badgr** and **Credly**, platforms used by European and North American universities for managing digital certifications;
- The **European MOOC Consortium (EMC)**, which developed the **Common Microcredential Framework (CMF)** to standardize micro-credentials across the **European Higher Education Area** (MicroHE Project, 2019).

The adoption of these tools responds both to students' need for flexible and continuous learning and to the requirements of the labor market, where digital skills and niche specializations are becoming increasingly valuable (Oliver, 2019).

## 3.4. Gamification and Educational Games

Gamification involves the integration of game-specific mechanisms (competition, scores, levels, badges, rewards) into educational activities with the aim of stimulating student engagement, motivation, and performance. In higher education, the use of gamification techniques is associated with improved course participation, increased task completion rates, and the strengthening of active learning (Dicheva et al., 2015).

### 3.4.1. Digital Badges and Reward Systems

Digital badges and point-based systems are commonly used tools to reward academic achievements. They function as visible recognition of progress and can be stored in electronic portfolios or on professional platforms such as LinkedIn (Abramovich et al., 2013).

For example, online learning platforms such as Moodle and Coursera already integrate badge systems that certify module completion, which contributes to increased student satisfaction and reinforces the sense of progress (Gibson et al., 2015).

### 3.4.2. Business, Circular Economy, and Engineering Simulations

Another area of gamification application is educational simulations. In business and economics, platforms such as Capsim or Marketplace Simulations allow students to make managerial decisions in a virtual environment, practicing leadership, strategy, and critical thinking skills (Lean et al., 2006).

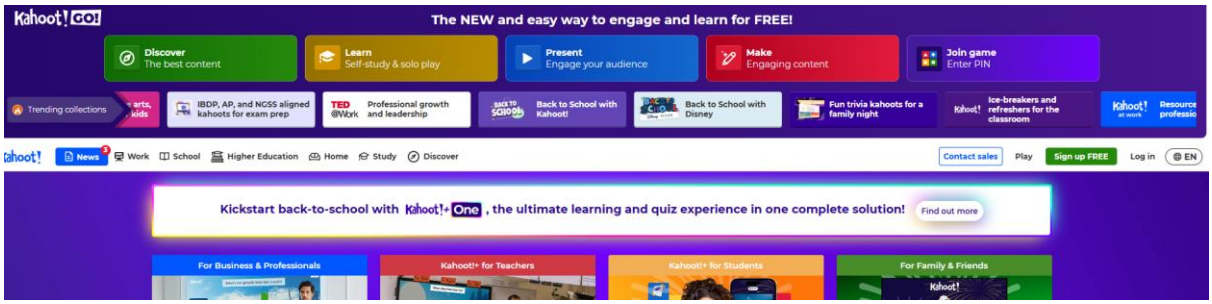
In engineering and applied sciences, digital simulations can replicate complex processes (e.g., the functioning of a production line or an electronic circuit), providing students with an immersive practical experience without the costs and risks associated with physical laboratories (Bellotti et al., 2013).

Additionally, in the field of sustainability, circular economy simulations are used to understand the impact of design decisions on the environment and resources, preparing students for the challenges of the green economy.

### 3.4.3. Increasing Student Motivation and Engagement

Numerous studies show that educational games and gamification contribute to enhancing intrinsic motivation and developing a sense of self-efficacy among students (Hamari et al., 2016). Through novelty, progressive challenges, and immediate feedback, games create a more engaging and interactive learning environment.

For example, the use of the Kahoot! platform (https://kahoot.com) in universities has demonstrated a significant increase in active participation and information retention compared to traditional assessment methods (Plump & LaRosa, 2017).




However, to achieve lasting positive effects, gamification must be integrated into a well-designed pedagogical strategy and not used merely as a mechanism for entertainment.

## 3.5. Smart Laboratories and the Internet of Things (IoT)

The concept of the smart laboratory integrates digital technologies, sensors, and IoT devices to provide an interactive learning environment based on real-time data and continuous connectivity. These laboratories allow students to participate in authentic experiments, either on campus or remotely, and contribute to the development of interdisciplinary skills required by the digital economy (Rios et al., 2020).

### 3.5.1. Connected Devices for Real-Time Measurements

IoT devices (temperature, pressure, humidity sensors, biometric sensors, smart cameras, etc.) enable the collection and transmission of real-time data. In technical and engineering education, they are used to monitor processes in electronics, mechanics, or chemistry laboratories, facilitating immediate analysis and data visualization (da Silva et al., 2019).

**Example**: The LabVIEW IoT platform allows the integration of connected sensors for physics and engineering experiments, giving students the ability to instantly observe variations in measured parameters.

LabVIEW, the graphical platform developed by National Instruments, is one of the most widely used environments for designing and implementing educational and industrial applications based on the Internet of Things (IoT). The white paper "A Practical Guide for Connecting LabVIEW to the Industrial IoT" (NI, 2024) highlights how LabVIEW and NI embedded systems (e.g., CompactRIO, PXI) can connect to cloud platforms such as Amazon AWS IoT, IBM Watson IoT, PTC ThingWorx, and Microsoft Azure IoT Suite.

LabVIEW supports the main protocols used in IoT ecosystems:

- **MQTT (Message Queuing Telemetry Transport)** – efficient protocol for applications with thousands of sensors (e.g., monitoring energy consumption, critical infrastructures). It is based on the publish/subscribe model and optimizes bandwidth and resource use (NI, 2024).
- **AMQP (Advanced Message Queuing Protocol)** – used for reliable transactional messaging between servers and devices, applicable in vehicle behaviouranalysis or industrial data. Libraries such as LabbitMQ enable AMQP integration in LabVIEW.
- **DDS (Data Distribution Service)** – allows real-time communication between intelligent machines, mainly used in automation and safety-critical systems.

**The role of edge devices in education and industry**

CompactRIO and PXI systems can function as edge devices, collecting and processing data close to the source and transmitting it to cloud platforms. This architecture is particularly relevant for education: students can work with real data collected from connected sensors and visualize analyses in real time in LabVIEW or in the cloud.

**Challenges of implementing an IoT laboratory with LabVIEW include**:

- standardization and interoperability between protocols and platforms;
- Big Analog Data™ – managing large volumes of data from industrial sensors;
- security and privacy – regular device updates and the use of encryption (TLS/SSL) are mandatory for safe educational and industrial applications (NI, 2024).

**Educational relevance**

In universities, integrating LabVIEW with IoT and the cloud:

- enables the creation of virtual and remote labs, where students can access real equipment via the internet;
- facilitates interdisciplinary projects (engineering, automation, IT, energy, environment);
- provides a practical framework for learning Industry 4.0 and digital transformation concepts.

A significant example of IoT integration in higher education is the use of the LabVIEW platform developed by National Instruments for connecting embedded systems (e.g., CompactRIO, PXI) to industrial cloud ecosystems such as Amazon AWS IoT, IBM Watson IoT, PTC ThingWorx, and Microsoft Azure IoT Suite (National Instruments, 2024).

By using IoT protocols (MQTT, AMQP, DDS), students can remotely control and monitor experiments in real time, accessing data collected from connected sensors. For instance, an automation laboratory can measure motor vibrations, with the data transmitted to the cloud via MQTT, allowing students to analyze system performance and detect potential faults.

This hybrid architecture—real equipment + cloud interface—allows universities to expand laboratory access to a larger number of students, while reducing costs and physical barriers. Moreover, projects carried out through LabVIEW IoT prepare students for Industry 4.0, where connectivity between devices, people, and IT systems becomes essential.

## 3.5.2. Remote Experiments through Virtual and Remote Labs

Remote laboratories (Remote Labs) allow students to access and control real equipment via the internet, reducing time and space barriers. This model is already applied in European and American technical universities for subjects such as electronics, automation, and robotics (Heradio et al., 2016).

In addition, virtual laboratories (based on 3D simulations and VR) complement the experience, offering the possibility to test scenarios that would be impossible to reproduce in a physical laboratory.

The combination of these two types of labs extends access to complex experiments for a larger number of students.

### 3.5.3. Environmental Monitoring and the Use of Data in Interdisciplinary Projects

oT plays a central role in environmental monitoring projects: sensor networks collect data on air quality, pollution levels, soil moisture, or energy consumption. These data can be used in interdisciplinary projects by students from engineering, agriculture, ecology, or urban planning (Farias et al., 2020).

**Example:** Smart Campus projects implemented in European universities use IoT to monitor energy consumption and environmental quality, transforming campuses into living laboratories for research and learning. Through distributed sensor networks, data can be collected on temperature, humidity, air quality, noise levels, or electricity and water consumption.

A concrete example is the use of the LabVIEW IoT platform, developed by National Instruments, which integrates embedded systems (e.g., CompactRIO) with cloud services such as Amazon AWS IoT, IBM Watson IoT, or Microsoft Azure IoT Suite.

Through these integrations, environmental and energy consumption data can be collected, processed at the edge device level, and then analyzed in real time in the cloud (National Instruments, 2024).

This architecture ensures:

- instant visualization of energy consumption per building or laboratory;
- identification of areas with resource losses;
- the development of interdisciplinary projects where students from engineering, IT, environmental sciences, and economics collaborate to propose efficiency solutions.

Thus, the university becomes a living experimental space, where real data collected through IoT contribute to the development of essential skills for the digital society and the circular economy.

## 3.6. Integration of New Technologies in the Teaching Process

The integration of new digital technologies in universities does not serve only a logistical support role but generates profound changes in teaching methodology and educational philosophy.

These transformations mark the shift from traditional teacher-centered models to modern paradigms that are student-centered and focused on acquiring competencies relevant to the 21st century.

**From teacher-centered instruction to student-centered learning**

New educational platforms, learning analytics tools, and AI-based applications enable the personalization of the educational process. Students become active participants in their own learning, with the ability to access diverse resources, work at their own pace, and receive instant feedback (Zawacki-Richter et al., 2019).

**Creating personalised learning experiences**

Through recommender systems and digital micro-credentials, instructors can configure learning pathways adapted to each student's level and interests. This shapes an adaptive

education in which technology facilitates the discovery of new resources and supports lifelong learning (Siemens & Long, 2011).

**Fostering critical, collaborative, and creative thinking through technology**

Digital tools such as gamification, virtual laboratories, educational chatbots, and VR/AR simulations transform learning into a collaborative and creative experience. These environments promote project-based and problem-based learning, stimulating critical thinking and interdisciplinary collaboration (Raes et al., 2020).

**Facilitating equitable access to resources, including for students with special needs**

Educational technologies contribute to inclusion through digital resources accessible and compatible with WCAG standards, multilingual language support, and integrated accessibility tools (e.g., screen readers, automatic captioning). This ensures equity and diversity in the teaching–learning process (Luckin et al., 2016).

**Conclusion**

The integration of these technologies is not merely a technical innovation but represents a paradigm shift in pedagogy, oriented toward a more flexible, inclusive, and digitally connected higher education system.

## 3.7. Challenges and Limitations of Integrating New Technologies in Teaching

The integration of digital technologies in university education brings clear benefits but also a series of challenges and limitations that must be responsibly managed.

The literature highlights the following key aspects:

- **High costs and insufficient infrastructure**

Implementing smart laboratories, IoT systems, or advanced learning platforms requires significant investments in equipment, software, and maintenance. Furthermore, major disparities exist between universities and regions regarding access to digital infrastructure, which may exacerbate educational inequalities (OECD, 2021).

- **The need for continuous faculty training**

The success of technology integration depends on the level of digital competence among instructors. Many require ongoing training to use tools such as analytics, VR/AR, or AI in education effectively. A lack of preparation can lead to superficial use of technology or resistance to change (Redecker, 2017).

- **Ethical and data security issues**

The use of artificial intelligence and monitoring systems raises questions concerning student data privacy, algorithmic bias, and excessive surveillance. Strict regulation and the enforcement of ethical and security standards in digital education are essential (Selwyn, 2019).

- **The risk of superficial learning**

If technology is used only for visual impact or as an educational "spectacle" without pedagogical grounding, there is a risk that learning will become superficial. Emphasis must be

placed on the pedagogical and critical integration of digital tools so that they support the development of critical thinking and academic competencies, rather than merely capturing short-term attention (Kirschner & De Bruyckere, 2017).

**Proposed Practical Topics**

**Artificial Intelligence in Education**

Case study: Analyzing the use of ChatGPT EDU in a university course (advantages, limitations, pedagogical recommendations).

Project: Creating a mini educational chatbot on a course topic (e.g., economics, agronomy, computer science).

**Educational Recommender Systems (ERS)**

Simulation: Configuring a resource recommendation system (articles, videos, MOOCs) for a university course.

Comparative analysis: What would a student's learning pathway look like with and without algorithmic recommendations?

**Automated Essay Scoring (AES)**

Comparative test between teacher-based evaluation and Automated Essay Scoring systems.

Case study: Critical analysis of automated feedback versus teacher feedback.

**Virtual and Augmented Reality (VR/AR)**

Project: Developing a mini-AR application for a specific field (e.g., anatomy, architecture, chemistry).

Case study: Assessing the impact of VR simulations on understanding a difficult concept (e.g., thermodynamics).

**Virtual Laboratories and IoT**

Implementation of a simple IoT sensor experiment (e.g., temperature, humidity) connected to a visualization platform (LabVIEW or open-source alternatives).

Development of a prototype Remote Lab for a technical discipline.

**Gamification in Higher Education**

Practical project: Creating an interactive quiz on platforms such as Kahoot!, Nearpod, or FlexiQuiz.

Simulation: Implementing a badge and reward system in a course and evaluating student motivation.

**Micro-Credentials and Digital Portfolios**

Developing an electronic portfolio with digital badges for a set of competencies (e.g., ICT, project management).

Analysis: Comparing micro-credentials offered by platforms such as Coursera, edX, and Romanian universities.

**Ethics and Security in AI Use**

Debate: “Is ChatGPT a threat to academic integrity or an indispensable tool in higher education?”

Project: Designing a set of ethical guardrails for AI use in a university course.

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# 4. OTHER DIGITAL PLATFORMS USEFUL IN THE EDUCATIONAL PROCESS

The integration of innovative educational platforms into university activities addresses the needs for digitalization, interactivity, and personalised learning. These tools support both faculties, by automating the assessment process and diversifying resources, and students, by providing dynamic and accessible learning experiences.

## 4.1. Liveworksheets.com

Liveworksheets is an online platform that allows the transformation of traditional worksheets (in Word, PDF, or image format) into interactive, self-correcting exercises that students can complete online and submit to the teacher (www.liveworksheets.com).

Teachers can upload existing documents and, through an intuitive editor, define response areas (text fields, multiple-choice, fill-in-the-blank, matching, etc.), turning static materials into dynamic resources. A suggested tutorial for creating interactive worksheets with this platform is available here: Working with libraries on the teacher dashboard.

A major advantage is that exercises can be completed directly online by students, and the responses are transmitted to the teacher for evaluation. The platform also offers the possibility of generating a digital student portfolio, where all completed worksheets are centralized, thereby facilitating progress monitoring and personalised learning (Liveworksheets, n.d.).

**Key Features**:

- **Automatic correction**: answers to multiple-choice or fill-in-the-blank exercises are graded automatically, reducing teachers' workload.
- **Advanced interactivity**: beyond traditional questions, audio, video, or pronunciation and listening exercises can be integrated – particularly useful in language teaching.
- **Integration with e-learning platforms**: Liveworksheets can be used alongside LMSs such as Moodle or Google Classroom, via links or access codes.
- **Accessibility: compatible with any device** (PC, tablet, smartphone), supporting mobile and independent learning.
- **Public library**: teachers can access and reuse worksheets created by educators worldwide, fostering collaboration and the sharing of best practices.

Examples of use in higher education:

- **Linguistics and philology** – translation or fill-in exercises based on literary texts.
- **Exact sciences** – tests with formulas, interactive diagrams, and mathematics problems.
- **Social sciences** – questionnaires with open-ended questions and self-assessment grids based on case studies.
- **Professional training** – simulations of interviews or business scenarios with multiple-choice options.

For those who wish to learn quickly how to create interactive worksheets, step-by-step tutorials are available. For example, the guide "Working with libraries on the teacher

dashboard" explains how to manage resource libraries and educational worksheets (Book Creator, 2024).

In conclusion, Liveworksheets represents a practical and accessible tool for digitizing traditional materials, offering benefits for both teachers (automated grading, reduced preparation time) and students (instant feedback, active engagement).

## 4.2. Wizer.me

Wizer.me is an online platform dedicated to creating interactive and engaging worksheets that combine visual elements, multimedia, and various types of questions. Its simple and intuitive interface allows teachers to quickly design personalised teaching materials, reducing preparation time and increasing classroom interactivity (Wizer.me, n.d.).

**Key Features**:

- **Variety of items**: open-ended questions, multiple-choice, matching pairs, fill-in-the-blanks, tables, sorting tasks, or image–text matching exercises.
- **Integrated multimedia**: the ability to add images, video clips, or audio files to create multisensory learning experiences.
- **Instant feedback**: students receive immediate responses to certain types of exercises, supporting self-assessment and learning adjustment.
- **Personalization**: teachers can adapt worksheets to the level and specific needs of each group, facilitating adaptive learning.
- **Collaboration and sharing**: the Wizer.me community provides resources created by other educators, which can be reused or modified.

**Examples of use in higher education**:

- **Social sciences:** students can work on case studies by completing comparative-analytical tables.
- **Linguistics and literature**: fill-in-the-blank exercises with key terms from a text or stylistic analysis tasks.
- **Exact sciences**: drag-and-drop exercises for formulas, diagrams, or concept matching.
- **Economics**: business simulations where students select multiple scenarios and analyze their consequences.

**Pedagogical advantages**:

- **Time efficiency**: teachers can rapidly design attractive materials without requiring advanced technical skills.
- **Student engagement**: the interactive format and appealing visual design increase attention and motivation.
- **Active learning**: Wizer.me stimulates problem-solving, knowledge application, and student collaboration.

The platform also provides an active online community where teachers can access sample worksheets or share their own resources. This collaboration supports the dissemination of best practices and the diversification of educational content (Wizer.me, n.d.).

In conclusion, Wizer.me is a practical and accessible solution for creating interactive materials that enhance both teaching efficiency and student engagement. Through the variety of exercises and multimedia integration, the platform becomes a valuable tool for interdisciplinary teaching.

## 4.3. Woot Math

Woot Math is an interactive digital application that supports the development, practice, and demonstration of conceptual fluency in mathematics. It provides students with dynamic tools for exploring mathematical concepts and understanding the relationships between them, transforming the learning process into a visual and participatory experience (Woot Math, n.d.-a). For instructors, the platform facilitates interactive classroom discussions and provides resources for identifying alternative strategies used by students, as well as common mistakes.

Key Features:

- **Real-time visualization**: teachers can monitor student activity while solving problems, allowing for immediate intervention.
- **Ongoing assessment**: activities are designed to support formative assessment by identifying knowledge gaps.
- **Detailed reports**: the platform provides both live visualizations of responses and individual reports, useful for progress analysis.
- **Teacher-led activities**: these can be used to guide discussions and stimulate critical and collaborative thinking.
- **Gamification**: mathematical exercises are presented in an engaging format that motivates students and reduces the anxiety often associated with learning mathematics.

**Examples of use in higher education:**

- **Applied mathematics and engineering** – interactive simulations for differential equations or linear algebra.
- **Economics** – exercises for statistical analysis and data interpretation.
- **Teacher training** – support for mathematics didactics through classroom scenarios and examples of frequent student errors.

**Pedagogical benefits**:

- Enhances transparency in the learning process, as teachers can observe not only final answers but also intermediate steps.
- Promotes collaborative learning by discussing diverse strategies used by students.
- Supports personalised instruction, since individual reports allow adaptation of future activities to each student's specific needs.

In conclusion, Woot Math is more than just a practice tool – it is an interactive environment for mathematical exploration, combining visualization, gamification, and formative assessment to improve both teaching and learning experiences.

## 4.4. Desmos

Desmos is an interactive web application dedicated to the teaching and learning of mathematics, with a particular focus on the gamification of equations, inequalities, and graphical representations. The platform provides an intuitive visual environment where students can explore mathematical functions, graphs, and complex models in an interactive manner (Desmos, n.d.-a).

**Key Features**:

- **Interactive graphs**: enable real-time visualization and manipulation of equations and inequalities.
- **Classroom activities**: instructors can create activity modules and distribute them via a link, directly monitoring student responses.
- **Gamification**: learning mathematics becomes more engaging through visual, interactive, game-based activities.
- **Integration into teaching**: can be used as a standalone resource or integrated into LMS platforms.
- **Instant feedback**: both students and instructors benefit from immediate visualization of results and progress.

Examples of use in higher education:

- **Fundamental mathematics** – visual representation of linear equations, polynomials, and trigonometric functions.
- **Engineering sciences** – modeling phenomena through dynamic graphs.
- **Economics and statistics** – illustrating functional relationships and data analysis.
- **Teacher training** – preparing future educators to use digital tools in mathematics instruction.

**Pedagogical benefits**:

- Enhances visual understanding of mathematical concepts, supporting students who struggle with abstraction.
- Promotes collaboration and interactive classroom discussions based on students' graphical representations.
- Supports personalised instruction, as instructors can track individual progress and adapt activities accordingly.
- Stimulates motivation and engagement, transforming the learning of mathematics into an exploratory and creative experience.

In conclusion, Desmos is more than an online graphing calculator; it is a comprehensive educational tool that facilitates visualization, gamification, and collaboration in teaching mathematics at the university level.

## 4.5. Nearpod

Nearpod is an interactive and dynamic platform designed to enhance student engagement through digital lessons integrated with practical activities, which can be delivered both synchronously (live) and asynchronously (student-paced). One of its major advantages lies in the ability to integrate external content and applications into a single lesson, reducing the need for students to navigate multiple websites (Nearpod, n.d.-a).

**Key Features**

- **Creation of interactive lessons**: instructors can combine multimedia resources (presentations, videos, simulations) with learning activities (quizzes, polls, collaborative tasks).
- **Formative assessment**: the platform includes instant feedback tools that allow monitoring of student progress throughout the lesson.
- **Detailed reports**: after each lesson, instructors have access to analytics on completion rates and both individual and collective performance.
- **Delivery flexibility**: lessons can be conducted in real time (in-class or online) or asynchronously for self-paced study.
- **Multiple integrations**: compatible with applications such as Google Slides, Microsoft Teams, and other educational platforms.

Examples of use in higher education

- **Social sciences and humanities** – for interactive discussions based on polls and case studies.
- **STEM disciplines** – for simulations and quick assessments integrated directly into lessons.
- **Medical education** – for visualizing and evaluating clinical scenarios through multimedia activities.
- **Teacher training** – for experimenting with modern teaching methods based on interactive technology.

**Pedagogical Benefits**

- Enhances active student participation through engaging, interactive lessons.
- Supports collaborative learning with tools that facilitate discussions and group activities.
- Provides rapid and personalised feedback, supporting continuous assessment.
- Offers a hybrid educational experience that combines traditional learning with digital advantages.

In conclusion, Nearpod has the potential to transform a traditional lecture into an interactive, engaging, and personalised experience, integrating assessment and collaboration tools that enhance the effectiveness of higher education teaching.

## 4.6. FlexiQuiz

FlexiQuiz is an online software application dedicated to creating and administering interactive quizzes and tests, supporting the rapid and efficient assessment of students' knowledge (FlexiQuiz, n.d.). The platform provides a wide range of predefined templates and customization options, making it suitable for both formative assessments and summative examinations.

**Key Features**

- **Variety of question types**: multiple choice, short answer, fill-in-the-blank, matching, essays, rating scales.
- **Customization options**: time limits per test or per question, item randomization, maximum number of attempts, the possibility to save progress and resume later.
- **Automated feedback**: the platform can display instant feedback for correct/incorrect answers and generate detailed reports by item categories.
- **Scores and progress tracking**: final scores, progress bars, and results broken down by competency categories.
- **Easy management**: instructors can distribute tests via secure links, access codes, or LMS integration.

**Examples of use in higher education**

- **STEM disciplines** – for quick assessments through multiple-choice tests or numeric-response problems.
- **Social sciences and humanities** – for short essays or reflective questions with personalised feedback.
- **Continuing education programs** – for online certifications and professional skills testing.

Pedagogical Benefits

- Efficiency in assessment saves instructors' time through automated grading.
- Flexibility: allows tests to be adapted to each student's level and pace.
- Transparency: students receive immediate feedback, which fosters self-regulated learning.
- Accessibility: compatible with multiple devices (desktop, tablet, mobile), making it suitable for remote testing.

FlexiQuiz is a valuable tool for the digitalization of academic assessment, combining flexibility in test design with the efficiency of automated grading and the immediacy of student feedback.

AI integration – many platforms (e.g., Wizer.me, FlexiQuiz) have begun incorporating artificial intelligence for automated question generation or adaptive feedback.

**Practical Assignments**

**Creating an interactive worksheet in Liveworksheets –** transforming a traditional test (Word/PDF) into a self-correcting digital exercise and integrating it into a Moodle or Classroom course.

**Designing an interdisciplinary activity in Wizer.me –** developing an interactive worksheet that combines texts, images, and questions from two fields (e.g., economics + ecology).

**Mathematical simulation in Desmos/Woot Math –** visual representation of an applied problem (e.g., cost function evolution, statistical distributions, or logistic growth models).

**Creating an interactive lesson in Nearpod –** integrating videos, quizzes, and polls into a seminar topic and presenting the generated reports.

**Digital assessment project in FlexiQuiz** – designing a complex test with multiple item types, setting time limits, and generating a performance report by competency categories**.**

**Critical analysis –** comparing two platforms (e.g., Wizer.me vs. Nearpod) and evaluating their advantages and limitations for a master's-level course.

**Digital accessibility –** designing an activity on one of the platforms that addresses the needs of a student with disabilities (e.g., audio integration for visually impaired learners).

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# CONCLUSIONS AND RECOMMENDATIONS

The integration of new technologies in higher education requires a strategic and adaptable approach. Professors must combine theoretical knowledge with practical applications, promote the responsible use of artificial intelligence, and prepare students for the technologies of the future.

By embracing these challenges, universities can contribute to shaping graduates capable of responding to the dynamics of a rapidly and profoundly transforming labour market. The technological transformations of the last two decades have fundamentally redefined the higher education landscape, driving an accelerated shift toward digitalization and interactivity.

The integration of educational platforms, automated assessment tools, and emerging technologies has reshaped the teaching–learning process, placing the student at the centre, while redefining the role of the professor as a facilitator and guide of knowledge.

A concrete example in this direction is the CBOL project (Online Cross-Border University Library for Equitable Access to High-Quality Educational Services – ROMD00388), which demonstrates how coordinated investments in infrastructure, modern equipment, and multilingual online platforms can reduce digital divides and strengthen a common academic identity in the Romania–Moldova border region. By digitizing university book collections, creating a joint educational platform, and directly involving faculty and students, this project highlights how external funding can become a catalyst for university modernization when aligned with the real needs of academic communities.

At the same time, university libraries have emerged as strategic knowledge hubs that transcend their traditional role as information repositories, becoming key actors in the digital ecosystem. Examples such as the digitization of rare collections, integration into European projects (e.g., Europeana), or the use of platforms such as OJS show how these institutions expand access to scientific resources and contribute to the development of digital competencies.

The integration of interactive digital applications—Liveworksheets, Wizer.me, Woot Math, Desmos, Nearpod, FlexiQuiz—has demonstrated the pedagogical value of tools that facilitate formative assessment, stimulate active student engagement, and reduce the repetitive tasks of instructors. Their use across diverse fields, from STEM and engineering to linguistics, economics, and vocational training, confirms their interdisciplinary potential and adaptability to varied educational contexts.

Furthermore, emerging technologies—artificial intelligence, augmented reality, smart IoT laboratories, and learning analytics—are transforming the classroom into an intelligent ecosystem where human–machine interaction supports personalised education, collaboration, and critical thinking. However, this transformation also entails significant challenges: high costs, insufficient infrastructure, the need for continuous faculty training, and ethical and data security dilemmas.

The integration of digital technologies in higher education is not merely a modernization of teaching tools, but a paradigm shift. Digitalization necessitates rethinking curricula, teaching and assessment methods, and the role of professors. At the same time, it lays the foundation for

training graduates able to meet the demands of an ever-changing labor market and contribute to the development of a knowledge-based, innovative, and digitally inclusive society.

**Final Recommendations**

- **Strengthening digital infrastructure in universities**

Continuous investment in modern equipment (servers, scanners, smart boards, smart laboratories).

Ensuring a secure and scalable IT network that enables access to resources for all users, including remote students.

- **Integrating university libraries into the European digital ecosystem**

Expanding digitization processes for collections and linking them with European platforms such as *Europeana*.

Implementing robust institutional platforms such as Open Journal Systems and interoperable digital repositories.

Transforming libraries into hubs for training digital and information literacy skills.

- **Using interactive tools for teaching and assessment**

Mainstreaming applications such as Liveworksheets, Wizer.me, Desmos, Woot Math, Nearpod, and FlexiQuiz, tailored to each discipline.

Creating open educational resources (OER) in a collaborative manner, by sharing best practices among faculty.

- **Continuous training of academic staff**

Organizing regular training sessions for ICT integration in teaching and assessment.

Building an organizational culture oriented toward digital innovation and collaborative learning.

Encouraging professors to experiment with hybrid methods and to use learning analytics for personalised instruction.

- **Ensuring digital equity**

Developing institutional policies that guarantee equal access to digital educational resources for all students, including those from disadvantaged backgrounds or with special needs.

Creating technical and pedagogical support centres for students.

- **Leveraging European cross-border cooperation projects**

Replicating successful models, such as CBOL – Online Cross-Border University Library, in other educational and research areas.

Aligning externally funded project objectives with real university development strategies.

Expanding partnerships with universities in Europe and neighbouring regions to strengthen a common academic identity and exchange best practices.

- **Managing ethical and security challenges**

Developing clear protocols for the protection of personal data and intellectual property in digital environments.

Promoting the responsible use of artificial intelligence and emerging technologies in education.