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"Fostering Socially Distanced and Inclusive on Campus Education in Armenian HEIs" - eCAMPUS

BEST PRACTICE REPORT

TECHNOLOGY ENHANCED TEACHING, LEARNING AND ASSESSMENT

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1. Executive Summary

The rapid development of digital technologies has brought about dramatic changes in higher education worldwide by improving the quality of instruction, learner engagement, accessibility, and flexibility. The attention of universities is now centred on building digital learning environments. This Best Practice Report examines European experiences in Technology Enhanced Teaching, Learning, and Assessment (TE-TLA) to identify best practices for adaptation in the Armenian context. One of the key messages coming out of this report is that technology should not be viewed as an independent factor but as an essential facilitator for improving the quality of teaching and learning. Effective use of technology requires alignment with pedagogical objectives, staff development, and a commitment to creating student-centred, active learning environments.

The report has been developed within Work Package 4 (WP4) of the Erasmus+ Capacity Building in Higher Education project eCAMPUS - Fostering Socially Distanced and Inclusive On-Campus Education in Armenian Higher Education Institutions. It builds upon the experiences of European partner universities, including the University of Genoa (UNIGE), the Autonomous University of Madrid (UAM), the University of Lisbon (ULISBOA), and KTH Royal Institute of Technology, as well as international research, policy frameworks, and digital competence models. The report adopts a broad understanding of TE-TLA as a strategic institutional approach that combines:

- digital infrastructure;
- innovative pedagogical approaches;
- digitally competent educators;
- student digital capability;
- smart learning environments;
- digital assessment strategies;
- quality assurance mechanisms;
- institutional leadership and governance.

The analysis demonstrates that successful technology-enhanced education does not result from technology adoption alone. Instead, sustainable transformation requires alignment between technology and educational objectives. European experience shows that institutions achieving effective digital transformation typically share several characteristics:

1. Institutional leadership in strategy: digital education is integrated into institutional strategies rather than treated as a separate initiative.
2. Digital learning ecosystem: the LMS, digital assets, communication and analysis tools, and support services function as integrated components of a cohesive ecosystem.
3. Educator digital competency: educators possess both pedagogical and technological skills.
4. Learner-centered teaching methods: promote active, collaborative, and personalized learning.
5. Assessment methods: innovative digital assessments provide feedback, flexibility, and authenticity, supported by quality assurance processes.

6. Inclusive learning environments: digital transformation must ensure accessibility and inclusivity.

The report highlights several practices that can be adopted by Armenian higher education institutions:

- development of institutional digital learning ecosystems;
- establishment of smart classroom environments;
- implementation of digital competence development programmes;
- enhancement of blended and hybrid learning models;
- integration of digital assessment approaches;
- development of institutional quality assurance procedures for digital education.

These findings support the development of benchmark standards for e-learning platforms and model smart classrooms within the eCAMPUS project. The benchmarks support Armenian HEIs in their digital transformation by offering practical, contextually relevant guidance.

2. Introduction

With the rapid advancement of digital technologies in the modern world, higher education worldwide has been reshaped by changes in how education is designed, implemented, and assessed. With the increasing use of learning management systems, cloud computing technologies, learning analytics, AI, and smart classroom technology, it becomes possible for higher education institutions to provide more adaptable, customised, and convenient educational settings. With the further development of digital transformation, there will be a shift from using digital technologies to creating educational ecosystems. The concept of smart education has emerged in response to these developments. Smart education is commonly understood as an educational system that leverages digital technologies to create adaptive learning environments and innovative pedagogical models, thereby enhancing the quality, efficiency, and equity of education. According to the National Smart Education Framework supported by UNESCO [1], smart education is defined as the integration of intelligent technologies, smart learning environments, and learner-centred pedagogies that provide diversified support services and facilitate the collection and analysis of educational data. Recognising the strategic significance of digital transformation in higher education, the Erasmus+ Capacity Building in Higher Education (CBHE) Project "eCAMPUS - Fostering Socially Distanced and Inclusive On-Campus Education in Armenian Higher Education Institutions" aims to assist Armenian universities in creating sustainable, inclusive technological learning environments. In this regard, Work Package 4 (WP4) aims to identify European best practices in technology-enhanced teaching, learning, and assessment to develop benchmarking standards for e-learning platforms and model smart classrooms in Armenian higher education institutions. The current Best Practice Report has been developed within the framework of WP4 based on the experience of European partner universities involved in the eCAMPUS project, such as the University of Genoa (UNIGE), the Autonomous University of Madrid (UAM), the University of Lisbon (ULISBOA), and KTH Royal Institute of Technology. The report provides a set of best practices, innovations, and transferable lessons that could be used in the modernisation and digital transformation of higher education in Armenia.

2.1 Background and Rationale

Smart classrooms have revolutionised education through the integration of diverse technologies into educational settings. The development of technology has been concurrent with that of computing and communication. However, countries have adopted and developed their own versions of smart classrooms at different times. Economic development, government policies, and other factors have significantly influenced their expansion.

The development of smart classrooms began with the incorporation of computer technology into education in the 1960s and 1970s, through computer-assisted instruction in the US [2], in which universities and research centres used mainframe computers to deliver instruction in mathematics, science, and engineering. In the 1980s, personal computers were being incorporated in schools in the US, Japan, and UK. Computer labs were created

to enhance students' knowledge about computer technology. While these labs lacked the interactive elements that current smart classrooms offer, they provided a platform for future technological advances.

The concept of "smart class room" emerged in the early 2000s through the integration of technologies such as interactive boards, projectors, computers, high-speed Internet, and Learning Management Systems into a single learning platform. The rise of these tools and the ability to use them effectively in classrooms are driving strong demand for advanced learning environments worldwide.

2.2 Purpose and Objectives

The deliverable analyses, examines and synthesizes European good practices in Technology-Enhanced Teaching, Learning, and Assessment (TE-TLA) to promote digital transformation in Armenian HEIs. The deliverable is based on the results of study visits to European partner universities, presentations by experts, institutional case studies and additional desk research. The specific objectives of this deliverable include:

- Analysis of current approaches to technology-enhanced teaching, learning, and assessment used in European higher education institutions;
- Analysis of digital learning ecosystems, e-learning platforms, instructional technologies and smart classrooms used in European partner universities;
- Identification of good practices in digital pedagogy, hybrid learning, learning analytics, digital assessment and student engagement;
- Analysis of institutional approaches to digital transformation and associated governance models and support systems;
- Identification of transferable good practices and lessons learned that could be transferred to Armenian higher education institutions;
- Establishing an evidence base for developing an e-learning platform and smart classroom benchmarks under the eCAMPUS project.

2.3 Methodology

This analysis is based on observations from study visits, institutional presentations, document analysis, and desk research. A two-day study visit to UNIGE offered project partners a firsthand experience of the technology-enabled learning environment, e-learning multimedia systems, instructional technologies, and smart classrooms deployed at European universities. Additional information was obtained through presentations and experience exchanges with representatives from the UAM, ULISBOA, and KTH. Furthermore, this report incorporates information from European policy frameworks, international reports, and academic literature addressing digital transformation in higher education, including the European Commission's Digital Education Action Plan 2021–2027 [3], UNESCO's Smart Education Framework, and other relevant sources. The collected data were analysed to identify common trends, innovations, facilitating factors, and transferable lessons applicable to the development of technology-enhanced teaching, learning, and assessment environments in Armenian higher education institutions. The findings provide an

evidence base for establishing framework benchmark standards for e-learning platforms and benchmark statements on model smart classrooms within the eCAMPUS project.

3. Conceptual Framework of Technology-Enhanced Teaching, Learning and Assessment

3.1 Technology-Enhanced Teaching, Learning and Assessment

The main focus of TE-TLA is the integration of technology into education to foster interaction and collaboration in the learning process. The scope of TE-TLA includes any activity concerned with designing, implementing and evaluating digital technologies used for efficient teaching and learning. Technology-Enhanced Learning (TEL), the basis of the concept of TE-TLA, has emerged from European research projects initiated in the early 2000s. Since then, TEL has become an interdisciplinary area of research that involves disciplines such as computer science, learning sciences, educational psychology, and the social sciences. Its primary objective is to investigate how digital technologies can enhance teaching and learning processes and to inform the design of new educational technologies.

The significance of TE-TLA is further demonstrated by EU educational policies. The European Commission's Digital Education Action Plan 2021-2027 sets out a common vision for quality, inclusive, and accessible digital education that aims to align the educational systems to the requirements of the digital age. Digital education is defined by the Action Plan as the application of digital technologies and content in teaching, learning, and evaluation processes to increase flexibility, accessibility, and resilience of the education system. Furthermore, the Action Plan emphasises the necessity of high-performance digital education ecosystems, supported by robust digital infrastructure, institutional digital transformation, high-quality digital content, educator digital competencies, and the responsible implementation of emerging technologies.

Within higher education institutions, TE-TLA encompasses a broad spectrum of pedagogical practices. These include blended and hybrid learning, learning management systems, virtual classrooms, collaborative online learning environments, digital assessment, learning analytics, virtual and remote laboratories, and applications of artificial intelligence and adaptive learning technologies. In this context, TE-TLA is defined as an institutional approach that leverages digital technology, advanced teaching strategies, learning environments, and support systems to enhance the quality and accessibility of higher education institutions. The definition mentioned above is the basis for analysing the best practices of European countries in TE-TLA and for developing an approach applicable to the development of smart classrooms and digital learning environments in Armenia.

3.2 Smart Education and Smart Learning Environments

Smart Education is a holistic educational framework that combines technology, evidence-based decisions, intelligent learning environment and innovative teaching practices to build a flexible, personalized and learner-centered education system. While other educational paradigms focus mainly on the technological aspect, Smart Education seeks to transform the whole educational context by connecting various participants in a network, such as learners, teachers, organisations, and emerging and existing technologies. Smart Education can be understood as the interaction among several interrelated elements. The elements include digital infrastructure, governance, the teaching and learning process, digital content, assessment, data management, and professional development and innovation. All these elements together provide an adaptive educational context that responds to changes in society, technology, and learners' requirements. Here, technology serves as an enabler of educational change, not the end.
An important element of Smart Education is the creation of Smart Learning Environments (SLEs). The SLEs involve integrating physical and virtual environments with smart technologies to create collaborative, personalised, and active learning. SLEs encompass learning management systems, cloud services, multimedia tools, intelligent classroom technologies, communication media, and learning analytics that enable a continuous learning process irrespective of time and place. Learners can access educational materials, collaborate with one another, receive feedback, and engage in self-regulated learning through various digital media. Unlike conventional classrooms, SLEs have the capacity of being adaptive, connected and responsive. Thanks to the use of data collected during the learning process, teachers are able to analyse learners' progress and make timely interventions. At the same time, learners have the opportunity to develop digital and collaborative skills needed in today's world.
Smart learning environments in universities support the adoption of blended, hybrid, and HyFlex learning approaches [4]. These environments enable flexible educational experiences while maintaining high standards of instruction and learner engagement. Emerging technologies such as AI, learning analytics, virtual and augmented reality, the Internet of Things (IoT), and adaptive learning platforms enhance the capabilities of smart learning environments by enabling personalised instruction, immersive learning experiences, and evidence-based educational management. Within the eCAMPUS initiative, Smart Education serves as a foundational concept for implementing technology-enhanced approaches to teaching, learning, and assessment, as well as for establishing model smart classrooms in Armenian universities. Conceptualising smart learning environments as integrated learning ecosystems supports the project's objective of achieving sustainable digital transformation through innovative teaching methodologies and advanced learning technologies.

3.3 Digital Learning Ecosystems

Successful sustainable deployment of technology-supported learning requires the creation of Digital Learning Ecosystems (DLEs). This ecosystem comprises the combined efforts of technological infrastructure, pedagogy, policies, management, and digital resources and services to support quality learning, teaching, and evaluation processes. "DLE is a system of components working together to accomplish organisational learning objectives." Rather

than viewing digital technologies as independent tools, the concept of DLE emphasises the importance of interaction among people, processes, technology, and organisational culture in achieving successful digital transformation.

There are several dimensions that make up DLE and work together to create an effective, smart, and resilient education system. The following are among those dimensions: digital infrastructure and connectivity, governance and leadership, learning platforms and digital content, teaching and learning, assessment and quality assurance, data management and learning analytics, professional development of teachers, and innovation. All of these dimensions are important, and the synergy among them creates an ecosystem in which flexibility, inclusiveness, and learner-centricity become possible. Digital infrastructure is the technological base of this ecosystem, and it consists of the following components: connectivity, cloud computing, LMS, communication, and digital content. However, the presence of digital infrastructure alone is not sufficient to ensure the success of digital transformation in educational institutions. Governance, policy-making, and leadership are equally important.

The use of a digital learning ecosystem approach offers many strategic advantages to higher education institutions. In the first place, it makes an organisation more resilient, promotes innovation in education and learning, facilitates collaboration among different parties, enhances the quality of education, and supports development through evidence-based decision-making. In addition, it provides the necessary conditions for the implementation of smart classrooms. In the context of the eCAMPUS project, DLE is an approach aimed at embedding technology-enhanced teaching, learning, and assessment and creating smart classrooms. To ensure sustainable development of DLEs that will stimulate innovation, improve educational quality, and comply with European digital education standards, Armenian higher education institutions need to develop governance, digital infrastructure, educator competencies, and learner services.

3.4 Emerging Technologies in Higher Education

HEIs are undergoing a revolutionary change due to the emergence of new technologies that affect not only the process of knowledge transmission but also completely change the processes of knowledge generation, distribution, evaluation, and validation. Modern universities have become hybrid institutions in which physical and virtual infrastructures coexist. The introduction of AI technologies to the educational process and learning management represents a revolution in higher education. Modern intelligent systems help perform adaptive learning, automated evaluation, academic counselling, and student attrition prediction. For example, intelligent tutoring systems allow the degree of difficulty to change dynamically based on the learner's progress. As a result, there appears to be an incredible possibility for personalisation of the educational process. Additionally, AI technologies are increasingly used in university administration.

Another revolution in higher education is the emergence of learning analytics and educational data science, which enable the collection of large amounts of data on students' interaction processes. A significant tendency is the usage of virtual reality (VR) and augmented reality (AR) technologies, which are especially useful in subjects that require

practical experience, such as medicine, engineering, architecture, and the natural sciences. VR and AR can be used to conduct experiments and training within controlled conditions.

The development of cloud computing and digital learning environments has also changed the boundaries of educational institutions. Cloud-based LMS make learning resources available via any device and from any location, making it possible to blend or purely virtual learning programs. This issue has been especially important during such crises as the COVID-19 pandemic. Blockchain technology is increasingly influencing credentialing and certification. With blockchain, it is possible to create safe, unalterable, and secure certificates and diplomas. In other words, blockchain can provide greater mobility and transparency in the global markets for education and work.

Lastly, the advent of generative AI technologies is another recent and highly disruptive technology. These technologies are revolutionising academia, from writing papers to conducting research and engaging with scholarly knowledge. While providing many opportunities to increase productivity and innovation in academia, it poses many threats to academic integrity and evaluation. The EU AI Act (2024) provides a regulatory framework HEIs should consider when adopting such technologies, especially regarding transparency, data governance, and human oversight requirements [5].

Despite numerous opportunities to implement innovations in the educational process, several challenges need to be addressed. They consist of the following: the digital divide, lack of readiness, lack of teacher training, security considerations, and ethical issues regarding the data collected and the algorithms. This rapid technological evolution, however, necessitates a deliberate and principled approach. Digital transformation in higher education should be understood as a human-centred process in which technology supports, rather than replaces, teaching, learning and institutional decision-making. The successful integration of digital technologies and artificial intelligence depends on maintaining human agency, pedagogical intentionality, ethical responsibility and critical reflection throughout educational processes. This principle is crucial to the vision of the eCAMPUS project to support inclusive and high-quality education, as it ensures that the technological standards and smart classroom examples discussed in this report will always be means, not ends, to empower teachers and students.

The new technologies and concepts outlined above are applied in the systematic approach to technical benchmarks and requirements, as described in Appendix A: Strategic Framework and Technical Benchmark Standards for E-Learning Ecosystems.

4. European Best Practices on TE-TLA

Changes in the use of technology-enhanced learning have been observed in European higher education institutions. At first, technology-based learning was perceived as an extracurricular activity introduced by specific educators or departments. The current

approaches to technology-enhanced learning in Europe indicate a shift toward an integrated strategy for implementing technology at the institutional level. The DIGI-HE survey collected data from 368 institutions across 48 member countries of the European Higher Education Area [6]. The findings indicate that institutional strategy is a critical factor in achieving digital transformation. Approximately 80% of institutions have developed a strategy related to digitally enhanced learning and teaching. European HEIs recognise that effective technology-enhanced learning requires institutional vision and leadership, alignment with learning and teaching strategies, adequate infrastructure, quality assurance, and active involvement of both teachers and students. The DIGI-HE project contends that digitalisation should be integrated into comprehensive institutional learning and teaching transformation, rather than maintained as an isolated technological agenda.

Table 1: Traditional approach vs Emerging European TEL approach.

Traditional approach	Emerging European TEL approach
Teacher-led experimentation	Institutional digital strategies
Technology as additional support	Technology integrated into pedagogical models
Department-level initiatives	Whole-institution transformation
Focus on tools	Focus on learning outcomes

Technology-enhanced student-centred learning promotes autonomous learning, flexible access, collaboration, personalised learning, and interaction between teacher and learner according to the systematic review [7]. Usage of LMS, blended learning environments, online collaboration tools, digital resources, and virtual mobility has increased in Europe. Based on the findings of the DIGI-HE study, blended learning remains the most popular form of digital delivery, employed by about 75% of European HEIs. Moreover, digital provision tends to focus more on expanding access, lifelong learning, and flexible learning paths. About 81% of institutions considered expanding access via digitalisation a strategic priority.

Digital assessment is now a central component of TEL development. European HEIs primarily emphasise online assessment tools, digital feedback systems, learning analytics, and authentic assessment techniques. European HEIs adhere to several key principles.

- Quality of assessment: enhance assessment techniques rather than digitise current exams;
- Scholarly integrity: address issues such as authentication, plagiarism, and the ethical use of technology;
- Accessibility: accommodate the needs of all learners.

It should be noted that the broader literature on technology-enhanced assessment states that the success of such a process largely depends on the institution's readiness, sound assessment design, student engagement, and outcome evaluation. The EU institutions are becoming more engaged in shifting their focus from the mere technical training towards the broader development of digital pedagogy practices.

Table 2: Less mature TEL model vs Advanced European practice.

Less mature TEL model	Advanced European practice
Training teachers to use software	Developing digital pedagogical competence
Optional workshops	Embedded professional development
Individual responsibility	Institutional support systems

Several barriers remain.

- Institutional challenges: insufficient funding; lack of staff time; difficulty developing coordinated strategies; and unequal digital maturity between institutions.
- Human challenges: limited teacher motivation; need for digital competence; and resistance to changing teaching practices.
- Ethical and regulatory challenges: GDPR compliance; data protection; platform dependence; and accessibility.

The main characteristics of advanced European practice are:

Table 3: Dimension and European TEL Practice

Dimension	European TEL Practice
Strategy	Institution-wide digital learning strategies
Pedagogy	Student-centred and active learning approaches
Assessment	Digital, authentic, flexible assessment
Teachers	Continuous digital competence development
Students	Flexible access and personalised learning
Governance	Self-assessment and quality enhancement
Collaboration	Peer learning networks across Europe

Based on European experience, the effective realisation of TEL mainly depends on building institutional capabilities, encouraging pedagogical innovations, and creating collaborative cultures, rather than merely buying technological tools. Thus, the future of TEL in Europe will be linked to integrated digital ecosystems combining physical and digital learning spaces. Based on the comparative analysis, European TEL practices can be conceptualised through a five-level maturity model.

- **Level 1 - Availability of Technology:** At the initial stage, institutions primarily focus on acquiring technological infrastructure: learning management systems; video conferencing systems; digital communication solutions; and online databases. At this stage, technology is adopted; however, pedagogical transformation does not occur. Many institutions had achieved this stage before the COVID-19 pandemic, as the necessary technology was available but not yet fully integrated into educational practices.

- Level 2: Online Learning and Blended Learning: The second stage is characterized by a significant increase in the adoption of blended and online learning modalities. At this stage, institutions begin to integrate the following components: classroom learning; online materials; asynchronous learning; digital communication.
- **Level 3 - Digital Pedagogical Transformation:** Technology becomes fully embedded within the philosophy of teaching at this level. It encompasses: active learning; collaboration; personalized learning; engagement; and digital learning design. The role of the teacher changes from the one of information dissemination to that of learning experience designer. Research on student-centered and technology-enabled learning reveals that digital technologies enable better interaction, autonomy, collaboration, and engagement of learners rather than the mere transfer of traditional pedagogic approaches to online learning environments.
- **Level 4 - Institutional Digital Ecosystems:** At this level, digital transformation evolves into an ecosystem of an institution which encompasses: infrastructures; quality assurance; learning analytics; digital assessment; professional development; and collaboration networks.
- **Level 5 - Innovative and Forward-Looking TEL:** It is the highest level of maturity and involves innovative technologies and continuous improvement. The features of it include: learning via artificial intelligence; adaptive learning; VR/AR; learning analytics; international digital collaboration; and open educational resources.

The top-level maturity stage of the TEL maturity model (innovative and visionary TEL) is further elaborated on platform architecture, KPIs, and governance frameworks in Appendix A, where benchmark standards for implementation at the institutional level are defined.

5. Technology-Enhanced Learning Ecosystems of EU Partner institutions

The benchmarking methodology is applied for the analysis, where the practices of the institutional settings are examined through a comparative framework in relation to four European partner institutions with different organisational settings, technological platforms, and educational backgrounds:

- **KTH Royal Institute of Technology** - a technological research university with a highly advanced digital environment and a well-defined digital competence and innovation policy.
- **Autonomous University of Madrid** - a public university, adopting an institutional approach to digital transformation, teaching innovation, and quality of education improvement.
- **University of Lisbon** - a leading engineering and science institution implementing a digitally enhanced campus model combining physical and digital learning environments.
- **University of Genoa** - a multidisciplinary university with long-term experience in e-learning development, institutional LMS implementation, and digital pedagogy support structures.

The comparative framework was developed based on the information collected through the **Best Practice Collection & Policy Paper on Technology-Enhanced Teaching, Learning and Assessment (TE TLA)** templates prepared within the eCAMPUS-EDU project. The analysis does not aim to identify a single "ideal" TEL model. Instead, it examines different institutional approaches and identifies common principles, successful practices, and implementation lessons that can be adapted to the Armenian higher education context.
The primary source of information for this report consists of institutional self-assessment documents prepared by European partner universities using a common benchmarking template.
The template collected information across the following areas:

- Institutional digital transformation strategy;
- Governance structures for digital education;
- Learning Management Systems (LMS);
- Multimedia and video learning tools;
- Digital assessment practices;
- Academic integrity mechanisms;
- Digital infrastructure and connectivity;
- Software licensing;
- Accessibility and inclusive technologies;
- IT support and faculty training;
- Pedagogical approaches;
- Smart classroom models;
- Hybrid and blended learning environments;
- Sustainability and future development.

This common structure enables meaningful comparison while allowing institutions to describe their own organisational models and development trajectories.

5.1 Comparative Dimensions

This analysis follows a nine-dimensional structure, which can be considered the building blocks of an advanced TEL system.

Dimension 1: Digital Transformation Governance and Institutional Strategy
This dimension examines how universities organise and govern digital transformation. Relevant metrics may include the presence of an institutional strategy for digital transformation, responsible departments/offices, IT services–academic department coordination, and compatibility between technology and educational goals.

Dimension 2: Learning Management Systems and Digital Learning Platforms
The second dimension examines the technological foundation supporting digital learning. Key factors are: Institutional LMS Adoption: Percentage of Courses Utilising Digital Platforms, Integration with Student Information Systems, Authentication System, and Assessment and Communication Features.

Dimension 3: Multimedia Learning Resources and Digital Content Ecosystems
This dimension examines the extent to which institutions provide support for the creation, management, and dissemination of educational resources in digital format. Indicators include: lecture capture systems; multi-purpose studios and video systems; interactive learning content; and digital resources.

Dimension 4: Digital Assessment and Feedback and Academic Integrity
This dimension evaluates how institutions use technology to support assessment quality and academic integrity. Indicators include online examinations; digital quizzes; automated feedback; plagiarism detection; and assessment redesign.

Dimension 5: Digital Infrastructure and Connectivity and Software Ecosystems
This dimension evaluates the infrastructure and connectivity required for TEL. Among the indicators are the presence of networks, Wi-Fi, research and education networks, laboratories, computing facilities, and classroom technologies.

Dimension 6: Accessibility and Inclusive Digital Learning
This dimension evaluates how the institution provides equal access to digital learning. Indicators such as accessibility principles, strategies of Universal Design for Learning, assistive technologies, and disability support services are among those considered.

Dimension 7: Faculty Digital Competence and Support Structures
Technologies alone cannot transform the learning process; the involvement of staff members is crucial in this regard. This dimension evaluates activities of teaching and learning centres, instructional design support, digital pedagogies and communities of practice.

Dimension 8: Pedagogical Models and Learning Innovation
This dimension examines the effect of technologies on the development of educational approaches. The issues of blended learning, active learning, project-based learning, collaborative learning, and personalised learning are among the issues examined here.

Dimension 9: Smart Classrooms and Hybrid Learning Spaces
This dimension explores the learning environments equipped with technologies. It includes the examination of classroom technology, hybrid teaching capability, recording systems, and collaborative technologies.

5.2 Analyzes and Evaluation

Dimension 1: Digital Transformation Governance and Institutional Strategy
KTH provides an example of a research-intensive university where digital transformation is integrated into institutional planning. The university's Digitalization Strategy 2023–2027 identifies digitalisation as a strategic priority and focuses on improving digital capabilities among staff and students; strengthening digital infrastructure; improving access to data and digital services; and supporting efficient institutional processes. Digital education

development is connected with broader organisational objectives, including teaching quality, research capacity, administration, and student services.

UNIGE demonstrates a particularly relevant model for universities seeking to combine technology, pedagogy, and institutional support. UNIGE has developed its digital transformation progressively over several years, moving from early e-learning initiatives toward an integrated ecosystem supported by central ICT services, the Teaching and Learning Centre (UTLC), e-learning and multimedia support services, and academic departments implementing digital teaching practices.

ULISBOA follows a digitally enhanced campus approach. Rather than replacing campus education with fully online learning, ULISBOA uses technology to strengthen traditional university education through blended learning, digital resources, online collaboration, flexible access to learning materials, and digital assessment. The institution's approach emphasises improving teaching quality, supporting flexible learning models, strengthening digital competences, and expanding access to educational resources.

UAM integrates digital transformation with educational innovation and quality improvement. The university connects digital development with teaching innovation, digital competence development, educational technology modernisation, emerging technologies including AI, and institutional data management. The UAM example demonstrates the importance of linking digital transformation with educational objectives rather than focusing only on technological infrastructure.

Dimension 2: Learning Management Systems and Digital Learning Platforms

KTH provides one of the strongest examples of LMS institutionalisation. Canvas has become the central learning environment, with full institutional adoption across courses. The platform is integrated with student information systems; authentication services; video platforms; and academic administration systems. This creates a consistent student experience where digital learning services are accessed through a unified environment.

UNIGE uses AulaWeb, which is based on Moodle and serves as the university's LMS. The platform offers support for content management, assignment submission, quizzes, interactive tools, feedback, and multimedia content. AulaWeb is one of the platforms developed by the university following earlier e-learning experiments.

ULISBOA experience differs in that it uses several platforms for its e-learning activities. FenixEdu is used for academic purposes, while Moodle and Open edX are used for teaching and MOOCs and other forms of digital learning, respectively.

Dimension 3: Multimedia Learning Resources and Digital Content Ecosystems

KTH uses various services and software, including Kaltura for video management, YouTube integration, Zoom for synchronous teaching, Camtasia for screen recording and video production, and Adobe Creative Cloud for multimedia production. It aims to capture

lectures and support different types of learning environments. They are flipped classrooms, blended learning, e-learning, and even multimedia production done by the students.

UNIGE uses Camtasia for lecture capture and video production, PeerTube for video hosting, H5P for interactive learning activities, and Microsoft Teams for live class lectures and recordings. These tools are incorporated into AulaWeb LMS. This approach enables teachers to create different types of digital learning experiences recorded lectures, Interactive videos, Digital learning objects. Teachers can create reusable resources that support independent learning.

ULISBOA provides classroom multimedia technologies, video production facilities, software tools, online learning platforms, and digital assessment environments. The institution has developed multimedia capacity through interactive classroom technologies, specialised production resources, and digital platforms supporting MOOCs and online learning.

UAM supports the development and use of digital learning resources through institutional learning platforms, multimedia teaching materials, digital repositories, online collaboration tools, and support for faculty digital innovation. The university promotes the integration of multimedia resources into blended and online learning, encouraging teachers to develop interactive and student-centred learning experiences.

Dimension 4: Digital Assessment, Feedback and Academic Integrity

KTH uses digital tools supporting online assignments, quizzes, interactive assessment activities, examination management, automated feedback, and academic integrity processes. Assessment activities are supported through the institutional LMS environment and additional specialised tools, including digital examination and mathematical assessment platforms. Key characteristics include integration between teaching activities and assessment, increased use of formative feedback, technology-supported monitoring of learning progress, and combination of automated and teacher-based evaluation.

UNIGE uses LMS-based assessment tools including online quizzes, assignments, discussion activities, feedback mechanisms, and grade management. Moreover, UNIGE integrates digital assessment with other forms of assessment, both conventional and creative, such as project-based assessment, oral assessments, and continuous assessment. Digital means facilitate fast feedback loops and assessment criteria that document progress effectively.

Dimension 5 Digital Infrastructure, Connectivity and Software Ecosystems

KTH's digital environment supports teaching and learning, research activities, collaboration, administrative processes, and digital services for students and staff. KTH's infrastructure approach is characterised by strong institutional coordination, advanced network capacity, integrated digital services, secure access management, and extensive software availability. The institution provides a broad ecosystem of digital tools supporting teaching activities, including learning platforms, communication systems, video services, and specialised academic software. A key strength of the KTH model is the integration of

infrastructure development with institutional digital strategy. Digital services are not developed separately but as part of a wider transformation agenda.

ULISBOA maintains advanced digital infrastructure supporting, teaching, research, online learning, computational activities, and institutional services. Its digital environment includes high-speed campus networks, wireless connectivity, research and education network connections, and specialised computing resources. ULISBOA's infrastructure reflects the needs of engineering and scientific education, where digital learning frequently requires simulations, computational tools, laboratory technologies, and specialised software environments.

UNIGE follows a progressive and scalable infrastructure development model.The institution combines central ICT management, distributed teaching facilities, digital learning platforms, multimedia services, and hybrid teaching technologies. However, software provisioning is usually handled centrally by ICT services to ensure security, consistency, and licensing compliance. Academic units also have some flexibility to adopt discipline-based tools when necessary.

Dimension 6 Accessibility, Inclusion and Universal Design for Learning

KTH approaches accessibility through accessible digital platforms, support services for students with disabilities, guidance for teachers, attention to inclusive digital content. Accessibility considerations are integrated into digital learning environments, including requirements related to readable digital materials, accessible documents, captioned multimedia, and compatibility with assistive technologies. KTH also recognises that accessibility requires staff awareness and competence, meaning that teachers need support in designing inclusive digital learning experiences.

UNIGE addresses accessibility through a combination of technological and organisational measures, including availability of digital learning materials through the AulaWeb LMS, multimedia platforms supporting captioning and structured video content, compatibility of digital platforms with assistive technologies, and support services for students with disabilities and specific learning needs. The university increasingly encourages teachers to adopt inclusive digital teaching practices, including clear content organisation, accessible formats, diversified learning materials. An important feature of the UNIGE approach is the recognition that accessibility cannot depend only on technology. It requires cooperation between ICT services, teaching support units, academic staff, student support services.

Dimension 7 Faculty Digital Competence Development and Institutional Support

KTH recognises that digital transformation requires continuous development of staff capabilities. Faculty members receive support in areas including digital teaching tools, online and blended learning, digital course design, and educational technologies. The institution combines technological support with pedagogical development, ensuring that digital tools are connected with teaching objectives. A key strength of the KTH model is the recognition that teachers require more than technical instructions. They need opportunities to explore how digital technologies can transform learning activities.

UNIGE provides one of the clearest examples of institutional support structures combining technology and pedagogy. UNIGE provides support through cooperation between ICT Area, UTLC, e-learning services, and multimedia support units. The ICT Area focuses primarily on operation and maintenance of digital platforms, technical assistance, and system reliability. The Teaching and Learning Centre supports instructional design, technology-enhanced teaching methodologies, course development, and digital assessment approaches. This division of responsibilities represents a highly transferable model because it recognises that technology adoption requires both technical expertise and pedagogical guidance.

ULISBOA provides an example of faculty support within a strongly disciplinary environment. As an engineering and science institution, ULISBOA faces specific challenges related to laboratory-based teaching, technical simulations, specialised software, and computational learning environments. Faculty support focuses on helping teachers integrate digital technologies into disciplinary teaching practices. Examples include support for digital learning platforms, online resources, multimedia teaching materials, and blended learning approaches. The ULISBOA experience demonstrates that faculty development should recognise disciplinary differences. A digital teaching model appropriate for engineering may differ significantly from approaches needed in humanities, medicine, or social sciences.

UAM links faculty digital competence development with broader educational innovation. The university promotes digital teaching innovation, experimentation with educational technologies, development of digital competences, and adoption of emerging technologies. UAM's approach reflects an important European trend: teachers are not only users of digital technologies but also innovators who contribute to institutional digital transformation.

Dimension 8 Pedagogical Models for Technology-Enhanced Learning

UNIGE is an example of a university that incorporates blended learning into its institutional learning methods. UNIGE uses face-to-face learning, LMS-based learning activities, multimedia materials, virtual communication, and digital assessment. The institution encourages technology-enabled learning, in which digital technology facilitates continuity of learning, learner engagement, and the availability of learning materials. UNIGE stresses that technology should not detract from teaching interactions but should enhance education through greater flexibility and improved accessibility. UNIGE draws attention to new AI-driven teaching methods, including conversational AI systems that help learners engage in problem-solving, reflect, think critically, and create knowledge collaboratively. The core pedagogical issue here is ensuring that learners have the capacity to use AI critically.

KTH incorporates digital technology into teaching methods to enhance student involvement and autonomy in their learning process. The use of digital technology facilitates collaboration, access to information, communication, and ongoing feedback. The

example of KTH shows that the combination of technology and the right pedagogical technique is critical for success.

ULISBOA is applicable due to its focus on engineering and science education. The use of digital technology supports problem-solving practice, simulations, engineering collaboration, and access to digital information.

Dimension 9 Smart Classrooms and Hybrid Learning Spaces

UNIGE provides one of the most relevant examples of a structured smart classroom development approach. Rather than implementing identical technology in all classrooms, UNIGE follows a differentiated model based on pedagogical needs and institutional priorities. The university identifies different levels of technology-enhanced classrooms: Basic digital classrooms, hybrid classrooms, advanced technology-enhanced classrooms This gradual development model allows institutions to expand smart classroom capacity according to available resources and educational priorities.

At **KTH**, there is an integration of digital learning spaces and innovative teaching approaches. Smart learning spaces facilitate collaboration, digital learning demonstrations, project-based learning, and interactions between students and teachers. The most important aspect of smart learning at KTH is that the technological classroom should be integrated with the teaching method. Just having a technology-driven classroom will not change anything without modifying teaching practices.

ULISBOA provides an example of smart classroom development in an engineering education context. Digital learning spaces support technical demonstrations, collaborative engineering activities, multimedia learning, and hybrid participation. For science and engineering disciplines, smart classrooms are particularly valuable because they can integrate simulations, digital models, specialised software, laboratory-related resources. The ULISBOA experience demonstrates that smart classroom design should consider disciplinary requirements rather than applying a single universal model.

UAM connects classroom digitalisation with broader educational innovation.Digital learning spaces support flexible teaching formats, digital resources, collaborative learning, experimentation with new methodologies.

The European experience shows that successful TEL transformation depends on the alignment of four key elements: **Strategic leadership + Digital infrastructure + Pedagogical innovation + Faculty capacity**. For Armenian higher education institutions, the priority should be to create sustainable digital learning ecosystems where technology enhances teaching quality, supports inclusion, and improves student learning experiences.

6. Technology-Enhanced Learning Ecosystems of the Institute for Informatics and Automation Problems

The Institute for Informatics and Automation Problems (IIAP) represent a cornerstone of Armenia's digital research and education infrastructure. IIAP, established in 1957, has played a pivotal role in developing and operating critical national information and communication technology systems for over six decades. Its expertise spans a wide range of fields, including computer science, applied mathematics, information security, and network technologies. This deep institutional knowledge and technical capacity have positioned IIAP as a key strategic asset for Armenia's digital transformation in higher education and research. IIAP's contributions extend across several interconnected domains. In scientific research, IIAP conducts fundamental and applied research in priority areas such as AI, machine learning, information security, and high-performance computing. This research not only advances scientific knowledge but also informs the development of practical solutions and services that benefit the wider academic community. In the area of national digital infrastructure, IIAP develops, deploys, and manages critical services that support education and research across Armenia. These include high-speed academic networks, e-learning platforms, cloud services, digital repositories, and supercomputing resources that would otherwise be unavailable to many Armenian institutions. In addition to the institutional practices of European partner universities, the eCAMPUS project benefits from this significant national asset: the technology-enhanced learning infrastructure developed and operated by IIAP.

As a leading research institute in informatics and applied mathematics, IIAP has a long history of developing and managing key national digital infrastructures. This includes the Academic Scientific Research Computer Network of Armenia (ASNET-AM), which provides high-speed connectivity to over 65 scientific and educational organizations across the country. Building on this robust foundation, IIAP offers a comprehensive and accessible national e-learning platform that serves as a powerful tool for digital transformation in Armenian higher education. The ASNET-AM network is itself a critical infrastructure that enables much of IIAP's educational work. It connects Armenian research and educational institutions to each other and to the pan-European GÉANT network, providing high-bandwidth connectivity that supports data-intensive research, international collaboration, and the delivery of digital education services. Without this network, the e-learning, cloud, and supercomputing services described below would be substantially less effective, as they depend on reliable, high-speed connectivity to function properly.

Cloud Infrastructure and Services

IIAP develops and operates industrial-grade server solutions based on a federated cloud platform, which requires not only high-performance computing and large volumes of data storage resources, but also skills in data analytics, cloud computing, and service provisioning. This cloud infrastructure provides the computational foundation for many of Armenia's national digital services, including e-learning platforms, digital repositories, and research computing resources. The cloud services provided by IIAP are designed to meet the needs of Armenian research and educational institutions at no cost to users. Through its

cloud platform, IIAP offers virtualized computing resources, storage capacity, and software services that institutions can leverage without having to invest in their own hardware or specialized IT staff. This democratizes access to advanced digital infrastructure, enabling smaller institutions to participate fully in the digital transformation of higher education. The federated nature of IIAP's cloud platform is particularly significant, as it enables integration with European cloud infrastructures and services. This federation allows Armenian researchers and educators to access resources beyond national borders, participate in international research collaborations, and benefit from the collective expertise and infrastructure of the European research and education community.

Digital Repositories and Open Science

IIAP plays a leading role in advancing open science and establishing digital repositories in Armenia. A key achievement in this area is the establishment of the Armenian National Open Access Desk (NOAD), which became part of the pan-European OpenAIRE open science infrastructure in March 2021. The NOAD serves as Armenia's national contact point for open science, providing training and operating helpdesks that advise on open access, research data management, and open science policies. The NOAD platform uses dLibra software, developed by the Polish national research and education networking organisation PSNC and introduced to Armenia through the EU-funded EaPConnect project. A significant achievement in this area is the Armenian Research & Academic Repository (ARAR), hosted at http://arar.sci.am. ARAR is a comprehensive digital repository that preserves and provides access to Armenia's scholarly and cultural heritage. To date, more than 94,000 digital objects have been created in ARAR, spanning around 300 years of Armenian history, including books, newspapers, articles, and other items. The repository contains digitised collections from Armenia's regional museums and an open-access collection of Armenian research outputs.

E-Learning and Web Conferencing

IIAP hosts and manages Moodle LMS, which serves as the central hub for course delivery, providing tools for content management, assignments, quizzes, communication, and collaborative learning. Its proven flexibility, noted in the European partner case studies, makes it a suitable platform for institutions with varying technical expertise. The Moodle instance has been configured and customised to meet the specific needs of Armenian HEIs, including support for the Armenian language and integration with other national services.
Second, integrated with this Moodle environment is BigBlueButton, an open-source web conferencing system hosted by IIAP at https://meet.asnet.am. BigBlueButton is specifically designed for online learning, supporting real-time virtual classrooms with features such as interactive whiteboards, screen sharing, breakout rooms for group work, and lecture recording. This directly supports the hybrid and blended learning models identified as a priority in the report's recommendations. The meet.asnet.am service has been deployed and maintained by IIAP as a dedicated resource for Armenian academic institutions, providing a reliable and secure platform for online teaching and collaboration at no cost to users. This service proved particularly valuable during the COVID-19 pandemic, when it enabled continuity of education across Armenian universities.

Third, a critical component for security and ease of use is IIAP's integration with eduGAIN, a global, secure, and federated authentication infrastructure. This allows users from all partner Armenian HEIs to access the e-learning platform using their existing institutional credentials, eliminating the need for separate usernames and passwords and streamlining secure access for students, faculty, and researchers. The eduGAIN integration represents a significant achievement for IIAP, as it required establishing technical interoperability with international authentication systems and building trust relationships with participating Armenian institutions. This work lays the foundation for future integration with other European and global services.

The Aznavour Supercomputer

Beyond its e-learning infrastructure, IIAP operates a significant national research asset: the "Aznavour" supercomputer. The "Aznavour" supercomputer is a powerful high-performance computing (HPC) resource that opened in Yerevan in 2024. Its establishment was made possible through collaboration with the Toulouse Institute of Computer Science (IRIT) in France and supported by the company ATOS. It provides an exceptional tool for research and development with the following specifications: 24,480 cores, 39 TB of memory, 1.5 PB of storage, and a peak performance of 861.7 teraflops per second. The Aznavour supercomputer enables research in a wide range of fields, including physics, biology, Earth science, data science, engineering, and artificial intelligence. The combination of e-learning infrastructure, cloud services, digital repositories, and supercomputing capacity is particularly significant because it creates a comprehensive digital ecosystem that supports both education and research. Armenian researchers and students can access learning materials, participate in online courses, deposit and discover research outputs, and conduct data-intensive research using the supercomputer. This integration of learning, research, and preservation capabilities is consistent with the European model of research-intensive universities and supports the development of a strong research culture within Armenian HEIs.

7. Recommendations for Armenian Higher Education Institutions

Based on European TEL practices, the following recommendations are proposed for Armenian higher education institutions.

Recommendation 1: Develop National and Institutional TEL Strategies and Governance Structures

Armenian HEIs should establish comprehensive TEL strategies that are compatible with institutional missions, national priorities as well as international standards. The above strategies must specify: national priorities for digital higher education; institutional duties; necessary infrastructure; teachers' development programs; and quality standards. A TEL strategy for each university must be developed independently, in accordance with its priorities and disciplines. A staged development strategy is recommended, beginning with pilot departments and then moving to full implementation.

Recommendation 2: Strengthen Digital Infrastructure and Develop Integrated Digital Learning Ecosystems

Digital infrastructure is the basis of successful TEL implementation. Armenian universities have to create integrated and interoperable digital ecosystems which provide opportunities for teaching, learning, assessment and institutional operations. The following measures should be prioritised: enhancing campus connectivity and digital infrastructure; improving Learning Management System capabilities; integrating the LMS with institutional information systems; ensuring cybersecurity and technical support; and creating institutional standards for digital services.

Recommendation 3: Develop Multimedia Learning Resources and Digital Content Ecosystems

Armenian HEIs should strengthen institutional capacity for producing high-quality digital learning resources. Priority actions include: establishing multimedia production support services; developing digital resource repositories; supporting interactive learning materials; promoting reusable digital learning objects; providing instructional design guidance for content development. Digital content should be developed according to pedagogical objectives rather than only technological possibilities.

Recommendation 4: Establish Digital Learning and Teaching Support Centres

It is necessary to create dedicated units within Armenian universities to oversee digitalisation. Such units can offer instructional design services, teacher training services, support for developing digital courses, online learning quality assessment, and research in digital pedagogy. According to European practice, such centres for teaching and learning play an important role in the development of sustainable TEL. Such centres need to be properly equipped with dedicated personnel and a sustainable funding model.

Recommendation 5: Develop Comprehensive Faculty Digital Competence Programmes

Universities should establish structured digital competence programmes for academic staff. Training should include:

- **Basic level:** learning management systems; online communication tools; and digital resources;
- **Intermediate level:** blended course design; online assessment; and interactive learning activities;
- **Advanced level:** learning analytics; AI in education; and digital learning research.

Continuous professional development should be recognised as a strategic institutional process rather than a series of isolated training initiatives. Sustainable digital transformation depends on universities' capacity to support educators throughout their professional careers by combining competence frameworks, mentoring, communities of practice, certification schemes, institutional recognition and appropriate organisational support. As part of developing competence frameworks for Europe, including DigComp 3.0, AI literacy is becoming an increasingly important aspect of teachers' digital competence. This means more than just the skills needed to work with AI; it also means being able to think about the

ethical considerations, limitations, and biases involved. Professional development programs for faculty should help them do that with regard to the use of AI technology in education.

Teacher participation should be encouraged through recognition, workload allocation, and career development mechanisms.

Recommendation 6: Promote Student-Centred Digital Pedagogical Models
The universities need to redesign their digital learning environments to meet students' needs. Areas of focus should include digital learning materials, interaction, student services, and flexible learning opportunities. The process of developing TEL should involve students through feedback forms, digital learning committees, and course evaluations.

Recommendation 7: Ensure Accessibility and Inclusive Digital Learning
Digital transformation should increase learning opportunities and equal participation of all learners in the process. Universities should: use accessibility standards when designing digital platforms and materials; apply the Universal Design for Learning approach; train employees in digital teaching methods for inclusive learning; ensure that multimedia resources and evaluations are accessible.

Recommendation 8: Develop National Standards for Technology-Enhanced Assessment

- Armenian HEIs should establish guidelines for digital assessment covering: assessment design; academic integrity; accessibility; student authentication; and ethical technology use.
- Universities should encourage innovative assessment methods such as digital portfolios; collaborative projects; simulations; and problem-based assessment.

Recommendation 9: Develop Digital Quality Assurance Frameworks
Quality assurance needs to concentrate mainly on the quality of teaching and learning and not on the technology itself. Digital technologies should be viewed as tools for innovation in education, while assessment should measure their impact on pedagogical efficiency and effectiveness.

Armenian universities should integrate TEL evaluation into existing quality assurance systems. Evaluation frameworks should examine course quality; student engagement; accessibility; teacher competence; and learning outcomes. Digital maturity assessment tools can help institutions identify strengths, weaknesses, and future priorities.

Recommendation 10: Establish National TEL Collaboration Networks
A national Armenian TEL network should be created to support cooperation between universities. The network could facilitate sharing of digital teaching practices; joint online courses; professional development activities; and collaborative research projects. Such cooperation would reflect the European model of peer learning and institutional knowledge exchange.

Recommendation 11: Encourage International Cooperation in Digital Education

Armenian universities should strengthen cooperation with European institutions through virtual exchange programmes; Erasmus+ digital initiatives; joint online courses; and collaborative research. International cooperation would allow Armenian universities to access European expertise and participate in emerging digital education networks.

The implementation of the recommendations outlined above may be systematically facilitated through the benchmark standards, performance indicators, and technical architecture presented in Appendix A: Strategic Framework and Technical Benchmark Standards for E-Learning Ecosystems. The detailed architectural, pedagogical, and technological specifications for the Model Smart Classroom are provided in Appendix B.

In summary, the digitalization of Armenian higher education institutions is an extensive possibility for increasing the quality, accessibility, and relevancy of the educational process. Nevertheless, the analysis of European best practices presented in this report shows that success depends not on the level of technological advancement, but on how well an institution manages to use them in its teaching process. It is important to implement the above-mentioned eleven recommendations as a strategic action plan for an institution that gives priority to human capital, innovation in pedagogy, and developing engaging and inclusive learning environments

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