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From theory to practice: Making interoperability become reality in European University Alliances

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Abstract

In the structure of European University Alliances (EU-As), more than 570 Higher Education institutions (HEIs) across Europe have embarked on a transformative journey to create a more interconnected European HE landscape and overcome current barriers that hinder seamless experiences in digital teaching and learning in HE. Building on the experiences of EU-As, HE experts have collaboratively developed a framework for HE interoperability. The initiative is set under the umbrella of the European Digital Education Hub (EDEH) and incentivised through the European Commission.

The paper start our by setting the scene for interconnected European campuses and describing the approach taken for the here portrayed endeavour. Next, based on insights generated during the engagement and data collection with alliances, the paper describes the current landscape of interoperability at EU-As, including patterns, trends and priorities observed and challenges encountered by alliances with regards to technological, semantical, organisational and legal challenges. The paper then continues with a forward-looking perspective, encouraging action and offering guidance and recommendations for alliances' interoperability journeys, before closing with a short outlook.

1 Towards European Campuses

At present, the European Higher Education (HE) area does not live up to its full potential. Characterized by fragmentation, the vision of an interconnected European inter-university campus that supports seamless educational journeys and mobility, allowing learners and other HE stakeholders to smoothly connect and move between institutions, seems far. Several initiatives aim to foster seamless collaboration, mobility, and integration across HE institutions in Europe: For instance, the European Student Card Initiative (ESCI) introduces a digital European Student Identifier, which facilitates the

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recognition of students across HEIs and across borders. EduGain, provides for a federated identity management, allowing students and staff to access academic resources using their home institution credentials. Erasmus without Paper (EWP) focuses on digitizing and standardizing the exchange of student mobility data, replacing traditional paper-based processes with digital workflows. All initiatives serve a specific need. What is missing, however, is a bird's eye view on interoperability, the ability to connect the dots and overcome sometimes too political driven developments.

This paper focuses on a flagship initiative of the European strategy for universities (European Commission, 2022), under which more than 570 HEIs have embarked on a journey to making the vision of truly interconnected European campuses become reality, step by step: in 65 so-called European University Alliances (EU-A), these HEIs lay the foundations for a sustainable and long-term cooperation on several levels. (European Commission, n.d.) The first EU-As have been in existence since 2019; further alliances have been established consecutively (European Commission, 2025).

The European Interoperability Framework (EIF) is a set of guidelines aimed at enhancing seamless services and data flows of digital public services across the EU. Interoperability is "the ability of organisations to interact towards mutually beneficial goals, involving the sharing of information and knowledge between these organisations, through the business processes they support, by means of the exchange of data between their ICT systems" (European Commission, 2017). Interoperability comes into play at four distinct layers that overall ensure that different systems and organisations can work together seamlessly: legal, organisational, semantic and technical.

In the context of HE, the EIF has a profound impact. Legally, it builds on existing frameworks such as Erasmus+ to create a solid foundation for cross-border cooperation. Organisationally, it encourages institutions to align their processes and structures, fostering collaboration and efficient data sharing. Semantically, the EIF promotes the use of common standards and vocabularies to ensure that data is understood consistently across different systems. Technically, it promotes the adoption of interoperable IT systems that allow seamless integration and communication between different platforms. Together, this powerful combination advances a more connected, efficient and innovative HE landscape.

Leveraging the pioneering experiences of EU-As, experts in the field of HE and interoperability, representing a broad variety of geographies, expertise and sectors and including key stakeholders[*] have collaboratively developed a *European Higher Education Interoperability Framework (HEIF)* over a period of 1,5 years. (European Commission, 2025) The dedicated working group on HE interoperability (European Commission, 2024) is set in the context of the European Digital Education Hub (EDEH) and supported by the European Commission. EDEH is an open online collaborative community for stakeholders in digital education in Europe and beyond, an EU flagship initiative and part of the European Commission's Digital Education Action Plan (European Commission, n.d.). The endeavour puts key stakeholders in the driver seat for their own change, while being embedded in and guided by European policies. The collaborative, agile and iterative development approach included engaging formats and continuous alignment, feedback cycles with stakeholders, for instance, through series of online working sessions in specialized interest-groups where use cases were developed, online exchanges to gather data on the implementation status of the use cases at EU-As, webinars to share interim-results as well as in-person events that leveraged the co-creation approach of Design Thinking. (Benzinger, Canellas Lardies, Lapuente, & Knoth, 2025) To further strengthen the ties with the expert community, the efforts have been widely discussed at international conferences[†].

The community was guided by a joint vision (European Commission: Directorate-General for Education, Youth, Sport and Culture, 2024). Key instances and challenges that mark a learner's journey

[*] This includes experts associated with, e.g., GEANT, European University Foundation (EUF), Open EdTech, and others.
[†] This includes, e.g., 1EdTech Europe conferences 2023 and 2024, EUNIS24 congress, TURN conference 2024, and others.

during its lifecycle have been reflected in eight use cases, based on the Higher Education Reference Models (HERM) (CAUDIT, 2022) framework. These use case developed and sharpened with the expert community were the backdrop against which a stock taking of standards and ICT tools in use across alliances was conducted, resulting in an inventory (European Commission: Directorate-General for Education, Youth, Sport and Culture, Deloitte, EDEN, German Academic Exchange Service, Knowledge Innovation Centre (KIC), Stifterverband and SURF, 2025a). The data was analysed following in inductive approach, describing the state of interoperability at EU-As (European Commission: Directorate-General for Education, Youth, Sport and Culture, Deloitte, EDEN, German Academic Exchange Service, Knowledge Innovation Centre (KIC), Stifterverband and SURF, 2025b). A reference architecture was developed, interconnected across three viewpoints in line with the EIF: organisational, semantic, and technical.[‡] The framework is completed by a proposal for a governance approach to ensure sustainability.

2 How ready are European University Alliances?

This chapter presents insights from the collective work that can describe the current interoperability status at EU-As overall, before zooming in on approaches observed and challenges encountered.

2.1 The bigger picture: Interoperability landscape

Each alliance has an internal ecosystem that results in unique priorities, strengths and opportunities. Coupled with the different staggered waves in which EU-As have come into existence, the level of interoperability maturity varies from one alliance to the next, portraying a diverse landscape. Alliances' not only have short-term, but also medium- and long-term priorities and plans for interoperability, speaking to the vision of European campuses being anchored in their strategies.

At the time of data collection undertaken for the stock-taking in a series of online sessions with EU-As, 50 alliances have been in existence. Over 40 have taken part in the data collection exercise, information on the remaining alliances has been gathered to the extent available. Thus, the data build a solid foundation to draw conclusions on the current state of interoperability at EU-As. Following an inductive approach of data analysis, HEIs can be grouped in three categories based on where they stand with regards to their interoperability efforts (European Commission: Directorate-General for Education, Youth, Sport and Culture, Deloitte, EDEN, German Academic Exchange Service, Knowledge Innovation Centre (KIC), Stifterverband and SURF, 2025b):

- Emerging focus: HEIs within alliances take first steps towards interoperability, e.g. conducting system inventories, analyzing the market, and deciding on priorities.
- Strong focus: Alliances are piloting interoperability, with decisions made on solutions and a clear path forward for implementation among members.
- Extensive focus: Fully operational interoperable workflows are in place. The alliance is working for any remaining workflows to reach the same level of interoperability.

More than 70% of alliances analysed show characteristics of the first category with an emerging focus on interoperability. Slightly less than 20% of alliances were found in the middle category; 10% can be described as having an extensive focus on interoperability in accordance with the above categories. This provides a picture in which, despite interoperability gaining importance among the priorities of various European alliances, most are in an early stage of adoption.

[‡] While legal interoperability is not in the focus of the proposed interoperability framework, alignment with existing European policy frameworks and agreements is taken into account.

Notwithstanding this distribution, a common pattern could be observed in how alliances approach interoperability and the priorities they set. Both the more mature alliances and those with an emerging interoperability focus share similarities in the process. Alliances focus their attention to advance interoperability in use cases with high relevance to learners. All eight use cases identified and in focus in the collaborative efforts, can be placed along a learner's journey: Starting from the orientation phase, where a learner informs themselves about learning opportunities of interest, continuing to the application for learning opportunities, followed by an educational time at the HEI, and closing with a certification, demonstrating learning achievements. The eight use cases describe key instances learners encounter on their journey. Out of these, four key focus areas have emerged during the continuous engagement with the community of experts and alliances:

First, attracting new learners is of paramount importance to younger alliances or those just starting to approach interoperability: Such alliances tend to prioritise making their offerings available to future learners. Learning offering catalogues are the gateway for learners to the institutions and represent the first step in the learner's journey. Second, the handling of application of future learners, recognition of prior learning achievements and enrolment has emerged as key priority, as it is a logical next step as part of a learner's journey. Third, closing the lifecycle of a learning experience, the issuance and management of credentials, is a priority. This, along with other topics that characterize the actual educational phase at HEIs, such as access to institutional tools and resources, dominates the medium and long-term plans of younger alliances and those with an emerging interoperability focus and is already a reality for those in a more advanced state. And fourth, underlying such core use cases, is the management of user identities. Representing a current challenge that is being addressed collectively, this is where the priorities of both younger and more experienced alliances converge. The goal is to enable learners to access learning opportunities and other educational resources with as few identities as possible. This is also constantly evolving with the emergence of new technologies such as wallets, where the identity paradigm is shifting and the end user becomes the owner of their own identity.

It is worth noting that in contrast to the management of user identities, institutional identity management has been reported as the lowest priority use case by the participating alliances. This indicates that, currently, the established relationships between institutions are focused within the intra-alliance framework, where institutions are easily accredited, and strong trust relationships exist. As barriers to interoperability are broken down, this scope will expand to relationships beyond the alliances, and this topic will gain prominence.

2.2 Zooming in: Approaches to interoperability

From a more practical and technical point of view, insights pinpoint challenges: Within a single alliance, its member institutions may have different levels not only of interoperability, but also of digitisation. The existing heterogeneity between types of data and systems within a single alliance poses manifold challenges when it comes to acting as a single entity and providing learning opportunities, as well as planning and following a common educational plan. This heterogeneity multiplies when expanding the scenario to the exchange between alliances. (European Commission: Directorate-General for Education, Youth, Sport and Culture, Deloitte, EDEN, German Academic Exchange Service, Knowledge Innovation Centre (KIC), Stifterverband and SURF, 2025a); (European Commission: Directorate-General for Education, Youth, Sport and Culture, Deloitte, EDEN, German Academic Exchange Service, Knowledge Innovation Centre (KIC), Stifterverband and SURF, 2025b)

At the same time, the mapping exercise with alliances and data collected have revealed trends in the use of certain types of tools or tools. The distribution by type of tools (open source, self-developed, and commercial) across the use cases is heterogeneous. This suggests that, despite having significant weight and being the main focus of attention for alliances, open source tools currently do not cover all needs nor adapt to all possible scenarios. In certain use cases, this increases the weight of

both commercial tools and self-developed solutions. The predominant use of the latter in certain use cases suggests a lack of market tools that satisfy the needs. Furthermore, the use of self-developed tools can often represent a logical intermediate step that allows for the adaptation to newly arising requirements without neglecting or modifying existing systems, thereby requiring fewer resources.

When developing new interoperability solutions, it is also advisable to get inspired by peers. Three patterns to approaches could be identified: centralisation, decentralisation, and broadcast.

Centralisation involves aggregating data from various systems into a central one that subsequently exposes them. In this way, the information is housed in a single standardised system. Conversely, decentralisation entails having the information distributed across the respective systems. This information will be collected by an external service, which will then be responsible for exposing it. The act of collecting information on demand from various systems requires either that the information is stored in a standardised manner within the distributed systems, or that the collection service itself standardises it. The broadcast approach implies that information is replicated and available in all systems involved in the data exchange. Therefore, when obtaining the information, consulting any of the systems provides a comprehensive view of all the information available across all systems.

These approaches represent valid methods for implementing solutions, although broadcast is the least used approach. Centralisation and decentralisation present advantages and disadvantages when it comes to scaling and avoiding data duplication and inconsistency. These approaches can occur jointly or in a hybrid manner due to the complexity of the ecosystem. Therefore, these patterns do not constitute a rigid model. In addition to these generalist approaches, an emerging data exchange methodology involves exchanging metadata instead of the actual data. This lightens communications between systems and is privacy-friendly by avoiding the exchange of data content.

2.3 Zooming in: Managing risks

In solution development, careful risk evaluation is crucial, not only as these could incur additional costs. The presented insights in relation to the four layers of the EIF (European Commission: Directorate-General for Education, Youth, Sport and Culture, Deloitte, EDEN, German Academic Exchange Service, Knowledge Innovation Centre (KIC), Stifterverband and SURF, 2025b), can provide guidance in accounting for risks and minimising their impact on future developments.

At the legal level, the main challenges identified relate to data protection and the potential exchange of sensitive data. Espcially more experienced alliances see themselves faced with this challenge, hence their inclination towards the aforementioned metadata sharing. Another legal challenge that has become apparent is the management of commercial licences and intellectual property rights of commercial tools when sharing resources between institutions.

With regards to the organisational layer of the EIF, the exchanges with EU-As pointed to budget constraints and IT staff shortages that represent significant issues, as institutions often lack resources and personnel for maintaining necessary tools. Additionally, differing development capacities within alliances pose challenges, with some institutions halting their own development to support alliance needs. Aligning joint processes is another problem, as local processes frequently conflict with each other and institutional interests. This complexity increases with interregional cooperation across Europe, where local, legal, and governmental requirements vary widely.

Considering the semantic layer, shared data model and semantic interoperability that rely on a commonly understood and agreed-upon vocabulary, is crucial for overcoming language barriers between national universities in an alliance. Controlled vocabularies, which are standardized sets of terms with specific meanings, ensure clear communication across systems and organizations. However, selecting and implementing standards in diverse HE environments is challenging. The lack of

coordination at the European level increases technological diversity rather than reducing it, leading to parallel efforts and poorly aligned initiatives that create technological silos.

Lastly, technical systems across alliances and countries are diverse. Varying technological approaches create a complex landscape. This diversity widens the gap when institutions develop their own solutions or purchase commercial tools that may not align with alliance standards. Security concerns, particularly the risk of fraud with digital credentials, necessitate digital signatures and robust identity verification mechanisms to ensure authenticity and validity. User identity management is challenging due to the evolving nature of identities throughout an individual's academic life, making it difficult to maintain accurate and secure identity data across institutions. Moreover, efficient role management is essential to ensure continued access to resources while preventing security issues. Ensuring the traceability and recognition of credentials, even when linked to previous identities, requires robust solutions that balance immutable and flexible identity attributes. Currently, there are projects such as the European Student Card Initiative (ESCI), Edugain and Erasmus Without Papers (EWP), aimed at simplifying the management and exchange of identities and standardising these identities. Certainly, such projects must be taken into account in order to ensure that the solutions for interoperability are in line with the main European approach.

The technical challenges are also reflected in the reference architecture, from which each alliance can extract the building blocks they lack to make their solution interoperable. Experiences in the architectural development process suggest that most alliances already have a great extent of the architecture in place, while only small parts are truly absent. However, these missing blocks are the most problematic ones as they represent the elements that allow the different systems to interconnect. These blocks usually come to light after the alliances conduct a gap analysis, identifying shortcomings.

3 Making interoperability work

This chapter takes a forward-looking perspective, providing guidance and encouraging an interconnected HE landscape and European campuses, based on the 1,5 years of engaging with EU-As and the expert community in the context of EDEH. The project has generated a wealth of data, insights, lessons learned and key resources in advancing towards interoperable campuses. To meet the identified needs of alliances, these resources have been compiled in what has emerged as a prototypical journey of collaboration (European Commission: Directorate-General for Education, Youth, Sport and Culture, Deloitte, EDEN, German Academic Exchange Service, Knowledge Innovation Centre (KIC), Stifterverband and SURF, 2025d). Alongside the journey, developed resources offer a modular and flexible toolkit, empowering alliances in their change processes.

Younger alliances that are just starting their journey, are likely new to the field of interoperability, thus aiming to understand the current state of the landscape overall. Their interest is on identifying priorities, missing components and tools to achieve their objectives, and finally initiate the change towards becoming more interoperable. More mature alliances, on the other hand, might have an interest in identifying improvements for their existing set-up and processes, align with best practices and implement further use cases. Especially for more mature alliances that have already gone parts of their interoperability journey, the resources can set impulses for reflection, in retrospect. Looking forward, the toolkit can provide guidance in priority-setting, decision-making and action-taking.

By helping alliances grasping the bigger picture of the status of interoperability at EU-As, a resource synthesising the insights sets the scene (European Commission: Directorate-General for Education, Youth, Sport and Culture, Deloitte, EDEN, German Academic Exchange Service, Knowledge Innovation Centre (KIC), Stifterverband and SURF, 2025b). Use-case specific self-assessments in alignment with the different layers of the EIF aid in identifying strengths, potential

gaps and development opportunities, thereby guiding reflection on an alliance's current state of interoperability and decision-making on objectives and use cases to be implemented. The inventory of tools in use across alliances (European Commission: Directorate-General for Education, Youth, Sport and Culture, Deloitte, EDEN, German Academic Exchange Service, Knowledge Innovation Centre (KIC), Stifterverband and SURF, 2025a), coupled with an understanding of missing building blocks as per the proposed reference architecture (European Commission: Directorate-General for Education, Youth, Sport and Culture, Deloitte, EDEN, German Academic Exchange Service, Knowledge Innovation Centre (KIC), Stifterverband and SURF, 2025c) and own tool inventories, can help in identifying solutions to fill the gaps. Hands-on resources for the top four use cases puts at the disposal of alliances and HEIs materials to move from theory to practice. (European Commission: Directorate-General for Education, Youth, Sport and Culture, Deloitte, EDEN, German Academic Exchange Service, Knowledge Innovation Centre (KIC), Stifterverband and SURF, 2025d)

Institutions and alliances that have embarked on the journey towards interoperability may start from different places, with different perspectives and different objectives. Nonetheless, a typical change journey became apparent. Based on an alliance's strategic objectives and priorities, use cases for interoperability to be implemented are identified. An assessment of the current approaches, solutions, and standards in place for the selected use cases, first, at the individual alliance members and consecutively, at the collective level of the alliance establishes a starting point to move forward. At the same time, this stock-taking can help identify areas for quick wins in interoperability. Moving from theory to practice, roadmaps help to plan for operationalization, providing guidance on steps, timelines, and responsibilities. Solutions can then be piloted in selected courses or activities, putting solutions to the test in real-life circumstances, allowing for comparisons and user feedback that can guide the decision for a broader roll-out. Implementation then involves integrating the chosen solutions into the existing ecosystem and training users with new systems and processes. Continuous monitoring and evaluation of systems ensure they meet their objectives, allowing for adjustments to enhance user experience and the value of implemented solutions.

The wealth of data gathered from EU-As, resulted in a series of valuable experience-based recommendations for advancing and transforming towards interoperability in alliances (European Commission: Directorate-General for Education, Youth, Sport and Culture, Deloitte, EDEN, German Academic Exchange Service, Knowledge Innovation Centre (KIC), Stifterverband and SURF, 2025c).

Five key categories of insights and recommendations aimed at enhancing collaboration and efficiency among HEIs relate to standardization, data management, role definition, innovation and strategy, and quality assurance.

Standardization and consistency are key. The adoption of established data standards and controlled vocabularies creates uniformity across institutions; standardized terms and definitions eliminate ambiguities. Such measures are crucial for effective course mapping, learning agreements, and credit transfers. The strong focus on data management and privacy underscores the need to share metadata responsibly to promote privacy and efficient communication while minimizing data exposure.

Furthermore, clear definitions of access roles and staff competencies reduce errors and streamline processes, thereby ensuring that HEI staff are adequately equipped to use necessary systems effectively. Exploring new technologies and implementing the latest versions of technical solutions enhances interoperability, security, and system robustness. Pilots or proofs of concept allow to test new solutions on a smaller scale before broader adoption.

Finally, transparency between institutions with regards to their quality assurance processes builds trust, boosts confidence in academic standards, and enhances institutional reputation through clear and open communication about quality measures.

More specific recommendations related to the creation of joint learning opportunity catalogues, user identity management, and other use cases are presented in the project report (European

Commission: Directorate-General for Education, Youth, Sport and Culture, Deloitte, EDEN, German Academic Exchange Service, Knowledge Innovation Centre (KIC), Stifterverband and SURF, 2025e).

4 Outlook

Advancing towards interoperable structures and inter-university campuses, EU-As are prototyping the future of the HE landscape in Europe. Having been developed in close collaboration with alliances and the community of experts under the umbrella of EDEH, the HE interoperability framework is based on experiences and insights from practitioners. The iterative and agile development ensures a robust framework that has been challenged and refined continuously throughout. While this set-up creates a strong foundation for the suggested framework elements, their implementation and validation remain yet to be put to the test. Thus, next steps encouraged are piloting priority use cases in alliances. Hopefully, there will be EU-support to not lose momentum and to help universities and their alliances to become more resilient.

To successfully implement prototypes for inter-university cooperation, the following steps should be considered:

(1) Define clear goals and requirements: Identify the specific goals and requirements for the prototypes to ensure they meet the needs of the HEI community.

(2) Work closely with alliances and expert communities: Work closely with existing alliances and expert communities to incorporate their expertise and experience into the development process.

(3) Apply agile development methods: Use iterative and agile development methods to continuously improve the prototypes and adapt them to the needs of the users.

(4) Implement the prototypes in real practice and validate them through pilot projects in the alliances. Gather insights and feedback to further refine the prototypes.

(5) Documentation and critical feedback: Record the experiences and findings from the pilot projects to learn from them and adapt the prototypes as well as the implementation guidelines (if necessary) accordingly.

(6) Scaling and dissemination: Use the knowledge and experience gained to further develop and scale the prototypes and extend them to other European Alliances.

This proof of concept and lessons learned can then contribute to the further advancement, adaptation and refinement of the proposed interoperability framework as well as its implementation, adoption, and scaling up, thus further easing the way towards more interconnected European campuses.

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