



National Digital Education Ecosystems: A Governance-focused Comparison

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Abstract

In recent years, various initiatives for the digital transformation of education have been launched. Their analysis can provide valuable insights into different approaches and best practices. This study compares three national initiatives in the Netherlands, Finland and Germany in terms of their objectives, technical approaches and governance structures. The results show that the initiatives pursue different philosophies, but all share the goal of promoting lifelong learning. Technical solutions and governance structures relate to the contextual conditions of the respective education systems. The study provides recommendations for the future design of such initiatives.

1 The last ditch effort to do something meaningful

Experiences gained during the pandemic have underscored the importance of resilient educational infrastructure that can adapt to disruptions. For several years now, European university alliances and national coalitions have been bringing together various institutions to further develop digital education. Studying these ecosystems can provide valuable insights into different approaches and highlight best practices that can be adopted elsewhere. Despite potential benefits, these initiatives face several challenges, including disparities in technological development, cultural differences, or uneven distribution of power and resources. Understanding the approaches and impact mechanisms of such initiatives can help in shaping policies that support cohesive and comprehensive digital education strategies. It can highlight competitive advantages and collaborative opportunities from large-scale infrastructures, while digital transformation becomes increasingly critical for education. Or, to quote Jos van der Woude in an interview on Npuls as a part of the study presented here: “This is the last possible, last ditch effort of public education to do something meaningful in the realm of life-long learning, before we all become obsolete because of other initiatives”.

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However, there is no blueprint of how to establish a digital ecosystem that supports education in all its facets, especially when it comes to larger and complex endeavours at national scale. Moreover, approaches must take specific cultures into account. Centralized approaches such as the Academic Bank of Credits (ABC) in India⁴ would probably not be acceptable in Europe for data protection reasons. But even within European countries, there is no homogeneity; e.g. differences in welfare regimes. For instance, literature assigns Germany to the conservative (status-preserving, stratifying) regime, and Finland to the social democratic (universalistic) regime (Holtmann, 2018). For the Netherlands, there is no consensus; they are assigned either to social democratic- or conservative-leaning regimes (Alber, 2006). Associated with this, there are distinctions in the countries' operating principles and structures of education systems (Lassnigg, 2016).

Against this background, we took a closer look at various projects in individual countries, all of which are dedicated to establishing a national digital education ecosystem, but with different approaches, levels of effort and degrees of success. We are particularly interested in the perspective of governance (in the sense of temporary project governance and also permanent platform governance structures), especially in interaction with the underlying structures of the education system and the chosen technical approaches. The remainder of the article is structured as follows. A brief overview of related work is presented in section 2. The method of the presented study is explained in section 3, followed by a description of the results in section 4 and a discussion of the findings, limitations and recommendations in section 5. Finally, a conclusion and outlook is given in section 6.

2 Related work on (governing) digitalization in education

Based on the provided IT infrastructure (which is often generic), education-specific functionality can be offered. This is aligned with the defined objectives of using technology for educational purposes, and it has to be anchored within the overall education system. To this end, governance aspects play a crucial role as a moderator between infrastructure and objectives, to exploit the technological potential and allow for sustainable operation.

Previous work has focused on implementing goals from pedagogy or educational policy (top-down) or exploring technological potential (bottom-up), and less frequently on accompanying governance structures. For the digital transformation in education, extensive research is available on pedagogical and technical aspects. This includes opportunities and risks arising from digital infrastructure, i.e. the question of how educational technology is transforming education and society (Macgilchrist, 2021), what this means for equal opportunities (Schiefner-Rohs et al., 2023) or what good education actually is (Nussbaum, 2006). At the same time, conceptual approaches to large-scale education infrastructure (Hartmann et al., 2025; Erdmann et al., 2026) have been made. However, first national solutions like inBloom in the US (Bulger et al., 2017), Denmark's Aula (Jørgensen et al., 2023), or Australia's Ultranet (Tatnall & Davey, 2018) have either failed or gained little relevance. This highlights the challenge of creating government-orchestrated education ecosystems.

Beyond education, there is plenty of research on (centralized) data platforms, (decentralized) data spaces or (complex) data ecosystems (Oliveira et al., 2019; Gawer, 2022; Möller et al., 2024) and their governance (Schurig et al., 2024; Kernstock et al., 2025). Research provides various analytical frameworks, focusing on ethnographic perspectives (Hartong et al., 2024), value streams (Beverungen et al., 2022) or tensions to be moderated (Kari et al., 2024). In contrast to the industry or health sector, research on the governance of digital ecosystems for the education sector is still rare. There are considerations on the structures of authority between state supervision and market power (Ozalp et al., 2022; Williamson, 2021). Moreover, empirical analyses on governance issues (Gleiß et al., 2023) or

⁴ <https://www.abc.gov.in>

ecosystem visions (Degen et al., 2024) for large-scale infrastructures were introduced. However, comparative perspectives – especially in an international context – are still missing. We will initially address these in comparison of three digital education ecosystems currently arising.

3 Method of the comparative study

The objective of this study was to generate spillover effects from initiatives launched simultaneously and with similar objectives in Europe, and in particular to gain inspiration for successful governance in digital education infrastructure. This brought up the research question: “What approaches to functionality and governance do national digital education initiatives take to achieve their self-imposed goals in relation to the existing conditions of the education system?” To this end, we carried out a qualitative content analysis (Kuckartz & Rädiker, 2020) of available documents from current national initiatives, substantiated by interviews with responsible persons from these projects. We selected the following sample cases to achieve a diverse, yet meaningful amount of information. Our selection criteria were: national range, fully covering at least one educational sector, beyond initialization phase, sufficient information available from website and/or publications. We focused on Europe in order to have a comparable legal framework (e.g. with regard to data protection). As a result, we included three initiatives: *Npuls*⁵ in the Netherlands, *Digivisio 2030*⁶ in Finland, and *Mein Bildungsraum*⁷ in Germany.

For identification of relevant documents, the official websites of the initiatives were browsed. Additionally, publications and other reports were retrieved via web search. To identify interview partners, official contact points of the initiatives were approached asking for technical and strategic decision-makers available for an one-hour online interview. Finally, we had a collection of 71 documents containing a total of 464 pages, accompanied by 5 interviews with 7 persons resulting in transcripts of additional 60 pages. Tab. 1 provides an overview of the resulting material basis.

	Npuls	Digivisio 2030	Mein Bildungsraum
Documents	<ul style="list-style-type: none"> ● 33 Websites (96 pp.) ● 2 Statistics (11 pp.) 	<ul style="list-style-type: none"> ● 22 Websites (223 pp.) ● 1 Scientific Paper (9 pp.) ● 3 Statistics (18 pp.) 	<ul style="list-style-type: none"> ● 6 Websites (87 pp.) ● 4 Statistics (20 pp.)
Interviewees	<ul style="list-style-type: none"> ● Strategic lead (1) ● Technical lead (1) 	<ul style="list-style-type: none"> ● Strategic lead (1) ● Technical lead (1) 	<ul style="list-style-type: none"> ● Strategic lead (2) ● Technical lead (1)

Table 1: Characterization of the source material for the analyzed cases

For interviews, audio recordings were taken with the consent of the interviewees and transcribed by an external service provider. Audio recordings were then deleted, and transcripts are kept in a local GDPR-compliant storage. For certain questions, help of the interviewees was given to retrieve additional documents that could not be found on the websites. Toolwise, MAXQDA was used for coding of documents and transcribed interviews. The category system for the analysis was developed in an iterative process combining inductive and deductive steps during the analysis of the documents, and was then validated during the interviews with the participants. The result was a hierarchical system with a total of 124 categories on four levels. With respect to the evaluation dimensions of the research question stated above, 89 of them were selected for the analysis (grey entries were not considered here), as depicted in Tab. 2.

⁵ <https://npuls.nl/>

⁶ <https://digivisio2030.fi/>

⁷ <https://www.meinbildungsraum.de/>

Education System	Initiative / Project	Functionality	Governance
Number of institutions Number of persons Number of levels Policies	Vision, goals, added value Education sector(s) Stakeholders Funding Challenges Schedule Quality assurance	Basic features Educational features Data features Other characteristics	Gov. structure Gov. issues Participation Change management

Table 2: Category system used for the analysis (top 2 of 4 levels)

The categories were applied to the documents and transcribed interviews. A main coder (with a background in social science) worked on this, and a second coder (with a background in computer science and education) provided support for the technical categories.

4 Results of the analysis

From our comparison, we first provide an overview of the respective education systems (section 4.1), followed by the objectives of the initiatives (4.2) and the functionality they provide (4.3) as a starting point. The governance aspects in the focus of our analysis are then presented in section 4.4.

4.1 Education systems

The national education systems behind the three case studies differ significantly in some respects:

- In the *Netherlands* (population of 18.1M), education is decentralized, but at the same time must be aligned with the regulations of higher-level governments (interdependence as a feature of the Dutch governmental system) (Hendriks & Schaap, 2011). Selection for secondary education starts at 12 years and is highly diversified into a strong application-oriented path leading either to vocational (MBO) or to applied education (HBO), while ensuring continued eligibility for academic training (WO).
- *Finland* (population of 5.7M) is characterized by extensive local autonomy, including in the field of education, and by consensus-based decision-making processes (Sjöblom, 2011). Educational institutions and teachers have high autonomy and responsibility (Miettinen, 2013). Lower secondary education covers the ages of 13 to at least 16, after which students can choose between general (lukio) or vocational upper secondary education (ammattillinen), followed by access to universities or universities of applied sciences. Finland is widely recognized as being at the forefront of digital education.
- In *Germany* (population of 83.6M), the education system is organized federally, with primary responsibility for educational matters resting with its 16 federal states (Bundesländer). There is comparatively early selection of educational pathways (Holtmann, 2018) after primary education, starting from the age of 10. Students are channeled toward specific qualification tracks, including general (Hauptschule), vocational (Realschule), and academic (Gymnasium), with the academic component being covered mainly by research universities and universities of applied sciences.

In this context, the focus of *Npuls* is on tertiary education, and *Digivisio 2030* on higher education, while *Mein Bildungsraum* addresses all domains, including schools, vocational training and continuing education. In relation to the complexity of the respective fields, the costs of *Digivisio 2030* (120 M€) and *Mein Bildungsraum* (630 M€) are correspondingly lower than for *Npuls* (560 M€).

4.2 Objectives

All initiatives aim at supporting life-long learning, in a broader or narrower sense. That’s why tertiary education and particularly higher education are always in their focus. However, provided statements on their objectives differ. Sometimes technical goals are addressed, sometimes educational goals:

- “The aim [of *Mein Bildungsraum*] is to interconnect widely available digital educational offerings and supportive services [...] within a digital ecosystem” (interview). “Learning progress, educational credentials, and certificates can be easily carried digitally and shared with educational institutions and administrative bodies along the individual learning journey.”⁸
- “What the [*Npuls*] program aims to do is to design and build a collective infrastructure for collaboration of institutes for learners to do a user journey, a learning journey without borders or hiccups, and deliver the best possible quality in education” (interview).
- “In the 2030s, Finland has an open and internationally esteemed learning ecosystem that widely benefits society as a whole. Learners – both degree students and people supplementing their skills – have access to a wide range of studies across institutional boundaries, allowing them to put together study entities that are suitable for them and best serve their needs. For learners, cooperation between higher education institutions manifests itself in the form of smooth learning paths and individual support that is not dependent on a specific higher education institution.”⁹

User-centredness is a shared key priority. *Npuls* and *Digivisio 2030* emphasize the ‘hands-on’ involvement of institutions and their cooperation. A common goal, to varying degrees, is to facilitate smoother educational, institutional, and interdisciplinary transitions.

4.3 Functionality

Except for the specific educational domains, the objectives of the three initiatives are quite similar. This poses the question whether this can be reduced to a common denominator also regarding used technological approaches and provided functionality. Tab. 3 summarizes the results of our comparison of technical design, divided into basic connectivity features and value-adding educational features. For the German initiative *Mein Bildungsraum*, we further distinguished between the externally visible interim product and the internal prototype BIRD (Hartmann et al., 2025), because both have very different degrees of maturity (albeit a comparable concept).

Features		Npuls	Digivisio 2030	Mein Bildungsraum	BIRD
Basic Connectivity Features	SSO	✓ (central IdM: national eduID)	✓ (federated IdM: national ID plus eIDAS)	✓ (federated IdM: institutional IDs plus BundID)	✓ (federated IdM: institutional IDs plus BundID)
	Metadata	✓ (educational)	✓ (educational, personal)	✓ (educational, personal anonymized)	✓ (educational, personal anonymized)
	Credentials	✓	✓	✓	✓
	Wallet	✗	✗	✓	✓
	Portal	(✓)	✓ (Opin.fi)	✓ (reference implementation)	✓ (reference implementation)

⁸ https://www.meinbildungsraum.de/fileadmin/user_upload/Informationen_und_Materialien/Downloads/2024-02_Handout_Mein-Bildungsraum.pdf

⁹ https://digivisio2030.fi/wp-content/uploads/2025/09/Digivision-tavoiteskenaario-2025-2027_EN.pdf

Educational Features	Content	✓ (Broker)	✓ (Broker)	✓ (Broker)	✓ (Broker)
	Recommend Content	✓ (personal advice)	✓	✓	✓ (Learning-PathFinder)
	Communicate	✓ (dedicated, staff-only)	✓ (dedicated, staff-initiated)	X	✓ (any via open interfaces, user-initiated)
	Recommend People	X	X	X	✓ (BuddyFinder)
	Collaborate	X	✓ (only for content creation)	X	✓ (Shared Workspace)
Data Features	Search	✓	✓	✓	✓
	Analytics	✓	✓	X	X

Table 3: Comparison of technical characteristic of the analyzed cases

Unsurprisingly, the shared objective also results in comparable core functions of all systems, creating **basic connectivity** of educational services, namely: identity management / Single SignOn, metadata management, digital credentials, and a portal (as a central point of entry). Digital credentials (from micro-credentials to diplomas) in established formats, and infrastructure to issue and share it, are part of all initiatives. Regarding the other core components, internal realization differs. For instance, the highly fragmented education system in Germany requires a federated IdM, while the smaller and more homogeneous systems in the Netherlands and Finland are able to use centralized IDs. In addition, other IDs like the European eIDAS (in Finland) or the federal-level citizen identity BundID (in Germany) can be used for authentication. Accordingly, metadata contains information on offered content in all three initiatives, while information on individuals is contained in Finland, not contained in the Netherlands, and contained only in anonymized form in Germany. Another difference is how portals are used. While *Npuls* describes it as a developer platform, *Digivisio 2030* has a dedicated portal-based approach, and *Mein Bildungsraum / BIRD* provide their portals only as a reference implementation to demonstrate possible educational gains, leaving existing platforms of education providers the main entry points for users. A major difference in core components is that the German approach is characterized by the prominent use of a data wallet for storage of personal data, including credentials.

In the sphere of value-adding **educational features**, differences between the initiatives become clearer. The common denominator is that all rely on brokerage of educational content, including services to recommend suitable offers. While the latter is realized as face-to-face counselling in the Netherlands, the German approach makes use of the data wallet to generate personalized recommendations for learning pathways without managing the users' data by the system. Quality assurance is realized by offering educational institutions in all initiatives. Regarding communication features, differences appear. While *Npuls* and *Digivisio 2030* only offer dedicated communication tools that can be used by teachers or in teaching, the *BIRD* prototype focuses on integrating any communication tools that are connected to the middleware by the providers and can then be used freely by all users. The differences become even clearer in the area of cooperation and collaboration. *Digivisio 2030* uses this in the background for content creation, while *Npuls* and *Mein Bildungsraum* do not provide such tools. The *BIRD* prototype, in contrast, allows all users to share their personal workspace with others and work together on digital artefacts. Consequently, *BIRD* is the only approach offering a recommender to find teaching or learning peers. This might seem surprising given the strong privacy concerns in Germany; here, the limited regulatory flexibility has led to technical innovation in the form of privacy-conserving buddy matching based on homomorphic cryptography.

Moreover, we identified differences between the initiatives in their way to handle, and further process gathered **data**. While all offer a search function, only *Npuls* and *Digivisio 2030* mention further

data analysis (i.e. for quality management). In contrast, *Mein Bildungsraum* and *BIRD* prevent analysis of personal data (beyond analysis of educational metadata) by design. The use of AI is on the roadmap for all initiatives, and there are experimental prototypes, particularly for recommender systems. However, there is no sign of consistent consideration and systematic integration of AI so far.

4.4 Governance aspects

Information on long-term platform governance was underrepresented in the source material. This may be because the initiatives are still in the implementation phase and not yet fully operational. We have therefore omitted this perspective for the time being and focused on two sub-questions relating to current project governance:

1. What structures and processes were established for the governance of the project?
2. What opportunities for participation were provided for stakeholders in the education system?

The findings of the investigation into these questions are presented in the following two sections.

4.4.1 Project governance

Mein Bildungsraum consists of 43 research and development projects aimed at developing the ecosystem both conceptually and technologically. Networking among the projects took place in various formats, where projects met to discuss specific focal topics, shared progress and coordinated activities. The projects adopted agile working methods, using user stories and personas to align with user needs. In 2024, the basic prototype was transferred to the Federal Agency for Disruptive Innovation (SPRIND) for further technical development, go-to-market planning, and establishing a sustainable operating structure. SPRIND has some decision-making autonomy, but ultimate authority remains with the Federal Ministry. In *Mein Bildungsraum*, it did not establish a permanent operating structure or strategic body, such as an advisory board, steering group, or committee. One challenge was that accountability with regard to a clearly defined target group benefit was not sufficiently developed. The stakeholder field – characterized by complex processes and a multitude of diverse actors with varying motivations – had highly divergent expectations regarding technical solutions. Furthermore, the various educational fields feature different processes and decision-making logics.

Npuls uniquely involves students directly in its steering committee, the main decision-making body, where they have an advisory role. Further seats are held by the five partners consisting of the three sector associations HBO, MBO, and WO, SURF, a joint institution representing the participating institutions, and the Dutch Research Council (NRO). Solutions are developed through agile working methods, quickly tested by users in pilot hubs. Overall, the 105 participating institutions “have more influence than the governments because together these institutions determine the course of *Npuls*” (interview). The governance structure, defined by a top-down approach but also by complexity, “is not very well-structured from a classical governance [...] perspective” (interview). Both implementation and operation are shared responsibilities: Implementation is carried out by SURF, hubs, chain partners, and linking teams, while operation will be mainly handled by SURF, NRO, sectoral infrastructures, and linking and adoption teams (see 4.4.2). Challenges in *Npuls* arise from sector-related different legal frameworks and involvement of many institutions, each with distinct perspectives, technical infrastructure, expertise, and governance systems. In the initiative, the technical aspect is not the main challenge, “but the co-creation part. You need to find solutions that work for 105 different institutions” because “in the end, the parts of the educational process or the institutional process that should be changed, it’s times 105” (interview).

Digivisio 2030 utilizes a top-down governance structure with strong HEI involvement, guided by joint decision-making. The general assembly and steering group serve as supreme decision-making bodies. Institutions shape the vision, but decision-making is more concentrated, with the Ministry of Education retaining influence. *Digivisio 2030* demonstrates high flexibility in structural and operational

organization, which have been continuously adapted over time. The focus is on integrating HEIs (e.g. through the stronger use of their networks), increasing efficiency, institutional autonomy, and fostering program-intern collaboration via agile working methods. Regarding implementation and operation of the central Opin.fi service, the principles and standards are defined by the HEIs and shaped by user feedback. This foundation steers the operational effort, which is carried out by smaller development teams, partners and HigherEd Hub Finland Ltd, a company founded by the HEIs that works alongside the *Digivisio 2030* program. The institutions are fully involved in all phases, from vision work to service operation. The challenges arising from multi-actor-involvement are similar to those in *Npuls* and primarily stem from the diversity (perspectives, conditions, competences, and levels of digitalisation) and number of HEIs, the latter being also considered a strength. It was noted that “probably the most important challenge is to create the vision together” (interview). Additional dynamics (such as shifts in government strategy and funding, impacts on inter-institutional competition, trade-offs between timeline and motivation) introduce degrees of uncertainty.

In summary, institutional conditions pose challenges for all programs, with *Mein Bildungsraum* and *Npuls* especially affected by cross-domain differences. The structural and processes organizations designed to address these challenges are decisively shaped by the education system, its stakeholders and the policy framework: *Digivisio 2030* has a focused, flexible structure with very strong HEI autonomy. *Npuls* features a branched, interlinked governance with strong institutional autonomy. *Mein Bildungsraum* combines a fragmented process-oriented responsibility arrangement across multiple projects with a top-down structure and decision authority by a national government actor.

4.4.2 Participation

For *Mein Bildungsraum*, engagement of the broad spectrum of the targeted educational sectors was primarily realized through direct exchanges between funded projects and relevant stakeholders. In addition, formats such as expert discussion rounds and panels were employed. Federalism, domain sovereignty, sensitivity, and regulation necessitated varying approaches and focus to stakeholder involvement (e.g. universities or early childhood education). User feedback was incorporated at an early stage with initial pilot users and was subsequently deepened through a closed beta phase. In exchanges, education providers raised some concerns, particularly regarding added benefit given an established market position and potential cannibalisation of existing offerings. However, *Mein Bildungsraum* aims to enhance discoverability of existing offerings, not to create content. Notably, it was emphasized that “providers operating commercially should never be excluded” (interview). There was collaboration with other federal government platform projects.

Npuls establishes various communities for different stakeholder groups such as teachers (e.g. Edusources Community). Pilot hubs are scaled up to transformation hubs when successful, enabling user groups such as researchers, employees, and suppliers to collaborate on complex issues. *Npuls* maintains cooperation with national and international initiatives and regularly organizes conferences with education professionals. The three sector organizations further support *Npuls* in connecting to the separate tertiary education sectors. Stakeholders like lecturers advise the steering committee. In addition, there are structures that bundle, support, and facilitate communication, development, and change. A central mechanism are the Centres for Teaching and Learning (CTL), mandatory for all institutions but varying in form (e.g., physical, department, network, or online platform). CTLs serve as an inter-institutional exchange network, a communication node with *Npuls*, and an internal knowledge and advisory resource for transformation. Moreover, each institution has a linking team composed of influential individuals: “Those are our ambassadors and those are our feelers into what's going on in all those 105 institutions” (interview). These teams identify problem areas, advise institutional members on *Npuls*, and help develop solutions and establish activities internally. Finally, the adoption team is technically oriented; it “assists institutions in public secondary education in

connecting to technology infrastructure”¹⁰. Content is provided by institutions and may be open, semi-open, or commercial, but commercial providers cannot participate in *Npuls*.

Digivisio 2030 funds a change coordinator at each HEI, responsible for institutional transformation and fostering interdisciplinary collaboration. Several networks are used; e.g. IT director’s networks for benchmarking and sharing of best practices. HEI networks support strategic (long-term) planning, align the initiative with institutional needs, validate solutions, and facilitate inter-institutional collaboration. Communication and participation of HEIs within the initiative are further supported through synchronous (e.g., webinars, workshops) and asynchronous formats (e.g., demos, videos). To align participation and decision-making, each HEI must have minimum personnel resources, including a rector/vice-rector-level decision-maker at the general assembly, an operational, a communications, and a financial contact person. User feedback is collected at various stages (e.g., directly within the *Opin.fi* service, during development or testing phases) and feeds into development work. Additional groups, such as IT experts and pedagogical experts, are involved on specific occasions. Finnish HEIs provide content and ensure its quality, while commercial provider inclusion is a long-term goal.

Overall, participation in *Mein Bildungsraum* is peripheral, whereas in *Npuls* and *Digivisio 2030* is institutionalized and formally structured. This is coherent in that, in both programs, participating institutions operate simultaneously as agents of action, main decision-makers, and as those subject to the changes induced. All three initiatives emphasize networking, with content provided by participating institutions.

5 Discussion of the results

We found that the initiatives follow different philosophies, though all state the same objective to support life-long learning. *Npuls* appears to be strongly organization-driven; the documents describe organizational development on campus rather than the creation of a comprehensive technical solution. *Digivisio 2030* pursues a strongly platform-centred approach. *Mein Bildungsraum* emphasizes the ecosystem idea in the interplay of distributed technical infrastructure and largely autonomous actors in a federal education system. This is reflected in strongly divergent value-adding education services. Basic connectivity components are comparable, but implemented differently in its internals.

While the three programs share some governance and participation features, their differences reflect variations in scope and alignment with their respective national education policy frameworks and systems. *Digivisio 2030* centralizes decision-making in the higher education institutions and with a clear governance structure. In *Npuls*, institutions have strong decision rights within a denser network of institutional linkages. *Mein Bildungsraum* relies on task-oriented projects under national state authority. While all initiatives involve external actors, *Npuls* and *Digivisio 2030* institutionalize participation via structures also for operation and organizational transformation. In contrast, *Mein Bildungsraum* has outsourced its operation and transformation tasks to a federal agency.

We see that program structure and working methods should always be adapted to the cultural, national, and educational policy framework. It should be ensured that institutions who drive and implement changes are directly involved. This contributes to mitigating later difficulties. The program should be linked to an operational or concrete formative mandate. Defining a shared, realistic vision can guide developments and operations across contexts and phases while highlighting benefits for each user group, especially in initiatives spanning multiple educational domains.

We also recognized that different semantics of used terms reveal differences in underlying concepts. While the English term “education” (i.e. to educate or teach somebody) is focused on the act of teaching and thus connects to given content, the German “Bildung” (i.e. to let something grow or build) points

¹⁰ <https://npuls.nl/en/adoption-team>

towards cognitive construction processes and expresses a learner-centered perspective (Ludwig & Kohl-Dietrich, 2022). That's why connecting and communicating with others, and jointly working on shared artifacts are so significant to the *BIRD* prototype (Bustorff et al., 2023; Krishnaraja et al., 2026). Surprisingly, none of this has yet found its way into the *Mein Bildungsraum* prototype, because there were concerns at political level about criminal offences from user-generated content; there is a gap between pedagogical demands and the reality of education policy.

The results of our study could guide education institutions in enhancing their offerings and fostering cross-institutional and transnational collaboration, thus maintaining the momentum of enthusiasm surrounding digital education. The challenge is to properly align technical possibilities with pedagogical demands by providing adequate functionality and governance structures for digital education. Effective and sustainable governance cultivates innovative practices and ensures consistent engagement and participation from stakeholders. By addressing these points, the study contributes to the development of robust and innovative digital education ecosystems in Europe, leveraging both the critical insights and the enthusiasm generated by current discussions surrounding digital education. By emphasizing governance, the study provides insights on how to enable an effective transition from temporary initiatives to lasting, scalable digital education platforms.

However, several limitations apply to the presented study and should not be neglected. Firstly, our selection of studied cases, analysed documents and interviewed people may have been insufficient. We tried to minimize this risk by repeatedly consulting with other researchers from various disciplinary backgrounds. For this article, some categories had to be excluded; accordingly, the scope presented here is narrower than the full range of results derivable from the developed category system. Finally, our interpretations and conclusions may be biased. Through intensive exchange with the community, we hope to recognize this and, if necessary, make adjustments.

6 Conclusion and outlook

By comparing the objectives, technical approaches and governance structures of three national education initiatives, we can show how technical and organizational solutions relate to the basic conditions of the respective education systems. On the one hand, this allows us to derive recommendations for the future design of such initiatives. On the other hand, it clarifies the scope that interconnection initiatives have at a higher level in terms of technical or governance design decisions.

At European level, the decentralized approaches could act as a valuable starting point. Where there is considerable concern about political influence from central government, distributed governance and distributed technical architectures can be particularly important (Knoth et al., 2022). A federated technical infrastructure with common interfaces and standards can establish interoperability without, on the one hand, calling into question the legitimate autonomy of individual institutions or individuals or, on the other hand, degenerating into fragmentation and paralysis (Endries et al., 2026).

Our analysis is only a snapshot. The initiatives and the solutions they produce are evolving, as are the education systems they address. Therefore, a comparative study of this kind should be repeated at a later date. This would also allow for the identification of development vectors regarding mid- or long-term platform governance. It would also be interesting to include other initiatives in the comparison. New ones are likely to develop, and countries outside Europe have not been considered at all so far. The current category system as an analytical grid facilitates such a comparison.

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Ulrike Lucke is a professor of computer science at the University of Potsdam, Germany. Her research activities include institutional infrastructures for education, research and administration. Among other activities, she coordinated a large-scale national initiative to create a digital ecosystem for education across Germany. Until 2018, she was responsible for e-learning and IT strategy as Chief Information Officer of the University of Potsdam. She is a founding member and was vice chair of the German University CIO Association until 2020, and from 2020 to 2024 she was a vice president of the German Informatics (GI) society.