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Public education data at the crossroads of public and private value creation: Orchestration tensions and stakeholder visions in Germany's emerging national digital education ecosystem

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Abstract

Accelerated by the COVID-19 pandemic, private EdTech companies and emerging digital education ecosystems have significantly reshaped digital governance in education. This shift has pressured governments into rapid digital transformation while also raising concerns about increasing inequalities, fueled by a data-driven approach to teaching and learning. The public education debate increasingly calls for tighter data regulations, alternatives to private sector dominance, and digital education offerings by traditional education actors that create value in the digital realm. Responding to these pressures, the German government develops a national digital education ecosystem (NDEE) to guide this transformation. Using data from 10 semi-structured interviews, a stakeholder survey ($n = 121$), and three stakeholder workshops with in total of 80 participants, our mixed-method research contributes to the discourse on digital education governance and the creation of public data ecosystems. We identify 19 orchestration tensions, aggregated into four tension groups, shed light on education stakeholders' preferences, and identify with the three ecosystem vision models: "Education Interconnectivity Infrastructure," "Public Education Space," and the "Public–Private Education Marketplace." These findings underscore the importance of a coherent ecosystem vision that balances public and private interests, leads the foundation for ecosystem governance, and aligns the ecosystem's scope with government orchestration capabilities. We offer valuable insights for researchers and policymakers working toward a government-orchestrated national digital education ecosystem.

Keywords Data ecosystems · Education data · Governance · Educational technology · Education governance · Government as a platform

JEL Classification O38 · D47 · H52 · I28 · L38 · M15

Government orchestration of national digital education ecosystems

In education policy and public debates, a growing concern exists that the digital transformation in the educational sector could exacerbate long-standing inequalities and injustices (Hartong & Förschler, 2019; Page, 2017). A quantitative, metrics-oriented view (in the sense of datafication) is repeatedly identified as a driver for this change (Schiefner-Rohs et al., 2023), which permeates all areas of society (Häußling, 2020). This shift is putting pressure on national governments and education institutions to embrace digital transformation (Knoth et al., 2022). The current public discourse advocates for establishing (new) arrangements governing data use and inter-organizational data exchange (Beverungen et al., 2022; Gleiss et al., 2023b; Macgilchrist, 2021).

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To counter the ongoing value capture by private organizations in the education sector, critical voices stress the need for governance mechanisms rooted in a public interest paradigm and the creation of alternative education offerings (Williamson, 2016a; Ozalp et al., 2022; Seemann et al., 2022). The motivations for this are varied, including the desire to strengthen the data sovereignty of individuals and public organizations, alongside pedagogical and political concerns over the growing commercialization of education, the increasing reliance on technology providers, and the shift of learning experiences away from public oversight and quality control within the institutionalized education system toward a (digital) education economy beyond public welfare.

In parallel to these concerns, initiatives from various domains (e.g., mobility, healthcare) try to foster inter-organizational data exchange and facilitate collaborative value creation (Beverungen et al., 2022; de Reuver et al., 2024). Data ecosystems like Gaia-X and Catena-X are designed to integrate institutional data spaces, effectively balancing individual and collective interests (Otto et al., 2022; Azkan et al., 2022). In the education sector, the tension between public governance and market-driven activities surrounding the use and ownership of data reshapes established relationships and gives rise to conflicting interests. Key issues include ecosystem access, value-creating mechanisms, commercialization, and the challenge of uniting diverse, autonomous actors under a shared vision—underscoring the crucial role of ecosystem governance. Information system (IS) research has extensively explored these issues and the emergence of data ecosystems and data spaces (e.g., de Reuver et al., 2024; Möller et al., 2024) through an economic, technical, and governance lens. Research case studies and initiatives in practice often focus on private domains, resulting in a significant research gap concerning the emergence and orchestration of data ecosystems in the public sector and through the government as an orchestrator (Fassnacht et al., 2024; Möller et al., 2024; Degen & Teubner et al., 2024).

In practice, the German government has declared its intention to establish a national digital education ecosystem (NDEE) to fast-track the digital transformation in the education sector (BMBF, 2021; Lucke et al., 2023). This ambitious initiative calls for enhanced orchestration capabilities from the government and necessitates cultivating a shared vision among diverse stakeholders (Cordella & Paletti, 2019; Addo, 2022; Gleiß et al., 2023a). The federal structure of Germany's education system, characterized by a strong autonomy of the states and the involvement of numerous non-profit and private educational and technological organizations, creates a multifaceted stakeholder landscape (Förschler, 2018; Lassnigg, 2016). The complexity of this landscape becomes especially evident when attempting to integrate a diverse range of educational stakeholders and offerings, spanning from schools

and universities to vocational training, services for job seekers, and lifelong learning (Bustorff et al., 2023). For this reason, the objective of our study is to gain a deeper understanding of the varied stakeholder interests related to orchestration tensions and possible ecosystem visions for the design of the German government's NDEE initiative. We seek an answer to the following research question:

What visions do German education stakeholders have for a national digital education ecosystem, and what tensions must the government orchestrator address to align their interests?

We define a stakeholder vision as a clear and cohesive framework for understanding a complex and evolving phenomenon. It defines boundaries, promotes collective sensemaking, and provides a solid foundation for aligning stakeholders toward a unified perspective. By using empirical data gathered from 10 semi-structured qualitative interviews, an education stakeholder survey with $n = 121$ full responses, and a validation workshop with more than 30 representatives of various education institutions in Germany, our mixed-method research contributes to the ongoing discourse on digital education governance and the development of data ecosystems initiated by governments (Beverungen et al., 2022; Degen & Teubner, 2024). With our research inquiry, we shed light on government orchestration that needs to overcome orchestration tensions to craft an ecosystem vision to be able to align and steer various autonomous education actors. Our findings provide insights into aligning stakeholder interests and shaping the ecosystem's scope and governance. We identify 19 orchestration tensions, aggregated into four tension groups, which reveal the preferences of educational stakeholders and outline pathways to balance these interests through three identified ecosystem vision models. We further emphasize the importance of a unified ecosystem vision and the need for governments to establish effective governance and build orchestration capabilities crucial for successfully driving this digital transformation journey.

The remainder of this article is structured as follows. The “[Current research and practice on data ecosystem orchestration and digital education governance](#)” section provides an overview of the current state of related research and practice. The “[Research design](#)” section explains the study's empirical basis and research design. The “[Findings](#)” section describes our findings on orchestration tensions, stakeholder group preferences, and ecosystem vision models that can serve as government orchestration models. In the “[Discussion](#)” section, we discuss the implications of our findings for theory and practice and reflect on our limitations. Finally, the “[Summary and outlook](#)” section summarizes the study results and their consequences and offers an outlook on future research avenues.

Current research and practice on data ecosystem orchestration and digital education governance

In the following sections, we analyze the field from four perspectives: research on (1) data, (2) governance, (3) education, and (4) the current German initiative that forms the practical subject of our observations.

Foundations of (public) data spaces and data ecosystems in research

IS research focuses intensively on data spaces and data ecosystems. These concepts are becoming dominant governance and organizational forms in our networked and interconnected digital world, appearing in various forms and application domains. Möller et al. (2024) define data spaces as “decentralized data infrastructures designed to enable data-sharing scenarios across organizational boundaries by implementing mechanisms for secure and trustworthy data sharing—such as distributed data storage and the sharing of meta-data” (p.6). According to Schurig et al. (2024), their governance design follows “a participatory governance configuration for sovereign data exchange oriented toward distributing decision rights between stakeholders” (p.1). In addition, the ownership and sovereignty over the value generation are shifting from private to shared or public structures, making it more challenging to privately monopolize value generation (Scherenberg et al., 2024).

Thus, the focus is on public value generation, and the aim is to strengthen public interests and generate value through federated IT infrastructures shaped by collaborative governance (Möller et al., 2024; Schurig et al., 2024). Inter-organizational data exchange spaces emerge in various industry and domain applications, e.g., mobility or cloud, and build the foundation of data ecosystems (Beverungen et al., 2022). The trend significantly impacts regulated domains and the public sector. The adoption of the European Health Data Space Regulation exemplifies how governments are creating and regulating data spaces to harmonize public and private interests, orchestrating value generation in the digital realm (Hoeyer et al., 2024; Kari et al., 2024).

In contrast to data spaces, data ecosystems can be characterized as a distributed network of actors accelerating data collection, transfer, and utilization to achieve co-creation value (Oliveira et al., 2018, 2019). In comparison to data spaces, they have less formal governance and a more open structure and boundaries. According to Möller et al. (2024), data ecosystems “represent the sum

of collaborative data-sharing activities built on the secure and trustworthy data-sharing paradigm of data spaces to realize shared goals (e.g., innovation, compliance, optimization) for their members” (p.8). Following this definition, data spaces and data ecosystems are interconnected, forming a hierarchical structure focused on data sharing among autonomous actors, supported by data infrastructures and shared governance. However, data ecosystems feature broader boundaries and span across multiple industries. For instance, the eIDAS 2.0 regulation aims to create an identity data ecosystem that enables the secure, digital, and user-friendly exchange of digital credentials, such as educational certificates, across various industry domains (Degen & Teubner, 2024).

In the public sector context, open data as a concept plays an important role in practice and research (e.g., Reggi & Dawes, 2022; Zuiderwijk & Janssen, 2014). Open data ecosystems initiated by the government aim to generate value by leveraging government data through collaborative efforts with third parties (Dawes et al., 2016). Open data ecosystems comprise data providers, intermediaries, and users who use public data to improve private and public services (Reggi & Dawes, 2022). Open data (platforms) can lead—when effectively orchestrated—to greater transparency, better decision-making, (social) innovation, and an enhanced government-citizen relationship (Allen et al., 2020; Fang et al., 2024; Gegenhuber et al., 2023; Janssen & Estevez, 2013). Meijer and Boon (2021) outline three fundamental configurations for establishing such ecosystems within a governmental context: (1) contracting a private sector organization to manage infrastructure and (data) platform components, (2) creating a (data) ecosystem controlled by a government entity, and (3) initiating an open (data) platform operated by a civil society organization. In making these decisions, the orchestrator must balance effectiveness with legitimacy to ensure alignment between public and private sector interests. Co-creation based on collaborative governance helps to balance diverse interests (Ansell & Gash, 2018).

Government orchestration visions as an ecosystem governance blueprint for addressing stakeholder tensions

The successful coordination of various autonomous actors by the orchestrator—typically the government in public sectors such as healthcare, education, or administration—is essential for realizing value creation. Achieving this requires breaking down organizational and technical silos to facilitate data sharing. Successful private platforms like Google and Amazon demonstrate how effective ecosystem governance can foster value mechanisms, overcome tensions, and generate collaborative value (Gawer, 2022). However, governance can also be leveraged to shape outcomes in favor of the

orchestrator—or potentially result in adverse effects for third parties and society as a whole (Gleiss et al., 2023b).

The governance configuration is crucial for governing an ecosystem (Gorwa, 2019). Governance “refers to the structure, process and methods to make decisions related to collective activities” in an ecosystem (Mukhopadhyay & Bouwman, 2019, p.334). Here, the majority of the research focuses on critical governance configurations that are governed—such as ecosystem access and standards (de Reuver et al., 2022), ecosystem architecture and interface design (Mukhopadhyay & Bouwman, 2019), the role of data and sharing (Fassnacht et al., 2023; Jussen et al., 2023), value-creating and revenue-sharing mechanisms (Halckenhäusser et al., 2020; Schrieck et al., 2016), and conflict resolution (Gorwa, 2019). To design the governance, Schurig et al. (2024) synthesize from IS literature seven critical governance dimensions: (i) ownership, (ii) decision and control rights, (iii) ecosystem access, (iv) boundary resources, (v) actor interactions and relationships, (vi) pricing and revenue, and (vii) values, trust, and beliefs; we adopt this perspective for our research inquiry.

In our education context, the government acts as the orchestrator of an ecosystem. Here, orchestration refers to inter-organizational cooperation within the education domain, as well as control over IT systems and data resources (e.g., Cordella & Paletti, 2019; Klievink et al., 2016). Building on this, government orchestration involves the strategic coordination and management of government-provided systems, platforms, and infrastructures utilized by various autonomous actors within a complex ecosystem (Degen & Teubner, 2024). This orchestration aims to generate collaborative value, accountability, legitimacy, and efficiency (e.g., Addo, 2022; Cordella & Paletti, 2019). Creating ecosystems in public domains such as education holds the potential to fundamentally reshape the organizational structure, power relationships, and value creation of various stakeholders and can lead to political controversy.

Orchestrating and aligning various autonomous actors naturally lead to conflicting interests and tensions that must be addressed by the government orchestrator. We define tension as a dynamic state of opposition or conflict between interconnected elements, ideas, or forces (Ciriello et al., 2018). These paradoxical elements—both opposing and interdependent—create a complex interplay that resists simple resolution, requiring ongoing adaptation (Hargrave & Van de Ven, 2017). At its core, tension highlights oppositional forces as catalysts for change, often emerging as pluralistic perspectives, conflicting events, or competing values (Hoppe et al., 2024). This interaction generates a dynamic environment where resolution is elusive, yet progress and innovation arise through balancing these elements. Tensions are not merely challenges but essential drivers of growth, adaptation, and transformation (Ciriello et al., 2018; Hoppe

et al., 2024). Engaging with such paradoxes helps individuals, organizations, and systems navigate complexity and foster meaningful development.

Tensions in data ecosystems arise “when actors confront apparent social, technical, legal, and organizational dichotomies, obscuring the simultaneous presence of conflicting elements or actions” (Kari et al., 2024, p.14). Organizational tensions emerge when complex systems within an organization produce conflicting processes and designs that require resolution (Mini & Widjaja, 2019). Performing tensions emerge when multiple actors pursue conflicting goals. Learning tensions occur when creating new practices necessitates the use and often the destruction of past practices. Belonging tensions stem from competing identities with which individuals identify (Mini & Widjaja, 2019; Smith & Lewis, 2011). The government orchestrator’s task is to resolve these tensions when initiating an ecosystem to persuade autonomous actors to participate or compel them through regulation, ensuring the generation of shared value. Therefore, organizing, performing, learning, and belonging tensions are subtensions of orchestration tensions that arise during the creation of an ecosystem.

This paradigm shift from linear service provision to multi-sided interactions in emerging ecosystems presents opportunities and risks to fundamentally change the digitization of the public sector and societal welfare distribution (Clemons et al., 2022; Gawer, 2022; Klievink et al., 2016). Therefore, the perspective of educational stakeholders is critical in understanding how governments (should) create and orchestrate data ecosystems. Their perspectives help define the vision and scope (e.g., an education data ecosystem or data space), establish ecosystem boundaries (e.g., reach, access criteria), and identify key actors (e.g., schools, learners), design value creation mechanisms and governance structures, and determine the necessary capabilities to bring these initiatives to life successfully. From a government orchestration perspective, the stakeholder view is a crucial input for shaping an ecosystem vision that aligns diverse, autonomous actors with the orchestrator’s activities, facilitating the successful creation of these ecosystems. The ecosystem vision promotes alignment among the involved actors, defines value mechanisms, and establishes clear ecosystem boundaries (Gupta, 2020).

Given these new realities, the expectations placed on government-orchestrated ecosystems are steadily rising, surpassing the current realities of open data ecosystems (van Loenen et al., 2021). This indicates a shift toward more needed enhanced orchestration capabilities to “govern” various public and private actors rather than just opening up public databases for third parties (Cordella & Paletti, 2019). The necessary capabilities extend beyond data and computing resources, leading to the need to develop an orchestration vision for a redesign of regulations, policies, processes,

services, and systems (Su et al., 2011). Therefore, we are examining how education stakeholders perceive the value and design of an emerging national education digital ecosystem, enabling the government orchestrator to integrate these perspectives into the ecosystem's development.

Emerging ecosystems in digital education research

The digital transformation of the education sector is an ongoing phenomenon gradually shaped by various education stakeholders and governments worldwide (Hartong & Förtschler, 2020; Verständig, 2022). At the same time, the disruptive influence of BigTech introduces challenges, posing a risk of monopolizing digital education privately (Ozalp et al., 2022) and subjecting learners and educators to surveillance capitalism, given the pivotal role of data (Schiefner-Rohs et al., 2023; Williamson, 2016b; Zuboff, 2015). These developments show the need for public value-oriented offerings gaining the acceptance of numerous actors in an emerging digital education ecosystem (Kerssens & van Dijck, 2021; Knoth et al., 2022; Williamson, 2021). On a national scale, the US platform inBloom (Bulger et al., 2017), Denmark's Aula (Jørgensen et al., 2023), or Australia's Ultranet (Tatnall & Davey, 2018) wanted to provide a distributed teaching and learning environment for schools. However, these initiatives have either failed or gained little relevance and highlight the challenge of creating government-orchestrated education ecosystems. For higher education, the UK initiative Data Futures (Williamson, 2018) aimed at a nationwide data-driven decision support system. Also, there are punctual cooperations between schools (Denys & Klimczuk, 2022) or universities (EC, 2021) to establish digital education ecosystems. Governments in many countries are driving the digital transformation of the education sector in alignment with public values, efficiency, and private market interests.

Digital education and media research have drawn extensive attention to the importance of data and digital platforms in the sector's digital transformation. The research focuses on a political-economic perspective regarding the role of educational platforms and a socio-technical viewpoint centered on how education ecosystems reshape the dynamics of teaching and learning (Kerssens & van Dijck, 2022). While digital platforms and tools have demonstrated their public value for education during the COVID-19 pandemic, there is growing criticism in education policy debates concerning the gradual privatization of public education. This criticism stems from high dependencies on offerings from the private sector, rooted in information technologies and existing data infrastructures (Hartong & Förtschler, 2019; Williamson, 2021). Williamson et al. (2022) contend that global technology corporations like Amazon have begun acting as connectivity governance organizations in education.

Viewed through a socio-technological lens, this trend raises concerns about the need for interoperability between education systems and tools (Jakimoski, 2016), harmful learner and teacher surveillance (Nottingham et al., 2022; Page, 2017), and biases in algorithmic decision-making (Perrotta & Selwyn, 2020; Prinsloo, 2020). Moreover, digital technologies can potentially complicate school processes and practices, diverging from their intended goal to support. This situation may benefit vendors' private interests but pose disadvantages for both schools and users (Pangrazio et al., 2023). The digital education discourse has focused on improving digital learning collaboration and opening up education resources and systems (Llorens et al., 2014; Tuomi, 2013) for years. Recently, a shift of academic interest to education governance can be seen leading to a growing number of governmental arrangements, operating across traditional scales, levels, or policy approaches (Hartong, 2018; von der Heyde, 2023).

Our assessment of the academic literature on data, spaces, ecosystems, and digital education identifies the following research gaps:

First, while IS research has extensively explored data ecosystems and the creation of data spaces in various private application domains, such as cloud or mobility, there remains a research gap in studying these concepts within the public sector. This gap is particularly evident in the education domain, which has undergone a fundamental and accelerated digital transformation since the COVID-19 pandemic. Second, from a digital education research perspective, there is an ongoing and intensive debate about educational content, tools, and infrastructures, the role of private digital platforms and EdTech, and their implications for learners and teachers. However, while these themes have been studied at individual and organizational levels, the ecosystem perspective from a governmental viewpoint remains a significant research gap. This gap is particularly noteworthy given the various practical initiatives and debates aimed at initiating education ecosystems that unify traditional education segments—such as schools, universities, and other educational services—and reshape the relationships among various public administration and non-governmental organizations. Third, the orchestration of such an ecosystem extends beyond the current scope of providing open data and digital platforms in the public sector. Given the large number of diverse governmental and non-governmental organizations, as well as the variety of educational segments, orchestrating a unified government-initiated ecosystem is a complex undertaking. This orchestration must align the autonomous actors behind a common vision to ensure effective value generation and legitimacy. The perspectives of these autonomous actors involved in creating such an ecosystem are crucial for identifying potential governance tensions that must be overcome to develop a common education ecosystem.

vision. Gleiss et al. (2023a) have identified relevant aspects for designing a governance structure for a national educational platform ecosystem. However, the focus on the stakeholder perspective in creating such an education ecosystem is missing in research, despite being highly relevant for practical implementation.

Education ecosystems in practice: the German federal government initiative to create a national digital education ecosystem

The German federal government initiated the development of a National Digital Education Ecosystem (NDEE) immediately after COVID-19 made the digitization needs in the German education system visible (BMBF, 2021). Among the funded projects, there were several dozen focused on specific educational offerings and services as well as four dedicated to general platform development. Among the latter, the BIRD project (in German, “Bildungsraum Digital” or Digital Education Space) plays a central role. It was funded in advance of the call for proposals, and all other projects had to demonstrate their connectivity to the BIRD prototype to prove their interoperability with such a national educational ecosystem. Thus, BIRD defined the scope and architecture of the prototype (Knoth et al., 2022) and oversaw the other projects from a bird’s-eye perspective. This oversight includes targeted educational scenarios—addressing all

domains from schools to higher education, from vocational training to lifelong learning—as well as platform functionality, ranging from basic interoperability to AI-driven, personalized composition of individual knowledge spaces (Bustorff et al., 2023).

Orchestrating a national education ecosystem in Germany presents a unique challenge due to the highly decentralized education structure and governance in the non-digital world (Lassnigg, 2016). Regarding primary, secondary, and tertiary education, individual institutions are managed by municipal authorities, which are also responsible for providing digital services. Policy decisions are handled by the federal states, with the federal government offering support only in specific areas (e.g., infrastructure and research). These complex requirements necessitate an ecosystem architectural approach that respects the legal and organizational boundaries of education services and responsibilities while ensuring shared value creation.

The stakeholder landscape shaped by the introduction of an NDEE brings together various providers and consumers of educational services, as depicted in Fig. 1. They take on roles that can be assigned to the supply side (left) and demand side (right), on the institutional and individual levels, for public welfare and commercial interest. Individual players can take on several roles and thus strengthen the internal structure of the ecosystem. For example, a university or individual lecturers can both access offers from

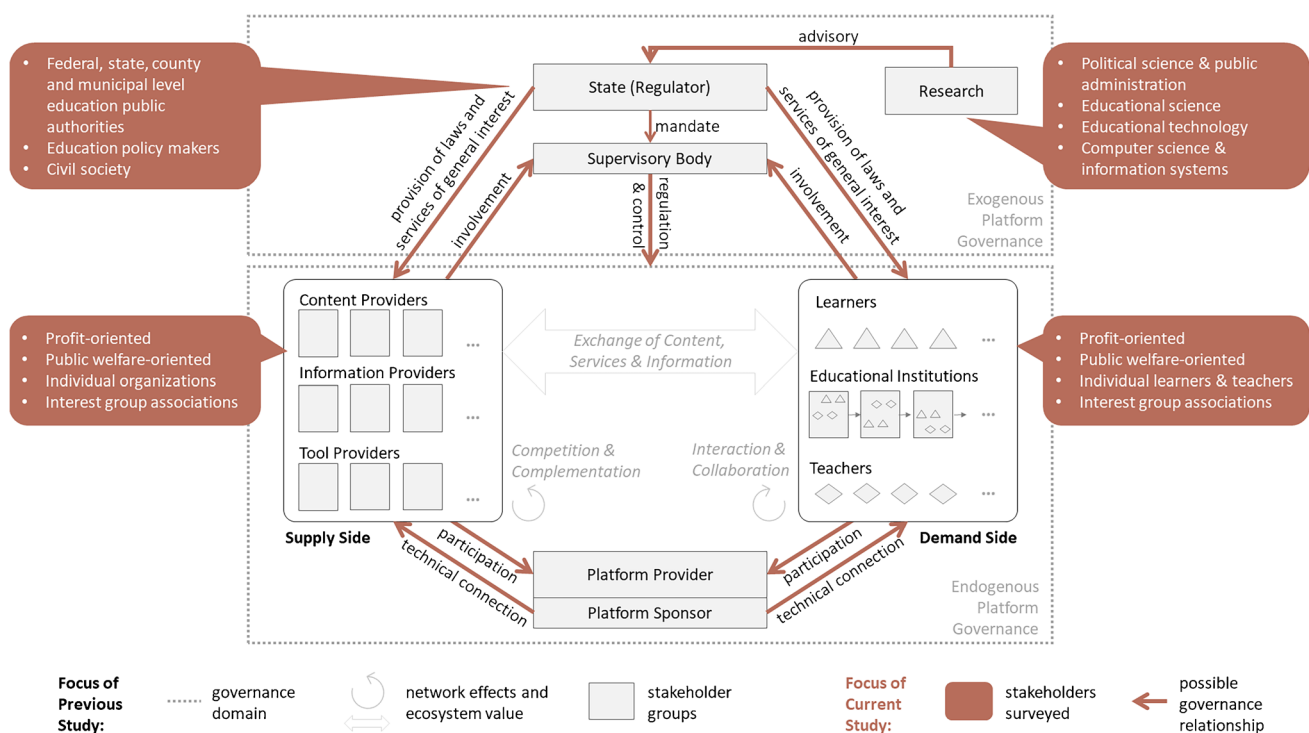


Fig. 1 Ecosystem actors and value mechanisms in an NDEE (extended from Gleiß et al., 2023a)

other players and offer content themselves. The basis for such interactions is a common networked infrastructure (bottom). It acts as a platform that enables providers to publish and advertise their offerings, allows learners and teachers to find relevant offerings according to their current context or needs, provides technical interoperability between systems and services on both sides, and ensures seamless transfer of the necessary educational data and credentials. Moreover, stakeholders from policy and research are involved from a supervisory perspective (top).

We adopted this education ecosystem perspective and used the visualization in Fig. 1 to identify relevant ecosystem actors and stakeholders (in red color). Our research focuses on their perspectives on identifying governance tensions and developing shared ecosystem vision model patterns that can help the government orchestrator to align the various actor interests in such a national education ecosystem.

Research design

We apply a mixed-method research design to generate insights and theory through collecting, interpreting, synthesizing, and triangulating knowledge from qualitative semi-structured expert interviews, an online survey, and two validation workshops. An inductive research approach is appropriate to fundamentally advance theory creation through insights into specific phenomena (Bansal & Corley, 2012). Our research approach allows us to collect comprehensive data covering the entire spectrum of education

stakeholders. By integrating qualitative and quantitative methods, we utilize distinct approaches: qualitative methods delve deeply into expert perspectives, while our quantitative survey, supplemented with qualitative feedback options, offers broad insights into stakeholder viewpoints. Triangulating these methods following the recommendations proposed by Jack and Raturi (2006) enables us to develop robust insights and findings. Our research design allows a focused analysis of insights to develop new knowledge, identify more comprehensive explanations, and achieve greater generalizability (Skinner et al., 2022). Our research inquiry contains the following steps: (i) selecting a theoretical framework, (ii) data collection, and (iii) data analysis and is described in Fig. 2.

Literature review and theoretical framework selection

Before initiating data collection, we began with a literature review, employing dual search term combinations (using “AND”) for keywords such as “data ecosystems,” “open government data,” “government ecosystem orchestration,” “digital education,” and “education ecosystem.” This search was conducted through Google Scholar and the AISEL database. Backward and forward searches discovered further academic literature in IS, Management Science, Public Administration/e-Government, and Digital Education and Media Research. We identified 68 publications in journals and conference proceedings, which form the basis for the literature discussion in the background section and lead us

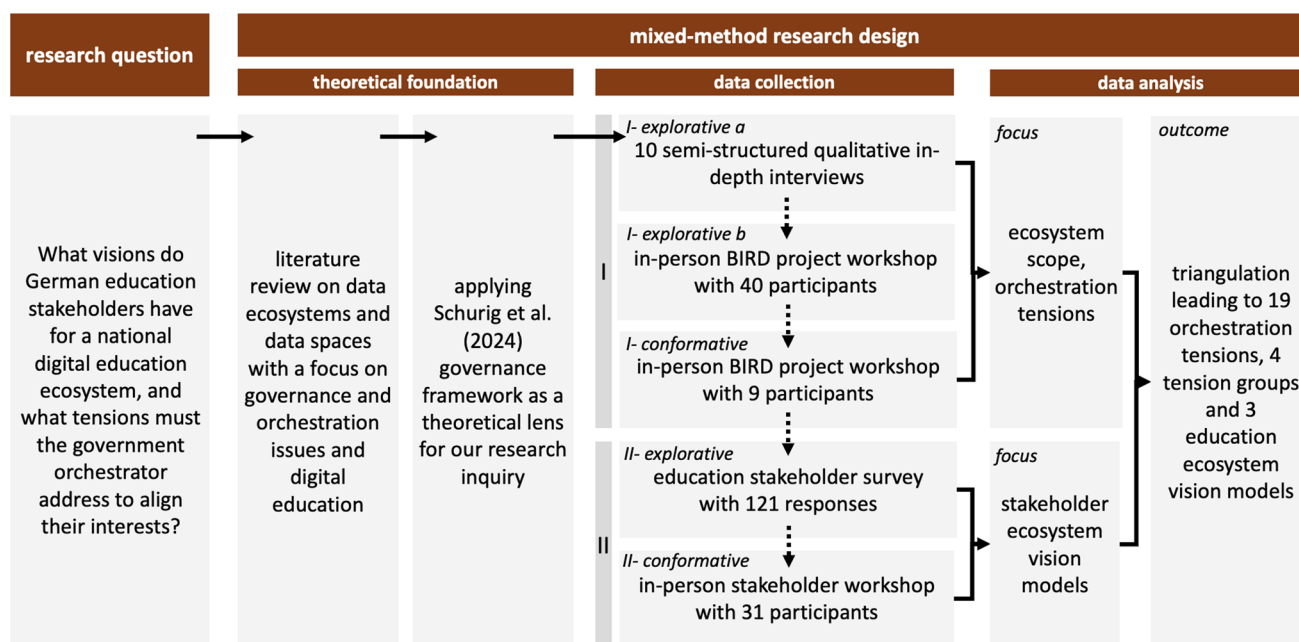


Fig. 2 Mixed-method research design

to select the governance framework developed by Schurig et al. (2024) as the theoretical lens and starting point of our research inquiry. We applied the identified seven governance dimensions of the framework to our collected data and identified 19 orchestration tensions. This approach enabled us to assess government orchestration tensions while structuring our research process according to the seven governance dimensions.

Data collection I: Semi-structured qualitative interviews and expert workshops

As a second step, we leverage stakeholders from the BIRD research project to access a diverse range of education experts. Given the novelty of the NDEE approach, we were limited to those internal experts for the first step of data collection. Through semi-structured qualitative interviews, we gain in-depth insights into their perspectives (see Annex A for details on participants and interview guidelines). The interviewees were carefully selected to cover the entire spectrum of perspectives, including overarching project management, IT architectures and applications, educational concepts, systems, and markets, as well as political and federal structures, conditions, and objectives. This comprehensive approach allowed us to collect targeted, focused, and insightful first-hand information, generating an expert stakeholder sample. Through our ten in-depth interviews, we were able to understand the relevant stakeholders' conceptual understanding and sensemaking of an emerging digital education data ecosystem, as well as their practical reasoning. Each interview lasted 90–120 min.

Resulting from this overview, we carried out a structured discussion of selected governance aspects in a 90-min session during an in-person BIRD project workshop with approx. 40 participants. Using visualization and placement techniques, we discussed the overall platform vision, the possible function scope, and perspectives on governance aspects. The outcome of the discussion revealed shared ideas among all participants as well as initial tensions. Details on the participants and the workshop agenda are provided in Annex B.

The interim findings, particularly focusing on the orchestration tensions, were then compiled for an online stakeholder workshop with the BIRD steering board. Nine participants, including 3 of the previous interviewees, attended the 60-min online meeting. The study team presented their findings to the sub-project leaders and collected their feedback, which resulted in a first set of identified tensions.

Data collection II: Stakeholder survey and stakeholder workshop

On this basis, we were now able to include other stakeholders in the data collection—especially those representatives

from the public policy sector who were not involved in the first step. A quantitative survey with qualitative free text response options was developed to capture the broad perspective of the identified stakeholder in Fig. 1. The online questionnaire contained a total of 20 items on governance issues leading to potential orchestration tensions as well as additional 6 items on the personal importance of those governance fields and 7 items on demographic aspects. The survey was cross-checked by four researchers from the project (with a background in computer science, educational technology, and information systems) as well as four external researchers (with a background in information systems, empirical social science, and political science with a focus on public administration). More details on the participants and the survey can be found in Annex C.

Over the 46-day course of the survey, it was accessed 668 times. A data record was created by the system after each completion of the welcome and explanation page, of which there were 327 in total (two quit there). One hundred twenty-one data records were completed in full, and 206 were partially completed.

Out of the 121 participants, members of the public authorities of the federal states (36) and educational institutions (25)¹ were overrepresented, while school students (3) and vocational students (1) are underrepresented and were excluded from our further analysis. Fifty-two stated that they belong to the group of educational providers, with 35 of them in the non-profit sector. The majority of respondents identified as male (80), around a third (38) as female, and 3 as diverse, which constitutes a bias almost comparable to that in decision-making levels of most large organizations. Almost all participants (91.7%) had at least a Bachelor's degree. Representatives from all age groups could be identified, with most participants between 20 and 65, while under-age students were explicitly not targeted. It is also interesting to note that 71% of respondents declared that they regularly use digital learning platforms. This corresponds to the typical characteristics of stakeholders in the education system. However, the sample cannot be classified as representative; instead, evaluations must be group-sensitive. The perspective of institutional stakeholders emerged as dominant based on the data response. Due to the small sample size, no significance calculations were performed, but purely descriptive statistics were compiled.

Afterward, we organized a full-day offline stakeholder workshop to validate our findings. We invited education stakeholders through an open process, leveraging multipliers such as the German Academic Exchange Service to ensure broad stakeholder participation. Our workshop was attended

¹ Based on role assignment including multiple roles (see Annex C for details).

by 31 representatives from a diverse range of German public and private education stakeholders (see Annex D for details on participants and agenda).

Data analysis and triangulation process

The data analysis process for this study followed a structured approach, beginning with data collection I, which included semi-structured qualitative interviews and an online expert workshop. After conducting 10 semi-structured interviews, we transcribed the recordings, resulting in 318 pages of text. Two researchers then independently applied thematic coding to analyze the interviews. During the analysis, the data was critically evaluated and continuously adjusted following an inductive category formation process (Mayring, 2014). We identified three major analytic categories: brokerage vs. integration of services, third-party vs. own services, and scope of providers and consumers.

These fields were deepened by a broader expert consultation during a 90-min BIRD project workshop with appr. 40 participants following the workshop-based research recommendations of Storvang et al. (2018). In a group-based discussion on the above-mentioned categories, we gathered the perspectives of participants in card-based visualizations and placement techniques to stimulate creative thinking and visualization opportunities (Kerzner et al., 2018) (see Annex B for examples). The discussion revealed a lack of a shared vision for the NDEE, emphasizing the need to gather additional data on stakeholder perspectives to strengthen the reliability of our findings. We identified three fields of tensions, building on each other: ecosystem service scope, endogenous and exogenous governance.

A conformative analysis workshop was then conducted to discuss and synthesize the findings. These findings provided an initial iteration of the orchestration tensions, functional ecosystem scope, and various public–private stakeholder interests. Additionally, questions emerged around the significance of a centralized platform, along with the ownership and responsibilities of central and decentral data providers, which became a focal point of tension.

Data collection II involved an education stakeholder survey designed to gather both quantitative and qualitative data, conducted by two other researchers of the team. The survey questionnaire was developed based on findings from data collection I, and the analysis was carried out by the two researchers and presented in an internal research team workshop of approximately 90 min. During this data collection phase, a central theme emerged regarding the responsibilities of government versus non-government actors and the role of a central (platform) actor in governing the educational ecosystem. From a stakeholder perspective, key governance design configurations were identified, including ecosystem access, value creation mechanisms, and responsibilities to

prevent ecosystem misuse. In three follow-up triangulation workshop sessions, each approximately 90 min, the four-person research team followed the recommendations of Jack and Raturi (2006) to present, compare, and refine findings from both data collection I and II. These sessions were complemented by individual analyses presented during the workshops, enriching our overall analysis process. Throughout this triangulation process, we identified three distinct ecosystem visions from a stakeholder perspective and delved deeper into the orchestration tensions and their interplay with the vision patterns.

To further strengthen the reliability of these findings, the research team organized a full-day education stakeholder workshop, where they presented their empirical findings and discussed the implications with 31 participants in card-based visualization activities (see Annex D for examples). The primary outcome was a confirmation of the three ecosystem vision models. Subsequently, the research team held a fourth triangulation workshop of approximately 90 min to enhance and refine the ecosystem vision model descriptions. In conclusion, our study employed a rigorous and structured approach to data collection and analysis. We began by defining the scope of the ecosystem, then identified and categorized orchestration tensions, and ultimately developed three vision models for national digital educational ecosystems from a stakeholder perspective.

Findings

We can derive results on three levels from the empirical data. In the “[Identifying government orchestration tensions from stakeholder perspective](#)” section, we first identify the tensions with regard to the governance issues of an NDEE. In the “[Mapping orchestration tensions to stakeholder preferences](#)” section, we connect these tensions to the positions of certain stakeholder groups and the resulting potential alliances. In the “[Three education ecosystem visions to manage orchestration tensions](#)” section, we aggregate this into three possible ecosystem visions and associated governance approaches responding to those tensions.

Identifying government orchestration tensions from stakeholder perspective

We have identified 19 orchestration tensions from a stakeholder perspective that a government orchestrator must resolve to initiate a successful NDEE. These tensions are structured using the seven governance dimensions proposed by Schurig et al. (2024). The results are presented in Table 1.

Governance dimension #1 *value, trust, and belief* addresses key goals and the collaboration spirit (Schurig

Table 1 Mapping governance dimensions and identified orchestration tensions

Governance dimension	Identified government orchestration tensions
#1 Value, trust, and beliefs	(1) Involvement of private actors (2) Preferencing open educational resources (3) Degree of digital transforming the current education system (4) Function scope and role of the platform and ecosystem
#2 Ecosystem access	(5) Degree of ecosystem reach (6) Degree of ecosystem openness (7) Efforts to fulfill digital inclusion and literacy
#3 Boundary resources	(8) Used data formats and technical standards (9) Inventing new vs. using existing boundary resources (10) Organizational responsibility for providing boundary resources
#4 Actor interactions and relationships	(11) Responsibilities across education segments and public administration levels (12) Level-playing field between education service providers and users
#5 Pricing and revenue	(13) Public financing vs actor co-financing (14) Design of ecosystem actor co-financing contributions
#6 Decision and control rights	(15) Usage obligations for institutional actors (16) Prohibition of platform service self-preferencing (17) Governance rule setting, enforcement, and misuse handling
#7 Ownership	(18) Autonomy of the platform provider from the government orchestrator (19) Platform provider ownership between government and non-government actors

et al., 2024). Here, we identify a first tension regarding the involvement of private education actors (1). While private education stakeholders, such as content or tool providers, envision an NDEE with a public–private focus, some education stakeholders are critical of involving private actors due to fears of increasing the commercialization of the public education system. For example, one participant of the survey emphasized that “good and free learning content” is important; another wants to exclude commercial providers generally (“must be completely free of commercial interests of the providers/companies and only convey offers from non-profit organizations”). One even wrote: “No commercial providers, otherwise boycott.” But interviewee I4 pointed out that open education resources (OERs) might have, on the other hand, the disadvantage of a more difficult quality check. Unlike the well-established school books, which have rigorous processes to filter out inaccuracies, the OER sector lacks standardized validation mechanisms to ensure content reliability.

This leads to a second tension concerning the exclusivity or promotion of OER (2). Educational scientists and advocates argue that promoting these resources should be a key goal of an NDEE, citing the normative advantages of OERs such as cost saving or more equal access. However, the preferential or exclusive use of these resources within the ecosystem is opposed by disadvantaged groups, such as private providers. They argue that it should not be the task of a government orchestrator to intervene in the selection of educational content; rather, this responsibility should

lie with learners and teachers. Therefore, they believe the NDEE should reflect the variety of existing educational offerings. Some participants polled even argued for a “unification” respectively “bundling of (all) relevant sources/tools in the German-speaking world.”

As a third tension, we identify that the creation of an NDEE can drive changes in organizational, economic, and user preferences between the traditional education actors to a different degree (3). This indicates that an NDEE can shift the balance of power between stakeholders during the transition from an analog to a digital (or rather hybrid) education ecosystem. Especially traditional education providers must develop relevant digital offerings to maintain their relevance. “Promoting and enabling innovation, i.e. not lagging behind the state of digital possibilities, but adapting and moving forward” is a general demand mentioned by one participant of the stakeholder survey.

Another tension in dimension #1 underscores the existence of differing stakeholder perspectives regarding the ecosystem and platform scope (4). Here, we identify a broad range of functionalities and core values that, while not necessarily in conflict, highlight the diverse approaches to creating an NDEE. These include, for example, the intermediation of educational services, the collaboration between learners and teachers, the integration and standardization of various IT systems, and the provision of content and learning resources.

Governance dimension #2 *ecosystem access* highlights as a first tension the degree of ecosystem reach (5). In this

context, most education stakeholders recognize the importance of connecting traditional educational segments such as schools, universities, and vocational training. Individual education segments are already working toward creating segment-specific digital educational ecosystems. However, a tension exists between public and private education stakeholders. Public education stakeholders tend to focus on creating an ecosystem primarily covering traditional public education institutions, while private stakeholders seek a broader reach. For example, “High-quality training courses that convey up-to-date content and are not outdated (ChatGPT, Bitcoin, React, Crypto and no longer Wordpress, Cobalt, et al.)” was one comment in the free text field of the stakeholder survey. In addition, the question comes up whether the NDEE should be open to a wide range of educational tool providers, in addition to content providers. This is closely tied to the vision of the NDEE. Depending on its design, the ecosystem may either have a wide reach or a dedicated scope which highlights the need to define the boundaries.

Another tension arises regarding the openness of the NDEE toward various ecosystem actors (6). This includes whether access thresholds are necessary to prevent misuse and enhance quality. In this context, educational scientists and teachers argue that ensuring the quality of content is a crucial responsibility of the orchestrator, as it enhances educational value. “Quality must be checked and ensured” is one demand of non-profit providers. On the other hand, interviewee I9 said, it is not possible to, for example, protect the users from bad-quality content; rather, the governance task should be to protect the users from illegal (and/or dangerous) influence. However, imposing access barriers can slow down ecosystem adoption by making it harder for users to engage within the ecosystem easily. Focusing on institutional educational actors can help strike a balance between the need for access control and promoting rapid user adoption. Another facet of access control concerns safeguarding users themselves, particularly minors in the school sector are important to protect. Interviewee I4 emphasizes that the NDEE has a responsibility not to bring together participants who should not be brought together, especially concerning children and adolescents. Moreover, interviewee I5 pointed out that cybermobbing is another relevant topic which must not be lost sight of. Similarly, platform operators must protect against copyright infringement and regulate content distribution to uphold their own interests and maintain ecosystem integrity.

The third tension in this dimension addresses the socio-technical access of users to the ecosystem (7). Depending on the technical design, they must meet certain technical requirements (e.g., new smartphone needed) to operate effectively within the NDEE. Ecosystem actors unanimously recognize that digital inclusion and literacy are crucial.

However, there is a divergence in opinions regarding the prioritization of these issues. Representatives with backgrounds in education or educational science stress the significance of prioritizing digital inclusion and literacy (“make education more accessible,” “easy access and usage,” “every user and his needs should be able to find themselves reflected in the ecosystem”). They argue that prioritizing these aspects should ensure, and even enhance, educational equity within an NDEE (UN, 2015), even if it reduces value creation for other actors.

Governance dimension #3 *boundary resources* addresses orchestration tensions related to data formats and technical standards (8). For the interconnectivity and interoperability of educational services and digital credentials in an NDEE, standards for data and metadata formats (from a syntactical and semantical perspective) as well as standardized interfaces are crucial. The use of multiple technical standards adds to the complexity of this task and forces the government orchestration and platform providers to define key boundary resources.

Another tension in this dimension is whether the NDEE should be based on existing standards or new ones (9) and whether these standards should be enforced or if a standard-agnostic approach is preferable. Furthermore, there is tension regarding which organization should define and enforce these key boundary resources (10). Related comments in the stakeholder survey were: “It [NDEE] would have to fill the infrastructural gaps (e.g. joint, cost-sharing media playout) and develop and define standards with (active) experts,” “the platform should be based on open standards and not require proprietary software or even devices from specific manufacturers,” and “make interfaces available after an uncomplicated testing process.” Standards and interoperability were mentioned repeatedly in the interviews. For instance, I9 pointed out that it would make the user transition from the platform to external providers more convenient, if they do not have to go through another registration process, but could instead access an offer directly. Both, the orchestrator and platform providers, play crucial roles in this process.

Governance dimension #4 *actor interactions and relationships* highlights as a first tension the creation of an NDEE in relation to the existing education governance (11). Creating value for various actors might require adjusting and reshaping the roles and responsibilities of selected stakeholders. For example, despite education being a responsibility of federal states and municipalities in Germany, the federal government has taken the initiative to create an NDEE. This tension arises from the need to adjust traditional education governance to enhance the ecosystem’s value while preserving the political and legal responsibilities established over decades (Lassnigg, 2016).

A second tension in this dimension emerges in data utilization (12). The analysis of user data generated within the

NDEE has the potential to facilitate numerous educational innovations and personalized offerings. Educational providers as well as researchers often underscore the importance of educational data to increase value creation and fulfill education policy goals (e.g., offering better education quality). They have commented like “release data for research purposes” or have demanded “open data.” Furthermore, interviewee I9 supports this with the argument that anonymized data would be important to properly set the budget. However, individual learners, teachers, educational administrations, and supervisory authorities are sensitive to data (mis)usage and user surveillance, leading to tension between potential benefits and sovereignty concerns. For instance, interviewee I5 emphasizes the platform provider’s responsibility in the event of data protection violations within the ecosystem.

Governance dimension #5 *pricing and revenue* identifies tensions related to the economic perspective. The first tension addresses how to secure financing for the ecosystem (I3). As the government acts as the orchestrator, education stakeholders generally agree that financial contributions from public funds are necessary. However, opinions on the participation of ecosystem actors in financing are more varied. Individual learners and teachers as well as representatives of education administration, in particular, are skeptical about co-financing by ecosystem actors. Several participants of the stakeholder survey noted their preference for complete government funding. Interviewee I6 said, the financing depends on the type of the ecosystem offerings and what benefits it generates.

The second tension of this dimension explores how potential ecosystem actor co-financing contributions should be designed (I4). Here, various options are possible, such as transaction fees for intermediation services or flat ecosystem access fees. The majority can only envision a financial contribution from private actors if they play an active role in the education ecosystem. However, private actors’ willingness to contribute financially depends on the perceived added value of the ecosystem, making them rather skeptical about the approach, even though they are accustomed to financially contributing when being part of private platforms and educational ecosystems.

Governance dimension #6 *decision and control rights* sheds light on incentives and obligations of ecosystem actors. To build a successful education ecosystem, the government as an orchestrator must motivate a diverse range of actors. There is a tension between positive incentives, such as the added value provided by the ecosystem, and obligations that force ecosystem-critical actors (like public education institutions) to contribute to value creation (I5). From the government’s perspective, regulatory obligations are an effective tool, but they are often viewed critically by the affected actors due to their coercive nature. This creates a tension regarding the extent to which the orchestrator should

impose obligations and which actors should be subject to them. Interviewee I1 pointed out that imposing an obligation on schools to use the ecosystem might be feasible because of their subordination to the education ministries of the federal states, while the universities might resist because of their autonomy.

Further tension arises when the orchestrator offers services within its own ecosystem (I6). Private platforms like Google and Apple face criticism for self-preferencing and bundling services to their advantage (Gleiss et al., 2023a, b). Even if a government orchestrator has no commercial interests, potential self-preferencing or exclusive use of public collaboration tools or content can negatively impact similar offerings. Specifically, the promotion of open-source software and open educational resources may be perceived by commercial providers as preferential treatment by the orchestrator (I3).

Ecosystem actors have various perspectives on who should establish and enforce governance rules to prevent abuse within the education ecosystem (I7). Different options exist regarding the appropriate authority to ensure fair practices and protect the interests of all participants. Interviewee I1 suggested that the community should play a role; some decisions should be left to it, due to the fact that many things cannot be judged externally. Moreover, interviewee I3 pointed out that it should be a public ecosystem, and (too many) top-down decisions would make it vulnerable. Both private and non-profit organizations and education researchers stress the importance of an ecosystem that remains largely independent of excessive government influence. This autonomy is viewed as essential for a successful implementation and for safeguarding against potential political misuse.

Governance dimension #7 *ownership* finally describes the design of the orchestrator and a (data) platform provider, emphasizing a tension in the provider’s autonomy relative to the government orchestrator (I8). A low level of autonomy, subject to political processes, can lead to inefficiencies or inappropriate political influence due to tight administrative control and a lack of (technical) capabilities. On the other hand, a high degree of autonomy and possible privatization of the data platform provider risks neglecting public interests, allowing commercial interests to dominate critical roles and activities of the NDEE. In every case, the question of market regulation and political decisions would play an important role, as interviewee I6 highlighted. According to our data and the findings of Meijer and Boon (2021), there is a tension in assigning the role of the (data) platform provider to a government organization, to a private organization, or to the public or a non-profit body (I9).

Based on our identification of 19 tensions across seven governance dimensions, we have identified four overarching groups of tensions that encapsulate the challenges faced

when a government orchestrator initiates an NDEE from the perspective of education stakeholders. These four tension groups encompass well-documented tension dimensions such as learning, belonging, performing, and organizing tensions found in academic literature (Smith & Lewis, 2011). Table 2 summarizes the tensions and identified group tensions:

A *learning tension group* revolves around the dilemma between *building on top of the current status quo* and *innovating with new approaches*. Education actors often debate whether to leverage existing systems and practices or to push for transformative changes that could redefine the educational landscape. A *belonging tension group* confronts the balance between prioritizing value capture or enhancing interoperability. This example illustrates a trade-off: building and enhancing interoperability can reduce lock-in effects, which may limit individual actors' ability to capture value. However, it simultaneously opens up new opportunities for value creation across the entire ecosystem. A *performing tension group* centers on the conflicting interests between individual stakeholders' self-interests and the collective interests of the ecosystem. It highlights the challenge of aligning personal motivations, such as organizational success or personal data sovereignty, with overarching, common goals. Resolving this tension group requires fostering collaboration and shared responsibility among diverse actors. An *organizing tension group* underscores the trade-off between making efficient decisions and maintaining legitimate decision-making processes and control rights within

the NDEE governance framework. This includes the choice between decentralized and centralized governance mechanisms. Navigating these tension groups requires a nuanced approach that acknowledges diverse perspectives and priorities. By addressing these tensions thoughtfully, government orchestrators and education actors can collaboratively shape the value creation to promote innovation, inclusivity, and sustainability of the NDEE. In the following analysis, we examine the four group tensions using survey results from the perspective of stakeholder groups.

Mapping orchestration tensions to stakeholder preferences

We use the four identified tension groups to analyze stakeholder preferences at the group level, highlighting the issues that reveal the most significant differences in positions. This provides insights into the preferences of ecosystem actors, helping to identify holistic ecosystem visions. It also sheds light on the government orchestrator to resolve identified orchestration tensions.

Stakeholder perspective on learning tension group

The first group of tension revolves around the dilemma between *building on top of the current status quo* and *innovating with new approaches*. Here, we investigate the impact of the NDEE and central platform components on the existing offerings in the education ecosystem. Figure 3

Table 2 Mapping of identified orchestration tensions to tension groups

Identified government orchestration tensions	Tension group
(3) Degree of digital transforming the current education system	Learning tension group
(4) Function scope and role of the platform and ecosystem	
(8) Used data formats and technical standards	
(9) Inventing new vs. using existing boundary resources	
(1) Involvement of private actors	Belonging tension group
(2) Preferencing open educational resources	
(5) Degree of ecosystem reach	
(13) Public financing vs actor co-financing	
(14) Design of ecosystem actor co-financing contributions	Performing tension group
(6) Degree of ecosystem openness	
(7) Efforts to fulfill digital inclusion and literacy	
(12) Level-playing field between education service providers and users	
(15) Usage obligations for institutional actors	Organizing tension group
(16) Prohibition of platform service self-preferencing	
(10) Organizational responsibility for providing boundary resources	
(11) Responsibilities across education segments and public administration levels	
(17) Governance rule setting, enforcement, and misuse handling	
(18) Autonomy of the platform provider from the government orchestrator	
(19) Platform provider ownership between government and non-government actors	

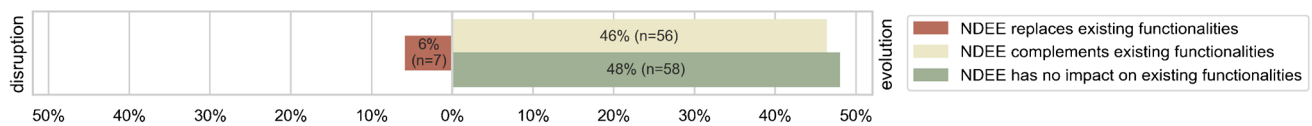


Fig. 3 Shall the NDEE replace or complement existing offerings?

describes the survey response to the exemplary question of whether the NDEE shall replace or complement existing educational offerings (single choice).

Across all institutional stakeholder groups, a clear pattern emerges: existing solutions and activities should be built upon rather than replaced by new services and structures with the initiation of the NDEE. Only about 6% of respondents favor replacing existing functions with new ecosystem offerings. Notably, teachers are disproportionately represented among these respondents. Our qualitative data gathering revealed their skepticism toward the value of current digital education offerings, which may explain their desire to replace existing functionalities. In our validation workshops, we explored possible reasons for this position. Frustration with current education offerings and technical solutions within the public education segments and a desire for clear guidelines on their use were identified as potential explanations. These reasons reflect a desire for digitization efforts in the education sector to better address user interests and deliver genuine added value. Primarily, they hope for a practicable and functional solution. For example, one of the teachers surveyed hoped for “fast and easy access to educational material integrated in the learning management systems of universities.” This insight is reinforced by the pattern observed in our survey, where learners, teachers, associations, and civil society education stakeholders express a preference for the NDEE and its associated offerings to enhance and improve existing functionalities within the education system.

Conversely, about 48% of respondents believe that the creation of the NDEE and its associated functionalities should not impact existing educational offerings and functionalities. This suggests that the NDEE should focus on addressing gaps in current offerings that are either overlooked or have limited interaction with organizations and sector-specific digitization initiatives due to its cross-organizational ecosystem approach. The actor’s responses indicate that representatives of education policy, particularly from the education ministries and authorities of the federal states—who are primarily responsible for educational digitalization in Germany—support this position. This highlights the tension between the federal government’s desire to initiate the NDEE and the autonomy and responsibility of the federal states. This raises the question of how the NDEE can add value to institutional education

actors if these actors do not foresee that the NDEE should affect their current activities or existing functionalities.

Furthermore, commercial education providers share a more similar perspective than education policy stakeholders regarding the impact of the NDEE on existing functionalities. In our research, we observed a tension regarding whether commercial actors should be part of the NDEE ecosystem, which may explain their response behavior. Additionally, our qualitative data collection revealed skepticism among these actors about whether the government is capable of successfully orchestrating such a large-scale initiative. Furthermore, commercial actors expect the NDEE to generate added value without interfering with or reshaping existing offerings, especially in terms of the use and preference of educational resources (I3).

Stakeholder perspective on belonging tension group

The second group of tensions confronts the balance between *commercializing educational ecosystems* and *prioritizing public value*. Here, we asked stakeholders whether there should be opportunities to generate revenue within the education ecosystem for associated (platform) offerings. Figure 4 consolidates the responses in “no revenue” (green), “revenue from own services” (red), or “revenue from mediation” (yellow), grouped by stakeholder and sorted by decreasing refusal of revenues.

Mediation includes functionality to access content and tool offerings; own services offered by the platforms may include content, tools, or other services. Multiple answers were possible for revenue options (left); however, selecting “no revenue” (right) prevents choosing any individual options (left).

The majority of respondents—including learners, teachers, public administration representatives, associations, civil society education stakeholders, and education policy decision-makers—express skepticism about generating revenues through mediation and content provision. In contrast, academic representatives and, notably, commercial entities within the potential ecosystem view revenue generation from the ecosystem as a possible option.

Regarding the various revenue options for content provision and mediation, stakeholders—excluding those from the public sector and education policy—generally view both options as equally desirable or undesirable. Representatives from education policy and public administration are notably

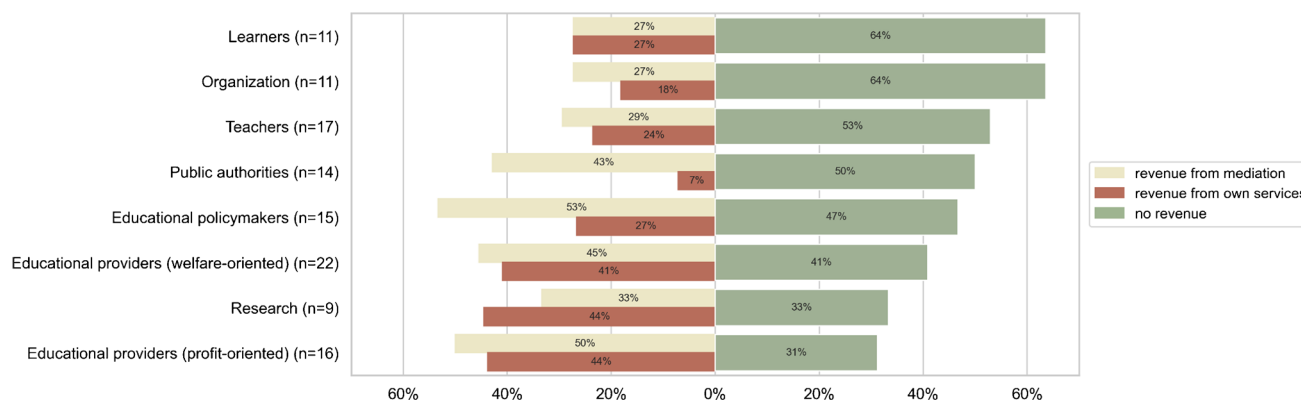


Fig. 4 Stakeholder positions on revenue options in an NDEE (independently of other, possibly paid offers)

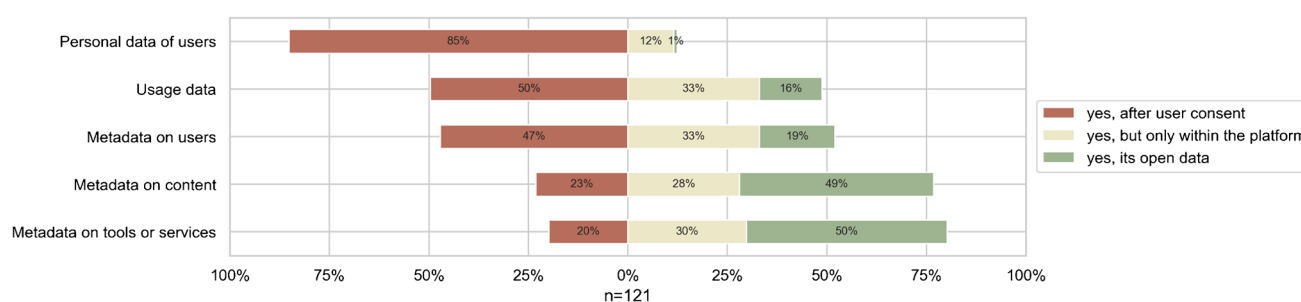


Fig. 5 Opinions on data sharing with a NDEE across all stakeholder groups

more critical of the platform as a competitor in the educational market that offers its own content or services.

Stakeholder perspective on performing tension group

The third group of tensions centers on conflicts between *individual stakeholders' self-interests* or the *collective interests of the education ecosystem*. The utilization of data generated by various actors within the ecosystem is crucial in this context. We survey the stakeholder groups whether and which data generated within the ecosystem should be utilized. Figure 5 explores if and which data should be shared within the ecosystem, grouped by data type and sorted by decreasing caution (single choice).

Note: The missing percentage to reach 100% is categorized as “no preference/no idea” and not depicted here. A pattern emerges that indicates that the more personal the data, the higher the barriers to sharing it should be. These barriers may include regulatory restrictions on specific use cases, such as sharing data about minors, or the need for user consent before data can be shared. The alignment of interests between individual data contributors and potential data users varies across different forms of metadata, depending on their intended functions.

Having a closer look at the data types, there is a broad consensus of personal data to be protected. Also, metadata related to content and tools with minimal personal reference should be shared openly within the ecosystem to maximize collective benefits. Both data contributors and data users generally agree on this approach.

However, a different pattern can be found for metadata of users (like age, last degree, place of living), which might be considered to be anonymous to some extent, yet still yielding when shared. Figure 6 depicts the opinion of single stakeholder groups on sharing user metadata, sorted by decreasing caution (single choice).

Note: As before, the missing percentage to reach 100% is categorized as “no preference/no idea” and not depicted here. A clear pattern emerges: individual users are generally more skeptical about the use of their metadata by other players in the ecosystem. Individual users, including teachers and learners, want to actively give their consent for data sharing and receive clear transparency about how their data is being used. Educational decision-makers and public administrators also express skepticism about the sharing of user metadata. This perspective is crucial for designing the NDEE, as these stakeholders will set the framework conditions and oversee the orchestration of

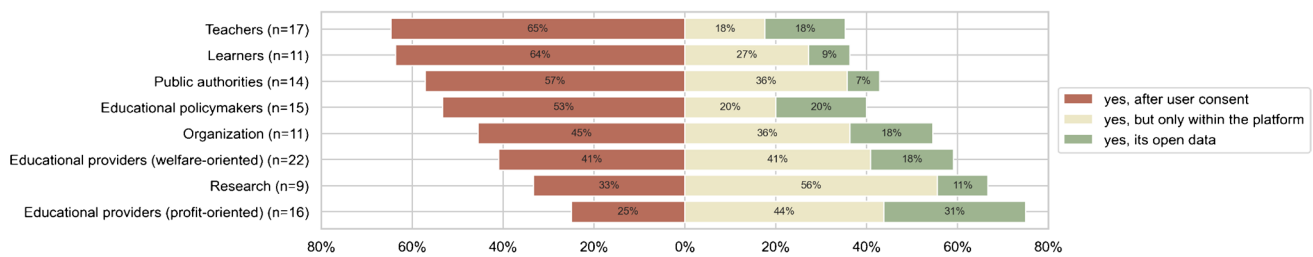


Fig. 6 Opinions on sharing user metadata within the NDEE

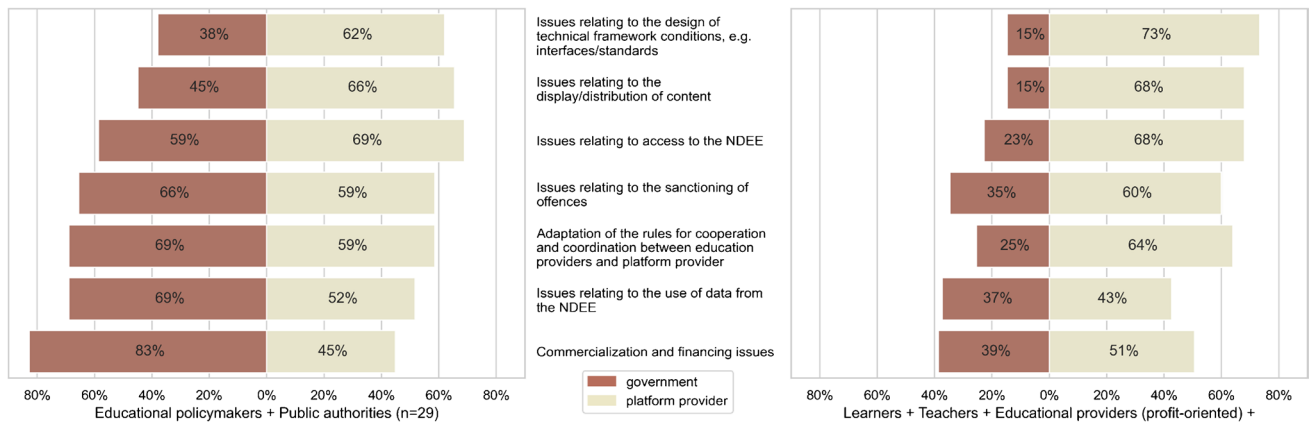


Fig. 7 Stakeholder positions on responsibility for rule setting in different governance areas; governmental actors (left) and all other stakeholder groups (right)

the education ecosystem. They must balance individual data protection with the potential benefits of personalized offerings. In contrast to individual users and decision-makers and public administration officials, educational content and tool providers have a strong interest in data to enhance their offerings and deliver personalized services that can improve educational quality. This desire for data is consistent across both non-profit and commercial providers, although commercial players tend to have a slightly stronger inclination to utilize data. This demonstrates that, even though such data is generated by individual actors, its aggregation provides valuable insights that can lead to improved offerings for the entire ecosystem.

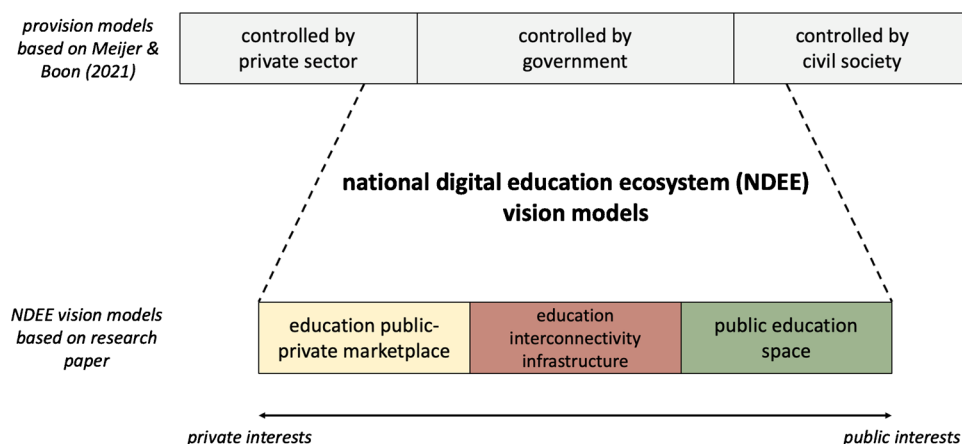
Individual users, educational decision-makers, and public administrators seek greater control over data use, while education and tool providers—who benefit from data—favor a more open and streamlined exchange to enhance the quality of offerings within the ecosystem. This highlights the need to balance individual interests with those of providers in the orchestration process, addressing the tension between individual sovereignty and the collective value of the ecosystem.

Stakeholder perspective on organizing tension group

The fourth group of tensions underscores the trade-off between *making efficient decisions* and *maintaining legitimate decision-making processes* and control rights within the NDEE governance framework. It explores who should make critical decisions regarding ecosystem governance and which actors should be responsible for operating critical components of the NDEE such as central platforms. Figure 7 provides a deeper look into the answers to our question, who should draw up the rules for the NDEE. We only selected the options “government” and “platform provider”; three other options were available (“external authorities/specialists,” “community of users and providers,” or “others”). We contrasted the positions of governmental stakeholders (left) with all other stakeholder groups (right), sorted by increasing preference for the responsibility of the government (multiple choice).

Education policymakers and public administration representatives (state actors) favor themselves as responsible for defining who should have access to the ecosystem, enforcing sanctions for misuse, setting interaction rules between ecosystem actors, defining data-sharing policies, and the commercialization and financing of the ecosystem.

Fig. 8 Refinement of the general governance models for the educational domain



However, non-government actors should be mainly responsible for standardizing and implementing the technical infrastructure and providing content and services within the ecosystem. In doing so, they reflect their established public administration modus operandi, wherein public actors define the requirements and framework conditions, while technical issues are typically handled by relevant (public) service providers.

Analyzing the perspectives of non-state actors, such as individual learners and teachers, non-profit and commercial education providers, and researchers, reveals a critical view of the responsibilities that should be undertaken by state actors. State actors, in particular, face criticism regarding their governance approach to access, enforcement of violations, and requirements for interaction between ecosystem players. There is a general desire for reduced state influence across all dimensions in comparison with the state actor perspective. Both actors agree that non-state actors should be responsible for technical and content issues. Non-state actors express a clear preference for their involvement in NDEE governance, advocating for collaborative governance involving state and non-state actors to participate in defining and enforcing policies. The varying assessments of responsibilities, competencies, and needed capabilities highlight the need for a collaborative approach. In summary, state actors should define the legal framework, while operational and technical tasks should be carried out by non-state actors or with at least their significant involvement.

The various ecosystem actor perspectives reveal differing views on the ecosystem vision and central governance issues, including the responsible actors, its financing, data sharing, and content control. This indicates the existence of multiple vision and implementation models, which contribute to resolving the tensions in one or the other way. Our study identified three distinct NDEE models, which are described in detail in the following section.

Three education ecosystem visions to manage orchestration tensions

Based on our analysis of government orchestration tensions and stakeholder preferences, we have identified three models for an NDEE vision. Referring to the provision models outlined by Meijer and Boon (2021), these three vision models describe national education ecosystems orchestrated and overseen by a government entity. The options of utilizing a private sector entity or an open platform operated by a civil society organization are not directly applicable in our case, given that the role of government in orchestrating the NDEE is politically defined and shapes the education actors' perspective. Figure 8 shows a schematic visualization of the interplay between Meijer and Boon's (2021) findings and our identified NDEE vision models. These models summarize those approaches to resolving the identified tensions that either favor private interests (yellow) or public interests (green) or that attempt to balance them out (red).

These NDEE vision models differ in their underlying ecosystem vision, value proposition, stakeholder preference, and how they address the identified groups of tensions.

Characterizing the value proposition of the vision models from stakeholder perspective

Ecosystem vision 1 represents a *public-private education marketplace* and has been characterized in one of the free text answers as a "marketplace for offers (courses; OER; books; other materials) that can be easily imported into one's own system." The open marketplace creates value by orchestrating supply and demand for public and private educational content and tools embedded in a learning collaboration space or as formulated in one of the free text answers by "matching of learners with offers." The ecosystem contains education institutions, content and tool providers, end-users, and service providers to process transactions, e.g., for payment. Beyond the involvement

of the government or public institutions and the platform provider, (commercial) marketplace participants can also contribute to the governance design and implementation through a community-based approach. There are claims that innovation in education would not be possible without such private sector involvement (Breitinger & Fritsche, 2021). The marketplace model facilitates a blend of public–private funding via for example transaction fees. For instance, the orchestrator could create an app-store-like model, generating income associated with intermediation services. Content quality control is based on market mechanisms; it aims to prevent misuse and helps prioritize its display. A striking message in support of this approach could be: “Innovation in education requires private sector players.”

Ecosystem vision 2 can be defined as a neutral *educational interconnectivity infrastructure*. One of the free text statements of our survey described this as “a technically stable, openly documented platform for simple and seamless integration.” The extensive technical integration of educational stakeholders enables learners and teachers to more easily access digital content and tools and, for instance, manage educational artifacts and acquired credentials. Therefore, the value of the ecosystem in model 2 lies in the digital education interconnection among stakeholders from a rather administrative perspective. Moreover, from an end-user perspective, the efficiency, transparency regarding personal data, and self-sovereign data control enhance the model’s value; this is particularly evident in the central role of a personal data wallet. Quality control may use a lightweight approach via certifying providers rather than single content or tools. Given the ecosystem’s narrowed functional scope, which includes only interconnecting public and private educational institutions as well as content and tool providers, the primary governance actors are the government/public authority and the operator of the infrastructure, both funded by public resources. A benefit proposed in one of the free text answers could be “to enable and promote a greater willingness to integrate between the stakeholders in the German education system” and thus increase interoperability between education institutions enabling a seamless digital user-centric journey. The underlying narrative could be summarized as “We are committed to the federated nature of the German education system.”

Ecosystem vision 3 embodies a *public education space* that excludes commercial actors, focusing on enhancing open education and facilitating interconnections among public education institutions in a kind of safe space. Therefore, the core resources are the OER content and a collaboration space based on non-commercial offerings, clearly marked as “OER offer instead of a marketplace,” “exchange forum,” “without the intention of making a profit,” and “free from tracking and third-party providers” in the free text answers. This ecosystem vision represents a

digital sovereignty strategy aimed at reducing educational stakeholders’ dependence on commercial actors. Funding for this vision model comes from public sources, and governance actors are not only government/public authorities and the platform operator but also require active participation from the non-profit community and education experts. This collaboration is crucial for ensuring the quality control of educational offerings. A claim in favor of this model could be “Innovative pedagogy is open and undefined and therefore requires safe spaces.”

Stakeholder preferences of the NDEE vision models

Ecosystem vision model 1, characterized by an open education public–private marketplace, is preferred by private actors because it positions them as integral to the ecosystem and provides a sales channel that stimulates digital demand for their offerings. Private actors appreciate how this model adapts familiar market mechanisms to a government-orchestrated NDEE. The platform consolidates public and private content and services, making them easily accessible and enhancing value for learners and educators. However, this vision model also signifies a move toward commercialization in the educational sector, sparking debates on the benefits and risks of involving private sector players (Kerssens & van Dijk, 2022). Public education stakeholders and scholars often oppose this trend (Deimann, 2019).

In ecosystem vision model 2, the education interconnectivity infrastructure generates added value for the ecosystem actors without displacing existing educational offerings or markets. This approach is crucial for current education platforms and solutions, as it complements rather than disrupts the existing educational landscape. Governmental stakeholders may favor this model due to its straightforward governance structure, which is appealing in complex educational environments. Educational institutions already engaged in extensive digitization initiatives find this model advantageous as it allows them to continue advancing autonomously. This aspect is particularly significant given the federated structure of the German education system, where federal influence indirectly shapes educational practices through the states.

In ecosystem vision model 3, which represents a public education space, public education institutions and advocates for open education play a pivotal role, motivated by their interests and political goals to align with the vision of an NDEE. This model emphasizes public stewardship as an alternative to private educational ecosystems, reinforcing digital sovereignty and public interests. Public education stakeholders and scholars often advocate for this model to bolster public education institutions, content quality, and educational equity ideals (Deimann, 2019).

Table 3 Mapping identified groups of tensions and the three ecosystem vision models

Ecosystem Vision Models	1. Public–Private Education Marketplace	2. Education Interconnectivity Infrastructure	3. Public Education Space
<i>Learning group tension:</i> building on top of the current status quo or innovating with a new approach	Innovating with new offering	Building on top of existing offerings	Innovating with new offering
<i>Belonging group tension:</i> prioritizing value capture or interoperability	Prioritizing private value capture	Prioritizing interoperability	Prioritizing public value capture
<i>Performing group tension:</i> focusing on individual stakeholders' self-interests or shared collective interests	Focusing on individual stakeholders' self-interests	Focusing on shared collective interests of the education ecosystem	Focusing on shared collective stakeholder interests
<i>Organizing group tension:</i> using decentralized or centralized governance mechanisms	Decentralized market mechanism	Centralized principal-agent mechanism	Decentralized non-market mechanism

Conceptualizing ecosystem vision models based on the identified groups of tensions

Mapping the identified group tensions with the three ecosystem vision models reveals that each vision adopts distinct characteristics to address these tensions. Table 3 provides an overview of these characteristics and maps the four identified group tensions “learning,” “belonging,” “performing,” and “organizing” to the three ecosystem vision models.

Examining the three education ecosystem vision models reveals that, despite differences in how they balance public and private interests and vary in scope, they are also interdependent and build upon each other. From the perspective of the government ecosystem orchestrator, the foundational data infrastructure conditions must be established to enable the emergence of an education ecosystem that addresses the identified orchestration tensions and creates a unified ecosystem vision based on three stakeholder vision models. Whether the unified target vision of the government orchestrator is a “Public Education Space” or a “Public–Private Education Marketplace,” the first step is to create an “Education Interconnectivity Infrastructure,” as it is a foundational requirement. This interplay underscores that the government’s orchestration capabilities are essential for establishing a digital education ecosystem, irrespective of the chosen vision model for that ecosystem (Lucke, 2024). This decision forms the foundation of the three identified ecosystem vision models, each requiring distinct orchestration capabilities and governance structures.

Discussion

Theoretical implications

As data ecosystems have gained traction in practice and research within the private sector, the initiative to establish a NDEE by the German federal government underscores the concept’s growing significance in the public sector. Governments are now beginning to orchestrate data ecosystems modeled after private sector practices, which holds the potential to significantly reshape relationships among ecosystem actors and enhance value generation. Government orchestration initiatives in healthcare, digital identities, and education exemplify the government’s evolving role as an orchestrator of data exchange and infrastructure provision, aimed at enhancing digital value creation while safeguarding public interests (Kari et al., 2024; Gleiss et al., 2023a, Degen & Teubner et al., 2024).

Our research sheds light on the development of an NDEE and the complexities involved in the government orchestration of autonomous ecosystem actors. The emergence phase is particularly critical, as it determines whether an initiative generates added value and whether the orchestrator gains the necessary support from ecosystem actors for success (Möller et al., 2024). We identify government orchestration capabilities and effective and legitimate ecosystem governance as critical building blocks for governments. Our 19 identified tensions for orchestrating an NDEE, which culminate in four groups of tensions, illustrate the diverse cooperative and competitive challenges the government orchestrator must address.

Our four identified tension groups confirm that the known tension dimensions of learning, belonging, performing, and organizing shape the relationships among ecosystem actors also in the educational sector (Mini & Widjaja, 2019; Smith & Lewis, 2011). However, we also observe a notable clash in IS research well-known data-sharing tensions between (private) education providers' interest toward data utilization and public stakeholders' and individuals' goal of stringent data protection and control (e.g., Jussen et al., 2024; Scherenberg et al., 2024). We corroborate similar findings from other regulated data space initiatives, e.g., in the healthcare sector (Kari et al., 2024). Our identified tensions surrounding the need for data sovereignty, particularly from the perspective of individuals versus other organizations, and the delicate balance between individual and collective interests underscore the necessity for technical, socio-technical, and regulatory solutions (Degen & Teubner, 2024; Scherenberg et al., 2024). This further emphasizes the importance of research that conceptualizes their complex interplay and implications from an interdisciplinary perspective.

Furthermore, depending on the ecosystem scope, tensions emerge concerning the integration of private actors within the public education sector. Clear role definitions and the development of viable operating and business models are essential for establishing a sustainable ecosystem and warrant further research. Experience from open data initiatives highlights that generating value, especially in collaboration with private actors, poses challenges due to issues like mistrust, conflicting interests, and simply a mismatch between provided data by governments and needed data for private sector innovation (Zuiderwijk et al., 2016). To successfully integrate private education actors into a NDEE, if this aligns with the ecosystem vision, it is essential to consider their needs from a government orchestration perspective. This approach not only increases added value creation but also reduces the risk of failure.

Collaborative governance involving the government, civic society, and private actors is necessary to reduce such failures. Here, our ecosystem perspective research confirms the findings by Klievink et al. (2016) and Janssen and Estevez (2013) that governments should consider outside-in transformation to leverage external developments or private sector innovations. However, in view of the sovereign, public welfare-oriented nature of the education system, caution is required when transferring the results of private ecosystem governance models to this domain (Ostrom, 1990). Therefore, in evolving the model by Meijer and Boon (2021), we simultaneously recommend a limitation of the outer margins of that governance spectrum as well as an internal differentiation of its middle area focusing on provisions controlled by the government. In any case, governance issues like the decision on central governance actors (such as an ecosystem orchestrator) and financing models are of key importance

and should therefore be quickly and transparently determined by the government.

Our study confirms that the government orchestration of data ecosystems and underlying infrastructures are a research area that needs further exploration due to the profound implications of these initiatives and the evolving role of governments in the digital transformation of public administrations, the economy, and society. We confirm and highlight Gupta et al.'s (2020) findings from the Smart City and Open Data domains, emphasizing the critical importance of developing a vision for the orchestrated ecosystem and the need for new dynamic capabilities for governments to implement it effectively. Orchestration becomes a crucial managerial task for public administrations and education organizations, enabling the efficient delivery of digital services that generate public value across diverse public–private domains (Cordella & Paletti, 2019; Degen & Teubner, 2024).

Policy and practical implications

Our analysis of the orchestration tensions and stakeholder preferences shaping the three ecosystem vision models highlights the critical need for a clear vision and a well-defined ecosystem scope—elements currently lacking in the German federal government's approach. These elements are critical for designing a legitimate and efficient governance system for a government-initiated national education ecosystem from the stakeholders' perspective. It is difficult to achieve this alignment bottom-up due to various stakeholders' different needs and interests. Therefore, the government must define an ecosystem vision, value-creating mechanisms, and boundary resources similarly to how private platforms and data ecosystems are orchestrated. Due to the complexity of the task, it is crucial to involve the ecosystem actors from the beginning and to create collaborative governance forms between public organizations, civic society, and private actors (if not for the implementation of the marketplace model, then at least as a platform operator or technology service provider). Significant heterogeneity, stemming from divergent goals and interests, complicates the establishment of a flourishing NDEE. Consequently, it is essential for the government, as the NDEE orchestrator, to adopt a more assertive, top-down approach in shaping this complex ecosystem. Legislative support could further strengthen these efforts.

Our research inquiry highlights that traditional education governance conflicts known from the analog world also exist in the digital realm. In addition to the tension between public and private interests in the education sector (Williamsen, 2016a), a cultural imprint on the education sector and public administration tradition is also decisive here (Bevir et al.,

2003). With a federal administrative system and an education system dominated by public institutions, Germany might have different ecosystem actor interests than an Anglo-Saxon digital education ecosystem in which private actors and, in the case of the UK, a centralized public administration play a more prominent role. In addition, existing higher education governance models like academic self-governance, the state-centered model, and a market-oriented approach are also reflected in the debate on how to orchestrate a NDEE initiated by a government (Dobbins et al., 2011). These results indicate that the orchestration challenges an NDEE faces involve navigating existing governance conflicts and models rather than establishing entirely new ones.

Furthermore, our research highlights that education actors' intentions for shaping the vision and governance of an NDEE depend on their own self-perception. This means, for example, that private education providers, which are market-driven, prefer a market-based governance design. In contrast, representatives of public administration and advocates for open education particularly favor government policies over market mechanisms. At the same time, this conclusion also means that when shaping the vision and governance of an NDEE, the ecosystem actors look at the requirements of a national education governance structure less from the perspective of a shared vision but instead try to anchor their interests, modes of operation, and structures of power.

This increases the risk that political compromises between education actor interests will form the basis for the government orchestration strategy in initiating a NDEE in Germany to ensure the initiative's legitimacy. In this case, however, necessary measures for effective orchestration may be neglected due to controversy, e.g., a (partial) usage obligation for specific user groups, making the creation of a flourishing ecosystem more difficult. Research on large public IT infrastructure projects shows the same pattern, explaining the number of implementations that fail due to low user relevance, e.g., in the healthcare sector or digital identities (Anthopoulos et al., 2016; Walke et al., 2023).

In essence, when designing the vision and ecosystem governance for an NDEE, governments must find a balance between the autonomy of the government orchestrator toward the government (efficiency) and the involvement of various ecosystem actors in the orchestration process (legitimacy). Maintaining this balance under changing conditions requires regular monitoring and adjustments. Our identified ecosystem vision models can serve as a strategic roadmap for the phased development of a NDEE. This process currently begins with a neutral education interconnectivity infrastructure (vision model 2). However, since characteristics of both other approaches are still very visible in the public discourse on the NDEE, but are mutually exclusive, there is a strong need for a transition to either vision model 1 or 3 bearing a more distinct value proposition. The effectiveness

of government orchestration and the legitimacy of the NDEE initiative are essential for creating a thriving, government-initiated digital education ecosystem that generates public value and social welfare. Instead of pursuing an elusive balance between private and public interests in digital education, governments should prioritize fostering collaboration grounded in a shared ecosystem vision, supported by collaborative governance and orchestration capabilities that extend beyond the current practices of government actors.

Limitations

Through our mixed-methods approach, which includes semi-structured interviews, workshops, and a stakeholder survey, we have employed a variety of methodologies to gather comprehensive data on our research phenomenon. This diversity in data collection and the triangulation of methods helped minimize potential biases, resulting in robust empirical findings. However empirical research, including our study, inherently faces certain limitations. First, our interview sample contains expert stakeholders involved in the BIRD research project, which represent critical education stakeholders and have a lot of expertise but do not fully represent the broader range of views within the education stakeholder landscape. Second, our stakeholder survey was not fully representative as certain stakeholder groups were underrepresented. Moreover, in view of the overlapping of different roles, the survey results cannot always be precisely assigned to all relevant stakeholder groups. Public authorities, for instance, responded to the survey but often did not mark this as their primary role. They declared themselves to be rather policymakers or individual learners. We see a similar reluctance on the part of political actors to comment publicly on NDEE governance issues. Also, we achieved a high dropout rate and incomplete responses. While this might be explained due to the technical survey design and the complexity of the research topic, it can lead to potential biases in the data collection process. Third, while our data analysis process might reflect some author biases due to our own expectations, we took proactive measures to ensure a balanced approach. We involved several team members with diverse professional backgrounds and conducted various individual and collective analysis steps to minimize any potential distortions. Fourth, the integration of qualitative and quantitative data requires careful triangulation. While triangulation is intended to enhance validity, it can also complicate the analysis and interpretation of results, potentially leading to overgeneralization or misinterpretation. To optimize our triangulation process, we validated our results with stakeholders from various educational institutions multiple times. The chosen workshop format facilitated intensive discussions, ensured broad stakeholder representation, and enhanced the validity of our findings.

Summary and outlook

In this study, we have examined the visions of German education actors for the NDEE and the tensions the government must address to align these various interests to successfully initiate an education data space. Given the initiative's complexity and its significant impact on various actors within the education system, we have identified 19 orchestration tensions. Aggregating the identified tensions led us to four groups of tensions that describe the critical orchestration decisions the government must make to craft an ecosystem vision and align the autonomous education actors. The identified tension groups are as follows:

- Maintaining the current status quo versus innovating with a new approach
- Prioritizing value capture versus fostering interoperability, thereby balancing ecosystem commercialization with a focus on public value
- Emphasizing individual stakeholders' self-interests versus promoting shared collective interests
- Balancing efficient, legitimate decision-making, and control rights, resulting in either more centralized or decentralized governance mechanisms

This illustrates the complex balancing act required in designing the NDEE, navigating cooperative and competitive tensions that influence conflict areas identified in academic tensions literature, including learning, belonging, performance, and organizational dynamics.

Educational stakeholders have varying preferences on how the government orchestrator should approach these issues. First, we found that the majority of stakeholders view the NDEE as a supplement to existing functionalities and solutions in education, rather than a replacement for, e.g., existing education platforms provided by the federal states. Secondly, private education stakeholders see themselves as part of the NDEE and consider it a potential revenue source for their offerings. Conversely, there are efforts, especially by civil society, researchers, and some education policy actors, to leverage the NDEE to strengthen open education. Third, we observed empirical evidence of known data-sharing conflicts between individual data sovereignty and the collective added value of using data to improve educational services. Fourth, we identified that education policymakers and public administration representatives place greater emphasis on their role in shaping NDEE governance compared to non-state actors (e.g., educational providers, learners, teachers). Non-government actors are more critical of government orchestration capabilities and advocate for more collaborative governance that includes civil society, academia, and private actors to successfully initiate the NDEE.

We identified three government-initiated NDEE vision models that provide a coherent approach for the government orchestrator to develop an ecosystem vision that aligns with the interests of educational actors and effectively addresses orchestration tensions through a coherent approach. The vision models vary in terms of ecosystem scope, key actors, and resources, as well as needed ecosystem governance, which focuses on decision-making, financing, and the role of data:

- Ecosystem vision 1 represents an open public–private education marketplace ecosystem based on a transaction platform that generates transactions and collaboration between multiple actor groups.
- Ecosystem vision 2 describes an educational interconnectivity infrastructure that creates a seamless digital education user journey and enables self-sovereign data control.
- In contrast, ecosystem vision 3, a public education space, can be defined as a protected safe space for open education based on free content and tools with equal access for all.

All positions are justified from certain points of view. Hence, the stakeholders mirror their own *modus operandi* as a basis for designing a national digital education ecosystem vision, which makes a political negotiation process indispensable.

Our study sets a foundation for further critical and constructive work on designing an NDEE in Germany and beyond. While our data and findings are specific to Germany, the identified tensions and ecosystem visions can serve as a foundation for national discussions in other countries. Similarly, these insights are applicable to other data ecosystems and space initiatives, particularly in regulated industry domains. Our research highlights the necessity for ongoing dialogue among education stakeholders and the government orchestrator to develop and support preferred ecosystem visions and governance models. Additionally, it highlights the need for the government to effectively communicate and coordinate these processes with the public, requiring robust orchestration capabilities. Genuine participation needs more than open discussion formats but requires specific mechanisms of empowerment, especially for actors who perceive themselves as having little voice. The study's methodology and insights are also relevant for other public sector domains facing similar digital transformation challenges. The rise of government-initiated data ecosystems and underlying digital public infrastructures represents both a challenge and an opportunity, where governments must ensure that the digital transformation is shaped with the active involvement of the economy and the civic society. We could demonstrate that in doing so, the governance has

to be more closely aligned with the public interest to correct monopolizing value capture by private interests.

Acknowledging the limitations of our study and considering the ongoing development and political debate surrounding the German NDEE initiative, we advocate for further research. This research should specifically focus on the three ecosystem vision models identified in our paper. Our findings offer a foundation for further exploration through additional studies, which can address and overcome the limitations identified in our current research. On the one hand, this concerns the systematic composition of governance structures, e.g., on the basis of specific resources which are necessary for the fulfillment of certain tasks and can only be provided by certain actors. On the other hand, further elaboration of the narratives already indicated above is necessary in order to develop comprehensible justification structures for political decision-making and implementation processes from the pointed statements. This can be supported by quantitative studies for further exploration of existing opinion patterns and belief coalitions. Furthermore, research on government orchestration of public data ecosystems and digital public infrastructures should delve deeper into how the current transformation is reshaping the role and function of the digital state in relation to the economy and society, as well as the interplay between infrastructure provision and ecosystem governance. These efforts aim to improve the digital transformation of the education sector, striving for a balance between efficiency, transparency, and legitimacy to create value for public and private stakeholders in favor of digital societies.

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