Digital Sovereignty: Insights from Germany's Education Sector

Christoph Meinel, Michael Galbas, David Hagebölling

Technische Berichte Nr. 157

des Hasso-Plattner-Instituts für
Digital Engineering an der Universität Potsdam

Technical Reports of the Hasso-Plattner-Institute for
Digital Engineering at the University of Potsdam

Technical Reports of the Hasso-Plattner-Institute for
Digital Engineering at the University of Potsdam | 157

Christoph Meinel | Michael Galbas | David Hagebölling

Digital Sovereignty: Insights from Germany's Education Sector

Universitätsverlag Potsdam

Bibliographic information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available on the Internet via http://dnb.dnb.de/.

Universitätsverlag Potsdam 2023
http://verlag.ub.uni-potsdam.de/

Am Neuen Palais 10, 14469 Potsdam
Phone: +49 (0)331 977 2533 / Fax: 2292
Email: verlag@uni-potsdam.de

The series **Technische Berichte des Hasso-Plattner-Instituts für Digital Engineering an der Universität Potsdam** is edited by the professors of the Hasso Plattner Institute for Digital Engineering at the University of Potsdam.

ISSN (print) 1613-5652
ISSN (online) 2191-1665

Layout: Tobias Pape
Typesetting: Martin Sievers – Einfach schöner publizieren
Print: docupoint GmbH Magdeburg

ISBN 978-3-86956-561-3

Also published online on the publication server of the University of Potsdam:
https://doi.org/10.25932/publishup-59772
https://nbn-resolving.org/urn:nbn:de:kobv:517-opus4-597723

Digital technology offers significant political, economic, and societal opportunities. At the same time, the notion of digital sovereignty has become a leitmotif in German discourse. This concept is understood as the state's capacity to assume its responsibilities and safeguard society's – and the individual's – ability to shape the digital transformation in a self-determined way. The education sector is exemplary of the challenge faced by Germany, and indeed Europe. That is, harnessing the benefits of digital technology while navigating the concerns around sovereignty. The sector encompasses education as a core public good, a rapidly growing field of business, and growing pools of highly sensitive personal data. The report describes pathways to mitigating the tension between digitalization and sovereignty at three different levels – state, economy, and individual – through the lens of concrete technical projects in the education sector: the HPI Schul-Cloud (*state sovereignty*), the MERLOT data spaces (*economic sovereignty*), and the openHPI platform (*individual sovereignty*).

Contents

1 Introduction: Digitalization and Sovereignty

Digitalization is now arguably the most transformative force in our society. Already, a significant share of political campaigning and deliberation happens online through social media and news platforms. Germany's economic competitiveness increasingly depends on the ability of its industrial base to harness digital technology. The fabric of society is changing as more and more people interact with their families, friends, and colleagues through mobile phone and video conferencing applications.

Against this background, the notion of *digital sovereignty* has become a key theme in the German discourse on digital technology. Calls for digital sovereignty are now common in government strategies and a frequent reference point for commentaries from the business community and civil society [20]. Although the concept of digital sovereignty appears in a large variety of contexts, it generally underlines the nation-state as an important unit for the governance of digital technologies and infrastructures [43]. Crucially, in the context of the German debate, digital sovereignty captures the state's capacity to assume its responsibilities and safeguard society's – and the individual's – ability to shape the digital transformation in a self-determined way. Former chancellor Angela Merkel stressed this in her opening speech at the 2019 Internet Governance Forum in Berlin, where she also drew a clear distinction between the German understanding of digital sovereignty, on the one hand, and isolationism, protectionism, and censorship, on the other hand [21].

The debate around digital sovereignty is in many ways a natural reaction to the enormous speed with which digital technology, and particularly the internet, has expanded into almost all realms of political, economic, and social life. Yet, concerns about sovereignty are also driven by shifts in political and economic power that accompany the rapid advancement of digital technology. Today, a small set of non-European companies provides a significant share of the key technologies and infrastructures that underpin the digital transformation. Cloud computing, that is, the use of IT resources such as software, platforms, and computing power via the internet, is a point in case. Cloud computing forms the backbone of the ongoing digital transformation; yet, three major companies – Amazon, Microsoft and Google – alone account for about two-thirds of the entire global cloud market. US- or China-based industry giants such as IBM, Oracle, and Tencent dominate much of the remaining market share [44]. A similar picture presents itself in other key technology areas such as web search and social networks [4, 10]. More broadly, among the largest technology companies globally, only two are European: Dutch

ASML (12th) and German SAP (21th) [8]. The German digital sovereignty discourse reflects an aspiration to recalibrate these asymmetric dependencies, challenge the power and influence of large corporate players, and restore governments' ability to regulate digital technology in keeping with its citizens' interests and values.

The digital sovereignty discourse also indicates the increasing interlacing of technological dependencies with national security concerns. The 2013 Snowden revelations brought to the fore the extensive capacity of US intelligence agencies to collect and analyze data globally [34]. Early debates about digital sovereignty in Germany and other European states were a response to these revelations and problematized the extensive US control over digital infrastructures. However, the rapid ascend of China as an autocratically governed but highly capable technology power as well as Russia's invasion of Ukraine have both augmented and shifted concerns about digital sovereignty [2]. In this geopolitically deteriorating international environment, a comprehensive consideration of national security dimensions as well as opportunities for partnership with like-minded states are now central components of strategic debates about digital technology [23].

The nexus of digitalization and sovereignty is thus set to shape policymaking and technology trajectories well into this decade. As opposed to political discourses and conceptual debates on the matter, this report approaches digital sovereignty from the vantage point of technical implementation. Specifically, it focuses on the education sector, which represents an ideal laboratory for analysis given the intensity of sovereignty concerns around, among other things, the generation, storage, and analysis of sensitive personal data. To operationalize the concept of digital sovereignty, the report draws on the systematization of related policy measures along three key dimensions: state, economy, and individual [43, pages 8–13]. These dimensions provide the framework for the discussion of concrete technical projects developed and implemented by the Hasso Plattner Institute for Digital Engineering (HPI) and which contribute to digital sovereignty. Notably, the report's discussion of these cases draws on the authors' first-hand insights from managing and implementing these technology projects at the HPI.

We begin with a brief synopsis of the concept of digital sovereignty and introduce its three dimensions – state, economy, and individual – as an analytical framework for this study. Afterwards, we examine pathways to mitigating the tension between digitalization and sovereignty through three technology case studies: HPI SchulCloud (today offered as dBildungscloud), MERLOT, and openHPI. In the final section, our report situates its findings within the larger European digital policy debate and develops several recommendations for strengthening digital sovereignty in ways that align with the EU's openness and crucial international partnerships, especially with the United States.

2 Digital Sovereignty: State, Economy, and Individual

As digitalization is changing political campaigning and deliberation, disrupting economic value creation, and transforming modern societies, it is also raising concerns about digital sovereignty in Germany and other parts of Europe. However, the notion of digital sovereignty is multi-faceted and varies somewhat depending on the context within which it is used.

Given its considerable conceptual complexity, digital sovereignty is the object of a growing body of academic literature. A common element is the understanding that sovereignty refers to an actor's, or unit's (e.g., the state), ability to act in a manner that is self-determined – as opposed to externally determined. Historically, this understanding is rooted in the work of 16th century political theorist Jean Bodin who held that decision-making power must be undivided, or else the ruler holding it would not be fully sovereign [6]. With the advent of Enlightenment philosophers like Thomas Hobbes, John Locke, and Jean-Jacques Rousseau, this absolutist notion gave way to an understanding of the people as the sovereign and the government as a distinct body, entrusted with power by the people's consent [27, 36, 46]. Today, the idea of territoriality as integral to modern notions of (state) sovereignty can conflict with the global scale of digital connectivity and related transnational interdependencies [32]. Indeed, in the context of digital technology, sovereignty currently tends to be conceptualized more pragmatically as the capacity for self-determination that lies between external determination and territorially defined autarky [33, pages 6–7].

This capacity for self-determination – and its realization as a condition for the rule of law – is a defining characteristic of the digital sovereignty discourse in modern democratic societies. Accordingly, in the German context, digital sovereignty captures the state's capacity to assume its responsibilities, including protecting its citizens' inalienable rights, and safeguard society's – and, broadly, individuals' – ability to shape the digital transformation in a self-determined way. Indeed, based on the recommendation of the Competence Center Public IT (Kompetenzzentrum Öffentliche IT), the Federal Government CIO describes digital sovereignty as "the sum of all abilities and possibilities of individuals and institutions to exercise their role(s) in the digital world in an independent, self-determined and secure manner."[1] [7, 22] According to this understanding of digital sovereignty, the report systematizes related policy measures along three key dimensions: state, economy, and individual. In this respect, it draws on Julia Pohle's and Thorsten Thiel's work,

[1] Authors' translation.

which integrates conceptual discussions with a pragmatic operationalization of the notion of digital sovereignty in the German and European context [43].

Digital sovereignty at the state level hinges on a conception of the state as the guarantor of public security and integrity of a defined territory [43, pages 8–10]. In the digital realm, this includes, among other things, the protection of key digital infrastructure and systems against malicious cyber activities. Such cyber protection also extends to critical infrastructures more broadly, where physical and digital systems increasingly interlink, such as in the energy, water, and transportation sectors.[2] To achieve this, government policies and instruments include, for example, cyber defensive capacities, data localization requirements, and cybersecurity obligations for operators of critical infrastructures. Digital sovereignty at the state level also encompasses the acquisition of trustworthy IT products for public administration. This includes, for example, political and governance criteria for procurement and requirements regarding open standards and open source to prevent vendor lock-in. Overall, digital sovereignty at the state level describes the bolstering of states' capacity to act and enforce the rule of law in the digital world.

The economic dimension of digital sovereignty revolves primarily around questions of strategic dependencies [43, pages 10–11]. German and European concerns about (asymmetric) dependencies are directly connected with the dominance of foreign companies across technology fields, such as cloud computing, online platforms, and semiconductor manufacturing. The efforts towards creating a digital single market in the EU exemplify policies that aim to tackle this dimension of digital sovereignty. Those include the creation of a performant and secure digital infrastructure, common regulations, and Europe-wide standardization and interoperability, for instance in the realm of data spaces and cloud infrastructures [13]. Beyond this, policies also encompass areas such as the provision of secure electronic identification and authentication and trust services to provide a framework for facilitating the digitalization of business relationships and products.

Finally, the individual and its ability to make self-determined choices in a digitalizing world is a crucial, albeit less frequently examined, dimension of digital sovereignty [43, pages 11–13]. Individual digital sovereignty builds on the idea that individuals, whether citizens or consumers, should be able to make informed decisions about what digital offerings they use and how much personal data they wish to disclose. In this respect, the individual dimension of digital sovereignty is closely related to adjacent concepts such as informational self-determination [31]. A range of policies relate directly to this dimension of digital sovereignty. This entails consumer protection measures such as mandating "privacy by design" in technology development and default settings, consumer-friendly privacy statements, and transparency requirements, for instance on algorithmic decisions. Relevant policies also comprise the development of digital literacy as the foundation for the individual's ability to take informed decisions, use digital technologies responsibly, and prepare for a changing labor market. Foundational components for this include the

[2] For an overview of cybersecurity challenges and state responsibilities in this domain, see, for example, the German government's respective strategy document [16].

availability of digital technology in educational institutions and opportunities for lifelong learning.

In practice, these three dimensions of digital sovereignty are frequently interlinked. From the discussion above, it is clear, for example, that the individual's ability to make sovereign choices regarding their use of digital technology supposes that basic conditions at other levels are in place. It requires secure digital infrastructures and a competitive digital economy providing a sufficiently large range of products and services from which to choose. Similarly, state-level policies aimed at making digital infrastructures more secure or individual-level policies designed to bolster individuals' digital literacy have the effect of increasing economic actors' capacity to successfully compete as their business models are transformed by technology.

However, the differentiation of these three dimensions provides a useful analytical framework for organizing empirical studies to identify opportunities and challenges related to digital sovereignty. Accordingly, the report adopts the three-dimensional characterization of digital sovereignty to examine the opportunities and challenges for strengthening digital sovereignty in the education sector. In the following, we explore the link between digitalization and sovereignty in the education sector through the lens of three technology case studies: HPI Schul-Cloud (*state sovereignty*), MERLOT (*economic sovereignty*), and openHPI (*individual sovereignty*).

3 Insights from the German Education Sector

3.1 Case Study I – State: HPI Schul-Cloud

Digital sovereignty is a crucial concern for the state when it comes to the digitalization of education. The data generated in education environments tends to be highly personalized and sensitive, providing detailed insights into individual's interests, dispositions, and cognitive abilities. Problematically, in school settings, such personal data is generated by minors who are not (legally) considered to be of age to decide in a fully self-determined manner how their data should be handled.

Despite these issues around the personal data of learners and minors, the adoption of digital technology in the education context has accelerated dramatically. According to a study by the University of Göttingen on the status of digitalization in Germany's schools, in 2021, 67.7 % of the surveyed teachers used digital media on a daily basis and 21.8 % at least once a week. Three years earlier, the respective shares were 23.2 % and 37 % [41, page 78]. During school lockdowns due to the Covid-19 pandemic, school boards frequently decided to resort to digital offerings from foreign providers in order to assure teaching continuity. However, the compliance of these offerings with the EU's General Data Protection Regulation (GDPR) was questioned, in large part because personal data is often stored on servers run by non-EU operators or even transferred abroad [28].

The German government reacted to this. Many German states are now trying to provide compliant solutions or have issued recommendations for offerings deemed compliant [39]. Moreover, in the 2021 coalition agreement, the current German government coalition decided to promote the development of license-free teaching and learning software [47]. On the flipside, this has given rise to countless variants of online learning platforms across Germany's sixteen federal states and municipalities. Many of these platforms lack cohesion and instead bundle various software solutions without sufficient integration and options for cloud storage and virtual interactions. Furthermore, this patchwork of digital offerings further stretches the already strained resources of educational institutions and makes collaborative teaching and learning across schools difficult. Because platforms require constant technical maintenance and upkeep, lack of scale decreases economic efficiency.

Therefore, a crucial foundation of digital sovereignty in the education space is the provisioning of a secure, compliant, and scalable digital infrastructure in the form of a learning platform that facilitates interactions among teachers, students, and parents. With the HPI Schul-Cloud ("School Cloud"), HPI has developed such a platform as part of a pilot project funded by the German Federal Ministry

of Education and Research (BMBF) [37]. The Schul-Cloud is designed to drive digitalization in education while ensuring interoperability and high levels of data protection.

The HPI Schul-Cloud, as a digital education infrastructure, forms the basis for both digitally supported and purely digital teaching in a wide variety of settings. From the start, it provides key tools, such as a teaching calendar, office solution, data storage, messenger, and video conferencing system that strictly conform to data protection laws. The Schul-Cloud also features an integrated learning store for teaching materials on specific topics and allows for easy plug in of additional offerings via respective pseudonymization interfaces. Through this, in principle, any kind of learning offerings can be implemented – even if they do not fulfill the strict European data protection requirements by default.

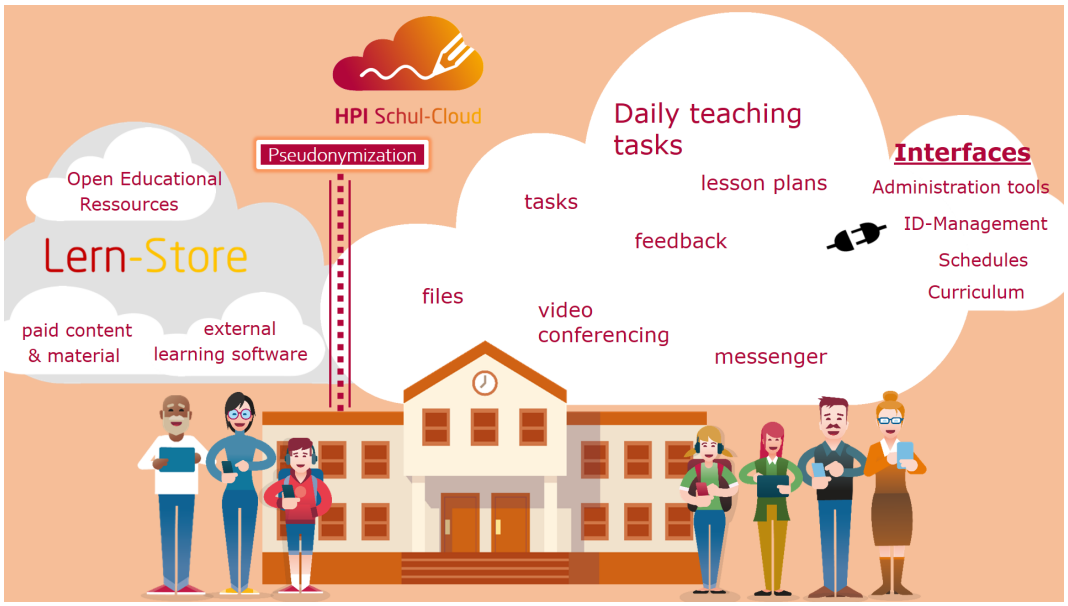

Figure 1: HPI Schul Cloud interface to pseudonymization
Source: Compiled by the authors.

This is because the interfaces of the Schul-Cloud are designed to prevent direct access to the user data by the providers of the education software components docked into the platform. In addition, the educational data is stored on servers located in Germany, which are subject to German laws and do not route through servers abroad. By doing so, the HPI Schul-Cloud enables the usage of digital offerings in a self-determined and GDPR-compliant manner. The HPI Schul-Cloud demonstrates a pathway to harnessing digital technology in the education sector in ways that address concerns about digital sovereignty.

The project also illustrates that developing required infrastructure is possible on a relatively compressed timescale. The Schul-Cloud started in 2017 with 27 schools of the project partner MINT-EC. Only four years later, the HPI Schul-Cloud was

handed over to the public IT service provider Dataport for regular operation and is currently being used under different names in Lower Saxony, Brandenburg, and Thuringia as well as nationwide in individual districts and schools under the label dBildungscloud. In total, it is now used by approximately 4,000 schools and almost two million users. The HPI Schul-Cloud thus provides a space for teaching and learning, which combines possibilities for collaborative work, interoperability, and data protection.

At the same time, obstacles remain to scale infrastructure solutions like the Schul-Cloud at the national, let alone European, level. In Germany, a key complicating factor is the division of responsibilities between the federal government and the governments of the individual states and municipalities. This is particularly true for the education sector, where responsibilities for education policy is largely with the individual states. Due to the flexibility for integrating a large variety of education content, the Schul-Cloud can serve as a shared digital education infrastructure even in a federal system like Germany's. From a technical standpoint, akin to the highway network, the federal government could operate a national digital infrastructure for schools throughout the country, and, in that way, ensure availability and efficiency [1]. In line with their responsibility for education content, the federal states could dock then their own learning programs and applications into that national platform. Yet, making multi-level government structures fit for purpose in the digital age continues to be an incremental process.

3.2 Case Study II – Economy: MERLOT

Smart education offerings and lifelong learning are becoming increasingly critical to building a skilled workforce, generating economic value, and, therefore, safeguarding Germany's competitiveness in a global marketplace disrupted by digital technology [3]. Indeed, digital education solutions open up opportunities for creating a more effective and fair learning system that prepares individuals for the economy of the future. Smart and adaptive learning programs enable specific content that is adapted to the individual's level of knowledge and that learners can follow at an individually optimal pace [29]. Similarly, Artificial Intelligence (AI)-supported career orientation and training services create the possibility to define individual learning paths. They summarize, for instance, what kind of prerequisites are required in a particular professional field and how an individual may proceed towards acquiring these [50].

This goes to show that digital technology not only can support building the type of training and skills that a future-proof workforce requires, but also that it induces a significant transformation of the education business sector itself. The greater demand for learning and collaboration platforms such as those used by schools is just one aspect of this. Indeed, the targeted promotion of young talent and talent development are a growing and lucrative space for both established companies and new education technology start-ups. Yet, harnessing digital technology for education and learning in this way requires access to large pools of relevant data,

especially on individuals and their learning paths. Much of this data, however, remains siloed in individual companies or public institutions. A key challenge for the German and European education sector, therefore, is to gain access to data pools that break down such silos in ways that are transparent and in line with strict data protection requirements.

Somewhat analogous to the provision of a common infrastructure in the realm of online learning platforms (see HPI Schul-Cloud case study), the creation of national and, where possible, European, data spaces represents one key approach to fostering competitive business models. In the context of the German education sector, HPI acts as part of a consortium of partners that builds such sectoral data spaces: the MarkEtplace foR LifelOng educaTional dataspaces and smart service provisioning (MERLOT) [25].

MERLOT started in January 2022 and is one of several projects associated to the Franco-German initiative Gaia-X [15]. Gaia-X aims at creating a performant European digital ecosystem based on a trustworthy and transparent data infrastructure that promotes innovative business models and products. Gaia-X is not based on an understanding of digital sovereignty that excludes non-European companies, nor does it envision the creation of a European hyperscaler. Instead, it centers on defining open interfaces and standards for a federated infrastructure that enable data exchange and processing. In line with this approach, MERLOT provides a means to de-silo data held by various parties. Notably, MERLOT aims to expand access to education data, including for SMEs, and thus bolster the potential for developing of innovative applications and products.

At the same time, MERLOT aims to ensure that the nascent education data ecosystem conforms to high data protection standards. Importantly, the owners of data in the MERLOT data spaces retain sovereignty over their data and can make it available to other users or services as needed. The MERLOT-based data infrastructure thus enables different stakeholders to exchange and share education data in a controlled manner, in compliance with the GDPR, and without having to conclude separate individual agreements with each party involved. This facilitates interaction and opens new possibilities in the processing of sensitive education data.

The MERLOT project illustrates how Gaia-X standards can be used to lay the foundations for a thriving data ecosystem in the education sector. Albeit still at an early stage, MERLOT's current implementation status already demonstrates the potential of sectoral data spaces, notably by counteracting data silos and reducing competitive disadvantages for SMEs and start-ups without access to their own large and proprietary data pools. The consortium, for example, is currently working on intelligent services that match student education data with competency models and information on career goals in order to recommend adaptive individual career pathways. Another focus is, for instance, on the development of data-driven business models for training providers to develop tailored courses for their customers.

Yet, the case of MERLOT also highlights continued challenges faced by project partners working jointly to build German and European data spaces. One key chal-

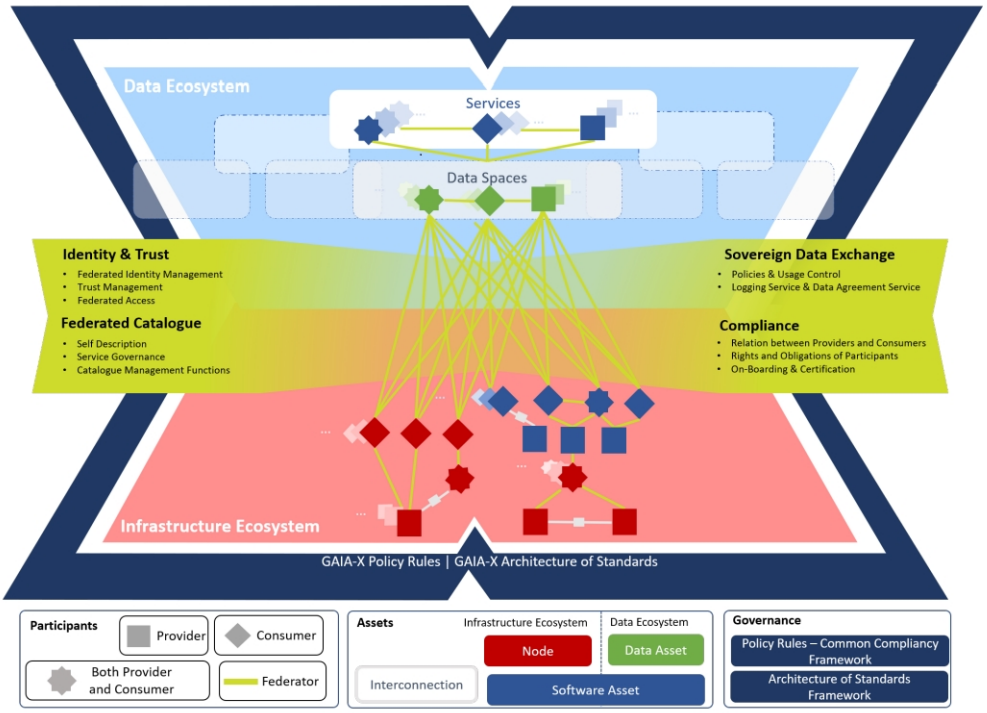

Figure 2: Gaia-X Ecosystem Visualization
Source: Gaia-X – Architecture [18]

lenge is the availability of sufficient financial and personnel resources, especially among SMEs, start-ups, and academic institutions, to develop sector-specific standards and undertake the technical implementation of data spaces. In this context, questions also arise with respect to long-term maintenance and development. For example, what will a self-supporting business model for the marketplace look like after the end of the project? Who will provide organizational and technical support for it? Such issues reflect broader challenges that Gaia-X and other sectoral data spaces face in terms of European capacity to deploy the resources required for effectively shaping and developing data spaces in the longer term.

3.3 Case Study III – Individual: openHPI

Adequate digital infrastructure, legal frameworks, and technical standards are all essential conditions for ensuring that the public can exercise choice in relation to digital technology freely and in line with their own values. However, for individuals to participate in an increasingly digitalized world in a self-determined and creative manner, core digital competencies and skills are also necessary. Moreover, the development of IT-talent is now a crucial pillar of digital sovereignty. According to the industry association of the German information and telecommunications sector,

Bitkom, Germany lacked around 140,000 IT specialists in 2022 to cope with the digital transformation and strengthen Germany's economic competitiveness [5].

One key pathway to both bolstering the individual's ability to navigate the digital world and address this talent gap is an expansion of computer science-related teaching beyond traditional classrooms. Currently, computer science courses in schools at the lower secondary level are not available across the board in all German states [48, pages 63–64]. The lack of qualified teachers is frequently cited as an important obstacle in this respect [42]. Moreover, the fast pace of technological progress requires constant updating of knowledge and skills. In typical classroom settings, this can only be addressed with substantial time commitment and organizational efforts on the part of teaching personnel.

Accordingly, the scientific body of the German Conference of Ministers of Education and Cultural Affairs (Ständige Wissenschaftliche Kommission der Kultusministerkonferenz) has recommended, among other things, new forms of classroom organization as well as the expansion of hybrid teaching and self-learning periods in higher grades [49, pages 20–25]. At the same time, the growing number of video tutorials for online instruction only partially addresses deficits in digital skills acquisition because learners frequently remain isolated in their learning experience. Therefore, instruments are needed so that individuals can effectively acquire digital skills and exercise self-determination in the digital world.

In this context, Massive Open Online Courses (MOOCs) are one such instrument to both enable digitally delivered education and to strengthen digital skills. MOOCs provide users with low-threshold educational offerings that can be worked through at an individual learning pace via video clips, quizzes, and reading material – independent of time and place. What sets MOOCs apart is that they combine elements of online self-study with collaborative learning. The first and largest European MOOC platform, launched in September 2012 under the name of openHPI, aims to harness these benefits of MOOC-based teaching [38].

openHPI's content is aimed at interested parties of all ages and levels of knowledge to prepare them in the best possible way for life in the digital world. In such a way, openHPI creates the possibility of continuing one's education free of charge with a tailored offering. To this end, HPI professors and e-learning specialists cover a broad range of topics, from how the internet works to exploring the future of computing. Discussion forums and mutual peer reviews of assignments enable interaction with other course participants and collaborative learning progress, which is documented with a course certificate at the end. Similar to in-person lectures and tutorials, learners thus receive hands-on support, thereby also lowering hurdles to switching to online learning.

As an infrastructure, openHPI also forms the foundation for a range of professional development offerings for the private and public sectors as well as international organizations. It serves, for example, as the infrastructure for the German government's KI-Campus and eGov-Campus learning platforms. These government-funded platforms aim to strengthen skills in the fields of Artificial Intelligence and e-government [30, 11]. MOOCs such as those offered through

Figure 3: Structure of an openHPI-course
Source: Compiled by the authors.

openHPI are also relevant for teacher training. A good example of this is the LERNEN.cloud platform established during the pandemic, on which more than 22,000 users are now taking part in self-directed training [26]. Here, as learners, teachers are already dealing directly and practically with digital forms of teaching and exchanging best practice experiences.

openHPI illustrates that education outside of traditional classroom settings can become a key building block for strengthening the individual's ability to engage with the digital world. To date, around 325,000 people from more than 180 countries are now regular users of the platform. Furthermore, learners have enrolled in almost 1.2 million courses and more than 130,000 certificates have been issued, making openHPI the largest lecture hall in Germany [24]. This is evidence that MOOC platforms like openHPI are meeting an urgent demand for formats that empower people as sovereign decision-makers in a world, where the pace of technological progress is increasing year by year.

However, the case of openHPI also calls attention to continued challenges. These concern, for example, questions regarding the official recognition of courses as educational micro-credentials as well as the establishment and assurance of certain quality standards. In order to achieve comparability of the varied courses offered on the different platforms as well as facilitate cross-platform catalogs, uniform metadata formats on course content are also required. This underscores that the efficient use of resources through interlinkages and scaling is crucial to leveraging MOOC platforms to enable societies to harness digital technology in a sovereign way.

4 Conclusion: Shaping a More Sovereign Digital Europe

Digital technology creates remarkable opportunities to improve people's lives – in Germany, Europe, and around the world. Yet, the digital transformation is also igniting concerns about *digital sovereignty*: the state's capacity to assume its responsibilities and safeguard society's – and the individuals' – ability to shape the digital transformation in a self-determined way.

The nexus of digitalization and sovereignty is set to continue shaping policy-making and technology trajectories. The discourse around digital sovereignty is spurred on by the enormous speed with which digital technology is expanding into almost all realms of political, social, and economic life. The broad applicability of technologies like Artificial Intelligence and the upcoming integration of billions of devices into the so-called "Internet of Things" (IoT) will further accelerate the pace and invasiveness of this digital transformation. Concerns about sovereignty are also driven by the interlacing of digital technology, economic competitiveness, and national security, which is likely to intensify amidst deepening geopolitical rifts, particularly those among democracies and autocracies.

Against this background, this report set out to explore pathways to mitigating the tension between digitalization and sovereignty from the vantage point of technical implementation. In this respect, it complements political discourses and conceptual analyses that characterize the ongoing debate on digital sovereignty [33, 43, 17, 9, 40, 45]. Specifically, this report has focused on the education sector to highlight Germany's – and, more broadly, Europe's – challenges in harnessing the benefits of digital technology while navigating concerns around sovereignty. The education sector represents an ideal laboratory: education is a core public good, a rapidly growing and technology-driven business domain as well as the building block for individual's ability to navigate a rapidly digitalizing world. Importantly, the education sector reflects a key source of sovereignty concerns, namely the generation, storage, and analysis of sensitive personal data.

To operationalize the concept of digital sovereignty, the report drew on a systematization of related policy measures along three key dimensions: state, economy, and individual [43, pages 8–13]. These dimensions provided the framework for a discussion of three concrete technology projects developed and implemented at the HPI: the HPI Schul-Cloud (*state sovereignty*), MERLOT (*economic sovereignty*), and openHPI (*individual sovereignty*). The case studies underscore that enhancing digital sovereignty depends on Germany's and Europe's ability to foster the conditions for scalable digital infrastructures and competitive digital platform and service offerings. Enabling government agencies, private businesses, and the tech-

nical community to do so requires a comprehensive and cohesive digital policy. Importantly, such digital policy should be designed to interoperate with other EU member states' initiatives in a joint effort to strengthen Europe's technological capacity to act.

In areas where sovereignty is a crucial and shared concern, Germany and other European member states should focus on enabling rapid scalability. The case of the HPI Schul-Cloud project underlines that Germany faces the challenge of making its decentralized federalist structure fit for the digital age. It has highlighted the benefits of scaling infrastructure at the federal level to enable both technically sound and economically efficient operation. Moreover, it is important that governments conceive such national efforts as a stepping-stone towards defining joint requirements for a European infrastructure that integrates sovereignty concerns with a commitment to openness and interoperability. In this respect, government procurement presents an important lever to advance digital infrastructures that enable Europe to shape the digital transformation in a self-determined manner.

Germany should also work closely with its partners to ensure that small and medium-sized businesses and the technical community have the necessary resources to contribute to a competitive European economy. The case of the MERLOT project has underlined the importance of building capacity for the development of standards for Europe's digital decade. Gaia-X now has over 300 members, among them US giants such as Microsoft, Google, and Amazon as well as Chinese companies such as Huawei and Alibaba [19]. Openness to international players is a crucial aspect for augmenting the global compatibility and attractiveness of European standards. Yet, such openness requires that European players have resources comparable to their foreign partners and competitors, or else concerns about an "unbalanced playing field" may become a hurdle for comprehensive participation.[1]

Finally, European governments should focus on strengthening the individual's ability to navigate the digital world in a more sovereign way. The case of openHPI made clear that scaling opportunities for lifelong education are crucial for enabling societies to harness digital technology effectively and in a sovereign way. It also stressed that a key enabler for successful lifelong learning is the possibility to explore new insights in a collaborative manner, especially when it comes to keeping up with the accelerating pace of the digital transformation. The European Commission could initiate a digital training platform that pools educational content from across member states and creates unified standards concerning the content and quality as well as credentials for online courses. In addition, this could be accompanied by an expansion of course metadata to streamline interlinkages between educational databases. This would create a European collaborative learning environment that empowers citizens to actively co-shape the ambitious goals that the EU has set through its call for a "digital decade" as well as its Digital Education Action Plan (2021–2027) [14, 12].

[1] Last year, Gaia-X founding member Scaleway, the largest French cloud provider, criticized an "unbalanced playing field" and left the initiative [35].

Going forward, it will be key to situate initiatives for strengthening German and European digital sovereignty – in the education sector and beyond – in a larger international context. Crucially, while asymmetric external dependencies require recalibration in some domains, openness should remain a key pillar of Germany's, and Europe's, approach to digital technologies. This is particularly true when it comes to sustaining partnership with allies; especially the United States, the close relationship with which remains a key pillar of European security and prosperity. It is from this vantage point that Europe should strive to become a more sovereign technology partner: willing – and able – to work together in shaping a thriving digital ecosystem that retains the ability to develop and use technology according to each partner's laws and values.

Bibliography

[1] Autobahn GmbH des Bundes. *Über Uns. Die Autobahn*. URL: https://www.autobahn.de/karriere/ueber-uns (visited on 2023-03-28).

[2] T. Barker and D. Hagebölling. *A German Digital Grand Strategy: Integrating Digital Technology, Economic Competitiveness, and National Security in Times of Geopolitical Change*. DGAP Report. Berlin, Nov. 2022.

[3] T. Barker and D. Hagebölling. *The Geopolitics of Digital Technology Innovation: Assessing Strengths and Challenges of Germany's Innovation Ecosystem*. DGAP Report. Berlin, Sept. 2022.

[4] T. Bianchi. *Worldwide desktop market share of leading search engines from January 2015 to January 2023*. Statista. Feb. 24, 2023. URL: https://www.statista.com/statistics/216573/worldwide-market-share-of-search-engines/ (visited on 2023-03-28).

[5] Bitkom. *Trotz Krieg und Krisen: In Deutschland fehlen 137.000 IT-Fachkräfte*. Nov. 16, 2022. URL: https://www.bitkom.org/Presse/Presseinformation/Deutschland-fehlen-137000-IT-Fachkraefte (visited on 2023-03-28).

[6] J. Bodin. *The Six Bookes of a Commonweale*. Edited by K. D. McRae. Cambridge: Harvard University Press, 1962.

[7] CIO Bund. *Digitale Souveränität*. URL: https://www.cio.bund.de/Webs/CIO/DE/digitale-loesungen/digitale-souveraenitaet/digitale-souveraenitaet-node.html (visited on 2023-03-30).

[8] Companies Market Cap. *Weltweites Ranking nach Marktkapitalisierung Stand März 2023*. URL: https://companiesmarketcap.com/tech/largest-tech-companies-by-market-cap/ (visited on 2023-03-28).

[9] S. Couture and S. Toupin. "What does the notion of 'sovereignty' mean when referring to the digital?" In: *New Media & Society* 21.10 (2019), pages 2305–2322. DOI: 10.1177/1461444819865984.

[10] S. Dixon. *Most popular social networks worldwide as of January 2023, ranked by number of monthly active users*. Statista. Feb. 14, 2023. URL: https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/ (visited on 2023-03-28).

[11] eGov-Campus. *Über das Projekt*. URL: https://egov-campus.org/projekt/beschreibung (visited on 2023-03-28).

[12] European Commission. *Digital Education Action Plan (2021–2027)*. URL: https://education.ec.europa.eu/focus-topics/digital-education/action-plan (visited on 2023-03-30).

[13] European Commission. *EU Digital Single Market*. URL: https://eufordigital.eu/discover-eu/eu-digital-single-market/ (visited on 2023-03-28).

[14] European Commission. *Europe's Digital Decade: digital targets for 2030*. URL: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en (visited on 2023-03-30).

[15] Federal Ministry for Economic Affairs and Climate Action. *Franco-German Position on Gaia-X*. Feb. 18, 2020. URL: https://www.bmwk.de/Redaktion/DE/Downloads/F/franco-german-position-on-gaia-x.html (visited on 2023-03-30).

[16] Federal Ministry of the Interior. *Cybersicherheitsstrategie für Deutschland 2021*. Aug. 2021. URL: https://www.bmi.bund.de/SharedDocs/downloads/DE/veroeffentlichungen/2021/09/cybersicherheitsstrategie-2021.pdf?__blob=publicationFile&v=2 (visited on 2023-03-30).

[17] L. Floridi. "The fight for digital sovereignty: What it is, and why it matters, especially for the EU". In: *Philosophy & Technology* 33.3 (2020), pages 369–378. DOI: 10.1007/s13347-020-00423-6.

[18] Gaia-X. *Gaia-x – Architecture Document – 22.04 Release*. URL: https://gaia-x.eu/wp-content/uploads/2022/06/Gaia-x-Architecture-Document-22.04-Release.pdf (visited on 2023-08-14). The reference in chapter 3 is to page 7.

[19] Gaia-X. *Members Directory*. URL: https://gaia-x.eu/membership/members-directory/ (visited on 2023-03-28).

[20] German Federal Government. *Digitalstrategie: Gemeinsam digitale Werte schöpfen*. 2022. URL: https://digitalstrategie-deutschland.de/static/67803f22e4a62d19e9cf193c06999bcf/220830_Digitalstrategie_fin-barrierefrei.pdf (visited on 2023-03-30).

[21] German Federal Government. *Rede von Bundeskanzlerin Angela Merkel zur Eröffnung des 14. Internet Governance Forums 26. November 2019 in Berlin*. URL: https://www.bundesregierung.de/breg-de/suche/rede-von-bundeskanzlerin-angela-merkel-zur-eroeffnung-des-14-internet-governance-forums-26-november-2019-in-berlin-1698264 (visited on 2023-03-30).

[22] G. Goldacker. "Digitale Souveränität". In: *Competence Center Public IT* (2017), page 3.

[23] D. Hagebölling. "The Geopolitical Struggle for Technology Leadership". In: *Internationale Politik Quarterly* (Apr. 12, 2022).

[24] Hasso-Plattner-Institut für Digital Engineering. *Erneut zehn Prozent mehr Nutzung: openHPI auch im 10. Jahr erfolgreich*. Dec. 12, 2022. URL: https://hpi.de/pressemitteilungen/2022/erneut-zehn-prozent-mehr-nutzung-openhpi-auch-im-10-jahr-erfolgreich.html (visited on 2023-03-28).

[25] Hasso-Plattner-Institut für Digital Engineering. *Gaia-X Projekt "MERLOT" erhält Förderzusage vom BMWK*. Mar. 8, 2022. URL: https://hpi.de/news/jahrgaenge/2022/gaia-x-projekt-merlot-erhaelt-foerderzusage-vom-bmwk.html (visited on 2023-03-30).

[26] Hasso-Plattner-Institut für Digital Engineering. *Lernen.cloud – Fortbildungen online*. URL: https://hpi.de/open-campus/hpi-initiativen/lernencloud.html (visited on 2023-03-28).

[27] T. Hobbes. *Leviathan*. Edited by J. C. A. Gaskin. Oxford: Oxford University Press, 2008.

[28] N. Horn and P. Otto. *Datenschutz versus Funktionalität: Das Dilemma der deutschen Schulen*. Apr. 2021. URL: https://www.boell.de/de/2021/04/15/datenschutz-versus-funktionalitaet-das-dilemma-der-deutschen-schulen (visited on 2023-03-28).

[29] P. Johanes and L. Lagerstrom. "Adaptive learning: The premise, promise, and Pitfalls". In: *American Society for Engineering Education Annual Conference & Exposition (ASEE 2017)* (Columbus, Ohio, June 24, 2017). DOI: 10.18260/1-2--27538.

[30] KI-Campus. *Über Uns*. URL: https://ki-campus.org/about (visited on 2023-03-28).

[31] C. Kodde. "Germany's 'right to be forgotten' – between the freedom of expression and the right to informational self-determination". In: *International Review of Law, Computers & Technology* 30.1–2 (2016), pages 17–31. DOI: 10.1080/13600869.2015.1125154.

[32] D. Lambach. "The Territorialization of Cyberspace". In: *International Studies Review* 22.3 (2020), pages 482–506. DOI: 10.1093/isr/viz022.

[33] D. Lambach and K. Oppermann. "Narratives of digital sovereignty in German political discourse". In: *Governance* (2022). DOI: 10.1111/gove.12690. The reference in chapter 2 is to pages 6–7.

[34] S. Landau. "Making sense from Snowden: What's significant in the NSA Surveillance Revelations". In: *IEEE Security & Privacy* 11.4 (2013), pages 54–63. DOI: 10.1109/msp.2013.90.

[35] Y. Lechelle. *Full steam ahead towards a true multi-cloud offering to deliver on broken promises*. Scaleway. Mar. 18, 2022. URL: https://www.scaleway.com/en/blog/full-steam-ahead-towards-a-true-multi-cloud-offering-to-deliver-on-broken-promises/ (visited on 2023-03-28).

[36] J. Locke. *Two Treatises of Government*. Edited by P. Laslett. Cambridge: Cambridge University Press, 1967.

[37] C. Meinel, C. John, T. Wollowski, and HPI Schul-Cloud Team. *Die HPI Schul-Cloud – Von der Vision zur digitalen Infrastruktur für deutsche Schulen*. Technische Berichte des Hasso-Plattner-Instituts für Digital Engineering an der Universität Potsdam 144. Potsdam, 2022.

[38] C. Meinel, C. Willems, T. Staubitz, D. Sauer, and C. Hagedorn. *openHPI: 10 Years of MOOCs at the Hasso Plattner Institute*. Technische Berichte des Hasso-Plattner-Instituts für Digital Engineering an der Universität Potsdam 148. Potsdam, 2022.

[39] Ministerium für Kultus, Jugend und Sport Baden-Württemberg. *MS365 im Einsatz an öffentlichen Schulen in Baden-Württemberg. Letter by the state secretary*. May 11, 2022. URL: https://km-bw.de/site/pbs-bw-km-root/get/documents%5C_E-1139838841/KULTUS.Dachmandant/KULTUS/KM-Homepage/Meldungen%202022/2022%2005%2012%20StS-Schreiben%20-%20MS365%20Einsatz.pdf (visited on 2023-03-30).

[40] L. Monsees and D. Lambach. "Digital sovereignty, geopolitical imaginaries, and the reproduction of European identity". In: *European Security* 31.3 (2022), pages 377–394. DOI: 10.1080/09662839.2022.2101883.

[41] F. Mußmann, T. Hardwig, M. Riethmüller, and S. Klötzer. *Digitalisierung im Schulsystem 2021: Arbeitszeit, Arbeitsbedingungen, Rahmenbedingungen und Perspektiven von Lehrkräften in Deutschland*. Kooperationsstelle Hochschulen und Gewerkschaften der Georg-August-Universität Göttingen. 2021. DOI: 10.3249/ugoe-publ-10. The reference in chapter 3 is to page 78.

[42] T. Peter. *Bildungsforscher fordern Informatik als Pflichtfach: Und woher sollen die Lehrer kommen?* RedaktionsNetzwerk Deutschland. Sept. 19, 2022. URL: https://www.rnd.de/politik/informatik-als-pflichtfach-wer-soll-das-unterrichten-B7I3VYDU6VCEFBAPAVURRGK7MU.html (visited on 2023-03-28).

[43] J. Pohle and T. Thiel. "Digital Sovereignty". In: *Internet Policy Review* 9.4 (2020). DOI: 10.14763/2020.4.1532. The reference in chapter 1 is to pages 2 and 8–13. The reference in chapter 2 is to pages 8–13. The reference in chapter 4 is to pages 8–13.

[44] F. Richter. *Amazon, Microsoft & Google Dominate Cloud Market*. Statista. Dec. 23, 2022. URL: https://www.statista.com/chart/18819/worldwide-market-share-of-leading-cloud-infrastructure-service-providers/ (visited on 2023-03-28).

[45] H. Roberts, J. Cowls, F. Casolari, J. Morley, M. Taddeo, and L. Floridi. "Safeguarding European values with Digital Sovereignty: An Analysis of statements and policies". In: *Internet Policy Review* 10.3 (2021). DOI: 10.14763/2021.3.1575.

[46] J.-J. Rousseau. *Du contrat social, ou, Principes du droit politique*. Amsterdam: Chez Marc-Michel Rey, 1762.

[47] SPD, Bündnis 90/Die Grünen, FDP. *Mehr Fortschritt wagen: Bündnis für Freiheit, Gerechtigkeit und Nachhaltigkeit*. Dec. 7, 2021. URL: https://www.bundesregierung.de/resource/blob/974430/1990812/04221173eef9a6720059cc353d759a2b/2021-12-10-koav2021-data.pdf?download=1 (visited on 2023-03-28). The reference in chapter 3 is to page 96.

[48] Ständige Wissenschaftliche Kommission der Kultusministerkonferenz (SWK). *Digitalisierung im Bildungssystem: Handlungsempfehlungen von der Kita bis zur Hochschule*. Gutachten der Ständigen Wissenschaftlichen Kommission der Kultusministerkonferenz. Bonn, 2022. The reference in chapter 3 is to pages 63–64.

[49] Ständige Wissenschaftliche Kommission der Kultusministerkonferenz (SWK). *Empfehlungen zum Umgang mit dem akuten Lehrkräftemangel*. Stellungnahme der Ständigen Wissenschaftlichen Kommission der Kultusministerkonferenz. Bonn, 2023. The reference in chapter 3 is to pages 20–25.

[50] S. Westman, J. Kauttonen, A. Klemetti, N. Korhonen, M. Manninen, A. Mononen, S. Niittymäki, and H. Paananen. "Artificial Intelligence for career guidance – current requirements and prospects for the future". In: *IAFOR Journal of Education* 9.4 (2021), pages 43–62. DOI: 10.22492/ije.9.4.03.

Current Technical Reports of the Hasso Plattner Institute

Volume	ISBN	Title	Authors/Redaction
156	978-3-86956-560-6	**Digitale Souveränität: Erkenntnisse aus dem deutschen Bildungssektor**	Christoph Meinel, Michael Galbas, David Hagebölling
155	978-3-86956-556-9	**Triple graph grammars for multi-version models**	Matthias Barkowsky, Holger Giese
154	978-3-86956-555-2	**Modular and incremental global model management with extended generalized discrimination networks**	Matthias Barkowsky, Holger Giese
153	978-3-86956-551-4	**Human pose estimation for decubitus prophylaxis**	Benedikt Weber
152	978-3-86956-550-7	**RailChain : Abschlussbericht**	Ingo Schwarzer, Said Weiß-Saoumi, Roland Kittel, Tobias Friedrich, Koraltan Kaynak, Cemil Durak, Andreas Isbarn, Jörg Diestel, Jens Knittel, Marquart Franz, Carlos Morra, Susanne Stahnke, Jens Braband, Johannes Dittmann, Stephan Griebel, Andreas Krampf, Martin Link, Matthias Müller, Jens Radestock, Leo Strub, Kai Bleeke, Leander Jehl, Rüdiger Kapitza, Ines Messadi, Stefan Schmidt, Signe Schwarz-Rüsch, Lukas Pirl, Robert Schmid, Dirk Friedenberger, Jossekin Beilharz, Arne Boockmeyer, Andreas Polze, Ralf Röhrig, Hendrik Schäbe, Ricky Thiermann
151	978-3-86956-547-7	**HPI Future SOC Lab – Proceedings 2018**	Christoph Meinel, Andreas Polze, Karsten Beins, Rolf Strotmann, Ulrich Seibold, Kurt Rödszus, Jürgen Müller (Hrsg.)
150	978-3-86956-546-0	**openHPI : 10 Jahre MOOCs am Hasso-Plattner-Institut**	Christoph Meinel, Christian Willems, Thomas Staubitz, Dominic Sauer, Christiane Hagedorn

ISBN 978-3-86956-561-3
ISSN 1613-5652