Organisational Data Work and Its Horizons of Sense: On the Importance of Considering the Temporalities and Topologies of Data Movement When Researching Digital Transformation(s)

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Juliane Jarke, Irina Zakharova & Andreas Breiter *

Abstract: *»Organisationale Datenarbeit und ihre Sinnhorizonte: Über die Bedeutung von Zeitlichkeiten und Topologien von Datenflüssen für die Erforschung digitaler Transformationsprozesse«.* Reconstructing topological and temporal accounts of data movement is an approach to researching digital transformation(s) that challenges distal assumptions of organisations as fixed structures through which data flow like immutable mobiles. Based on a case study in education, we present and reflect on the challenges of reconstructing and visualising data movement. In particular, we attend to how the often-conflicting views of organisational members about how data "actually" move pose a challenge to reconstruct a "full picture." We propose the notion of horizon of sense to grasp the situated data practices of organisational actors and reconstruct their horizons of sense through two perspectives: First, data movement connects different social actors, documents, information systems, or databases in different forms. This perspective considers the *topologies of data movement* and foregrounds the relationality of data movement at a given point in time. Second, the movement of data is made possible through different interconnected activities that unfold over time. This dimension relates to the *temporalities of data movement* and foregrounds processes and activities that connect data work in its temporal flow. We demonstrate why it is important to consider both perspectives when researching digital transformation(s).

Keywords: Data journey, critical data studies, data movement, datafication, BPMN, topology, temporality, education.

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1. Introduction

Digital technologies reconfigure formal and informal organisational structures and practices, redefine organisational borders (Wessel et al. 2021; Büchner 2018b), and provide shared infrastructures for organisational action (Büchner 2018a; Bowker et al. 2009; Star and Ruhleder 1996). They have allowed for the emergence of new means to measure, capture, describe, and represent social life in numbers (Jarke 2018). By now, digital data are used as instruments of management and categorisation (Alaimo and Kallinikos 2021; Currie, Paris, and Donovan 2019), representation (Saifer and Dacin 2021), accountability (Hartong and Breiter 2021), and redistribute power within and across organisations (Gerrard and Bates 2019). This has fuelled utopian visions featuring open and transparent ways of organising but also fears associated with increased surveillance and control (Jarke and Breiter 2019; Zakharova and Jarke 2022).

To attend to the digital transformation(s) in and of organisations, we take a processual view (Cooper and Law 1995; Langley 2007) that conceptualises organisations as networks or circuits of continuous movement, as "assemblages of organizings" (Cooper and Law 1995, 239). Such a view is interested in the processes, practices, and performances that create, change, or try to maintain states-of-being or, in other words, "orders of relations" (Cooper and Law 1995, 239). This view is aligned with Bruno Latour (2004) who argued that the social is about circulation, it is the association of materially diverse entities *and* their circulation. The notion of connecting and relating are not sufficient: "Something has to circulate too. There has to be movement between the points of action at a distance and mobilisation to be possible" (Callon and Law 2004, 4).

Data are one such circulating entity that connect and relate distant actors. As data continuously move within and across organisations, they also become central to the practices and processes that produce and transform organisations. This paper is hence led by the question: *If the movement of data is central to understanding digital transformation(s), how can we trace their movement?*

The movement of data within and across organisations is difficult to trace and reconstruct. For one, data are not mere "immutable mobiles" (Latour 2007) which do not change their meaning and form across social worlds. Rather, data's mutability is what makes them so powerful and allows them to travel across space, time, and social situations (Leonelli 2020, 6). Importantly, while data allow for mutability, it is through the work of organisational actors that data acquire new meanings as they "move about" (Law 2004, 78), and not simply an inherent property of data itself. Data, thus, move through the work of various organisational actors that interpret, process, and transform them.

However, not all of this work nor all organisational actors involved in data work are equally visible.

Hence, to respond to our question, we need to recognise that the movement of data has at least two dimensions: First, the movement connects different social actors, documents (e.g., spreadsheets, forms), information systems (IS; e.g., intra- and interorganisational), and data bases in different forms (e.g., aggregated, disaggregated). This dimension recognises the *topologies of data movement* and foregrounds the relationality of data movement at a given point in time (Law and Mol 2001; Straube 2016). Second, the movement of data is made possible through different interconnected activities that unfold over time. This dimension relates to the *temporalities of data movement* and foregrounds processes and activities that connect data work in its temporal flow (Baygi, Introna, and Hultin 2021; Langley et al. 2013).

In this paper, we explore temporal and topological accounts of data movement and consider how they may be visualised in order to facilitate qualitative research and analysis on digital transformation(s). To do so we first review two important approaches for researching and visualising data movement: (1) data modelling notations in software engineering (e.g., Becker, Probandt, and Vering 2012; Freund and Rücker 2014) and (2) "data journeys" in critical data studies (Bates, Lin, and Goodale 2016) and science and technology studies (STS) (Leonelli and Tempini 2020). Data modelling notations are a key (visualisation) approach to designing data-based systems and provide different, well-defined ways for visualising data movement. However, they lack considerations about the social, political, and cultural contexts in which data travel and invoke a "god's eye view" (Haraway 1988) on the ways in which data move. The data journey approach contributes a sensibility for the sociomaterial constitution of data movement but lacks considerations about how the situated data practices of organisational actors may be visualised.

Based on a case study in education, we present and reflect on the challenges of reconstructing and visualising data movement in qualitative research that explores the digital transformation(s) of organisations. In particular, we attend to how the often conflicting views of organisational members about how data "actually" move pose a challenge to reconstruct a "full picture" of data movement and rather creates different (in)visibilities. To do so, we propose the notion of "horizon of sense" (Nicolini 2009) to understand the situated data practices of organisational actors who can never assume a god's eye view on the ways in which data move. Akin to an observer standing on the ground and looking at the point where sky and ground meet, a horizon of sense marks the limits of certainty and the beginning of anticipation. Organisational researchers, however, encounter in their interactions with organisational actors a variety of potentially conflicting horizons of sense that guide their data practices. Often these accounts stand in stark contrast to

official documents that define the (ideal) flow of data. We demonstrate in this paper that rather than aiming for a coherent account of the ways in which data move and are made to move, attention should be paid to the temporal and topological unfolding of data movement within and across different horizons of sense.

2. Related Work

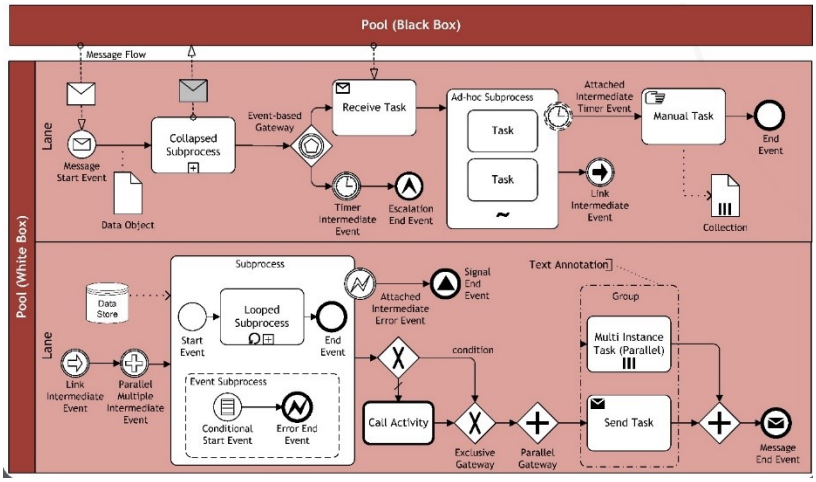
2.1 Data Modelling Notations as Visual Tools for Researching Data Movement in Organisations

One of the most common ways to design and model how data move in organisations and are integrated in different information systems is through visualising and mapping "data flows" based on standardised notations. These visualisations either depict ideal-typical or real data flows. One of the first graphical notations for modelling data and data flows was the Entity-Relationship-Model (ERM) developed by Peter Chen (1976). It allows for the visualisation of complex conceptual systems using an accessible graphical notation that centres two types of constructs: *entities* (concrete objects in the world) and the *relationships* between these entities (Becker, Probandt, and Vering 2012).

To extend this view on object relations and to visualise organisational processes, process modelling languages such as Event-driven Process Chains (EPC) were developed in the early 1990s (van der Aalst, Desel, and Kindler 2002). *Process mapping* allows for the representation of interlinked and sequential work tasks while with ARIS (Architecture of Integrated Information Systems), Scheer (2000) proposed a comprehensive model for business processes integrating a variety of visualisations: data movement with ERM, organisational charts, function trees, sequence diagrams, and event-driven process chains. This provided a basis for the development of integrated information systems. In software engineering (e.g., Sommerville 2007), visualisations are often based on the Unified Modelling Language (UML). While its scope covers a wide range of processes, it is not designed for practitioners or domain experts but for software developers. For this reason, new forms of modelling notations have been suggested. The Business Process Modelling Notation (BPMN) is one of the most common modelling languages to date (e.g., Freund and Rücker 2014). BPMN mappings are produced for three reasons: (1) to document a business process, (2) to introduce a new process, or (3) to improve an existing process. BPMN's second release (BPMN 2.0) was extended to represent data objects with more clarity and to help non-experts improve their understanding of process modelling.

BPMN mappings represent data movement with a "start event" that eventually leads to one or more "end events"; they allow for the depiction of sequential and parallel data work. The notation includes a set of pre-defined symbols for roles, activities, connectors, and events (see figure 1 for an overview of symbols and the notation) and includes the definition of organisational "pools," and in these pools, different "lanes" for specific roles (members of an organisation) that perform activities relevant to a data-related business process. Activities visualised with BPMN may represent points in which decisions are required by organisational actors. Connections across organisational pools and lanes are restricted. The advantage of BPMN is its openness, a community approach to its further development, and its generalisability beyond specific domains. It allows to leave data work that is conducted outside the realm of an organisation (and the horizon of sense of its actors) to remain as a black box (figure 1, depicted as pool [black box]).

Figure 1 Overview of the Basic Structure and Elements of BPMN



Source: http://www.bpmb.de/index.php/BPMNPoster (Accessed 05 November 2022).

To identify barriers to data flows within and across organisations, Eleftheriou et al. (2016, 2018) have worked on the development of a new notation. They identified social and technical barriers as the main reasons for why the "movement of data within and between organisations was a key indicator of high cost and risk" (2016, 11) and developed a step-by-step guide on how to model data flows and data friction across organisational boundaries, explicitly marking where friction occurs to eventually smooth the flow. These frictions are depicted through red circles. Different organisational roles (depicted as people), information systems (depicted as boxes), and databases (depicted as storage space) are connected through arrows that describe the

types of data work required. Through coloured boxes around selections of these entities, organisational units are depicted.

What the presented modelling notations have in common is their focus on those aspects of data movement that are mainly relevant for business processes to increase workflow efficiency. From this perspective, data are understood as by-products of organisational activities that need to be processed by information systems so that they may be available for further data-driven decision-making. Neither approach includes cultural, social, or political aspects, nor do they represent people as acting subjects with their own agendas, beliefs, and motives. Instead, people involved in organisational data work are represented as emotionless, functional parts and the activities they are involved in as transparent and predictable. To consider how these contingencies of data movement may be addressed, we now turn to the data journeys approach that has emerged as a generative conceptual and methodological approach in the interdisciplinary fields of science and technology studies (STS) and critical data studies (CDS). We subsequently demonstrate how it can complement our conceptual and methodological repertoire for research digital transformation(s).

2.2 Data Journeys as an Analytical Lens Considering Social, Political, and Organisational Contexts of Data Movement

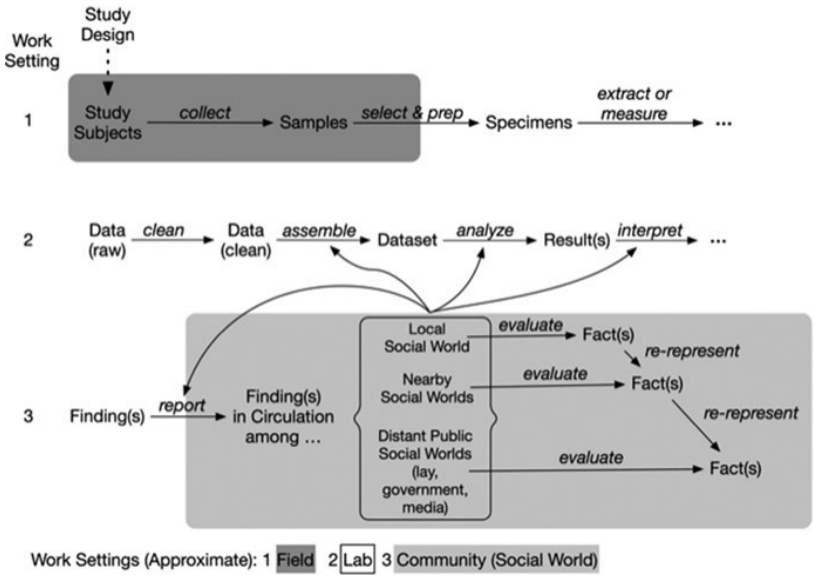
Within the fields of science and technology studies (STS) and critical data studies (CDS), the concept of "data journeys" has been proposed as a critical approach to study data movement, each with a slightly different focus and collectively as a sensibility towards the critical analysis of datafied phenomena. In STS, scholars are particularly interested in the ways in which data transform scientific practice (Leonelli 2013, 2014). In the interdisciplinary field of *critical data studies,* the term was first introduced by Jo Bates and colleagues (Bates, Lin, and Goodale 2016; Bates 2018). They examine the socio-cultural values, power dynamics, political, organisational contexts, and material conditions that constrain or enable the mobility of weather data turned climate data as they move from local weather stations to climate science and financial markets (Bates, Lin, and Goodale 2016, 3). Other scholars further adopted the concept of data journeys for studying social, cultural, and political issues related to power dynamics in the production, use, and movement of health data (Medina Perea 2021) or the entanglement of data infrastructures and geography, their materiality, and their relationality (White 2018).

The concept of data journeys encompasses several critical assumptions of about what data are. It is in line with scholarship that does not view data as somewhat foundational to our knowledge, as merely referential to the world and naturally occurring (e.g., Jones 2019; Gitelman 2013; Kitchin 2014;

Borgman 2015; Hepp, Jarke, and Kramp 2022). A data journey approach assumes that data always emerge through (organisational) knowledge practices (e.g., Gitelman 2013; Jones 2019) and hence pays attention to the ways in which data are "cooked" (Bowker 2008) and the wider technical, organisational, political, or social aspects of its creation and use (e.g., Kitchin 2014).

Methodologically, data journeys can serve as an analytical lens for studying datafied organisation. For example, a temporal account of a data journey is provided by Griesemer (2020) (figure 2). It illustrates a generic data journey in population genomics across different "work settings" and along different types of data-related practices. The work settings appear similar to BPMN as separate lanes (in the figure depicted through the numbers 1 = Field, 2 = Lab, and 3 = Social World). The different data-related activities (arrows labelled as data collection, selection, cleaning, analysing, report, evaluating) facilitate the movement of data across organisational settings (in the figure labelled as field, lab, or social world). In contrast to existing notations from software engineering (see previous section) that illustrate organisational roles as constitutive for data-related processes, human actors remain invisible in Griesemer's account in favour of generic "work settings" and their position in the *temporal* unfolding of data movement.

Figure 2 Data Journey for Conceptualising the Temporal Movement of Data in Population Genomics



Source: Griesemer 2020, 147.

Bates, Lin, and Goodale's (2016) data journey in the study of climate data is depicted in figure 3. In this *topological* account, no arrows with data-related practices are depicted, but the focus is on organisations as points of passage through which data move. Different paths are differently coloured distinguishing the production of weather data by citizens, scientists, and official weather stations (stops "amateur observers," "archives," or "Weston Park Weather Station"); the use of these data in climate science (stops "Climatic Research Unit," "IPCC"); and eventually in financial markets (stops "Weather Market Data Supplier," "Financial Markets"). The UK Met Office serves as a network node for the distribution of data. Such a topological account foregrounds how different social actors connect through the movement of data rather than how their data-related work practices make data move.

Figure 3 Weather Turned Climate Data Journey

Source: Bates, Lin, and Goodale 2016.

In both visual accounts of data journeys, we find representations of data flows through organisational contexts. Yet whereas Bates, Lin, and Goodale (2016) colour code different organisational contexts of the journey and their relation (figure 3), Griesemer (2020) foregrounds the data-related practices across

"work settings" (figure 2). The visual account provided by Bates et al. (2016) traces the flow of data through different types of organisational actors in climate change policy debates; in Griesemer's data journey, the different "work settings" are further abstracted. Both visualisations focus on the life cycle of data from their generation through various stages of preparation, cleaning, processing, and reporting. Throughout, the data on these journeys undergo "mutations" according to the cultural values and sociomaterial conditions in that they move (Bates, Lin, and Goodale 2016). Griesemer (2020) provides a *temporal* account that connects different data-related work practices, whereas Bates et al. (2016) provide an account that highlights the *topology* of a data journey. In both cases individual organisational roles and actors are not depicted.

We now consider how these two approaches – data modelling notations and data journeys – may provide complimentary ways of researching, reconstructing, and visualising data movement for the study of digital transformation(s).

2.3 The Importance of Actors' Horizon of Sense for Data Movement

Above we have presented two important approaches to reconstructing data movement: (1) data modelling notations stemming from software engineering and organisational information systems to visualise the movement of data and (2) data journeys as a concept and sensibility towards the cultural, social, and political contexts in which data movement is made possible.

In *data modelling notations*, the depiction of data movement invokes a god's eye view in that they provide an assessment of "everything from nowhere" (Haraway 1988, 581) and the full movement of data from a "beginning" to an "end" is visible and certain. We argue in the following that such a perspective on data movement within organisations is highly reductive and writes out social, political, and cultural aspects that govern and shape the data work performed by organisational actors. Furthermore, the extent to which actors know about the different connections data make on their way through the organisation is unclear, as is whether and how this affects their own data work. Some notations (e.g., EPC or BPMN) also invoke a rather linear view on data movement alongside organisational processes, while attention to the changes of data throughout their movement is also lacking. This linearity, however, allows to depict certain organisational processes in their (temporal) unfolding. Other notations (e.g., ERM or UML) place the focus on the connections between various entities, while the notation developed by Eleftheriou et al. (2016, 2018) also takes into account some topological relations (e.g., organisational boundaries).

Data journeys contest the idea of data flowing smoothly between and through various organisational destinations. Data journeys include friction, and unaccomplished movements need to be made visible and direct the researchers' attention to data disregarded and excluded from circulation (Edwards et al. 2011; Bates, Lin, and Goodale 2016; Aula 2019). This friction is grounded in the fact that an organisation that produces data is made up of various, interrelated elements, processes, and practices. These elements include data sharing infrastructures (such as information systems, technical infrastructure); socio-cultural factors (such as the frames of relevance of various social actors); and regulatory frameworks (such as policies and legal frameworks). At times however, these elements restrict or hinder movement. It is hence important to consider and observe "the forces that are acting to move data between social actors" (Bates 2018, 423).

We argue here, that it is exactly the frictions emerging in data movements through different power relations and organisational contexts that a focus on actors' diverging "horizons of sense" (Nicolini 2009) makes visible. The concept was proposed by organisation studies scholar and practice theorist Davide Nicolini to describe how "practices constitute the horizon within which all discursive and material actions are made possible and acquire meaning" (ibid., 1394). Practitioners are "tuned into the horizons of sense and the set of practical concerns sustained by the practice they contribute to sustain" (ibid., 1403). We argue that these horizons frame the practical concerns, sensibilities, and accountabilities that govern organisational data work and are subsequently decisive for the technical, social, and economic contingencies in which organisational data work is performed. As different actors have different horizons of sense which prevent them "from seeing things differently" (ibid., 1405), their collision can lead to friction. Taking these frictions as a starting point for analysis and visualisation, we argue, allows reconstructing data movement and the usually invisible work required to put data on the move.

While most of the notations from software engineering and business informatics (e.g., BPMN) are widely used in practice, approaches of visualising data movement have so far received little attention as analytical tools for qualitative research on digital transformations. Overall, the usefulness of visualisations for qualitative organisational research has been long established (e.g., A. Meyer 1991; Miles and Huberman 1984; R. Meyer et al. 2013). However, visual artefacts have still been mainly understood as an object of inquiry in organisational research (e.g., photographs, drawings, and buildings are understood as research data) rather than as "elements of analysis and theorizing *of* qualitative data presenting itself in verbal form e.g. field notes, interviews, documents" (Langley and Ravasi 2019, 174, own emphasis). Visual artefacts such as matrices, graphs, and charts enable the organisation of information in a more compact and accessible form than

narratives and in so doing can contribute to the quality of data analysis. This reduction of complexity through drawing and composing images helps to think and "crystallize our ideas" (Ravasi 2017). However, visual artefacts come with their own affordances and constraints in terms of how they allow to represent reality. They are, as Langley and Ravasi (2019) argue, "inevitably 'performative'" in that they foreground certain things and relations that come to be seen as constitutive, while excluding others.

In sum: While there exists important work that attends to data movement, we are currently lacking a consideration about the affordances of different ways of interpreting and potentially visualising data movement. In this paper, we demonstrate how complementary views on data movement help to uncover organisational actors' diverging horizons of sense that guide the work required to put data on the move. As we empirically demonstrate in the next sections, attending to data movement through such a complementary analytical lens allows for a better understanding of the role digital data play in the digital transformation(s) of organisations.

3. Methodology and Case Study

Our paper is based on research conducted as part of the project DATAFIED: DATA For and In EDucation. The aim of the project was to investigate the implications of the increasing importance of digital data for decision-making across all levels of education. To do so, the project researched the design and use of school management information systems (SMIS) and related data in four federal states in Germany. The authority over all matters in K-12 education in Germany lies with the federal states' ministries of education. While most schools in Germany are public, both public and private schools as well as public education administrations in Germany use different SMIS. Hence the *organisation of education and related SMIS* differs in each of the federal states (Hartong et al. 2020; Breiter and Lange 2019).

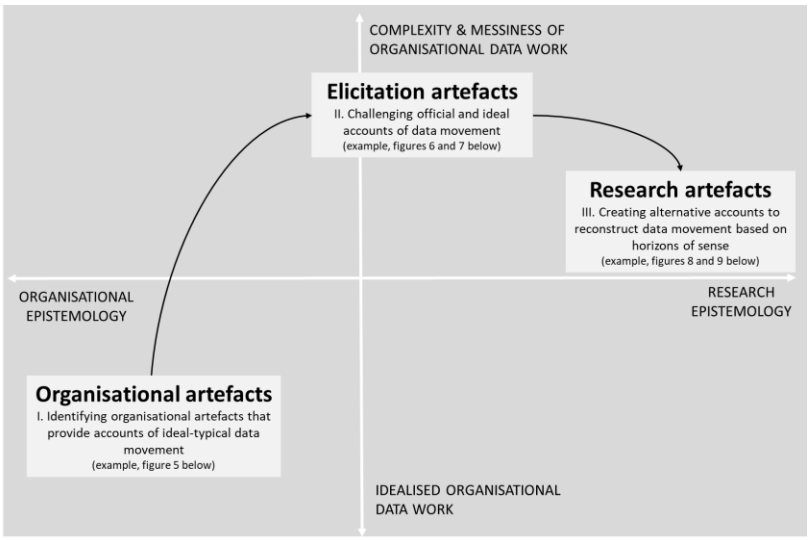
Whereas in the broader project we studied ten K-12 schools in four federal states of Germany, in this paper we draw on a case study from one of the schools that is exemplary for our observations in the others. We focus here on one aspect of the datafied organisation of education – data about lessons cancellation. Lesson cancellation data are particularly interesting for studying datafied organising because they have been attributed increasingly high political, public, and organisational significance in recent years. In the public and media discourse on education, there has been an increasing demand for the state-led provision of sufficient specialised teaching. In most schools, several different actors with varying responsibilities are involved in the lesson cancellation-related data work. Besides filling in the gap in the school timetable left by a cancelled lesson, school actors also have to

document and transmit cancellation data to the ministries of education and the monitoring agencies for statistics and controlling purposes. In this way, lessons' cancellation data travel across information systems used in schools and ministries and acquire new meanings every time they pass various organisational entities on their way from a classroom to the publicly available statistics about the quality of education in a federal state.

To reconstruct the movement of lessons' cancellation data from the classroom to political actors, we, first, conducted a qualitative analysis of different *organisational artefacts*, either publicly available (e.g., on the websites of the ministries of education) or acquired from the relevant organisational actors for research purposes (Trausan-Matu and Slotta 2021). In addition, we conducted a document analysis of legal texts regulating data generation, storage, and processing; software specifications describing and depicting data models and flows (e.g., UML data flow model); press releases informing the publics in respective federal states about educational matters; and relevant parts of the websites of the federal states' ministries of education, their recent policy documents, and reports. With artefacts we refer here to human-made, material objects that serve a specific purpose. These organisational artefacts are situated within the organisational epistemologies and knowledge practices in which they are created. They make sense to certain actors as they are an articulation of how they anticipate how the movement of data "ought to be" (figure 4, step I). Hence, organisational artefacts do not represent the complexity and messiness of organisations in the making, but rather idealised versions of how data movement ought to unfold according to the horizon of sense of specific organisational actors. This situatedness is very often not visible in these kinds of artefacts. Rather, very often such artefacts suggest a "god's eye view" on idealised pathways of data movement.

Second (figure 4, step II), we complemented and constructively challenged these accounts of ideal data movement that are presented in organisational artefacts with interviews with various educational actors to capture data movement in practice. We conducted interviews with school employees (principals and school management teams, teachers) and ministry staff (usually, project, department or team leads). In the interviews with the SMIS designers and developers we applied a card-sorting technique (Hepp and Hasebrink 2018) to first assemble an overview of all relevant human and non-human actors (e.g., other organisations and organisational actors, different information systems, datasets, and various organisational artefacts) and second put these in relation to each other and the interviewed SMIS designers themselves. The resulting elicitation artefacts are highly messy in the ways in which they account for different organisational data work. Their framing however (e.g., the categories used) shifts towards the epistemology as provided and framed by us as researchers.

Figure 4 A Trajectory of Reconstructing Data Movement



Third (figure 4, step III), based on these elicitation artefacts we produced *research artefacts* in the form of *temporal* and *topological accounts* of data movement that are based on the situated work practices of different educational actors. The resulting visual data accounts are not at all as messy as the elicitation artefacts and much more grounded in our research epistemology. In the following, we present this process in detail and reflect on the ways in which such an approach allows to reconstruct the horizons of sense in which the data work of different educational actors is performed.

4. Reconstructing data movement

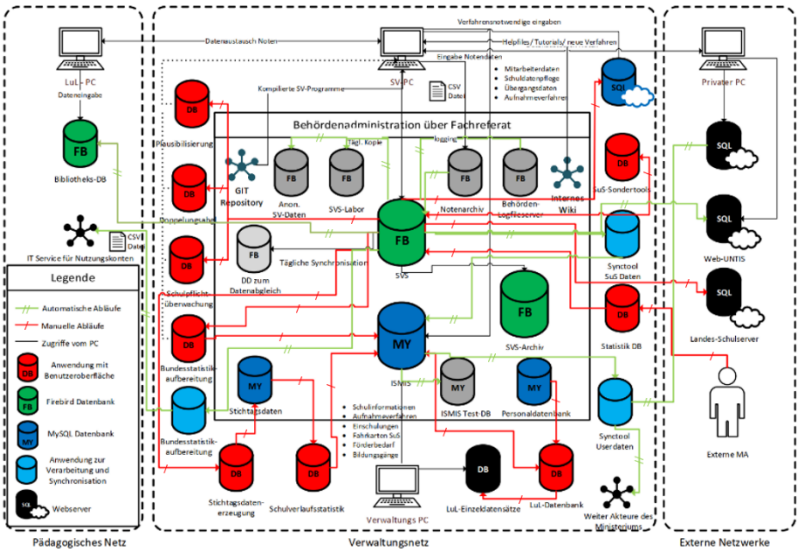
4.1 Step I: Identifying Ideal Accounts of Organisational Data Movement

In the first step to reconstruct data journeys, we identified organisational artefacts that provide accounts of ideal-typical data movement. An example of an organisational artefact that we used to reconstruct the topologies of data movement is the following anonymised version of an educational data infrastructure from one of the federal states in our study (figure 6).

The ways in which data move within and across different networks (e.g., pedagogical network, administrative network, and external networks is depicted through dashed lines) and between different information systems

and data bases (depicted as storage boxes in different colours depending on their type) render the social actors involved in producing, processing, and transferring data invisible. There is only one human actor depicted in this organisational artefact: This actor is positioned as external to the educational infrastructure and accesses statistical data about education through their own private computer (bottom right of figure 5). All other data work and the human actors performing this work remain invisible in this figure. The arrows that signify data flows between different information systems use two different colours to represent automated data transmission (labelled in green with two dashes) and manual data work (labelled in red with one dash). Access to databases through computers is represented through black arrows. Overall, *this educational data infrastructure map suggests that data flow smoothly between different systems, networks and organisations.*

Figure 5 Anonymised Version of an Educational Data Infrastructure Map of a Federal State in Germany



The artefact suggests to present a "god's eye view," a view from above, on to the data infrastructure as an existing and frictionless network. Far from true, we want to argue that it is a reductionist account of data movement by those running the educational infrastructure, which disregards and/or is unaware of the work required by organisational actors (on the ground and in schools) to make data move. Hence, friction and any type of work required to ensure the flow of data are not considered. However, such organisational artefacts

allowed us to gain a first understanding of the complexity and relatedness of this data infrastructure and the journeys that data are meant to undertake.

4.2 Step II: Exploring Data Friction

Throughout our interviews, school principals, teachers, and school IT-staff contested these kinds of neat accounts in which data appear to move seamlessly. In order to reconstruct topologies that are grounded in the lived experiences of educational actors, we had to engage different kinds of methods. In our second step, we therefore invited educational actors to challenge official and idealised accounts of data movement.

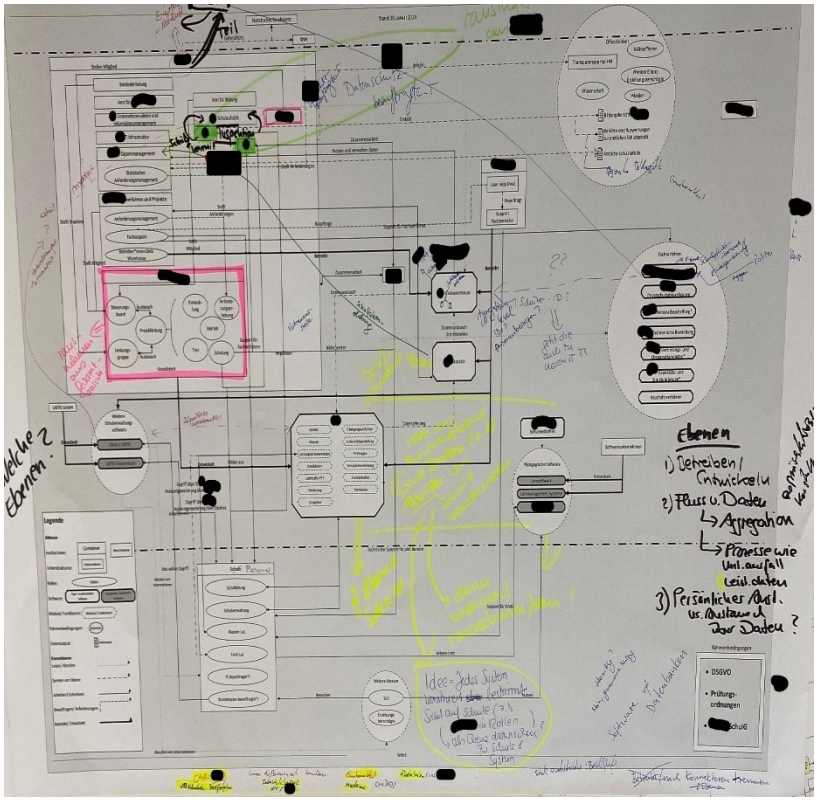
Figure 6 A card-sorting Map from an Interview with the Educational Ministry's Information System Developers from one of the Examined States

Pink sticky notes (the darkest notes in greyscale) describe human and organisational actors, green and yellow notes (the lightest notes in greyscale, e.g., "SAP" and "Personal-daten SAP") describe technological systems, and blue notes (slightly darker than the previous notes in greyscale, e.g., "Daten" in the bottom right) describe data.

One of the first steps that we undertook was to ask our study participants to position differently coloured sticky notes (colours signify types of entities, e.g., people, information systems, datasets) on a prepared poster according to their relation to the analysed SMIS (figure 6). We invited the interview partners to challenge our categories in order to facilitate a discussion about their "horizon of sense and landscape of artefacts amid which they unfold" (Nicolini 2009, 1403). Subsequently, we analysed the placement of different

sticky notes in relation to SMIS and the boundaries the interviewees drew between SMIS, organisations (e.g., ministries of education, education monitoring agencies, schools), organisational units (e.g., various departments within education ministries like K-12, statistics, IT and SMIS), and frictions in the data flows between these boundaries.

Figure 7 Snapshot of the Reconstruction of a Topological Data Journey Making Visible the Ambiguity of Connections and Researchers' Decisions on which Actors to Assemble How



The map was developed in collaboration with our project colleagues Tjark Raabe, Sigrid Hartong and Vito Dabisch.

In a next iteration, and in order to move beyond an initial and often times messy or very complex mapping, the initial visual elicitation artefacts were digitalised, aggregated, compared, and interpreted in a way that allowed patterns to emerge (see Langley and Ravasi 2019 for theorising through visual research artefacts). Based on the interviews and results of the card-sorting, we developed a topological account of educational data movement that

locates different organisational actors (including information systems and data) spatially according to the relations enacted through different organisational data-related processes (figure 7). This first mapping visualises the systems used by the ministries of education, in schools, and by other stakeholders and locates these spatially according to the relations enacted through different data practices. Depicting data movements through lines and arrows renders visible the multiplicity of educational data. The circles and boxes distinguish organisations and roles as actors, various information systems, and databases. The connectors (lines and arrows) between these actors provide an insight about the relational organisation of data movement, but not about what educational actors *do* with the data.

Far from being a simple representation of data movement, figure 7 demonstrates the multiplicity, heterogeneity, and messiness we encountered while trying to "make sense" and decide which actors and connections are relevant to the data movements we wanted to "trace" and reconstruct. Hence, the creation of the visual representation was an iterative process of re-negotiating – also with interviewees – how an account of educational data movement should look like. Naturally, we encountered conflicting accounts of how the movement of data "really" takes place, demonstrating again the impossibility of a "god's eye view" onto data journeys. To further explore and understand these conflicting accounts of different interviewees, we decided to reconstruct the temporal flow of a specific and highly relevant data-driven process (lesson cancellation). It allowed us to visualise how the data work of different educational actors connects and unfolds over time.

4.3 Step III: Creating Alternative Visual Accounts of Data Movement

4.3.1 Reconstructing the Temporal Flow of Data Journeys

As a first way of reconstructing and potentially visualising data journeys, we developed an account of the data journey's temporal unfolding. Such an account *zooms in* on the work that is required to move data. It renders visible *how* a specific data journey establishes connections; how it relates particular entities over time and leaves other entities unrelated. For this, we drew on the business process modelling notation BPMN 2.0 and adapted it to meet the needs of our own research (for example, we allowed for connections between lanes in different pools).

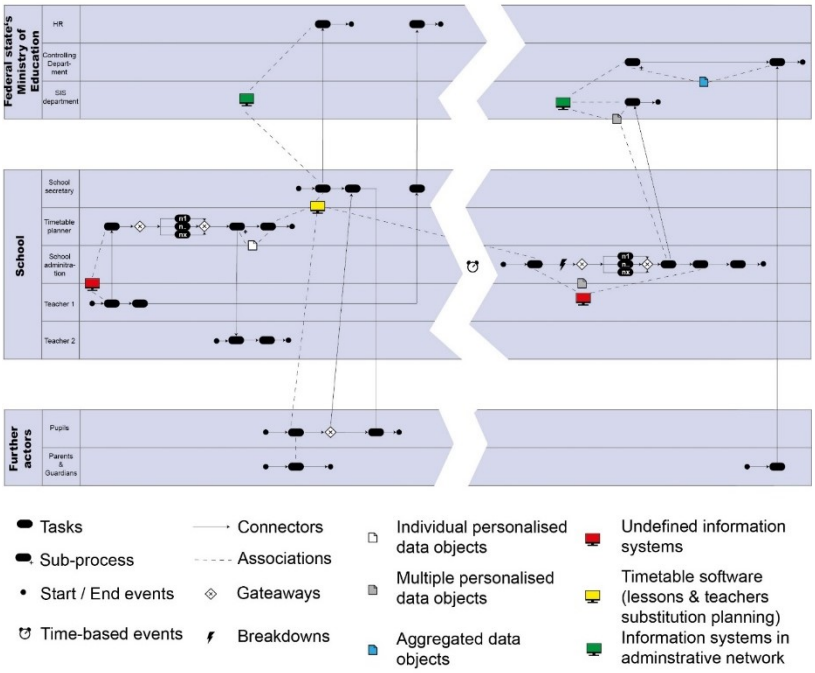
Figure 8 depicts the case when lessons need to be cancelled because one teacher calls in sick. Within schools (pool "schools"), involved actors are a team of teachers specifically responsible for the cancellation process (lane timetable planner in figure 8), teachers cancelling or substituting the lessons (lanes "Teacher 1 and 2"), school administration (same-titled lane), and school secretaries (same-titled lane). When a team member responsible for

the cancellation process is notified about a cancelled lesson, they seek a substitute teacher first using any information systems they have, including private ones (coloured in red and labelled as "Undefined information systems"). Upon finding a substitute teacher, they document the changes in the timetable in the designated software (coloured in yellow and labelled as "Timetable software (lessons & teachers substitution planning)"), while different actor groups have different degrees of access to these changes. For example, pupils and their guardians (same-titled lanes) can access their timetables online through a web or mobile interface to receive information about any changes to the schedule. School secretaries support the organisational processes of changes in the timetable in ways that are invisible in the official organisational documents that we sourced and analysed in step 1 of our reconstruction (e.g., figure 5). They make phone calls to missing teachers, spontaneously organise substitutes from the teachers' room, inform pupils about timetable changes, or, if necessary, take over the supervision of a class themselves. In addition, they forward sick-leave data to the human resource department of the ministry of education. When the changes in the timetable are successfully made, cancellation data temporarily cease moving within the school, as depicted by a zigzag line in figure 8.

With the next data-reporting cycle from a school to the ministry of education of the federal state, cancellation data continue their journey. Much of the school internal data work (e.g., that of secretaries) becomes invisible. During the reporting process, the cancellation data mutate – they are being pseudonymised and aggregated within the designated SMIS. These mutations, however, do not take place "automatically," but require additional work of interpreting and contextualising in order to fit the actors' differing horizons of sense. For example, before transmitting cancellation data to the ministry, the school administration members go through the dataset of the latest reporting cycle in order to correct the interoperability flaws between the different systems and to produce a dataset that they conceive of as appropriate for transmission. As the school principal of the case study school stated: they want to provide "honest" and "correct" data, that represents the schools' "colourful and manifold" realities as closely as possible. Their ambition is to create a particularly inclusive and inspiring learning and teaching environment, which should be represented in the data they transmit. We observed, however, that school actors lack knowledge about how data move on. Their data work, therefore, was strongly informed by their *anticipations*: the actions and individual decisions of many people were guided by *assumptions* about what might happen to the data on the other side of their horizon of sense (in the ministries of education) and what this might mean for their own school. This relates, for example, to anticipations about how cancellation data may find their way into official statistics in aggregated

and disaggregated form and are subsequently open to the scrutiny of school inspectors, parents, or the general public. Such representations of a school may have an impact, for example, on the number of school applications (e.g., schools with higher rates of class cancellation may be chosen less often by parents) and the general reputation of a school.

Figure 8 Process-Oriented Data Journey of a Lesson Cancellation Process in



One School

The individual context and the individual values of the interviewed actors led to very different expectations and, subsequently, varying data practices and evaluations of the information systems used, sometimes even within the same school. For school ministries, this lack of clarity manifested even stronger, so that throughout the investigation period it was not possible for us to completely reconstruct the movement of lesson cancellation data from their production in schools, through their use by the school inspectors, to their final, aggregated publication in policy documents and reports in each of the federal states.

In contrast to our temporal account of the data journey of lesson cancellation data, the planned or ideal data movement, as represented in the software documentation of the SMIS, merely describes the monthly data

transmission required from the school by the state laws. The work that takes place within the school is black boxed. Hence, the school-internal topology – pupils and their guardians, sick-leave data, phone or messenger services used to notify various stakeholders, etc., are absent in the organisational account.

In sum, we adopted a BPMN visualisation (as a research artefact) to reconstruct the temporal unfolding of otherwise invisible data work. It comprises of activities and work organisational actors perform in order to make data move. Breaks in the temporal flow hint at the transformations that data undergo, i.e., the changing of forms, formats, and meanings. Both represent instances in which the actors' horizons of sense end and anticipation about the further movement of the data begins. This kind of visualisation and analysis, however, does not give an account about what is being anticipated by various actors, how, and why. In order to attend to the ways in which these horizons of sense produce different topologies of data movement, we now turn to an alternative (and complementary) visualisation.

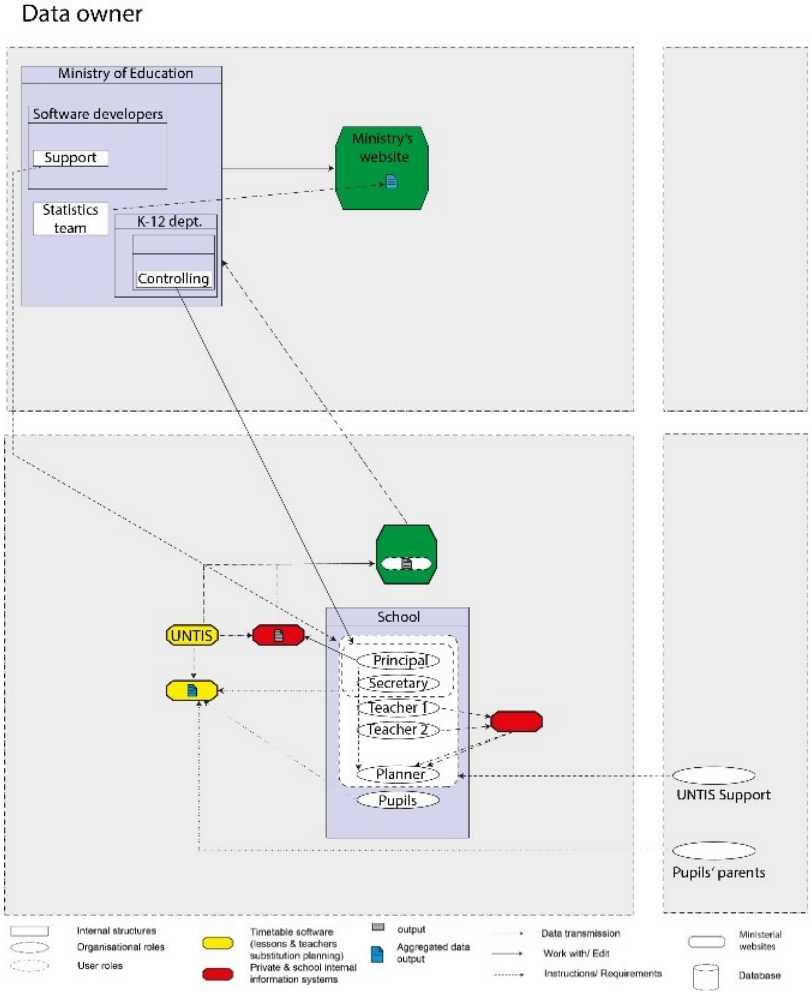
4.3.2 Reconstructing Horizons of Sense in Data Journeys

Expanding on our exploration of the temporal unfolding of data work and data movement, a topological perspective of data movement allows for reconstructing the differing horizons of sense of the actors involved in data work. For the data journey of lesson cancellation, we created visualisations of two topological perspectives. In the first instance, school management understands schools as *data owners*, as the entity that creates and uses data with the ministry as a secondary data user (figure 9). This refers to the work of actors and their relations within the school and before the data are reported to the ministry of education. In the second instance, schools are perceived of as a *data source* by the ministry and the internal processes, data practices, and roles collapse. This relates to the work and relations of those actors involved in the transmission of cancellation data from a school to the respective ministry of education.

Both views depict the ministry of education in the upper left corner and the school at the bottom. In both cases, a timetable software (yellow shape [lightest-coloured octagonal shape in greyscale]) and the state's SMIS (green shape close to the school [slightly-darker octagonal shape in greyscale]) are depicted. These perspectives differ, however, with respect to the entities that they assemble for describing the organisational data work of lesson cancellation. For example, for the horizon of sense of ministerial employees and their data work, the school and its different sets of actor roles collapse to school management and SMIS providing data for the ministry's statistics unit (*school as data source*). In contrast, the horizon of sense from the perspective of school management (*school as data owner, figure 9*) involves a great number of different actor roles and information systems that are used in the school (marked in red and yellow [in greyscale: the darkest and lightest octagonal

shapes respectively]). There are further differences with respect to different publics that use and interpret aggregated lesson cancellation data. Whereas the school is mainly concerned with pupils and parents being informed about the immediate cancellation of classes, the horizon of sense of ministry employees extend to political decision makers, media, and the wider public.

Figure 9 Topological Data Journey Visualising the School's View as Data Owner for the Movement of Lesson Cancellation Data



According to the *data owner perspective* (as depicted in figure 9), material artefacts (e.g., filing cabinets) and information systems (e.g., those localised

in the schools' pedagogical network) are entry points to the journeys of lesson cancellation data. However, these entities are not necessarily visible to educational actors outside a school (e.g., the school ministry). In fact, during our interviews, several school principals explained that they understood one of their tasks to be safeguarding certain data from travelling altogether. They argued that in order to provide a safe and caring school environment, certain data needed to stay within the school and under the control of school management. Data non-movement is hence not understood as a bad thing per se but can be understood as an important articulation of different horizons of sense and their related aims, interests, value dispositions, and/or obligations. That school actors are able and keen to keep data within "their walls" and from travelling altogether is hence one of the key findings of examining data movement through their horizon of sense.

This perspective contradicts the horizon of sense established by ministry officials, who conceive of a school as a "black box" where the school-internal data practices are "hidden" as long as the data coming out the school are fulfilling required criteria. For this perspective, *schools are data sources* for further data-driven decision-making taking place in the ministry. Often, such a perspective goes hand in hand with the idea that the data about schooling that the ministries of education request and receive are by-products of managing and organising schooling. However, in several interviews and also workshops, school management pointed out that the ever-increasing demand on data about school organisation (e.g., also related to COVID-19 cases, number of refugee children) have little to no relevance to everyday schooling and are by no means data that can be understood as by-products of organisational processes. Rather, these kinds of data require additional data work.

Reconstructing differing horizons of sense along the paths that data move hence allows to explore how various organisational socio-cultural factors, data-sharing infrastructures, and regulatory frameworks shape the data work of different organisational members. These practices and the resulting data (non)movement produce different, distinctive modes of organising. Switching between different horizons of sense, we can observe how actors collapse into one entry point and others enfold.

5. Conclusion: Reconstructing Data Movement as Approach for Researching Datafied Organisation

Ideal-typical accounts of data movement, as can be found in software documentation or official organisational infrastructure documents, represent data movement as taking place along stable and well-defined paths

and processes. These kinds of organisational artefacts are similar to organisational charts that depict idealised, non-messy representations of organisational roles and hierarchies. However, such representations only capture a certain point in time – a "distal view" on organisation (Cooper and Law 1995) – while informal aspects of organising remain "unreported 'back stage' work" (Star 2010).

To reconstruct and visualise data journeys, we propose, as a first step, to look at the organisational artefacts they relate to in order to identify ideal views on data movement and anticipated work practices (e.g., the infrastructure map in figure 5). Such ideal views, however, are never fully able to anticipate the technical, social, and economic contingencies of data work. In addition, there exists a plethora of organisational artefacts that are traces of data movement themselves such as charts, print-outs, or published reports, which can be used for tracing data movement in practice. These are tidy versions of messy organisational realities. Including such artefacts in the process of the initial mapping helps to preserve – to some degree – the organisational epistemologies and knowledge practices in which they were created. These artefacts make sense to organisational actors as they are an articulation of their *horizons of sense* and their anticipations of how things *ought to be*. In the second step, different kinds of organisational artefacts are analysed together with further research materials, such as interviews or ethnographic observations, that relate to the kinds of data work performed (such as card sorting [figure 6] or mind maps [figure 7]). Based on this mode of analysis, initial visualisations of data journeys can be produced as a tool for thinking (otherwise) and analysing, coding, categorising, or clustering qualitative data (figure 8 and 9). The development of these kinds of initial visualisations may follow notations that are already established, such as BPMN in our case, or resort to alternative ways of visualising. Of course, each of these visualisations comes with their own affordances and constraints in terms of how they allow to *represent* data movement.

We have presented two ways of visualising data movement (temporal and topological) that are grounded in the differing horizons of sense of those members of an organisation that are involved in data work. While the *topological visualisations* of data movement (figure 9) allow for the reconstruction of the diverging horizons of sense of different social actors and how they perceive of organisational boundaries and positions of power, for example, those positioned as "gate keepers" or best connected to multiple other actors. A topological perspective visualises different modes of ordering datafied organisation, different forms of organisation, and their boundaries. The relationality of data becomes visible in this type of artefact as it connects and relates heterogeneous sets of entities that are required to produce, process, and move data. In contrast a *temporal visualisation* of data movement (figure 8) renders visible specific moments in time when horizons of sense

collide or are positioned out of sight and friction occurs. It allows to explore how and in which ways data move from one setting to another, it makes visible the interconnected work that is required to move data in practice.

Overall, these two ways of reconstructing and visualising data movement are part of a continuum of possible ways to reconstruct data journeys in organisations. Data movement is always both: (multiple) temporalities and (multiple) topologies emerging through organisational data work amidst the horizons of sense of those performing data work. Reconstructing data movement in such a way then allows for the exploration of (in)visibilities of digital transformation(s) in three ways.

First, invisibilities in data movement relate to the *invisible data work* of organisational actors that goes unnoticed because it escapes the horizon of sense of the dominant organisational perspective, as has long been argued in research on the digital transformation of organisation (e.g., Star and Strauss 1999; Nardi and Engeström 1999). This was, for example, prominent in our case study in relation to the work of secretaries for facilitating the data movement of lesson cancellation data. In the formal process, they do not play a defined role in any of the federal states, but in the interviews, it became obvious that school secretariats often step in when the movement of data stagnates. Attending to data movement provides a heuristic to consider these sites of passage and attend to otherwise invisible work in digital organising. It further allows for the consideration of these sites of passage as constitutive elements for performing and producing organisation from a process perspective (Cooper and Law 1995; Langley 2007).

Second, the invisibilities addressed through the study of data movement also cover those *data that are missing or do not travel* (e.g., Onuoha 2018; D'Ignazio and Klein 2020). For example, in our study, lesson cancellation data represented different things in different federal states: How schools may deal creatively and strategically with a shortage of qualified teachers remains largely invisible to the ministries (e.g., disregarding data and seeking external substitution staff, or transmitting "bad data"). Hence, connecting data across organisations impacts on the ways in which responsibility and agency are distributed across data infrastructures; attending to data movement allows for the capturing of those points of passage.

Third, invisibilities in data movement may cover those *actors* who are affected by organisational data practices and *whose perspectives are often silent or silenced* (e.g., Noble 2018). This relates, for example, to the question of who counts as a creator or user of data at different points of passage and how different actors' situated horizons of sense are configured through data movement. Research on datafied organising all too often reduces people to roles (and rationale actors) and in so doing misses out on their tacit knowledge, motives, and beliefs. Setting out to trace the data work carried out behind data movement allows for the capture of different actors' horizons of

sense and helps situate their data work within wider social, political, and economic contexts.

In sum, reconstructing topological and temporal accounts of data movement is an approach to researching digital transformation(s) that challenges widespread, distal assumptions of organisations as fixed structures through which data flow like immutable mobiles. We argue to understand organisation as a process where relations enacted through data movement (re-)configure modes of ordering. Attending to data work and its horizons of sense is key for researching digital transformation(s) and its many invisibilities.

References

Aalst, Wil van der, Jörg Desel, and Ekkart Kindler. 2002. On the Semantics of EPCs: A Vicious Circle. *EPK*: 71-79.

Alaimo, Cristina, and Jannis Kallinikos. 2021. Managing by Data: Algorithmic Categories and Organizing. *Organization Studies* 42 (9): 1385-407. doi: 10.1177/0170840620934062.

Aula, Ville. 2019. Institutions, Infrastructures, and Data Friction – Reforming Secondary Use of Health Data in Finland. *Big Data & Society* 6 (2). doi: 10.1177/2053951719875980.

Bates, Jo. 2018. The Politics of Data Friction. *Journal of Documentation* 74 (2): 412-29. doi: 10.1108/JD-05-2017-0080.

Bates, Jo, Yu-Wei Lin, and Paula Goodale. 2016. Data Journeys: Capturing the Socio-Material Constitution of Data Objects and Flows. *Big Data & Society* 3 (2). doi: 10.1177/2053951716654502.

Baygi, Reza Mousavi, Lucas D. Introna, and Lotta Hultin. 2021. Everything Flows: Studying Continuous Socio-Technological Transformation in a Fluid and Dynamic Digital World. *MIS Quarterly* 45 (1): 423-52. doi: 10.25300/MISQ/2021/15887.

Becker, Jörg, Wolfgang Probandt, and Oliver Vering. 2012. Modellierungssprachen. In *Grundsätze ordnungsmäßiger Modellierung*, ed. Jörg Becker, Wolfgang Probandt, and Oliver Vering, 4-30. Berlin, Heidelberg: Springer Berlin Heidelberg. doi: 10.1007/978-3-642-30412-5_2.

Borgman, Christine L. 2015. *Big Data, Little Data, No Data: Scholarship in the Networked World*. Cambridge, Massachusetts: The MIT Press.

Bowker, Geoffrey C. 2008. *Memory Practices in the Sciences*. Cambridge, Massachusetts; London: Mit Pr.

Bowker, Geoffrey C., Karen Baker, Florence Millerand, and David Ribes. 2009. Toward Information Infrastructure Studies: Ways of Knowing in a Networked Environment. In *International Handbook of Internet Research*, ed. Jeremy Hunsinger, Lisbeth Klastrup, and Matthew Allen, 97-117. Springer Netherlands.

Breiter, Andreas, and Angelina Lange. 2019. Die Digitale Schulverwaltung. In *Handbuch Digitale Verwaltung*, ed. Henning H. Lühr, Roland Jabkowski, and Sabine Smentek, 330–42. Wiesbaden: Kommunal- und Schulverlag.

Büchner, Stefanie. 2018a. Digitale Infrastrukturen - Spezifik, Relationalität und die Paradoxien von Wandel und Kontrolle. *AIS-Studien* 11 (2): 279-93. doi: 10.21241/ssoar.64878.
Büchner, Stefanie. 2018b. Zum Verhältnis von Digitalisierung und Organisation: On the Relationship of Digitization and Organization. *Zeitschrift für Soziologie* 47 (5): 332-48. doi: 10.1515/zfsoz-2018-0121.
Callon, Michel, and John Law. 2004. Introduction: Absence — Presence, Circulation, and Encountering in Complex Space. *Environment and Planning D: Society and Space* 22 (1): 3-11. doi: 10.1068/d313.
Chen, Peter Pin-Shan. 1976. The Entity-Relationship Model—toward a Unified View of Data. *ACM Transactions on Database Systems* 1 (1): 9-36. doi: 10.1145/320434.320440.
Cooper, Robert, and John Law. 1995. Organization: Distal and Proximal Views. *Research in the Sociology of Organizations* 13: 237-74.
Currie, Morgan E., Britt S. Paris, and Joan M. Donovan. 2019. What Difference Do Data Make? Data Management and Social Change . *Online Information Review* 43 (6): 971-85. doi: 10.1108/OIR-02-2018-0052.
D'Ignazio, Catherine, and Lauren F Klein. 2020. *Data Feminism*. Cambridge, Masachusetts: MIT Press.
Edwards, Paul N., Matthew S. Mayernik, Archer L. Batcheller, Geoffrey C. Bowker, and Christine L. Borgman. 2011. Science Friction: Data, Metadata, and Collaboration. *Social Studies of Science* 41 (5): 667-90. doi: 10.1177/0306312711413314.
Eleftheriou, Iliada, Suzanne M. Embury, and Andrew Brass. 2016. Data Journey Modelling: Predicting Risk for IT Developments . In *The Practice of Enterprise Modeling*, ed. Jennifer Horkoff, Manfred A. Jeusfeld, and Anne Persson, 267: 72-86. Lecture Notes in Business Information Processing. Cham: Springer International Publishing. doi: 10.1007/978-3-319-48393-1_6.
Eleftheriou, Iliada, Suzanne M. Embury, Rebecca Moden, Peter Dobinson, and Andrew Brass. 2018. Data Journeys: Identifying Social and Technical Barriers to Data Movement in Large, Complex Organisations . *Journal of Biomedical Informatics* 78 (February): 102-22. doi: 10.1016/j.jbi.2017.12.001.
Freund, Jakob, and Bernd Rücker. 2014. *Praxishandbuch BPMN 2.0*. 4., Aktualisierte Auflage. München Wien: Hanser.
Gerrard, Ysabel, and Jo Bates. 2019. Introduction to the Data Power Special Issue: Tactics, Access and Shaping. *Online Information Review* 43 (6): 945-51. doi: 10.1108/OIR-10-2019-396.
Gitelman, Lisa, ed. 2013. *Raw Data Is an Oxymoron*. Cambridge, Massachusetts ; London, England: The MIT Press.
Griesemer, James. 2020. A Data Journey Through Dataset-Centric Population Genomics. In *Data Journeys in the Sciences*, ed. Sabina Leonelli and Niccolò Tempini, 145-67. Cham: Springer International Publishing. doi: 10.1007/978-3-030-37177-7_8.
Haraway, Donna. 1988. Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective . *Feminist Studies* 14 (3): 575-99.
Hartong, Sigrid, and Andreas Breiter. 2021. Between Fairness Optimization and "Inequalities of Dataveillance": The Emergence and Transformation of Social Indices in German School Monitoring and Management. In *World Yearbook of Education 2021*, ed. Sotiria Grek, Christian Maroy, and Antoni Verger, 76-93. London: Routledge.

Hartong, Sigrid, Andreas Breiter, Juliane Jarke, and Annina Förschler. 2020. Digitalisierung von Schule, Schulverwaltung Und Schulaufsicht . In *Handbuch Digitalisierung in Staat Und Verwaltung*, ed. Tanja Klenk, Frank Nullmeier, and Göttrik Wewer, 485-94. Wiesbaden: Springer VS.
Hepp, Andreas, and Uwe Hasebrink. 2018. Researching Transforming Communications in Times of Deep Mediatization: A Figurational Approach. *Communicative Figurations*, 15-48. doi: 10.1007/978-3-319-65584-0_2.
Hepp, Andreas, Juliane Jarke, and Leif Kramp, eds. 2022. *New Perspectives in Critical Data Studies: The Ambivalences of Data Power*. Transforming Communications – Studies in Cross-Media Research. London, UK: Palgrave Macmillan.
Jarke, Juliane. 2018. Digitalisierung Und Gesellschaft . *Soziologische Revue* 41 (1): 3-20. doi: 10.1515/srsr-2018-0002.
Jarke, Juliane, and Andreas Breiter, eds. 2019. *The Datafication of Education*. Oxon, New York: Routledge.
Jones, Matthew. 2019. What We Talk about When We Talk about (Big) Data . *The Journal of Strategic Information Systems* 28 (1): 3-16. doi: 10.1016/j.jsis.2018.10.005.
Kitchin, Rob. 2014. *The Data Revolution: Big Data, Open Data, Data Infrastructures and Their Consequences*. Thousand Oaks, California: SAGE.
Langley, Ann. 2007. Process Thinking in Strategic Organization. *Strategic Organization* 5 (3): 271-82. doi: 10.1177/1476127007079965.
Langley, Ann, and Davide Ravasi. 2019. Visual Artefacts as Tools for Analysis and Theorizing. In *Research in the Sociology of Organizations*, ed. Tammar B. Zilber, John M. Amis, and Johanna Mair, 59: 173-99. Emerald Publishing Limited. doi: 10.1108/S0733-558X20190000059010.
Langley, Ann, Clive Smallman, Haridimos Tsoukas, and Andrew H. Van de Ven. 2013. Process Studies of Change in Organization and Management: Unveiling Temporality, Activity, and Flow. *Academy of Management Journal* 56 (1): 1-13.
Latour, Bruno. 2004. The Social as Association. In *The Future of Social Theory*, 77-90. London; New York: Continuum International Publishing Group.
Latour, Bruno. 2007. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.
Law, John. 2004. *After Method: Mess in Social Science Research*. International Library of Sociology. London, UK: Routledge.
Law, John, and Annemarie Mol. 2001. Situating Technoscience: An Inquiry into Spatialities . *Environment and Planning D: Society and Space* 19 (5): 609-21. doi: 10.1068/d243t.
Leonelli, Sabina. 2013. Why the Current Insistence on Open Access to Scientific Data? Big Data, Knowledge Production, and the Political Economy of Contemporary Biology . *Bulletin of Science, Technology & Society* 33 (1-2): 6-11. doi: 10.1177/0270467613496768.
Leonelli, Sabina. 2014. What Difference Does Quantity Make? On the Epistemology of Big Data in Biology: *Big Data & Society*, April. doi: 10.1177/2053951714534395.
Leonelli, Sabina. 2020. Learning from Data Journeys . In *Data Journeys in the Sciences*, ed. Sabina Leonelli and Niccolò Tempini, 1-24. Cham: Springer International Publishing. doi: 10.1007/978-3-030-37177-7_1.
Leonelli, Sabina, and Niccolò Tempini, eds. 2020. *Data Journeys in the Sciences*. Springer International Publishing. doi: 10.1007/978-3-030-37177-7.

Medina Perea, Itzelle Aurora. 2021. Socio-Material Factors Shaping Patient Data Journeys in the United Kingdom . Sheffield, UK: University of Sheffield.
Meyer, Alan D. 1991. Visual Data in Organizational Research. *Organization Science* 2 (2): 218-36. doi: 10.1287/orsc.2.2.218.
Meyer, Renate E., Markus A. Höllerer, Dennis Jancsary, and Theo van Leeuwen. 2013. The Visual Dimension in Organizing, Organization, and Organization Research: Core Ideas, Current Developments, and Promising Avenues . *Academy of Management Annals* 7 (1): 489-555.
Miles, Matthew B, and A Michael Huberman. 1984. Drawing Valid Meaning from Qualitative Data: Toward a Shared Craft . *Educational Researcher*, 11.
Nardi, Bonnie A., and Yrjö Engeström. 1999. A Web on the Wind: The Structure of Invisible Work. *Computer Supported Cooperative Work (CSCW)* 8 (1-2): 1-8. doi: 10.1023/A:1008694621289.
Nicolini, Davide. 2009. Zooming In and Out: Studying Practices by Switching Theoretical Lenses and Trailing Connections. *Organization Studies* 30 (12): 1391-1418. doi: 10.1177/0170840609349875.
Noble, Safiya Umoja. 2018. *Algorithms of Oppression: How Search Engines Reinforce Racism*. New York: New York University Press.
Onuoha, Mimi. 2018. On Missing Data Sets. 2018. https://github.com/MimiOnuoha/missing-datasets.
Ravasi, Davide. 2017. Visualizing Our Way through Theory Building. *Journal of Management Inquiry* 26 (2): 240-43. doi: 10.1177/1056492616680575.
Saifer, Adam, and M. Tina Dacin. 2021. Data and Organization Studies: Aesthetics, Emotions, Discourse and Our Everyday Encounters with Data. *Organization Studies*, March, 01708406211006250. doi: 10.1177/01708406211006250.
Scheer, August-Wilhelm. 2000. *ARIS--Business Process Modeling*. 3rd ed. Berlin ; New York: Springer.
Sommerville, Ian. 2007. *Software Engineering*. 8th ed. International Computer Science Series. Harlow, UK: Addison-Wesley.
Star, Susan Leigh, and Karen Ruhleder. 1996. Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces. *Information Systems Research* 7 (1): 111-34.
Star, Susan Leigh, and Anselm Strauss. 1999. Layers of Silence, Arenas of Voice: The Ecology of Visible and Invisible Work. *Computer Supported Cooperative Work (CSCW)* 8 (1): 9-30. doi: 10.1023/A:1008651105359.
Straube, Till. 2016. Stacked Spaces: Mapping Digital Infrastructures. *Big Data & Society* 3 (2): 205395171664245. doi: 10.1177/2053951716642456.
Trausan-Matu, Stefan, and James D. Slotta. 2021. Artifact Analysis. In *International Handbook of Computer-Supported Collaborative Learning*, ed. Ulrike Cress, Carolyn Rosé, Alyssa Friend Wise, and Jun Oshima, 551-67. Cham: Springer International Publishing. doi: 10.1007/978-3-030-65291-3_30.
Wessel, Lauri, Roxana Ologeanu-Taddei, Jonghyuk Cha, and J Cha. 2021. Unpacking the Difference between Digital Transformation and IT-Enabled Organizational Transformation, 58.
White, James Merricks. 2018. Following Data Threads. In *Data and the City*, ed. Rob Kitchin, Tracey P. Lauriault, and Gavin McArdle. Abingdon, Oxon; New York, NY: Routledge.

Zakharova, Irina, and Juliane Jarke. 2022 Educational Technologies as Matters of Care. *Learning, Media and Technology* 47 (1): 95-108. doi: 10.1080/17439884.2021.2018605.

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