



Affordances of narrative and numerical data: A social-semiotic approach to data use

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ABSTRACT

Data use in education is a sensemaking process in which practitioners and researchers interact with different systems of meaning such as anecdotes or spreadsheets. The representational qualities of data and their influence on practice are critical but less well-discussed aspects of data use. Drawing on social semiotics, this theoretical article proposes that data should be discussed in terms of narrative and numerical modes of representation. Narrative data typically consist of protagonists and actions organized in a temporal structure, while numerical data typically consist of mathematical notations and visual representations such as graphs and figures. We argue that the representational properties of these two modes affect how data are interpreted and acted upon. We then present two contrasting cases from New Zealand and Norway of how affordances affect teachers' data use processes. Finally, we discuss five challenges arising from our theorization about the affordances of data.

1. Introduction

Data use in education is a complex sensemaking process in which practitioners and researchers interact with different systems of meaning, such as anecdotes obtained from working with students or spreadsheets containing the results of assessments. However, despite its proliferation in the last decade, research on data use in education is characterized by the pervasiveness of empirical studies and corresponding lack of theorization (Prøitz, Mausethagen, & Skedsmo, 2017). The under-theorization has been explained variously as a result of the multiple origins and purposes of data use: for evidence-based teacher inquiry (Earl & Katz, 2006), as part of the accountability movement (Nichols & Harris, 2016; Penuel & Shepard, 2016), and as a component of design-based approaches to educational research (e.g., Lai & McNaughton, 2016). These different traditions influence what counts as data, how data use is perceived by users, and whether multiple forms of data are perceived to have equal weight in decision-making (Lai & Schildkamp, 2013). However, although teachers' beliefs about and capacity for data use are considered central to the connection between data and instructional change (Datnow & Hubbard, 2016), the representational qualities of data and their influence on practice are critical but less well-discussed aspects of data use.

The representations used in data collection are likely to affect

practitioners' (i.e., school leaders' and teachers') inferences, decisions, and actions, and they may affect school improvement work in various ways. Furthermore, these representations both shape and are shaped by the tools and media used to represent key aspects of schooling, such as students' learning or staff members' wellbeing. For example, in US schools, interim assessments are made available electronically, and score reports are generated so that teachers may use them to identify students falling significantly below cutoff points (Datnow & Hubbard, 2015). Other educational systems rely primarily on holistic letter or number grades awarded upon the completion of a school year or the end of a cycle. For instance, until the turn of the millennium, students in Norwegian schools were graded using summative holistic numbers, and more specific data about learning outcomes were not available (Hopfenbeck, Tolo, Florez, & El Masri, 2013, p. 22). Assessment data consisting of summative grades are challenging to disaggregate and come into play too late to impact teaching or learning.

Educators define "data" in mixed ways, from narrow conceptions of data as quantifiable and objective numbers to broader sets of information including parental input, homework, and quizzes (Jimerson, 2014). Here, we propose that data should be discussed in terms of narrative and numerical modes of representation. Narrative data typically consist of protagonists and actions organized in a temporal structure (e.g., anecdotes from the classroom), while numerical data typically consist of

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mathematical notations and visual representations such as graphs and figures (e.g., scores from student surveys). We argue that the representational properties of these two modes affect how data are interpreted and acted upon. This article is organized into three broad sections. First, we describe the key aspects of affordance theory in relation to narrative and numerical modes of data, including how data are conceptualized and how affordance theory contributes to the understanding of narrative and numerical data. Drawing on these concepts from theories of representation (i.e., social semiotics, multimodal theory, and literary theory), we argue that researchers must consider how the affordances of data affect data use. Second, we present two contrasting cases of how affordances affect teachers' data use processes. Third, we discuss five challenges arising from our theorization about the affordances of data.

2. Section one: affordance theory in relation to data use

2.1. How is data use in education conceptualized?

Data use is a phenomenon that spans disciplines, involving issues related to measurement and assessment, learning and cognition, organizational context and change, and power and politics (Coburn & Turner, 2011a). One definition that is commonly used in research on data use in education is where data are broadly defined as information that is collected and organized to represent some aspect of schools (Lai & Schildkamp, 2013, p. 10). This implies that information from multiple sources counts as data (e.g., teacher observations and parental information, locally developed assessments, or mandated achievement tests (Jimerson & Wayman, 2015)). Most conceptualizations of data use include similar steps: goal identification, collection of data, analysis, interpretation, and use (see, e.g., Schildkamp et al., 2013). However, these steps are framed differently within different theoretical and methodological frameworks. For example, the steps can be framed as part of a design-based methodology process of iterative design and redesign or framed as part of an action research cycle to improve practice. A key part of design-based methodology is the gathering and use of data using the typical data use steps to improve the design of the intervention, programme or tool that is the focus of the research. Similarly, action research requires the gathering and using of data to improve the practice under investigation. While both action research and design-based methodology share similarities in terms of the steps, there are also significant differences for example in the extent and type of evidence required in each step. The multidisciplinary nature of data use in education means that multiple theoretical approaches are needed to examine it.

Unsurprisingly, existing research uses various conceptualizations, including *data literacy* (Gummer & Mandinach, 2015; Mandinach & Gummer, 2016a, 2016b), *data use in education* (Coburn & Turner, 2011b; Little, 2012; Moss, 2013; Sun, Przybylski, & Johnson, 2016), and *data-driven decision making* (Mandinach, 2012; Schildkamp et al., 2013, 2017). Data use conceptualizations vary in their emphasis on the content of curricula and whether the data process is applied to curriculum or non-curriculum related problems (e.g., the Data Team project in the Netherlands and the Learning Schools Model in New Zealand, see Lai & McNaughton, 2016; Lai & Schildkamp, 2013). These differences influence whether data use can be conceptualized as an intervention or professional development in its own right or as an important part of a larger intervention (Lai & McNaughton, 2016). For example, the Learning Schools Model employs the steps of data use in conjunction with other research and professional development processes that build content knowledge and establish partnerships with schools, but the designers argue that it is not a data use intervention.

Since data can be derived from a range of sources, different systems of codification are used to represent information in an organization (e.g., creating curriculum documents or descriptions of data use processes to ensure that individual practitioners can access new understandings developed in the organization as a whole) (Jimerson & Wayman, 2015).

Practitioners need a particular kind of literacy to critically engage as users of data, and they must develop “ecologically valid approaches to identifying and interpreting a range of significant educational outcomes” (Cochran-Smith & Lytle, 2009, p. 141) to avoid focusing on narrow conceptions of schooling and ensure that data use does not become an end in itself. In many educational contexts, practitioners are expected to make sense and use of multiple types of data, such as casual observations, informal conversations with students, and test results presented as statistics. Unsurprisingly, teachers struggle to use these different types of data at the classroom level (Hoogland et al., 2016; Schildkamp & Kuiper, 2010; Schildkamp & Teddlie, 2008). Also, teachers collect data through both rational and intuitive processes and may use personal criteria when interpreting data (Vanlommel & Schildkamp, 2019). Data use therefore requires familiarity with multiple ways of representing information and their corresponding affordances.

Data, like texts in a more general sense, are not self-sufficient repositories of meaning; rather, readers make sense of data by entering into a dynamic relationship with the data and applying their expectations, projections, conclusions, judgments, and assumptions (see Fish, 2000). This is true even for numerical data. The meaning of a statistical concept such as a frequency count is self-sufficient, but readers contribute to sensemaking by, for example, making judgments about the appropriateness of using frequency counts given the overall purpose of the analysis and drawing conclusions about the validity of using frequency counts. Thus, meaning is not produced through mechanical extraction from an entity, but through an event that emerges from interaction between the text and the reader. Furthermore, the sense-making processes through which individuals and communities make sense of data are shaped by a range of mental models and may be influenced by formal training, the actions of leaders, social interaction with colleagues, or one's personal experiences (Jimerson, 2014). However, little attention has been given to the representational properties of data sets and how these properties empower or hinder data use in practice.

2.1.1. Affordances of data

The concept of *affordance* was first introduced in 1979 (Gibson, 2015) to describe the complementary relationship between an environment and what it offers, provides, or furnishes to the actors within it. Later, social semiotics used the term to describe the characteristics of sets of sensemaking resources recognized in a community (i.e., the specific ways of representing used within a community and the strategies that community members use to understand these ways of representing) (see, e.g., Bezemer, Jewitt, & O'Halloran, 2016; Knobel & Lankshear, 2007; Kress, 2010; Kress & Van Leeuwen, 2001). These sets, termed *modes*, are used for communication in various ways across contexts. For example, stories serve quite different purposes when colleagues discuss their work in a lunchroom, witnesses share their accounts in a court of law, or a parent reads a picture book to their child. To specify the relationship between a mode and its use in a given environment, the concept of *modal affordance* was introduced. According to this concept, different modes have different potentials for sensemaking. Modal affordances “affect the kinds of semiotic work a mode can be used for, the ease with which it can be done and how” (Bezemer et al., 2016, p. 72); the affordances of a specific mode are shaped by its material and social histories and affect its signifying work (p. 155). For example, the transition from print to digital means of storing and retrieving information has impacted the ways in which people make sense of and engage with knowledge. The affordances of a given mode do not only offer certain possibilities but also actively invite certain actions (Aagaard, 2018). Consequently, studying meaning requires one to pay attention to all the semiotic resources used to make a complete whole (Bezemer et al., 2016, p. 3).

Although the concept of affordances is often mentioned in data use literature (e.g., Datnow, Park, & Kennedy-Lewis, 2013; Schildkamp, Karbautzki, & Vanhoof, 2014), few researchers have explored how

affordances can shape data use in detail. In this paper, we distinguish between numeric (e.g., statistics, graphs, survey results) and narrative (e.g., interview transcripts, observation notes, student essays) data as two fundamentally different modes with varying affordances. Moreover, we acknowledge that what counts as data and the approaches that practitioners use to make sense of and act upon data are affected by the educational context, including assessment regimes, legal requirements, pedagogical traditions, teacher beliefs, and other situated phenomena. Understanding the affordances of these two modes is crucial for practitioners to make sense and use of data in their efforts to improve schooling.

Data have a physical aspect (i.e., they are associated with technologies of production and reproduction of information such as tests, surveys, software, or teacher logs) and a semiotic aspect (i.e., they carry meaning and value within and across cultural contexts and are interpreted in relation to present events, systems of meaning, and historical processes). The physical and semiotic aspects of data are closely related. We therefore characterize them as “material-semiotic artefacts” (Lemke, 2000, p. 281). The concept of affordance could be seen both as 1) related to the material properties of the medium through which data are collected, stored, and used, and 2) the cultural-historical functions of data in specific contexts, or 3) a combination of both (see Kress & Van Leeuwen, 2001, p. 125). Thus, a social semiotic approach to data use explores the ways and means of signification (e.g., how data represent certain aspects of learning processes or outcomes) and analyzes how readers’ interpretations are entangled in these representations (Culler, 2002).

Applying this perspective to data use in education reveals several insights into the technologies used for collecting, storing, and analyzing data. First, data have material properties that shape the way in which they are interpreted. Second, data are a component of cultural practices with varying characteristics and roles across educational systems. Third, data are involved with knowledge production and dissemination. Fourth, data are used as part of complex interactions between technology, individuals, and communities. For example, a key aspect of data in educational settings is the numerical nature of data sets generated through various forms of testing. The purposes of such data collection vary. It may be formative, summative, or evaluative; externally mandated by policy makers (e.g., standardized achievement tests); or requested by practitioners (e.g., screening tests as part of special education interventions). Numerical data sets may therefore require familiarity with quantitative ways of representing students’ learning, statistical reasoning, and mathematical notations. Additionally, data sets may consist of a combination of verbal, numerical, and graphic forms of representation, and technological tools may provide ways to manipulate these representations. The more complex such data sets and technologies become, the more data literacy and support practitioners will need in order to use them effectively.

While test results and other numerically configured data sets are common in schools, teachers also rely heavily on narratively configured data to make sense of their work and its impact on students and communities, such as when sharing which practices worked in their classes. These data are a key component of school culture, shaping identities and histories and mediating professional values in and across contexts (see, e.g., Clandinin & Connelly, 1995; Craig, 2007). While telling and interpreting stories, teachers use their professional judgment and experience to negotiate everyday demands and dilemmas as seen through the eyes of students, caregivers, and colleagues. In some contexts, narrative data may be dismissed as merely anecdotal and therefore of little value as evidence. However, given the sensemaking role of narratives, these data actually play an important role in the development of practitioners’ professional knowledge.

2.1.2. Narratively configured data

Narratively configured data typically consist of units such as protagonists and opponents, tools, dramatic encounters, and story arcs, and

they often conclude with a resolution of the conflict. The act of *employment* (Ricoeur, 2009) refers to the structuring of such disparate phenomena or seemingly unconnected events in discourse so that they make sense to the producer or recipient of the narrative. Narrative configuration has been therefore defined as “the process by which happenings are drawn together and integrated in to a temporally organized whole” (Polkinghorne, 1995, p. 5).

Time is an organizing factor in narrative configuration. The temporal character of emotions, values, memory, and experience means that narrative explanations of past events are dynamic and do not necessarily afford certainty (Clandinin & Connelly, 2000 p. 37). In narratives, time serves to fixate relations between disparate phenomena without determining the sense that phenomena make to the creator, listener, or reader. Narratives require close reading in order to reveal their meaning and interpretive potential (Riessman, 2008).

In educational contexts, narratively configured data abound; anecdotes describing student learning, memories of success or failure in the classroom, and stories describing teaching approaches are shared and discussed every day. A teacher’s personal practical knowledge is continuously storied and re-storied, which entails organizing and reorganizing the relationships between events, people, and things (Clandinin & Connelly, 1995, p. 5). The temporality of narrative configuration means that the meaning of narrative data may change over time or after exposure to other stories, experiences, or contexts. This suggests that narrative data are useful in continuous sensemaking processes but less suitable when a higher degree of certainty is needed. Vanlommel and Schildkamp (2019) argue that teacher decision-making does not always follow a rational process using transparent criteria; instead, teachers often use heuristic judgment in high-stakes situations. Understanding the potential pitfalls in interpretive processes is therefore important to avoid confirmation bias and ensure fairness (Vanlommel & Schildkamp, 2019).

In the teaching profession, narratives relating the professional lives of teachers can generate understanding and empathy for the challenges teachers encounter as part of their practice. For example, teachers might choose to present dilemmas from the classroom in a narratively configured format to communicate how a conflict between groups of students played out, with a series of dramatic events culminating in a meeting where the conflict ended. As such, a narrative creates contingency and meaningful patterns in the otherwise messy and fragmented world of experience (Riessman, 2008).

Given their emphasis on individuals or small social groups, it is likely that narrative ways of representing draw attention to micro-level decision-making and the realm of personal experience in schools. Much as case studies are used to illustrate the complexity of larger educational issues, such data may also act as a catalyst for improving awareness of and developing actionable knowledge. Researchers have attempted to create guidelines that could potentially ensure detailed and accurate narrative accounts when working with children (Brubacher, Powell, Snow, Skouteris, & Manger, 2016). However, such guidelines require rational processes for collection and interpretation, and may be unwieldy for heuristic judgment processes.

2.1.3. Numerically configured data

Numerical data, like narrative data, are part of a broad category. The most common numerical data that practitioners encounter are those that can be statistically analyzed, such as average test scores or the number of girls who chose a particular item on a survey. The primary modes of representation for these data are numbers and percentages, sometimes with mathematical notations, such as the notations in a *t*-test (often accompanied by text), and visual representations of data as graphs and figures.

Two main statistical methods are used for analyses in the field of data use: descriptive statistics, which describe the sample or population, and inferential statistics, which attempt to make inferences about a sample (e.g., whether a sample can represent a population). Descriptive

statistics focus on two sets of properties of distribution (of a sample or population): central tendency, which seeks to describe the center of the distribution or the typical value, and dispersion (or variability), which refers to the extent to which the distributed elements differ from the center and each other. Inferential statistics are statistical procedures that test the relationship between two statistical data sets, such as whether a control group of students performs better on a test than the students in an intervention.

Statistical discourse and modes of representation pose interpretive challenges for practitioners and may both enhance and hinder sense-making. For example, understanding the meaning of technical terms that are not necessarily part of teachers' standard lexicons, such as *mean*, *median*, and *population*, is one challenging aspect of statistical discourse. Furthermore, appropriate statistical analysis without a strong theory can result in nonsensical findings. For example, one statistical analysis showed that the number of people who drowned in pools between 1999 and 2009 is correlated with the number of movies in which Nicholas Cage appears (Vigen, 2015). Given that practitioners may believe that statistical forms of representation are more certain than others (Prøitz et al., 2017), understanding the theoretical principles underpinning statistical analysis is necessary to engage critically with statistical discourse and representations.

2.1.4. Comparing narrative and numerical data

Narrative and numerical data have a few commonalities. For example, inferences from both statistical and narrative data need to be justified by theory and the gathered data to demonstrate that the features of the data set (e.g., lots of missing data) warrant a particular form of analysis. Also, traits from one modality may be used to draw inferences from another; for example, numerically configured data may be interpreted as narrative arcs (e.g., going beyond reporting results to find the story behind the numbers). Furthermore, narratively configured data may contain pseudo-statistical expressions (e.g., "slow readers," "average students," "weak groups"). Such discourse may stem from a lack of familiarity with the precise meanings of mathematical concepts. In the context of data use, this may lead to misrepresentation of students' learning processes and outcomes or unsuccessful implementation of professional development.

The affordances of data relate both to their material aspects (i.e., the technologies with which they are associated) and their semiotic aspects (i.e., their meaning and value in and across systems). First, the two modes of representation have different effects in terms of the perceived distance from the context. While narratives afford emotional and moral engagement as they relate to the world of personal experience, numerical data appear more objective and thus may have a distancing effect, as shown by Porter (2001). For example, Moss (2012) notes that incentives for the development and use of data use technologies may run parallel with requirements to use such tools "to impose decisions or ways of making them from afar" (p. 229). Second, differences between the two modes may correspond to epistemological schisms between teachers' interpretations of everyday observations and empirical data collected through testing and measurement. For example, literacy teachers with a strong interest in literary instruction may not find psychometric data convincing as a source of information about students' performance.

Certain ways of representing the world claim to be—or are perceived as being—more objective or authoritative than others. This could explain why numerical data and quantitative approaches to measurement are hegemonic in certain school systems and why educators' holistic judgments and classroom-based assessment practices are less valued in some contexts: they simply do not count as data in data use practices. To tap the potential of both narrative and numerical data, practitioners and researchers should be mindful of their affordances, for example by triangulating findings and interpretations. Also, developing shared understandings of the material and semiotic aspects of different kinds of data could lead to more data literate teams in schools.

2.1.5. Interpretive communities and the production of meaning in data use practices

To conceptualize how practitioners and others make sense of data and how affordances affect sensemaking processes, we use the concept of *interpretive communities*. Interpretive communities produce meaning through historically established conventions of representation and shared interpretive strategies (Fish, 2000, p. 14). In other words, the ways in which we make sense of documents or spreadsheets are defined by the social group to which we belong. For example, district administrators with little knowledge about students' reading development might interpret test scores in reading fluency as a representation of students' overall reading ability. Furthermore, a community's set of interpretive strategies comprises not only ways of receiving information but also ways to act upon it. In the context of data use, this suggests that there is no single "correct" or "natural" way of reading a data set; all ways of reading data are contextually bound extensions of community perspectives (p. 16). As such, any interpretation coexists with and must relate to other interpretations in a reciprocal manner.

We do not adopt a relativistic stance on the meaning of data, but a nuanced understanding of when additional sensemaking is required. For example, in the case of statistics, there is only one correct definition of the concept of *mean in statistics* in that there is only one correct way to calculate a mean, but there are multiple possible interpretations of what that mean means. For example, a mean score might be perceived to a good score by one teacher but not by another teacher who believes a good score must be above the mean. Moreover, in other cases, such as statistical modelling, there are multiple possible models, each of which needs to be defended by theory and statistical rigor. Furthermore, statistical decisions can be laden with value and may result in different analyses and conclusions. For example, including all children within an intervention in an analysis may produce different results than an analysis that includes only those who fully participated in the intervention. Thus, approaches such as the notion of data-driven education could be questioned by investigating the properties of data sets, how educators think and speak of them, and the ways they are used across contexts. Specifically, the apparent objectivity associated with certain representational modes should be investigated.

3. Section two: contrasting case studies

In the following section, we compare two instances of how the affordances of numerical and narrative data affect and are affected by the educational context. These two contrasting examples were selected to show how the affordances of data play in specific cultural, curricular and policy settings. The first example, drawn from New Zealand, discusses the affordances of data used in a systematic approach to improving practitioner capacity for data use. The second, a Norwegian example, illustrates how less systematic approaches may be affected by teacher conceptions of numerical data as "external" (i.e., for accountability and not improvement purposes), and illustrates how this may impede constructive approaches to data use.

3.1. Case study: the learning schools model in New Zealand

Our first example shows how the affordances of numerical and narrative data are combined in discussions with teachers about student achievement data, using the Learning Schools Model approach to collaboratively analyze data (Lai, McNaughton, Jesson, & Wilson, in press). The Learning Schools Model is an intervention in which researchers and practitioners work to co-design rigorous research that solves shared and urgent problems of practice. Its theoretical and methodological foundations primarily lie in design-based research (e.g., Anderson & Shattuck, 2012) and research-practice partnerships. The model has been tested over 15 years in about 400 schools across five countries, primarily in New Zealand. Achievement in general has accelerated relative to multiple comparisons (e.g., in relation to national

expectations or a comparison group) (see [Jesson, McNaughton, Rose-dale, Zhu, & Cockle, 2018](#); [Lai & McNaughton, 2016](#); [Lai et al., in press](#)). A key feature of the model is collaborative analysis of data; researchers and practitioners discuss data to understand the problem, co-design solutions, evaluate the effectiveness of these solutions, and refine them accordingly. Here, we focus on one aspect of the approach: the process of discussing achievement data at the start of the intervention.

When using the Learning Schools Model approach, researchers and practitioners start by discussing and agreeing on a problem related to student learning (e.g., poor reading comprehension scores) that must be solved. This typically involves both narrative data (e.g., anecdotes about the student learning problem) and numerical data (e.g., low scores on an assessment). Based on this discussion, researchers and practitioners come to an agreement about what data to collect to understand the student learning problem, typically beginning with data from assessments. These assessments provide numerical data about how well students are performing against an agreed-upon point of reference (e.g., national norms) and data about the specific learning problems that contribute to patterns in the numerical data. The latter type of data is both numerical (e.g., how well students perform on different subtests within a reading comprehension test such as decoding or vocabulary) and narrative (e.g., qualitative examinations of open-ended responses on the tests; [Lai & McNaughton, 2009](#)).

In the Model, the narrative and numerical patterns are then discussed with teachers to determine how the patterns in each mode (i.e., narrative and numerical) support or differ from each other and what that could mean. In one study, for example ([Lai & McNaughton, 2009](#)), the numerical data showed that students performed poorly on cloze passages (i.e., test items for which students must fill in a blank with an appropriate word) relative to the expectations in the assessment manual. However, the numerical data did not reveal why they scored so poorly. The narrative data were used in an analysis of errors to uncover what specific elements students misunderstood or did not understand and thus determine what led to the lower performance. The data showed that many students did not have sufficient vocabulary to insert the correct word and did not understand how sentences functioned in relation to a paragraph. This finding was backed up by numerical data from the vocabulary subtest; students' scores on this subtest were also low relative to expectations. The numerical data were also tested against teachers' experience by researchers, who did the numerical data analysis, asking teachers whether these patterns were similar to what they experienced in class. Thus, both numerical and narrative sources were critical for identifying the problem (numerical) and understanding why the problem might exist (numerical and narrative).

The Learning Schools Model approach also uses narrative techniques to integrate the two modes of data, and the approach can be seen as using an overarching narrative arc to try to solve a problem. The first act of this arc introduces a potential problem that requires a solution along with the key characters (i.e., the teachers and students). In the second act, a detailed investigation of the problem takes place, leading to a potential solution. In the third act, the key players (i.e., teachers and researchers) are brought together to discuss the solution. Finally, in act four, the solution is co-designed and there is a resolution. It is hypothesized that this approach helps literacy teachers understand how numerical and narrative data both contribute to solving a problem.

Discussions about the data serve as a form of social apprenticeship; researchers who are skilled with regard to numerical data support practitioners in understanding the technical aspects of numerical data and making sense of these data. An example of the latter practice is when researchers discuss with practitioners the assumptions that underpinned their decisions for analyzing both narrative and numerical data, which helps practitioners see how meaning is created from data and challenges the notion that objectivity is an inherent part of numerical modes of representation.

3.2. Case study: national literacy initiatives in Norway

Our second example is drawn from the Norwegian education system. Past literacy reform efforts focused on narrow conceptions of reading motivation or sustained silent reading and were driven by simplistic notions of reading instruction ([Buland, Dahl, Finbak, & Havn, 2008](#); [Fjørtoft, 2018](#)). Therefore, a more ambitious policy initiative called Motivation and Mastery for Better Learning ([Utdanningsdirektoratet, 2013](#)) was implemented from 2012 to 2017. All lower secondary schools (which serve students aged 13–15) were encouraged to participate by national educational authorities. The aim was to improve at least one of the following areas: classroom management, reading, writing, and numeracy. Additionally, schools were encouraged to explore formative assessment and organizational learning. The theory of action underpinning the strategy was based on school-based inquiry, use of online resources (e.g., theoretical frameworks, brochures offering pedagogical advice for use in the classroom, and short videos depicting instructional strategies), and learning networks (consisting of several schools with support from higher education institutions, resource teachers assigned a special leadership role within schools, and regional development advisors facilitating networks between schools, school leaders, and local authorities).

However, despite schools' reports that school leaders and teachers emphasized systematic school development, establishing links between policy initiatives, support in networks, and local developmental work proved difficult ([Lødding et al., 2018](#)). One reason for this may be the lack of detailed and disaggregated data in the Norwegian school system. The Norwegian school system is often characterized as a high-trust, low-accountability system ([Hopfenbeck et al., 2013](#)) with few external accountability mechanisms. Before the introduction of a national quality assessment system in 2005, systematic achievement data were not accessible ([Mausethagen, Prøitz, & Skedsmo, 2017](#)). Standardized mathematics, reading literacy, and English language tests were introduced in 2006 for students aged 10, 13, and 14. Still, schools receive little practical support for analyzing and using results. Instead, teachers rely on holistic classroom assessments they design themselves. Consequently, there is an abundance of narrative data but relatively less numerically configured information available for Norwegian schools. Moreover, access to databases with numerical data is a relatively new phenomenon, with little support available to practitioners who want to make use of the data stored therein.

Although teachers have access to varied knowledge sources such as results on standardized tests in literacy and numeracy or statistics on student wellbeing and motivation, a large amount of data stem from their general teaching experience. In one study, only 21 % of the data used by practitioners in meetings about students' test results were numerical in nature; these data were primarily used to decide on further testing (e.g., using reading scores to determine whether some students should be tested for dyslexia by specialists) and to calibrate scores on standardized tests with teacher designed tests ([Mausethagen et al., 2017](#)). The most prominent sources of knowledge used were past teaching experiences, pedagogical content knowledge, and knowledge from relations with students and parents. Furthermore, the numerical data were termed "external" by teachers, implying that they were less relevant than the narrative data gained from firsthand experience with students in the classroom ([Mausethagen et al., 2017](#)). This is problematic, given the need for data triangulation to avoid problems related to measurement errors in single data sources, confirmation bias, and ensure that teachers reach the right conclusions based on the data ([Vanlommel & Schildkamp, 2019](#)). Other studies have shown that teachers struggle to make sense of and recontextualize the numerical data provided by reading literacy tests, the underlying constructs being assessed (e.g., reading comprehension or reading speed), and the relation between specific reading competencies measured in tests and students' behavior in classroom situations ([Fjørtoft, 2016](#)). The dependence on narrative data in the Norwegian system could mean that students'

learning and development is mis- or underrepresented. Norwegian school leaders must therefore strike a balance between trust and data, and encourage teachers to draw on both personal knowledge and data sets in order to avoid blind trust on the one hand, and distrust and micro-management on the other (Tolo, Lillejord, Flórez Petour, & Hopfenbeck, 2019).

Capitalizing on the affordances of both numerical and narrative data appears to be associated with greater data use, which in turn is related to improvements in student learning. The New Zealand example shows that numeric and narrative modes of representation can be leveraged together to understand problems of practice and their underlying causes. In contrast, the Norwegian case exemplifies that reform efforts may fall short if data are not available in modes that are congruent with teachers' beliefs or the problem to be solved. We have already suggested that some modes may be perceived as more objective or authoritative than others. In the Norwegian case, the numerical data were seen as "external", a perception which is likely to stem from the teachers' experiences with numerical data being primarily used in externally mandated evaluations and for accountability purposes. This suggests that the material-semiotic nature of data requires attention to the specificity of cultural settings and the historical ways in which such data have been used in the past. Furthermore, the examples show that attempts at improving practitioner data literacy should be attentive to existing interpretive strategies in school communities as this will shape both the understanding of data and the ability to act upon interpretations.

4. Section three: implications

By bridging data use research with concepts from theories of representation, we offer an approach to understanding the representational qualities of data in data use practices. Fine-grained explorations of the affordances of numerical data could yield a greater understanding of how such data are used in instructional change processes. For example, analysis of the boundaries between modes may illuminate what happens when reconfiguring data from one mode to another or when practitioners metaphorically see numbers as stories or stories as numbers. Dealing with such instances of cross-modal mobility (Newfield, 2014) (i.e., transformations from one mode to another) would require careful analysis of how such reconfiguration affects the interplay between semiotic resources and the context. Also, increased awareness of possible misconceptions related to the affordances of a mode could ensure that data are used appropriately.

Furthermore, the affordances of data are inherently associated with questions of accountability systems and the role of teachers' professionalism in education. Researchers have often criticized the use of performance indicators in education, arguing that overreliance on metrics may trap teachers between a vision of education as schooling with a moral purpose on the one hand and a market-driven competitive logic on instruction and achievement on the other (Sahlberg, 2010). Teachers, school leaders, and other stakeholders may even feel pressured to manipulate test results in response to school inspections and other types of evidence-based governance (Altrichter & Kemethofer, 2015; Ehren & Swanborn, 2012). Such criticism is common in school systems using numerical data from standards-based achievement tests to evaluate students' learning and teachers' performance for accountability purposes. This confirms the commonly held belief in social semiotics that sensemaking processes are entangled in questions of power and agency; makers of representations are "makers of knowledge" (Kress, 2010, p. 27). The relation between numerical modes of representation and the perceived certainty or distance implied by quantification (Porter, 2001) could be studied when investigating the balance between trust and accountability in assessment cultures or when analyzing power relations between stakeholders in capacity-building processes (e.g., teachers, school leaders, school administrators, or policymakers). Such studies could reveal how the affordances of data relate to the conceptualization of learning and student achievement in data use

efforts and policy reforms or across school contexts.

The literature used in this comparison does not allow for a systematic cross-case analysis. Furthermore, concepts from social semiotics are mostly used to analyze fine-grained phenomena and may not always be the best fit to study large-scale processes such as research-practice partnerships. However, the cases described above show how the affordances of data in different settings, including how data are introduced to and discussed with teachers, can shape the application of data use processes in each context. For example, these case studies indicate that a healthy combination of data modes provides richer information about students' learning and development. Conversely, a lack of numerical data (or rejection of statistics because they are perceived as useless for improvement purposes) may occlude teachers' understanding of key aspects of student learning. The case studies also exemplify how the phenomenon of data use spans disciplinary boundaries and how it relates to measurement and assessment, learning, organizational context and change, and power (Coburn & Turner, 2011a). Insufficient knowledge of how student data are collected and stored through material and semiotic systems may lead practitioners to view data at face value. Similarly, without an understanding of inference-making and the various ways in which assessment data can and should be interpreted (Kane, 1992; Moss, Girard, & Haniford, 2006), practitioners may not be able to transform raw data into actionable knowledge. In both cases, data displace the phenomena they represent, effectively eclipsing the very problems they are meant to help solve.

A theoretical understanding of limitations in validity and reliability may lead to constructive criticism of limitations in data sets and may strengthen practitioners' ability to explore and question the inferences and interpretations that arise in the school community and beyond. Teacher may not know or be able to employ concepts such as validity or reliability but may still be able to discuss whether a given test "covers" the curriculum objectives (i.e., whether it elicits evidence that might lead to valid inferences about student learning outcomes) or whether teachers generally agree when grading student work together (i.e., whether inter-rater reliability is satisfactory). Moreover, psychological factors such as teachers' beliefs and attitudes may affect their interpretations of data (Prenger & Schildkamp, 2018). Knowledge of various aspects of the curriculum (e.g., goals and objectives, literacy requirements, disciplinary norms, and values) may lead to more productive criticism of both test results and teachers' judgments.

4.1. Five challenges for data use in education

In this study, we have argued that the representational qualities of data matter in data use practices. In this final section, we propose five challenges related to the affordances of data of critical importance in this context.

Firstly, affordances shape the flow and aggregation of data through school systems. Policy issues related to alignment and accountability affect how practitioners think and act within the larger systemic context of education (Coburn, Hill, & Spillane, 2016). The affordances of data affect how information is interpreted and used from systemic perspectives (e.g., regarding issues of timescale and granularity (Moss, 2013)). Narrative and numerical modes may be treated differently for accountability purposes. For example, numerical data tend to be aggregated as they flow from classroom to system contexts, and disaggregation from numbers to personal experience is difficult at best. Narrative data do not afford aggregation in the same way. Greater awareness of the affordances of different modes could improve practitioners' interaction with data at different system levels.

Secondly, numerical data may be misperceived as neutral or objective. Teachers or other stakeholders may want assessments to be "objective" and thus worry about subjectivity in holistic evaluations of student work, or they may prefer formula-based approaches with quasi-numerical methods. The power of such beliefs must be acknowledged and challenged in change processes (Shepard, 2000). A theoretical

understanding of the affordances of numerical data could reduce misconceptions about statistics and other kinds of numerical information.

Thirdly, silo problems may be exacerbated when data are represented in multiple modes. Given their different affordances, narrative and numerical data may be contained in silos. For example, statistics on students' reading development (e.g., reading speed or reading comprehension) may not be matched with rich narrative evidence of students' reading behavior in the classroom (i.e., use of background knowledge from personal experiences or participation in discussions). Silo problems could be ameliorated by strengthening educators' ability to connect numerical and narrative data in sensemaking processes.

Fourthly, empathy resides in narratives, not in numbers. Accounts of students' attempts, failures, and perseverance in learning are continuously retold and reinterpreted in teachers' professional knowledge landscapes. Key aspects of teaching and learning are therefore often represented in a narrative mode. If practitioners focus solely on statistics, the role of narrative data in practitioners' interpretive communities and the importance of empathy as a source of understanding students' needs may be overshadowed. However, narratives must be adequately theorized so that their affordances are understood, for example, in relation to how the act of employment structures narrative accounts or to how diverse interpretive communities respond to such narratives.

Finally, simplistic interpretations of the representational qualities of data sets should be challenged. Data are representations of real-world phenomena. If taken at face value as complete depictions of the phenomena they represent, there is a risk that data use may lead to "data myopia" (Harris, 2012). Simplistic beliefs about the supposed objectivity of data should be challenged as part of data use processes.

To develop critical and ecologically valid understandings of data, practitioners must explore the affordances involved in data collection, interpretation, and use. Awareness of these five challenges may be a first step towards a stronger theoretical foundation for data use in education.

Declaration of Competing Interest

None.

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