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Designing and Evaluating Data Dashboards for Educators

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Data-driven decision making is an important area of education. One topic related to this area is understanding the kinds of tools, such as data dashboards, educators need in order to manage the day-to-day tasks of working with student data. This article presents the design and evaluation of a collection of data dashboards built specifically for a school district. The paper describes five principles used to guide the initial design of the dashboards, along with several of design trade-offs faced by the design team. In turn, a formative evaluation was conducted with stakeholders (n = 43). The evaluation assessed the dashboards' usability, perceived usefulness, and potential to improve teaching. The implications of this work are discussed in reference to designers, educators, and researchers interested in empowering educators with data.

Keywords: Data-Driven Decision Making, Dashboards, Usability, Data

Introduction

A decade ago, the Institute of Education Sciences identified data use as a key topic for improving student achievement (Hamilton et al., 2009). Data use involves making decisions based on data and is often referred to as data-based decision making (Lai & Schildkamp, 2013). A critical aspect of supporting data use in schools is providing a "secure and reliable data management system" (Hamilton et al., 2009, p. 7). Ideally, such a system will be user-friendly and seamless, producing results that draw on data from multiple systems (Breiter & Light, 2006).

An important component of any data use and management initiative is the dashboards made available to educators and support staff. Typically, a dashboard is a visual display of the most important information needed to achieve one or more objectives (Few, 2013). Dashboards often compile key metrics in simple and easy to interpret interfaces (West, 2012). But designing quality dashboards for education is challenging given a wide range of pedagogical, administrative, and technical considerations. As summarized by Ahn et al. (2019), some of the design considerations include "how to visualize data, which data to show educators or learners, and for what interpretation aims" (p. 71). For these reasons, the design and evaluation of data dashboards is a growing area of inquiry within education and related fields (e.g., learning analytics).

It is within this context that the current work describes the design and evaluation of a collection of 14 data dashboards created for school district. The article begins with a review of relevant literature related to data-driven decision making and dashboard design. It then goes on to describe the design principles that informed the initial design and development of the district's dashboards. This is followed by sharing the results of a formative evaluation conducted to capture stakeholders' perceptions of the dashboards' usability, perceived usefulness, and potential impact on teaching. The paper ends with a discussion of the evaluation results and how they relate to specific design decisions. Implications for designers, educators, and researchers conclude the paper.

Literature Review

Data-driven decision making has become a "ubiquitous part of policy and school reform efforts" (Park & Datnow, 2017, p. 281). A common definition for data-driven decision making is the systematic collection and analysis of different kinds of data to inform educational decisions (Hamilton et al., 2009). The rationale for promoting data-driven decision making is the premise that educators, informed by data, will be able to

prioritize instructional time, meet students' individual needs, and refine instructional methods (Hamilton et al., 2009; Vanlommel et al., 2017). While early efforts involving data-driven decision making focused primarily on accountability, more recent efforts have shifted to emphasizing continuous improvement (Mandinach & Schildkamp, 2020) and teacher empowerment (Lockton et al., 2020; Weston, 2018).

Much of this movement has been propelled by the digital transformation of education, which has led to an "unprecedented level of datafication of learning and teaching" (Berthelsen & Tannert, 2019, p. 89). This has made schools and school systems data rich (e.g., Earl & Katz, 2006). According to Wahlstrom (2002), there are three primary types of education data: demographic data, process data, and outcome data. While other scholars have suggested alternative typologies (see Bernhardt, 2013), one analysis of a student data system found a variety of data types related to attendance, grades, and demographics, as well as administrative and course enrollment data (Gallagher et al., 2008).

Efforts have been made to make good use of these growing collections of education-related data. Technically, there has been a "quiet revolution in the quality of education data systems" (Slotnik & Orland, 2010). Pedagogically, there have been many efforts to understand how school systems and individuals within schools use data (Boudett et al., 2013; Datnow & Hubbard, 2015). And, by combining technology and supporting educators in the process of extracting meaning from data, many hope to "empower teachers and teaching assistants to make smarter decisions" (Weston, 2018, p. 31).

One area of data-driven decision making that is under researched is understanding the kinds of tools practitioners need and want to manage the day-to-day tasks of working with students. Means et al. (2010) found evidence that data system usability problems such as interface issues, limited system functionality, and a perceived lack of timeliness and relevance were barriers to meaningful use. More recently, Farley-Ripple et al. (2020) noted that few studies have explored the types and features of tools through which understanding of data use is constructed.

One type of tool that is essential to data-driven decision making is that of the dashboard. A dashboard is a visual display of the most important information needed to achieve one or more objectives (Few, 2013). And, according to West (2012), dashboards "compile key metrics in a simple and easy to interpret interface" (p. 6). Rothman (2015) argued that districts should consider using data dashboards as a means of helping improve performance for all students.

Taken together, these studies suggest a need to better understand how dashboards can be designed to facilitate data-driven decision making. In an effort to contribute to this need, the following sections describe a project that designed and evaluated a set of data dashboards for a school district. Describing this work offers some insight to the design process, the trade-offs involved in designing data dashboards, and ultimately, how a group of end-users felt about the dashboards during a formative evaluation.

Project Description

Context and Objectives

This project's design work took place at a school district in the Western part of the United States. This multi-school, multi-campus district serves about 7,000 students from pre-Kindergarten through grade twelve. At the time of the project, one of the district's long-term goals was to improve the quality, access, and transparency of information. In an effort to support this goal, district leadership assembled an interdisciplinary team of educators, analysts, and systems engineers charged with designing data dashboards for the district. The target audience for the dashboards spanned all levels of the district from administrators to teachers to support staff.

At the outset, the project team defined an overarching project aim, which was to provide access to reliable, scalable, self-service analytics. The dashboards had to be reliable both technically and pedagogically. Technically, it was important that the dashboards be available at any time. Pedagogically, it was important

to ensure that the information presented via the dashboards was trusted by stakeholders. The dashboards had to be "scalable" in two ways. First, the dashboards had to be scalable in their ability to accommodate new student data throughout the school year. This was to avoid the data becoming stale or out-of-date for stakeholders. The second way the dashboards had to be scalable was that they should be built such that new dashboards could be added if and when stakeholders asked for new views of the data. Finally, the project had to provide "self-service" analytics such that stakeholders could access and use the data directly.

In order to achieve this overarching aim, the team identified a number of principles that would guide the project's design and development work. These guiding principles included the following: 1) use clean, up-to-date data, 2) connect data sets, 3) deliver meaningful views, 4) be easy-to-use, and 5) provide a single point of access. Table 1 provides a brief description of each guiding principle.

Table 1
Guiding Principles Used to Design the Dashboards

Principle	Description
1. Use clean, up-to-date data	Dashboards should use data that is valid and current
2. Connect data sets	Dashboards should connect different data sources (e.g., demographic to achievement)
3. Deliver meaningful views	Dashboards should deliver visualizations that are expected and commonly used
4. Be easy to use	Dashboards should be intuitive and hide complexity
5. Provide a single point of access	Dashboards should be available in one location

Design Work

With the project aim defined and the working principles identified, the team set out to build the dashboards. Ultimately, 14 dashboards were designed and implemented. These dashboards were divided into three "collections", which were groups of two or more dashboards related to a core dataset. As the number of dashboards grew, a landing page was created so end-users could easily navigate between dashboards. Figure 1 shows a screenshot of the project landing page.

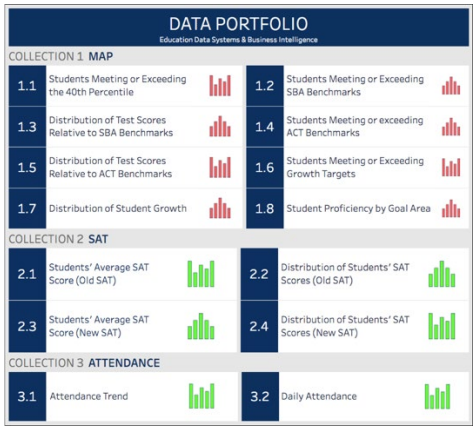

Figure 1. The landing page provided a single point of access and made it easy for end-users to navigate between dashboards.

One key decision during the design process centered on whether or not the data dashboards should be static or dynamic. Static dashboards showed one, pre-defined view of data, whereas dynamic dashboards showed multiple views that could be altered through user interaction. The trade-off inherent in this decision dealt with the preferences of the target audience. Would they prefer simple or more complex dashboard interfaces? Static dashboards were less complex in terms of navigation and control. On the other hand,

dynamic dashboards were more complex to maneuver but offered end-users more control over what was seen and how it was presented. In the end, the team decided to provide dynamic dashboards that tried to "hide" some of the underlying complexity. This was done by only showing detailed information about the underlying data if and when users requested that information by clicking a "Show Data" button.

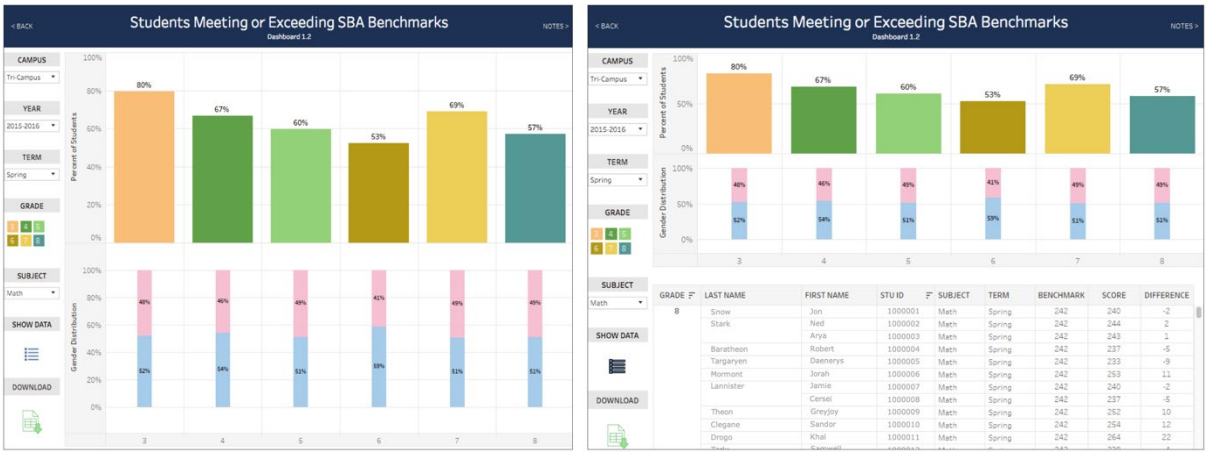

Figure 2. By default, the dashboards presented a more simplistic view of the data (left). However, users interested in the dashboard's underlying data could reveal more complexity by clicking "Show Data" (right).

Another important design decision involved how "open" the data should be. In other words, who could see what data? The answer to this question involved a trade-off between transparency and privacy, as different schools within the district had different cultures around data use and access. In the context of this project, district leaders decided the dashboards were an opportunity to embrace a more open stance regarding data and data use.

A third design decision dealt with the level of aggregation used while presenting the data in the dashboards. At the most aggregated level, the data could be organized such that it represented and summarized various measures pertaining to the entire district as a whole. At the most disaggregated level, the data could be organized such that it represented and summarized various measures pertaining to individual students. The trade-off with this decision was simplicity versus complexity, as well as acknowledging the various perspectives of the target audience: 1) teachers and staff working directly with students and 2) administrators and staff leading entire schools or the district itself. For this project, the decision was made to support everyone. This was done by showing aggerated views by default but allowing end-users to view (and download) student-level data as needed. This was an effort to accommodate the varying data needs of teachers, administrators, and support staff.

Yet another design decision dealt with the degree of customization applied to student assessment data. Should the data be used to present basic counts and averages? Or, should the data be analyzed and "cut" in different ways to add value for users? The trade-off associated with this decision dealt with time and expertise. Simple counts and averages were easy to represent, but they provided somewhat limited insight. In contrast, more customized views required time and expertise to design, develop, and validate; however, the possible benefit was gleaning additional educational insight from the data. Figure 3 provides an example of a customized dashboard which used stacked column charts to cut data by quintiles and goal areas.

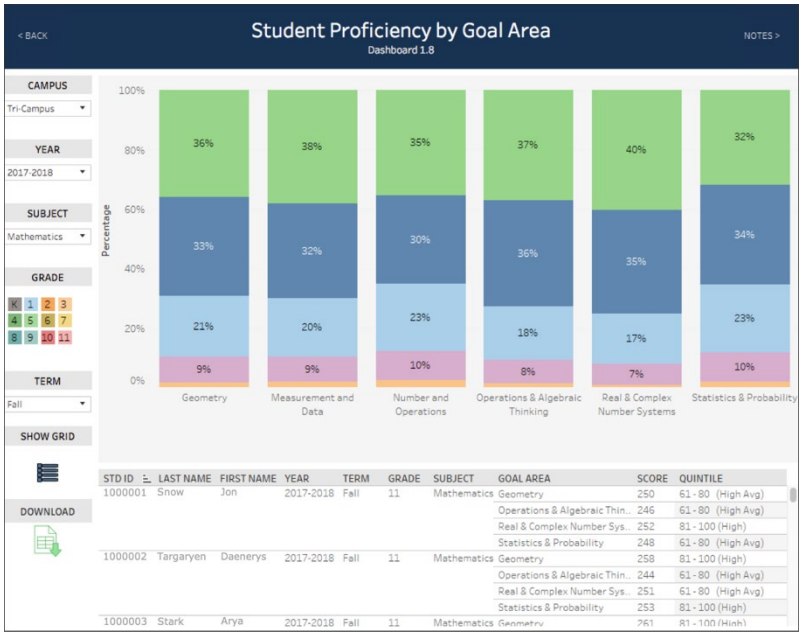

Figure 3. An example of a more customized dashboard that used stacked column charts to display data cut by quintiles and goal areas.

Project Evaluation

Participants and Procedure

Over a three-month period, a total of 51 educators and support staff from the district were invited to participate in a formative evaluation. Of the 51 participants, 34 (67%) were female and 17 (33%) were male. In terms of roles within the school district, six (12%) participants worked at the district level, 13 (25%) participants worked at the campus level, and 32 (63%) participants worked at the level of individual schools.

In terms of the procedure, the evaluation began with an orientation to subsets of participants. The orientation was designed to introduce the dashboards and explain how they could be accessed and used. The researcher led the orientation, which lasted about 90 minutes, answering questions about individual dashboards and their underlying data. It was explained that participants could use the dashboards as much as they wanted in the course of their everyday work for the district. At the end of the three-month period, a follow-up survey was sent.

Instruments and Measures

The evaluation of the dashboards involved a single online survey. This survey was compiled by the researcher and designed to evaluate the dashboards along three dimensions: usability, perceived usefulness, and potential to improve teaching. In total, the survey consisted of 20 items, described below.

The usability of the dashboards was assessed using a modified version of the System Usability Scale, a 10-item questionnaire designed to measure the usability of a product or service. It was created by Brooke (1996) who described usability as a "general quality of the appropriateness to a purpose of any particular artifact" (p. 1). The instrument has been used extensively by researchers and practitioners (see Bangor et al., 2008) and has been shown to be valid and reliable (Lewis, 2018).

Perceived usefulness, the "degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p. 320), was assessed using six items from the Technology Acceptance Model (TAM; Davis, 1989). The TAM has been shown to be a reliable and valid predictor of the intention to use information technology such as dashboards. More recently, perceived usefulness has

been found to be an important factor in the use of education-related technology (Abdel-Maksoud, 2018). All items used a five-point Likert-scale anchored only at the endpoints (1 = Strongly Disagree; 5 = Strongly Agree).

To assess the potential of the dashboards to improve teaching, four Likert-scale items were developed by the researcher. These items were based on the Danielson Framework for Teaching (Danielson, 2013) which identifies "those aspects of a teacher's responsibilities that have been documented through empirical studies and theoretical research as promoting improved student learning" (p. 1). The framework consists of four domains of teaching responsibility: 1) planning and preparation, 2) classroom environment, 3) instruction, and 4) professional responsibilities. One Likert-scale item was developed for each domain (e.g., "The dashboards will help educators improve their planning and preparation.").

Results

Forty-three (n = 43) participants responded to the survey resulting in an 84% response rate. The first step in the analysis was to examine the ten items related to the dashboards' usability. The average usability score was 4.52 (SD = 0.42) out of five. Two usability items were tied for the highest average score. The first item stated, "I thought the dashboards were easy to use" (M = 4.60, SD = 0.82). The second item tied for the highest score, used reverse coding (i.e., higher ratings are positive when statement is negative), and stated, "I found the dashboards very cumbersome to use" (M = 4.60, SD = 0.62). The item with the lowest average score, also reversed coded, stated, "I think I would need the support of a technical person to be able to use the dashboards" (M = 4.40, SD = 0.85). Overall, even though there were some minor difference between items, as shown by the average score, the participants' responses to the dashboards' usability were positive. See Table 2 for descriptive statistics related to the dashboards' usability scores.

Table 2

Descriptive Statistics Related to Usability

Usability Item	*n*	*M*	*SD*
I think I would like to use the dashboards frequently.	43	4.56	0.67
I found the dashboards unnecessarily complex. *	43	4.58	0.73
I thought the dashboards was easy to use.	43	4.60	0.82
I think I would need the support of a technical person to be able to use the dashboards. *	43	4.40	0.85
I found the various functions in the dashboards (e.g., selecting years, downloading data) were well integrated.	43	4.51	0.63
I thought there was too much inconsistency in the dashboards. *	43	4.58	0.63
I would image that most people would learn to use the dashboards very quickly.	43	4.47	0.67
I found the dashboards very cumbersome to use. *	43	4.60	0.62
I felt very confident using the dashboards.	43	4.51	0.51
I needed to learn a lot of things before I could get going with the dashboards. *	43	4.44	0.83
Average	43	4.53	0.42

* *Responses were reverse coded*

The second step in the analysis was to assess the six items related to the dashboards' perceived usefulness. The average perceived usefulness score was 4.26 (SD = 0.62) out of five. The item with the highest average perceived usefulness score stated, "I would find the dashboards useful in my work" (M = 4.49, SD = 0.59). The item with the lowest average perceived usefulness score stated, "Using the dashboards in my work would increase my productivity", earning an average score of 4.12 (SD = 0.88). Taken together, the results

suggest participants felt the dashboards were useful. See Table 3 for descriptive statistics related to the dashboards' perceived usefulness.

Table 3
Descriptive Statistics Related to Perceived Usefulness

	n	*M*	*SD*
Using the dashboards in my work would enable me to accomplish tasks more quickly	43	4.28	0.77
Using the dashboards would improve my work performance	43	4.16	0.69
Using the dashboards in my work would increase my productivity	43	4.12	0.88
Using the dashboards would enhance my effectiveness	43	4.30	0.67
Using the dashboards would make it easier to do my job	43	4.21	0.83
I would find the dashboards useful in my work	43	4.49	0.59
Average	43	4.26	0.62

The third and final step of the analysis was to analyze the dashboards' potential to improve teaching. The average score for potential to impact teaching was 4.06 (*SD* = 0.79) out of five. The first item, which stated, "The dashboards will help educators improve their planning and preparation" averaged 4.16 (*SD* = 0.78). The second item, which stated the dashboards would "help educators improve their professional responsibilities" earned an average score of 4.12 (*SD* = 0.82). The third item related to improving educators' "classroom environment" earned an average score of 3.84 (*SD* = 0.95). The final item related to improving educators' instruction earned an average score of 4.12 (*SD* = 0.88). While the overall responses were positive, it was noted that the score for potential to improve teaching earned was lower compared to the average usability and perceived usefulness scores. See Table 3 for descriptive statistics related to the dashboards' potential to improve teaching.

Table 3
Descriptive Statistics Related to the Potential to Improve Teaching

The dashboards will help educators improve their…	*n*	*M*	*SD*
planning and preparation	43	4.16	0.78
professional responsibilities	43	4.12	0.82
classroom environment	43	3.84	0.95
Instruction	43	4.12	0.88
Average		4.01	0.79

Discussion

The overarching aim of this project was to design and evaluate a collection of data dashboards designed for educators. After identifying five design principles and developing the dashboards, a formative evaluation was conducted with a group of 51 district stakeholders. The purpose of the formative evaluation was to gather feedback about three key areas: usability, perceived usefulness, and potential to improve teaching.

In terms of usability, the dashboards earned a positive. This result suggests that participants found the dashboards to be useable, which has been defined as the capability of being used (Bevan et al., 2015). How can this result be explained? One possible explanation has to do with the relationship between the landing page and the individual dashboards. One of the main terms in the definition of usability is *efficiency*, which the International Organization for Standardization defines as "resources expended in relation to the

accuracy and completeness with which users achieve goals" (ISO 9241-11, 1998). In this case, the landing page allowed users to access any of the available dashboards with a single click. This approach allowed stakeholders to easily move between dashboards, a design decision that aligns with one of Nielsen's (1995) ten usability heuristics: user control and freedom. Another factor that likely contributed to the dashboards' high average usability score was the alignment between the users, the surrounding environment, and the product design (Johnson, 2008). In this case, the interdisciplinary team designing the dashboards was familiar with and worked closely with many of the stakeholders. Understanding this context, likely contributed to the team's ability to design dashboards that aligned with users' needs.

The evaluation's second area of focus assessed the extent to which the dashboards would be perceived as useful. Participants' responses suggested they perceived the dashboards as useful. How might this be explained? This result may be related to the third guiding principle, delivering meaningful views of the data. The design team used this principle to drive much of its work so when it came time to define what data would be used and what dashboards would be created, the design team worked closely with stakeholders to ensure that the visualizations made available through the dashboards were expected and aligned with their needs. This approach aligns with Ahn et al.'s (2019) notion of *designing in context,* which encourages partnership research as opposed to positioning designers as separate from the research or practice partners. Ahn et al. (2019) argued that "being embedded as design-researchers provides rich, implicit, understanding of the local contextual factors and design tensions that may be easily lost through only doing interviews or a few observations" (p. 81).

The evaluation's third area examined how participants rated the dashboards' potential to improve teaching. Again, the participants reported positive ratings overall. However, the average rating for this measure was lower than the ratings for usability and perceived usefulness. This is not that surprising since the relationship between the dashboards and the four domains of teaching (planning and preparation, the classroom environment, instruction, and professional responsibilities) varies. For example, it makes sense that participants felt the dashboards could be used for planning and preparation. Similarly, it is understandable that participants did not see the dashboards as being helpful when it comes to improving the domain of classroom environment. To learn more about how these participants felt about the potential of dashboards to enhance or hinder aspects of teaching requires further investigation, possible through focus group interviews and observations.

Conclusion

The current work contains a number of implications for designers, practitioners, and researchers. For designers, one of the implications is the importance of identifying guiding principles from the beginning of the design process. In this case, having principles defined and available provided a valuable "check point" for making important decisions related to dashboard design. Such principles may also be used to help facilitate conversations with stakeholders and decision makers. For practitioners, one of the implications of this work includes insisting on being a voice in the design process. It is critical to communicate with designers to inform them of data needs and wants and how that information might be integrated into day-to-day practice. For researchers, perhaps the biggest implication is underscoring the importance of conducting formative evaluation. Systematic formative evaluations will provide valuable insight into how data dashboards are perceived and used by education stakeholders.

The work presented here has a number of limitations that are worth noting. First and foremost, the formative evaluation relied solely on a survey methodology that used close-ended questions. Future research should use a mixed-method approach that captures both quantitative and qualitative data. Another possible limitation is research bias as the researcher was a part of the design team. Ideally, an external evaluator would be brought in to provide a more objective analysis to the project's evaluation.

In conclusion, designing data dashboards for education is complex because they are "bearers of values and interpretations of the social worlds that are materialized and operationalized by particular concrete techniques and tools" (Williamson, 2016, p. 125). Sharing how the dashboards for one school district were

designed and evaluated, is one way to help the field improve its understanding of what works when it comes to providing reliable, scalable, and self-service analytics to educators.

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